INSTRUCTION, RESEARCH, AND STUDENT AFFAIRS
JUNE 16 , 2021

SUBJECT

Higher Education Research Council Report – FY20

REFERENCE

February 2017	The Board was provided the annual update of the Higher Education Research Council and approved the second reading of amendments to Board Policy III.W.
February 2018	The Board was provided the annual update of the Higher Education Research Council
June 2019	The Board was provided the annual update of the Higher Education Research Council
June 2020	The Board was provided the annual report of the Higher Education Research Council

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.W. Higher Education Research

BACKGROUND/DISCUSSION

Board Policy III.W. Higher Education Research recognizes the significant role research plays in innovation, economic development and enhanced quality of educational programs. By developing and leveraging the state's unique research expertise and strengths, Idaho's universities and colleges serve as catalysts to spur the creation of new knowledge, technologies, products, and industries. This in turn leads to new advances and opportunities for economic growth.

The Board's Higher Education Research Council (HERC) provides recommendations to the Board regarding statewide collaborative efforts and initiatives to accomplish these goals and objectives. In addition, HERC provides direction for and oversees the use of the limited resources allocated by the Board for higher education research by promoting research activities that will have the greatest beneficial effect on the quality of education and the economy of the state.

HERC also administers the Incubation Fund and HERC Idaho Global Entrepreneurial Mission (IGEM) Fund programs, disbursement of Infrastructure Funds, and the oversight of matching funds for our Idaho Established Program to Stimulate Competitive Research (EPSCoR) Track 1 project (Managing Idaho's Landscapes for Ecosystem Services) on the Board's behalf and in compliance with Board Policy III.W. Additional responsibilities include receiving annual reporting on the institutions' activities in relation to the Center for Advanced Energy Studies (CAES).

Incubation Fund projects are single-year projects that are at the proof-of-concept stage. Through a competitive process, HERC awards funds to those projects where the principal investigator can rapidly move their project into the development stage. IGEM Fund projects are awarded for competitive state university research in support of the goals of the Idaho Global Entrepreneurial Mission (IGEM) initiative. These funds are to be used as seed funding for strengthening Idaho's future by strategically investing in the development of expertise, products, and services which result in state economic growth. While these awards may be for up to three years, the funding is contingent upon successful progress as determined by HERC at an annual review of the project.

CAES is a research and education consortium between the three Idaho public research institutions (Boise State University, Idaho State University, University of Idaho), and the Idaho National Laboratory.

IMPACT

Taking a strategic approach to invest in the state's unique research expertise and strengths will lead to new advances and opportunities for economic growth and enhance Idaho's reputation as a national and international leader in excellence and innovation. This update will provide the Board with the opportunity to provide input to the Higher Education Research Council on areas of focus and strategic direction.

ATTACHMENTS

Attachment 1 – FY20 HERC Report Presentation Slide Deck
Attachment 2 – FY20 Research Performance Measure Report
Attachment 3 – FY20 Research Activity Report
Attachment 4 – FY20 HERC Budget Allocation
Attachment 5 – FY20 Infrastructure Summary Report
Attachment 6 – FY20 Idaho Conference on Undergraduate Research Report
Attachment 7 – FY20 Undergraduate Research Report
Attachment 8 – FY20 IGEM Grant Reports
Attachment 9 – FY20 Incubation Fund Grant Reports
Attachment 10 – 2020 CAES Annual Report

STAFF COMMENTS AND RECOMMENDATIONS

The HERC report will be provided by Dr. Christopher Nomura, who was hired as the Vice President for Research and Economic Development at the University of Idaho in Fall 2020. Dr. Nomura will become the new Chair of HERC on July 1, 2021.

BOARD ACTION

This item is for informational purposes only.

Higher Education Research Council

Report on activities from July 1, 2019 - June 30, 2020
(Fiscal Year 2020)

Dr. Christopher Nomura
June 16, 2021

Idaho State Board of Education
BOISE STATE UNIVERSITY
Idaho State UNIVERSITY
University of Idaho A LEGACY OF LEADING
Lewis-Clark STATE COLLEGE

Attachments

- FY20 Research Performance Measure Report
- FY20 Research Activity Report
- **FY20 Infrastructure Summary Report**
- **FY20 Undergraduate Research Report**
- **FY20 Idaho Conference on Undergraduate Research Report**
- **FY20 HERC Budget Allocation**
- **FY20 IGEM Grant Reports**
- **FY20 Incubation Fund Grant Reports**
- 2020 CAES Annual Report

HERC Mission

Strengthen the research capabilities at Idaho's public, four-year institutions and contribute to the economic development of the state of Idaho.

HERC Membership

Higher Education Representatives

Dr. Christopher Nomura, *University of Idaho*

Dr. Donna Lybecker, *Idaho State University*

Dr. Harold Blackman (Chair), *Boise State University*

Dr. Lori Stinson, *Lewis-Clark State College*

Industry Representatives

Robin Woods, *Alturas Analytics*

Marianne Walck, *Idaho National Laboratory*

Eileen Barber, *Keynetics*

Heather Messenger, *Life Sciences and Biotech Industry*

FY20 HERC Budget Allocation

Research Infrastructure Funds	$850,000
Matching Grants (EPSCoR)	$800,000
Undergraduate Research	$217,000
IGEM Grants	$2,066,500
Incubation Fund	$244,670
Administrative Costs	$2,700
Total	**$4,160,870**

Research Infrastructure

Funding to support science, engineering, and other research infrastructure

FY20 Infrastructure Budget - $850,000

Major line items:

- **BSU** – High performance computing equipment/software
- **ISU** – Equipment to support the IGEM 20-001 grant
- **UI** – Post-doctoral fellows and lab equipment
- **LC State** – Library support and lab equipment

Undergraduate Research

Funding to support STEM undergraduates in research projects and travel to conferences

FY20 UR Budget - $185,000

Student research projects supported in FY20:

BSU – 17
ISU – 10
UI – 11
LC State – 11

Idaho Conference on Undergraduate Research (ICUR)

Funding for two day undergraduate conference held each July

FY20 ICUR Budget - $32,000

FY20 ICUR Outcomes:

- 291 attendees from 26 different institutions/organizations
- 189 students
- 150 poster presentations
- 102 faculty, industry and governmental representatives

Idaho Global Entrepreneurial Mission Fund (IGEM)

Competitive grant program used as seed funding for strengthening Idaho's future by strategically investing in the development of expertise, products, and services which result in state economic growth.

1- to 3-year grants up to $700,000 per year

FY20 IGEM Grant Budget – $2,065,500

Active Grants in FY20: 4

FY20 Active IGEM Grants

Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management

University of Idaho – $700,000 – Year 3

Nucleic Acid Memory

Boise State University – $665K – Year 3

A Disaster Response Complex for Emergency Responders in Idaho

Idaho State University – $525K – Year 2

Cellulosic 3D Printing of Modular Building Assemblies

University of Idaho – $175K – Year 2

Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management (U of I)

- Build capacity and partnerships among UI, BSU, ISU and CAES to assist Idaho food producers and processors in reducing water, energy, and waste footprints
- Demonstrate/transfer technologies for reducing water/nutrient use
- Pilot at field-scale and transfer technology for recovering valuable nutrients/byproducts from waste streams
- Provide decision support tools for community and business stakeholders to better understand the interconnections and trade-offs between energy, water, nutrients, and land use
- Include workforce development in the use of new technologies

Nucleic Acid Memory (BSU)

- 16 trillion GB of data were produced in 2016; 163 trillion GB of data will be produced in 2025
- Archival storage of this huge amount of data using electronic memory is reaching physical and economic finish lines
- Project will develop an optical technology using DNA to write, store and read digital information
- DNA as a digital storage/memory medium:
  - Retention time of thousands to millions of years
  - 1 kg of DNA can store the entire projected digital universe in 2040
  - DNA storage energy is 100 million times less than current electronic memory
- Creation of Nucleic Acid Memory Institute to meet critical innovation, economic, and workforce development needs in Idaho

A Disaster Response Complex for Emergency Responders in Idaho (ISU)

- FEMA has recognized the need to establish emergency management as both an academic field and as an applied practice
- Coupling academia to traditional emergency response structures will make the complex emergency management more effective
- Goal of this project is to develop and construct an outdoor campus called "Disaster Response Complex" at ISU
- DRC will become a premier regional/national response center for research, curriculum development, and training/exercises for military and law enforcement personnel in Idaho and beyond
- The DRC ideas is strongly supported by INL and CAES who wish to use the complex to develop workforce talent

Cellulosic 3D Printing of Modular Building Assemblies (UI)

- Identify a methodology, process, and materials necessary to 3-D cold print building assemblies using wood fibers
- Primary objective is the development of a cost-effective and reliable process for printing wall, roof, and floor assemblies on a horizontal plane.
- Target market is light commercial, residential and multi-family buildings.

Incubation Fund Grant Program

1-year grants up to $75,000

FY20 Budget - $224,670

FY20 Projects: 3

FY20 Incubation Fund Grants

Optical Sensors for Harsh Environment
Boise State University– $75,000

Ink Production Scale Up

Boise State University – $74,970

Darwin's Demons Mobile: Expanding the Market for Evolutionary Procedural Content Generation

University of Idaho – $74,700

Optical Sensors for Harsh Environment (BSU)

- Market need for optical sensors that can withstand extreme environments and that are immune to electromagnetic interference
- Such sensors can be used in places like jet engines, nuclear power plants, deep sea drilling rigs, etc., leading to more accurate information and increased efficiencies
- Idaho does not currently have capability to create these kinds of sensors locally
- Fiberguide Industries in Caldwell has partnered with BSU and has become the industry leader in the US for this technology
- This grant allowed BSU to purchase an ultrafast laser system that is used by researchers and Fiberguide staff to create sensors on specialty fibers and test them under harsh environments (extreme temperature and radiation)

Ink Production Scale Up (BSU)

- Scale up the synthesis of nanoparticle inks
- Several inks are not available commercially, including platinum, niobium, cobalt, tungsten, molybdenum, iron
- Great interest in these inks from industry, national labs, and governments
- Further fostering partnerships with industry, leading to commercialization of new inks and associated technologies

Darwin's Demons Mobile: Expanding the Market for Evolutionary Procedural Content Generation (UI)

- US video game market generates over $90B per year
- Content development for games is expensive
- In a previous IGEM grant, UI researchers created a game using evolutionary procedural content generation (IPCG)
- This approach uses evolutionary models to evolve game content rather than relying on pre-programmed content
- IPCG creates a competitive advantage by significantly reducing game development costs
- This grant allowed UI to develop a mobile version of the game that was previously developed using IGEM funds.
- The mobile market is very large potential source of income

Thank You

Idaho State Board of Education

RESEARCH STRATEGIC PLAN PERFORMANCE MEASURES

Goal 1: Increased research at, and collaboration among, Idaho universities and colleges to advance research strengths and opportunities pertaining to critical issues in Idaho, while also providing a vision for national and global impact.

Objective 1.A: Ensure growth and sustainability of public university research efforts.

Performance Measure	FY 2016	FY 2017	FY2018	FY2019	FY2020	Benchmark
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$154,989,123	$163,093,485	$171,052,983	$166,564,099	Not yet available	10% annual increase
Objective 1.B: Ensure the growth and sustainability of the existing collaborative research at the Center for Advanced Energy Studies (CAES).						
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$8,561,218	$9,489,612	$11,022,015	$11,724,216	Not yet available	10% annual increase
Objective 1.C: Expand joint research ventures among the state universities.						
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	92	119	100	82	94	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	58	70	76	69	50	30% annual increase
Establish/fund at least one HERC-directed research project per year which collaborates with one other Idaho university that directly addresses issues of particular importance to the State of Idaho.	NA	NA	NA	1		1 per year

Goal 2: Create research and development opportunities that strengthen the relationship between state universities and the private sector.

Objective 2.A: Increase the number of sponsored projects involving the private sector.

Performance Measure	FY 2016	FY 2017	FY2018	FY2019	FY2020	Benchmark
Number of new sponsored projects involving the private sector.	165	163	172	202	206	50% annual increase

Goal 3: Contribute to the economic development of the State of Idaho.						
Objective 3.A: Increase the amount of university-generated intellectual property introduced into the marketplace.						
Performance Measure	**FY 2016**	**FY 2017**	**FY2018**	**FY2019**	**FY2020**	**Benchmark**
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	44	33	29	29	28	15% annual increase
Number of invention disclosures (including biomic varieties)	40	38	45	46	58	1 for every $2M of research expenditures
Amount of licensing revenues.	$724,316	$1,271,819	$ 1,869,718	$ 2,607,055	$ 3,450,773	10% annual increase
Number of startup companies.	8	1	1	1	0	10% annual increase
Goal 4: Enhance learning and professional development through research and scholarly activity.						
Objective 4.A: Increase the number of university and college students and staff involved in sponsored project activities.						
Performance Measure	**FY 2016**	**FY 2017**	**FY2018**	**FY2019**	**FY2020**	**Benchmark**
Number of undergraduate students paid from sponsored projects.	1,683	1,811	2,100	1,926	1,993	20% annual increase
Number of graduate students paid from sponsored projects.	636	716	656	592	536	20% annual increase
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.	UI: 60.4%, BSU: N/A, ISU: 13%	UI: 66.0%, BSU: N/A, ISU: 12.1%	UI: 62.7%, BSU: N/A, ISU: 19.6%	UI: 64.4% BSU: N/A ISU: 12.7%	UI: 58.1% BSU: N/A ISU: 19.1%	20% annual increase
Number of faculty and staff paid from sponsored projects.	2,272	2,383	2,418	2,446	2,484	20% annual increase
K-20 Statewide Stratgic Plan Performance Measures	**FY 2016**	**FY 2017**	**FY2018**	**FY2019**	**FY2020**	**Benchmark**
Percentage of students participating in undergraduate research.	UI: 64%, BSU: 35%, ISU: 43%, LCSC: 10%	UI: 65%, BSU: 37%, ISU: 42%, LCSC: 14%	UI: 61%, BSU: 37%, ISU: 41%, LCSC: 16%	UI: 58%, BSU: 43%, ISU: 38%, LCSC: 20%	UI: 60%, BSU: 43%, ISU: 36%, LCSC: 12%	30%
Percentage of students participating in internships	5%	5%	8%	6%	6%	10%

Boise State University

Sponsored Project Activity Report FY2020

Awards for the Period July 1, 2019 through June 30, 2020

Activity Type		Federal	State	Industry	Other	Total	% of Grand Total
	Instruction:						
	Sponsored Programs	$ 3,248,152	$ 2,442,843	$ -	$ 322,855	$ 6,013,850	
	State Instruction Appropriations	$ -	$ 60,000	$ -	$ -	$ 60,000	
	Subtotal Instruction	$ 3,248,152	$ 2,502,843	$ -	$ 322,855	$ 6,073,850	10.43%
	Research:						
	Sponsored Programs	$ 32,193,801	$ 3,174,145	$ 923,494	$ 1,354,164	$ 37,645,604	
	State Research Appropriations	$ -	$ 816,470	$ -	$ -	$ 816,470	
	Subtotal Research	$ 32,193,801	$ 3,990,615	$ 923,494	$ 1,354,164	$ 38,462,074	66.04%
	Other Sponsored Activities:						
	Sponsored Programs	$ 9,802,730	$ 1,934,790	$ 548,142	$ 1,284,550	$ 13,570,213	
	State Other Sponsored Activities Appropriations	$ -	$ 133,366	$ -	$ -	$ 133,366	
	Subtotal Other Sponsored Activities	$ 9,802,730	$ 2,068,156	$ 548,142	$ 1,284,550	$ 13,703,579	23.53%
Grand Totals		**$ 45,244,683**	**$ 8,561,615**	**$ 1,471,636**	**$ 2,961,569**	**$ 58,239,503**	
Percent of Grand Total		***77.69%***	***14.70%***	***2.53%***	***5.09%***	***100%***	***100%***

Expenditures for the Period July 1, 2019 through June 30, 2020

Activity Type		Federal	State	Industry	Other	Totals	% of Grand Total
	Instruction:						
	Sponsored Programs	$ 2,955,733	$ 1,460,849	$ -	$ 88,181	$ 4,504,763	
	State Instruction Appropriations	$ -	$ -	$ -	$ -	$ -	
	Subtotal Instruction	$ 2,955,733	$ 1,460,849	$ -	$ 88,181	$ 4,504,763	9.33%
	Research:						
	Sponsored Programs	$ 27,058,048	$ 1,390,318	$ 358,136	$ 1,021,757	$ 29,828,258	
	State Research Appropriations	$ -	$ 248,976	$ -	$ -	$ 248,976	
	Subtotal Research	$ 27,058,048	$ 1,639,294	$ 358,136	$ 1,021,757	$ 30,077,234	62.31%
	Other Sponsored Activities:						
	Sponsored Programs	$ 9,307,481	$ 2,562,671	$ 82,938	$ 1,643,911	$ 13,597,001	
	State Other Sponsored Activities Appropriations	$ -	$ 91,638	$ -	$ -	$ 91,638	
	Subtotal Other Sponsored Activities	$ 9,307,481	$ 2,654,308	$ 82,938	$ 1,643,911	$ 13,688,639	28.36%
Grand Totals		**$ 39,321,262**	**$ 5,754,452**	**$ 441,074**	**$ 2,753,849**	**$ 48,270,636**	
Percent of Grand Total		***81.46%***	***11.92%***	***0.91%***	***5.71%***	***100%***	***100%***

Idaho State University
Office for Research
Award Breakdown by Funding Agency Type and Project Type
July 1, 2019 through June 30, 2020

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	4,534,826	3,523,750	3,474,710	804,041	12,337,327	45%
Training and Instruction	1,733,003	938,702	1,213,232	340,155	4,225,092	15%
Other/Public Service	7,028,149	2,662,092	1,144,804	259,605	11,094,650	40%
Totals	13,295,978	7,124,544	5,832,746	1,403,801	27,657,069	100%
Percent of Total	48%	26%	21%	5%	100%	

State = Awards from state of Idaho agencies, including other state universities and colleges

Other/Foundation = Awards from other funding agecnies, such as foundations, universities from outside of Idaho, local municipalities, non-profits, etc.

File Name: ISU OR Annual Awards FY20

Idaho State University
Office for Research
Expenditure Breakdown by Funding Agency Type and Project Type
July 1, 2019 through June 30, 2020

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	7,339,332	274,614	453,229	956,426	9,023,601	46%
Training and Instruction	5,785,978	785,328	407,657	111,507	7,090,470	36%
Other/Public Service	2,016,246	938,891	443,080	9,771	3,407,988	17%
Totals	15,141,556	1,998,833	1,303,966	1,077,704	19,522,059	100%
Percent of Total	78%	10%	7%	6%	100%	

File Name: ISU OR Annual Expenditures FY20

University of Idaho - FY2020 Research Activity Report

Awards for the Period July 1, 2019 through June 30, 2020

	Federal	State of Idaho	Industry	Other	Total	% of Grand Total	% of Sponsor Total
Instruction:							
Sponsored Programs	$ 2,552,894.63	$ 48,335.08	$ 59,905.00	$ 26,000.00	$ 2,687,134.71		**3%**
	$ 2,552,894.63	$ 48,335.08	$ 59,905.00	$ 26,000.00	$ 2,687,134.71	**2%**	
Research:							
Sponsored Programs	$ 52,242,047.61	$ 3,098,038.00	$ 1,240,140.79	$ 5,314,530.40	$ 61,894,756.80		**67%**
Federal Land Grant Appropriations (FFY20)	2,873,822.00				2,873,822.00		
State Research Appropriations (CALS,FUR,IGS,EPSCoR)		23,464,891.00			23,464,891.00		
Subtotal Research:	$ 55,115,869.61	$ 26,562,929.00	$ 1,240,140.79	$ 5,314,530.40	$ 88,233,469.80	**65%**	
Public Service:							
Sponsored Programs	$ 24,053,994.76	$ 1,989,118.04	$ 178,574.95	$ 1,879,768.92	$ 28,101,456.67		**30%**
Federal Land Grant Appropriations (FFY20)	3,050,887.50				3,050,887.50		
State Extension Appropriations		12,737,309.00			12,737,309.00		
Subtotal Public Service:	$ 27,104,882.26	$ 14,726,427.04	$ 178,574.95	$ 1,879,768.92	$ 43,889,653.17	**33%**	
Construction:							
Sponsored Programs	100,000.00	-	-	-	100,000.00	**0%**	**0%**
Total Sponsored Programs Funding	**$ 78,948,937.00**	**$ 5,135,491.12**	**$ 1,478,620.74**	**$ 7,220,299.32**	**$ 92,783,348.18**		
Percent of Total Sponsored Programs	***84%***	***6%***	***2%***	***8%***	***100%***		***100%***
Grand Total of All Funding Per Category	**$ 84,873,646.50**	**$ 41,337,691.12**	**$ 1,478,620.74**	**$ 7,220,299.32**	**$ 134,910,257.68**		
Percent of All Funding	***63%***	***31%***	***1%***	***5%***	***100%***	***100%***	

Expenditures for the Period July 1, 2019 through June 30, 2020 (includes accruals)

	Federal	State of Idaho	Industry	Other	Institutional	Total	% of Grand Total	% of Sponsor Total
Instruction:								
Sponsored Programs	$ 2,437,876.30	$ 64,329.59	$ 35,169.97	$ 229,136.32	$ 418,393.66	$ 3,184,905.84		**3.2%**
	$ 2,437,876.30	$ 64,329.59	$ 35,169.97	$ 229,136.32	$ 418,393.66	$ 3,184,905.84	**2.0%**	
Research:								
Sponsored Programs	$ 48,940,862.98	$ 2,709,475.44	$ 2,581,405.39	$ 3,733,600.79	$ 11,100,583.38	$ 69,065,927.98		**70.0%**
Federal Land Grant Appropriations	2,508,933.37					2,508,933.37		
State Research Appropriations (CALS,FUR,IGS,EPSCoR)		22,155,226.66				22,155,226.66		
State Other Appropriations		8,148,909.60				8,148,909.60		
Other Sources	-	-	-	2,496,438.41	8,435,022.14	10,931,460.55		
Subtotal Research:	$ 51,449,796.35	$ 33,013,611.70	$ 2,581,405.39	$ 6,230,039.20	$ 19,535,605.52	$ 112,810,458.16	**71.3%**	
Public Service:								
Sponsored Programs	$ 19,085,710.98	$ 1,453,471.02	$ 154,580.01	$ 1,673,231.38	$ 3,792,932.67	$ 26,159,926.06		**26.5%**
Federal Land Grant Appropriations	3,072,590.47					3,072,590.47		
State Extension Appropriations		12,840,873.71				12,840,873.71		
Subtotal Public Service:	$ 22,158,301.45	$ 14,294,344.73	$ 154,580.01	$ 1,673,231.38	$ 3,792,932.67	$ 42,073,390.24	**26.6%**	
Construction:								
Sponsored Programs	$ 100,000.00	$ -	$ -	$ -	$ 100,000.00	$ 200,000.00	**0.1%**	**0.2%**
Total Sponsored Programs Funding	$ 70,564,450.26	$ 4,227,276.05	$ 2,771,155.37	$ 5,635,968.49	$ 15,411,909.71	$ 98,610,759.88		
Percent of Total Sponsored Programs	***72%***	***4%***	***3%***	***6%***	***16%***	***100%***		**100%**
Grand Total of All Funding Per Category	$ 76,145,974.10	$ 47,372,286.02	$ 2,771,155.37	$ 8,132,406.90	$ 23,846,931.85	$ 158,268,754.24		
Percent of All Funding	***48%***	***30%***	***2%***	***5%***	***15%***	***100%***	100%	

FY 2020 Allocation of HERC Funds

		Total	FY2020 Proposed Allocation
		$4,163,200	
	HERC IGEM		2,066,500
	Infrastructure Funds		850,000
	Matching Grants (EPSCoR Match)		800,000
	Incubation Fund		224,670
	Undergraduate Research		217,000
	Administrative Costs		2,700
Total		**$4,160,870**	4,160,870
Balance			2,330

IGEM Funds		
BSU	IGEM 19-02	$666,500
ISU	IGEM 20-01	$525,100
UI	IGEM 19-01	$700,000
UI	IGEM 20-02	$174,900
LCSC		
Total IGEM		**$2,066,500**

Research Infrastructure Funds	$0
BSU	$250,000
ISU	$250,000
UI	$250,000
LCSC	$100,000
Total Infrastructure	**$850,000**

Matching Award Grants	
NSF-EPSCoR	$800,000
Total Matching Grants	**$800,000**

Targeted Research	
Idaho Incubation Fund (7th round)	
Kandadai "Optical Sensors" (BSU)	$75,000
Subbaraman "Ink Production" (ISU/UI)	$74,970
Robsion "Darwin's Demons" (UI)	$74,700
Total Targeted Research	**$224,670**

Undergraduate Research	
BSU	$55,000
ISU	$55,000
UI	$55,000
LCSC	$20,000
Idaho Conference for Undergraduate Research (ICUR)	$32,000
One-time money	
Total Undergraduate Research	**$217,000**
Administrative Costs	
FY20 Administrative Costs	$2,700
Total Administrative Costs	**$2,700**
Total Budget / Allocation	**$4,160,870**

Detailed Allocations	
Library Support	
Graduate Research Assistantships/Research Associates	10,000
Post Doctoral Fellows	
Technician Support	
Maintenance Contracts	
Research Equipment	210,892
Competitively Awarded Summer Research Support	
Start-Up Funds for New Hires	23,000
Incentives to Reward Faculty for Research Achievements	
Other	6,108 (refund 2019 funds)
Total Allocation	250,000

Detailed Allocations	
Publications in refereed journals	
Presentations at professional meetings and conferences	
Grants Received as a result	
Grants Pending	
Student Participation	
Faculty Participation	
Other Participation	
Patents Awarded	
Patents Pending	
Manuscripts Submitted	

Notes:
Research Equipment:
HPC (High Performance Computing) Equipment and Software - $140,868
Compliance (Vivarium/Animal cages/ Software) – $70,024

Startup – Biology - Buerki $23,000

GA – Biology/BMOL PhD Student - $10,000

Refund of 2019 funds (equipment funds encumbered at FY end then canceled/unspent) - $6,108

FY 2020 INFRASTRUCTURE REPORT SUMMARY - ISU

	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$0	
Technician Support	$0	
Maintenance Contract - Biology, Chemistry and Research Date Cnt.	$5,767	Shimadzu Scientific : Service Agreement for a microscope, Elite Services: moving service fo a freezer, OFR: Research Data Center SmartNet Maintenance. Peak Scientific: Compressor Complete
Equipment: IGEM 20-001 Disaster Response Complex Mustafa Mashal	$171,568	Advanced Air Products: MTS Temposonics, R-Series. Amazon: Hydraulic Cylinder Jack Ram, Double Acting, Hollow Ran 1 PCE. BTM: Cement Mixer. Campbell Scientific: Control Datalogger, Power Supply, 5V Analog, CPI Network Kit. Dell Marketing: Optiplex 7070 SFF XCTO Computer., Dylon Toyota: Forklift. EnerPac: Cutter Bar Electric. Interface Inc: 2160 Series Column Load Cell 2.0, Intelligent Digital Indicator. Kaman: Trompler fluid power, high pressure hose, simplex power unit, Continental Custom Hydraulic Power unit, 1-1/2 horse power generator. Spartan Steel: Isolation Frame.
Equipment- Biology	$15,527	Fisher Scientific: Temperature Freezers. Mechanical Solutions: Hoshizaki F-500 BAJ Ice Machine.

FY 2020 INFRASTRUCTURE REPORT SUMMARY - ISU

Supplies: IGEM Mustaf Mashal Civil Engineering	$52,616	Materials and Supplies: Time Lapse cameras, Blade adapter, screws and solder cup plugs, electrical supplies, Lab supplies, masks, safety supplies, Materials for aircompressor and plasma cutter, metal plates, propane and shop supplies.
Competitvely Awarded Summer Research Support		
Start-Up Funds for New Hires		
Incentives to Reward Faculty for Research Achievements		
Other- Shipping	$4,522	Shipping for engineering supplies, rubble materials, Electronic measuring equipment
Total Allocation	$250,000	

	Detailed Allocations
Publications in Refereed Journals	Several publications using the Shimadzu microscope: "Soil Signals tell of landscape disturbances, EOS, 101. "Influence of drying and wildfire on longitudinal chemistry patterns and intermittent streams", Frontiers in Water. "topographic controls on soil orgaic carbon on soil mantled landscapes", Scientific Reports. Identification and Quantification of Sesquiterpene Lactones (SLs) of Sagebrush (Artemisia tridentate) and its Biological Activity; Rosemary Anibogwu, Karl De Jesus, Kavita Sharma. In progress.
Presenations at Professional Meetings and Conferences	ICUR 2020; Fundamental Study on Desulfurization of Petroleum Using Synthesized Novel Ionicliquid and Betaines Moieties; *Bryson Blad, Evelin Noris, Peyton Kiggins, Karl De Jesus, Kavita Sharma*

FY 2020 INFRASTRUCTURE REPORT SUMMARY - ISU

Grants Received as a Result	SEE SECOND TAB
Grants Pending	SEE SECOND TAB
Student Participation	Undergradute and gradute students from chemistry and biology are receiving training for LC-MS.
Faculty Participation	Analysis of Plant metabolite (Dr. Sharma; Chemistry), Steroids analysis in fish and birds (Dr. Pradhan; Biology), Peptide analysis from sediments (Dr. Dudgeon; Geoscience), Analysis of organic compounds (Dr.Srinath Pashikanti; pharmacy)
Other Participation	N/A
Patents Awarded	N/A
Patents Pending	N/A

FY 2020 INFRASTRUCTURE REPORT SUMMARY - ISU

IGEM 20-001 Disaster Response Complex Mustafa Mashal	
	Detailed Allocations
Publications in Refereed Journals	(1) K. Hogarth, J. Cantrell, M. Mashal, B. Savage, and R. Khadka (2020). A Disaster Response Complex for Training of First Responders in the Northwest United States, Countering WMD Journal, United States Army Nuclear and Countering WMD Agency (Under Review). (2) J. Cantrell, M. Mashal, and A. Ebrahimpour (2021). “Large-Scale Testing of a Precast Bent System for Accelerated Bridge Construction: Seismic Performance and Comparison with Cast-In-Place”, PCI Convention and National Bridge Conference (accepted for presentation).
Presenations at Professional Meetings and Conferences	(1) The Center for Advanced Energy Studies (CAES) Fellows Meeting, September 3, 2020. (2) Several tours and open houses of the outdoor and indoor laboratories in August and September to leadership from ISU, Idaho National Laboratory, CAES, Department of Energy and many other professionals and responders from Eastern and throughout the state of Idaho.
Grants Received as a Result	(1) “Advanced Manufacturing for Bulk Storage of Hydrogen”, funded by CAES Tranche 3 for $7,000. PI = Dr. Mashal. (2) “RFID Based Cyber-Physical System for Tracking and Monitoring Movement of Precast Concrete”, funded by the College of Science and Engineering and Dr. Andrew Chrysler at ISU for $18,968. PI = Dr. Chrysler, Co-PI = Dr. Mashal. (3) “Student Internship Support” funded by ISU-CAES for $10,800. PI = Dr. Mashal.
Grants Pending	(1) “Enhancing Ductility of Reinforced Concrete Columns through Debonding of Flexural Reinforcing Bars in Seismic Regions” for $30,000. PI = Dr. Mashal. (2) “Experimental Testing of Blue Planet Building Panels” for $26,500 to Company 'A' in Idaho. (3) “Use of Novel Materials to Construct Seismic Resilient Precast Bridges with 100-Year Service Life” Submitted to 2020-2021 Precast/Prestressed Concrete Institute (PCI) Dennis R. Mertz Bridge Research for $40,000. (4) “Shake table testing of fiber optic bundle” submitted to Company 'B' in Idaho for $1,600. (5) “Freeze-thaw testing of self-consolidating concrete” submitted to Company 'C' for $1,200. (5) “Tensile Test on Ear Loops & Melt-Blown Fabric” submitted to Company 'D' in Idaho for $500. (6) “Shake Table Testing of Bridge Piers” submitted for Undergraduate Research Funds Application, FY21, for $9,000. (7) “RFID Measurement System for Nuclear Containment Structure” pre-application submitted under Nuclear Energy Enabling Technologies (NEET) funding opportunity for $786,000. PI = Dr. Andrew Chrysler; Co-PI = Dr. Mustafa Mashal. (8) “Confidential Title” whitepaper submitted to the Department of Defense’s Vannevar Bush Fellowship for $3M. (9) “Innovative Adjustable Anchor System” to be submitted to Idaho Global Entrepreneurial Mission (IGEM) Commerce for $152,766. PI = Dr. Arya Ebrahimpour, Co-PI = Dr. Mustafa Mashal.

FY 2020 INFRASTRUCTURE REPORT SUMMARY - ISU

Student Participation	This support allowed for the procurment of numerous equiptment specific for the use of high capacity sturctural testing. Thus addding to the ability of the Civil and Environmental Department to further extend its ability within strutural testing, specifically bridge bearing and large rock samples testing. This has directly resulted in the hiring of mutliple undergradute and graduate students to carry out numerous research projects. The funding also brought relief to the Disaster Response Complex allowing for three additional summer student hires.
Faculty Participation	Faculty and staff of multiple departments (e.g. Computer Science, Mechanical Engineering, Electrical Engineering, Nuclear Engineering, College of Technology) have been having the opportunity to write proposals and grants with the newly established capabilities brought to the civil and environmental engineering department.
Other Participation	Researchers from the Idaho National Laboratory, the Center for Advanced Energy Studies, and private industry have been collaborating with ISU on new and emerging research topics given the added capabilities by IGEM.
Patents Awarded	N/A
Patents Pending	M. Mashal (2020). “Ductile Connections for Pre-Formed Construction Elements”, United States Non-Provisional Patent Application, 16/817,042.

FY 2020 INFRASTRUCTURE REPORT SUMMARY - LCSC

	Total $	Detailed Allocations	
Library Support	$25,328	**PO #60972-$11,261.33**-Ebsco-Nature, England, Online Journal 2020- **PO #61328-$5447.62** Ebsco-cell online journal 2020-Infobase Learning-Allied Health-Nursing Video Coll. **- PO#61580 - $5020.20** Technical & Trade Education Video Collection; **Invoice #402507** to Infobase - for Allied Health, Nursing, Tech & Trade Ed Video Collection	
IR&E Qualtrics License	$7,150	**PO #819462**-Campus license for survey software-12 month Research License for Qualtrics.	
SPSS campus-wide licenses	$1,440	**PO #818951**-Pd **$1440.30** of a $5485.90 invoice on 7/31/2019 for use by faculty.	
Research Collaborative - faculty	$5,300	**$4,000.00-Kylee Britzman**. Social Sciences Division-Assessment Plan for process and results: With the pilot study, we will assess the results to make sure the go/no-go association worked (i.e. confirm we are actually measuring people's implicit rather than explicit political attitudes). Once we are confident that the design works, will implement the larger study on a national platform. The results will generally be analyzed through a statistical regression analysis. **$1,300.00-Collin Fehr**. The purpose of this research collaboration is to explore the effects of BEMER technology on recovery and performance parameters in anaerobic exercise. If found to be effective at enhanced recovery in active populations, this intervention could prove viable for reducing injury risk and positively affect return-to-exercise outcomes. Additionally, the improved recovery may secondarily lead to legitimate performance-enhancement in sport.	
HERC Research Grant	$1,500	**$1,500.00-Darci Graves.** Out of sight, out of mind: Exploring the individual impact of "sweeping" homeless camps. I have utilized grant funds to purchase two audio recording devices and noise-cancelling microphones. These devices will be used to record qualitative research interviews and came equipped with a USB port that allows the researcher to plug the device into a computer and download the audio files for transcription. I also purchased, with IRB approval, gift cards with a face value of $15.00 to Subway and McDonalds. These are intended to be gifted to research participants as compensation for their time and participation in the study.	
HERC-DONSAM-Faculty Affairs Grants	$5,441	**$1813.65-Keegan Schmidt.** Creating a multidisciplinary, student-centered research program in remote sensing and planetary structure; geoscience aspects**. $1813.65 Heather Moon.** Creating a multidisciplinary, student-centered research program using mathematical techniques for remote sensing of planetary structures. **$1813.65 Charles Addo-Quaye.** Improving the accuracy of in silico DNA mutation detection methods.	
DONSAM-Floor Centrifuge	$27,000	The floor centrifuge that we purchased is a Sorvall LYNX 4000 Superspeed Floor Centrifuge from Thermo Scientific and a Fiberlit rotor for use with 250mL vessels in the centrifuge. Thermo Scientific provided estimates with two rotors needed for very different (described later) purposes in our laboratories. After being granted funds to purchase the floor centrifuge, the cost of the rotors and centrifuge were beyond the funding amount. We asked Thermo Scientific if they could give us an option that was within our budget. We were able to get a newer model centrifuge (the model stated above) with the following accessories • A set of 6 adapters to allow the rotor to be used with 15mL conical tubes. • This purchase includes installation by a technician from Thermo Fisher. • And at no additional cost (because we opted for the above package): ◦ Additional sets of adapters (6 each) ◦ For 50mL conical tubes (Regular price $3200) ◦ For 50mL round-bottom tubes (Regular price $1400) ◦ For 16mL round-bottom tubes (Regular price $2150) The floor centrifuge is used in Biology (BIOL 182, 250, 341) and Chemistry (CHEM 481) courses and for faculty and student research projects in the lab of Leigh Latta. We estimate that each semester 50-60 students gain educational benefit (in the classroom and research) through use of the floor centrifuge	
DONSAM-Water Purification System	$10,000	The water purification system that we purchased is an Elix 10 from MilliporeSigma which will dispense 10L per hour of reverse osmosis purified water. The accessories that came with our purchase were • 2 pre-treatment internal filters, • 1 pre-treatment external filter, • 2 CO2 trap filters to allow use of a reservoir, • 2 filter units for the E-pod unitAt no additional cost, MilliporeSigma added an E-pod dispensing console valued at $1900. This is a handheld unit that can be set to dispense a set volume, reducing the chance of overfilling vessels. Also included in the purchase is the cost of installation by an engineer. The water purification system is used to prepare solutions for almost all Biology and Chemistry courses. The courses that use the system the most are BIOL 182, 341, 250, CHEM 111, 1112, 325, 454, and 481. Student and faculty research in Eric Stoffregen's lab adds to the demand when working with fly food and daphnia media. Chemistry courses and research use the system to prevent contamination when working with solutions and reactions. Nancy Johnston's research lab (students and faculty research) also require the use of the purification system. All-in-all, 100-150 students gain educational benefit in coursework and research through use of the water purification system.	
BEMER Equipment (MaSS)	$6,000	**Invoice #410200**-The BEMER Pro Set package was used to support faculty-student research on Physical Vascular Therapy experience. The purpose of this research collaboration was to explore the effects of BEMER technology on recovery and performance parameters in anaerobic exercise. This technology represents an investment in future high-impact practices for students at LCSC. The BEMER Pro Set includes a comprehensive set of application modules and accessories; the application modules direct the BEMER Signal from the control unit to the treatment area. The BEMER Pro Set includes: B.BOX Professional, B.BODY Pro, B.SPOT incl. Fixing Strap & B.GRIP, B.PAD, B.LIGHT incl. Protective Goggles, B.SCAN, Wall Mount, Foot Protection, Car Power Cable.	

Student-HERC	$1,085	**$448** to Judy Boozer for miscellaneous supplies (fish tanks, filters, water heaters) related to her project on the use of amphioxus as a model for regenerative medicine. Her project this semester was to establish an amphioxus culture on campus and then study the feasibility of maintaining the culture, as well as initiating a pilot study on regeneration.**$138** to Ryan Glimp and McKenzie Malm for miscellaneous supplies (latex gloves, pregnancy tests, alcohol wipes, bleach) related to their project on body dysmorphia occurrence in college athletes versus college students who are not athletes. **$579** to Mari Carillo for travel to southern Idaho to complete her research on Medical Pluralism: Shifts in Traditional Knowledge and Practice among Sobadores. Mari's research included interviews with traditional healers, such sobadores, in Latino communities	
Research Symposium	$10,000	Research Symposium	
HERC Allocation	$1,196	Stipend for Eric Stoffregen for a written proposal to National Institutes of Health. DNA damage adversely affects health and disease. The overall goal of this project is to investigate how the Bloom (BLM) DNA helicase prevents damage caused by repetitive DNA sequences, which pose a challenge to the DNA replication machinery. We will use the genetic and molecular biology tools of the model fruit fly to better understand how a lack of BLM protein in human patients leads to the developmental abnormalities, premature aging, and cancer susceptibility seen in Bloom Syndrome.	
Total Allocation	$101,440	Expensed FY20 approrpiation and $1,1440 of FY19 carry-forward.	

	Detailed Allocations	
Publications in Refereed Journals		
Presentations at Professional Meetings and Conferences		
Grants Received as a Result		
Grants Pending		
Student Participation	See above	
Faculty Participation	See above	
Other Participation	Community members, faculty and staff emeritus, and alumni are invited to attend the research symposium each year.	
Patents Awarded		
Patents Pending		

FY 2020 INFRASTRUCTURE REPORT SUMMARY - UI

	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$67,427	IWRRI PostDoc Fellow
Technician Support	$19,624	$1,336, Mass Specrotemry director provides research support to UI labs; $5,649 - Optical Imaging Director provides research support to UI labs; $12,638, set up donated D8 XRD microscope.
Maintenance Contracts	$0	
Equipment	$51,394	$4,296, Ductless hood; $3,215, replace heater exchanger in HVAC unit, HFCES; $25K Overheating issues in Ag Bldg 62; $18,883, EM Center microscope maintenance repairs.
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$6,545	Excellence in Research Award
Other	$105,010	$2,339 for PostDoc/Faculty Mentor Award; $3,485, conference and travel expenses related to cyber infrastructure; $29,901 to refinish floors and a small remodel in the Lab Animal Research Facility to meet federal guidelines and regulations; $40,000, funding to study water, water resources, and sustability; $1K Renfrew Colloquium; $8,620 AAALAC International new application fee; $7,033.22, COVID-19 modeling startup costs; $12,632.45, COVID-19 testing startup costs.
Total Allocation	$250,000	

FY 2020 INFRASTRUCTURE REPORT SUMMARY - UI

	Detailed Allocations
Publications in Refereed Journals	16
Presenations at Professional Meetings and Conferences	11
Grants Received as a Result	14
Grants Pending	5
Student Participation	87
Faculty Participation	65
Other Participation	1530
Patents Awarded	
Patents Pending	

NOTE: Other participation includes postdocs, research scientists, research specialists, stakeholders, and 1500 Colloquium audience members (50 members each of 30 sessions).

Final Report for HERC Funding for the 2020 Idaho Conference on Undergraduate Research (ICUR)
Submitted by Donna Llewellyn, Executive Director of the Boise State Institute for Inclusive and Transformative Scholarship

ICUR 2020 was held on July 23 and 24, 2020. Due to restrictions caused by COVID-19, the conference was moved to be an online event. We used the ForagerOne Symposium platform for the display of student posters and Zoom for the synchronous talks and workshops. The pandemic and this pivot to an online event caused some major changes from past years' conferences – fewer students across the state were participating in research this summer, and the conference expenses were of a very different nature. In terms of attendance, we were pleased that participation was still robust, perhaps due to the ability to log in and participate from anywhere in the world. And for the expenses, while we didn't incur any catering, facilities, or printing charges from Boise State (usually our largest expenses), we did purchase a license to use the Symposium site and we utilized a much greater amount of staff time to get the conference designed, planned, and implemented. We are grateful for the HERC funding that allowed us to hold ICUR this year in spite of the move to all remote events at Boise State.

The total attendance was 291, from 26 different institutions/organizations. This included 189 students with 150 poster presentations, and 102 faculty, industry, governmental, and community representatives. As mentioned above, each of the campuses across the state saw a decrease in undergraduate research this summer, so we were pleased with this attendance and participation. Note that none of our campuses hosted their usual REU programs with students visiting from other campuses this summer. Our planning committee of representatives from the different colleges and universities across the state really worked hard to encourage and facilitate participation.

There were two days of workshops and presentations – see the following pages for the program schedule. More details are also available at https://www.boisestate.edu/icur/. Note that A pdf version of the program is available at this website.

A survey was been sent out to all of the attendees. The likert scale responses and an overview of the open-ended responses are attached. We intend to use these results to improve the conference next year, especially since we currently expect that we will once again be holding a virtual conference due to COVID-19.

The funding from HERC went to the following categories of expenditures:

Item	Amount
Program Design	$1586.00
Online platform for poster displays	4000.00
Other expenses related to online conference	302.50
Materials and Supplies	788.64
Admin, Evaluation, and Director Support	$25229.76
TOTAL	**$31,906.90**

ICUR 2020 PROGRAM

TIMES	THURSDAY, JULY 23	
9 A.M.	**OPENING SESSION:**	**Donna Llewellyn**, Boise State University **TJ Bliss**, Idaho State Board of Education **Michal Temkin Martinez**, Boise State University
	Location:	Zoom Main Room
10 – 10:30 A.M.	**BREAK**	
10:30 – 11:30 A.M.	**HOW AND WHY TO GET INVOLVED IN RESEARCH WHILE AN UNDERGRADUATE**	
	Moderator:	**Marion Scheepers**, Boise State University
	Panel Discussion:	**Liljana Babinkostova**, Boise State University **Cynthia Campbell**, Boise State University **Thomas Klein**, Idaho State University **Krishna Pakala**, Boise State University **Dusty Perkins**, College of Western Idaho **David Pfeiffer**, University of Idaho **Michal Temkin Martinez**, Boise State University
	Location:	Zoom Breakout Room 1
	GRADUATE SCHOOL – THE REAL STORY	
	Moderator:	**Cecelia Staggs**, University of Oregon
	Panel Discussion:	**Jonathan Barnes**, University of Idaho **Averi McFarland**, Idaho State University **Carson MacPherson-Krutsky**, Boise State University **Cecelia Staggs**, University of Oregon
	Location:	Zoom Breakout Room 2
11:30 A.M. – 1 P.M.	**BREAK**	
1 – 2 P.M.	**STUDENT LIGHTNING TALKS**	
	Moderator:	**Keegan Schmidt**, Lewis-Clark State College
	Speakers:	**Emma Archey**, College of Western Idaho **Reagan Badger**, Idaho State University **Lance Fredericks**, University of Idaho **Mikayla Manzi**, Northwest Nazarene University **Dylan Miller**, Lewis-Clark State College **Allen Skirvin**, Boise State University
	Location:	Zoom Main Room
2 – 2:30 P.M.	**BREAK**	
2:30 – 3:30 P.M.	**STRATEGIES FOR A SUCCESSFUL RESEARCH EXPERIENCE**	
	Facilitator/Presenter:	**Jillana Finnegan**, Boise State University
	Location:	Zoom Main Room
3:30 P.M.	**ADJOURN FOR THE DAY**	

ICUR 2020 PROGRAM

TIMES	FRIDAY, JULY 24	
8:45 A.M.	**PAIRED RESEARCH TALKS**	
	Moderator:	**Tracy Yarnell**, Boise State University, Biomolecular Research Center
	Speakers:	**David Estrada**, Faculty, Boise State University
		Lynn Karriem, Student, Boise State University
		Devaleena Pradhan, Faculty, Idaho State University
		Melissa Rivas, Student, Idaho State University
	Location:	Zoom Main Room
10 – 10:15 A.M.	**BREAK**	
10:15 – 10:45 A.M.	**POSTER SESSION – PART 1**	
	Location:	Zoom Breakout Rooms
10:45 – 10:50 A.M.	**BREAK**	
10:50 – 11:20 A.M.	**POSTER SESSION – PART 2**	
	Location:	Zoom Breakout Rooms
11:20 A.M. – 11:30 P.M.	**BREAK**	
11:30 A.M. – NOON	**POSTER SESSION – PART 3**	
	Location:	Zoom Breakout Rooms
NOON – 12:05 P.M.	**BREAK**	
12:05 – 12:35 P.M.	**POSTER SESSION – PART 4**	
	Location:	Zoom Breakout Rooms
12:35 – 1 P.M.	**CLOSING SESSION**	
	Moderator:	**Donna Llewellyn**, Boise State University
	Speaker:	**Will Hughes**, Boise State University
2 P.M.	**INBRE SESSION**	
	Moderator:	**Dan Nogales**, Northwest Nazarene University
	Location:	Zoom Main Room

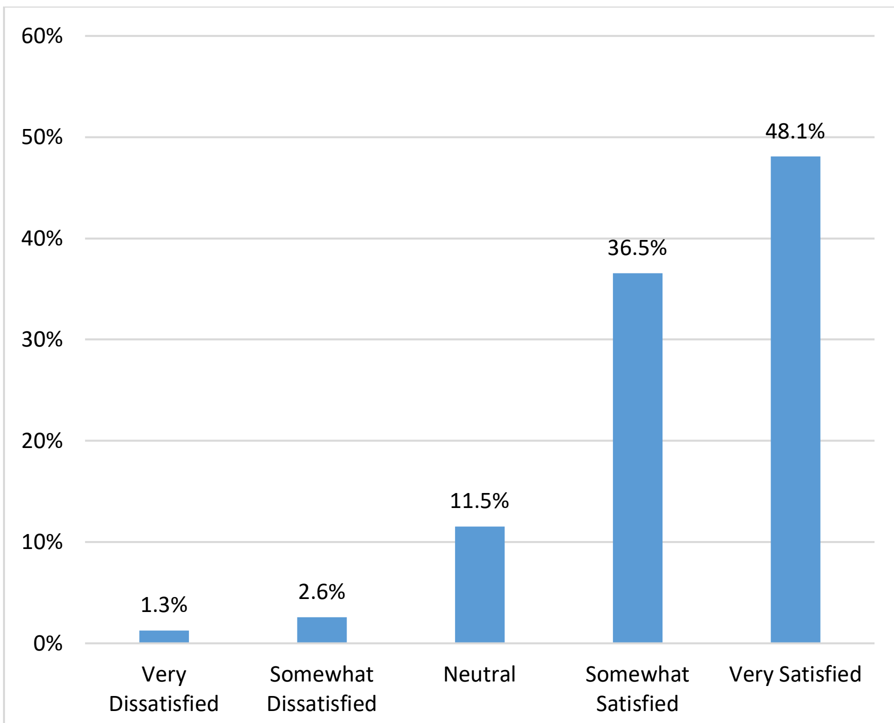
Idaho Conference on Undergraduate Research 2020
Survey Results

RESPONSE RATE: 54.9%

- 284 attendees (includes 6 IFITS staff who did not receive the survey)
  - 185 students
  - 93 faculty/staff/other

- 156 recorded responses

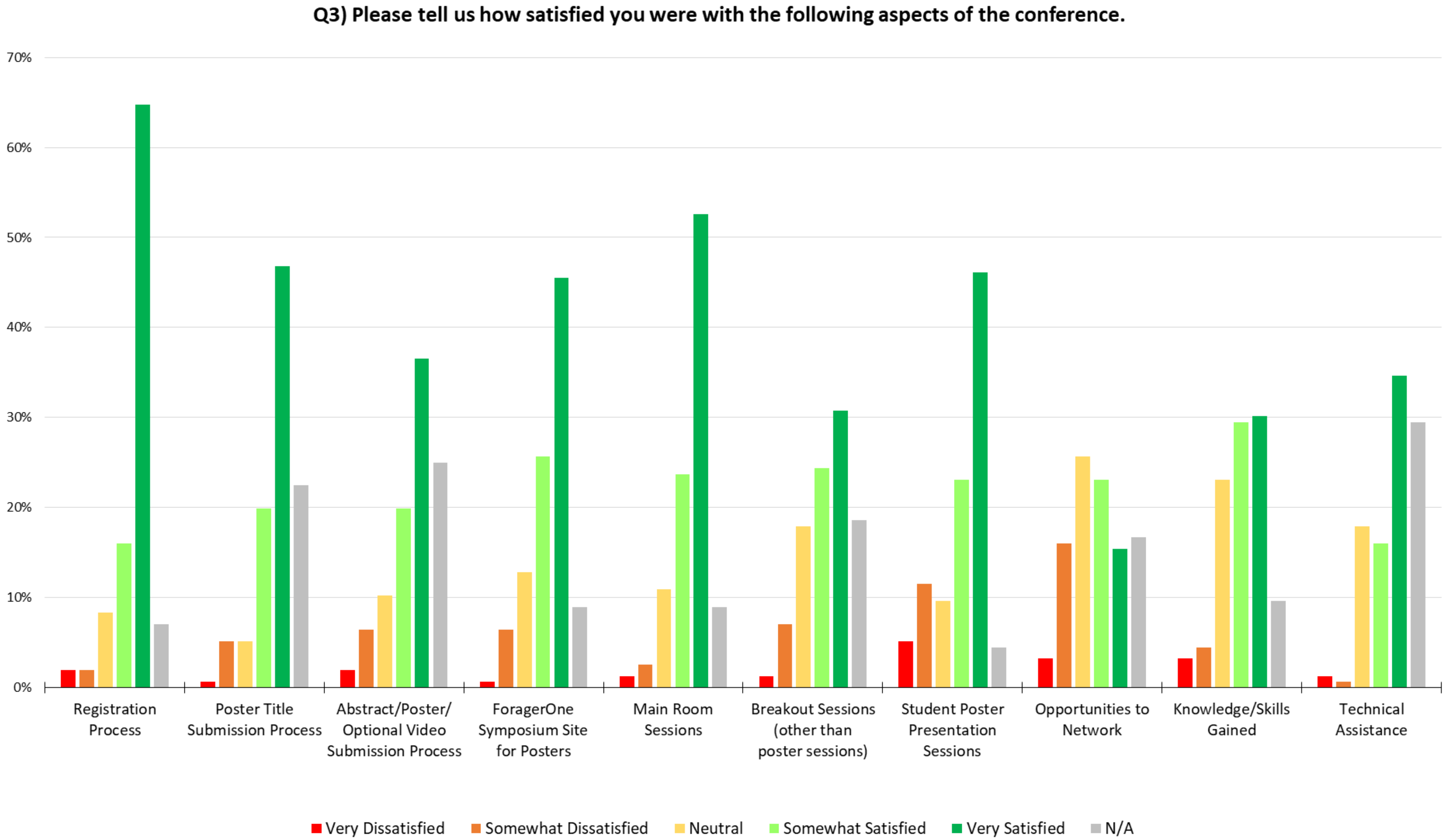
Q2) Please indicate your overall satisfaction with the 2020 Idaho Conference on Undergraduate Research.



Answer	%	Count
Very Dissatisfied	1.3%	2
Somewhat Dissatisfied	2.6%	4
Neutral	11.5%	18
Somewhat Satisfied	36.5%	57
Very Satisfied	48.1%	75
Total	100.0%	156

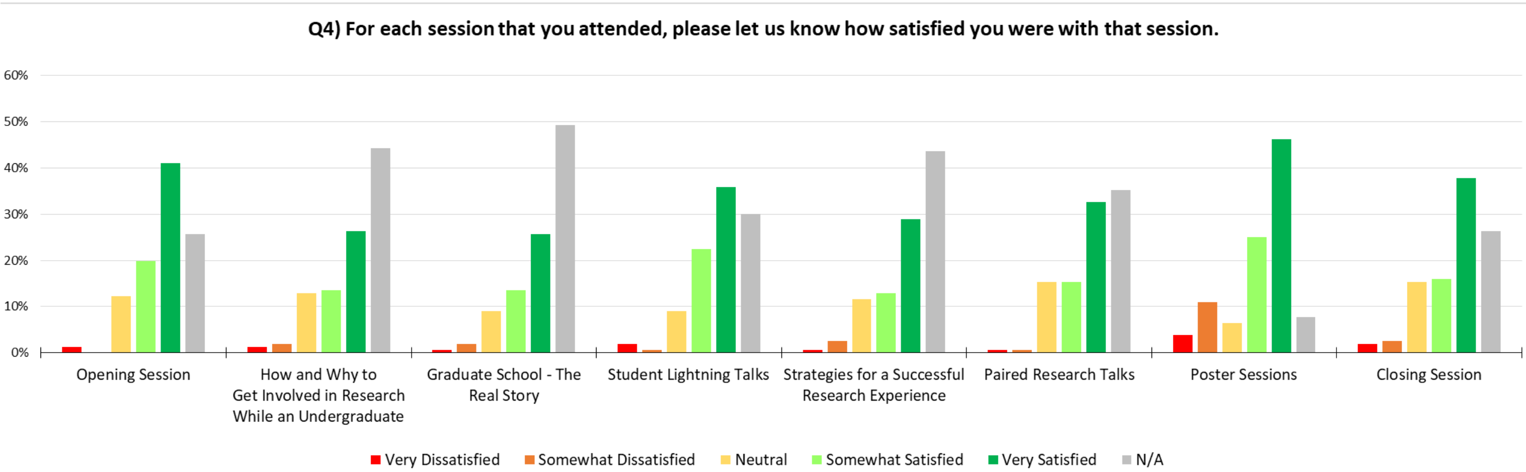
Q3) Please tell us how satisfied you were with the following aspects of the conference.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Aspect	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Registration Process	2%	3	2%	3	8%	13	16%	25	65%	101	7%	11	100%	156
Poster Title Submission Process	1%	1	5%	8	5%	8	20%	31	47%	73	22%	35	100%	156
Abstract/Poster/ Optional Video Submission Process	2%	3	6%	10	10%	16	20%	31	37%	57	25%	39	100%	156
ForagerOne Symposium Site for Posters	1%	1	6%	10	13%	20	26%	40	46%	71	9%	14	100%	156
Main Room Sessions	1%	2	3%	4	11%	17	24%	37	53%	82	9%	14	100%	156
Breakout Sessions (other than poster sessions)	1%	2	7%	11	18%	28	24%	38	31%	48	19%	29	100%	156
Student Poster Presentation Sessions	5%	8	12 %	18	10%	15	23%	36	46%	72	4%	7	100%	156
Opportunities to Network	3%	5	16 %	25	26%	40	23%	36	15%	24	17%	26	100%	156
Knowledge/Skills Gained	3%	5	4%	7	23%	36	29%	46	30%	47	10%	15	100%	156
Technical Assistance	1%	2	1%	1	18%	28	16%	25	35%	54	29%	46	100%	156

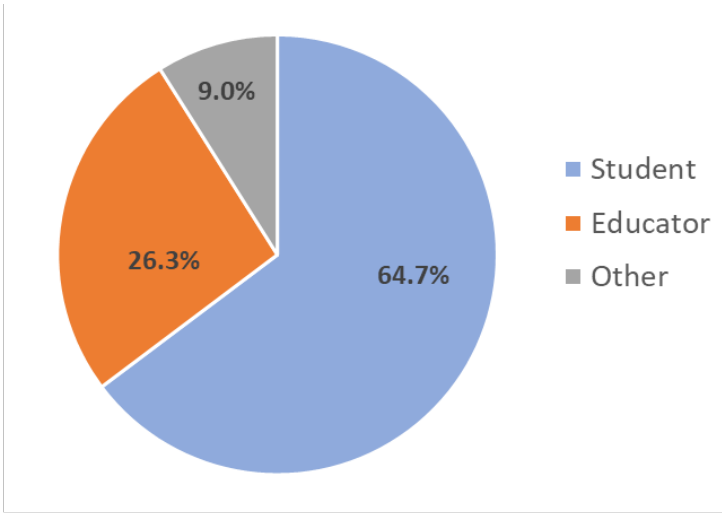

Q3) Please tell us how satisfied you were with the following aspects of the conference.
70%
60%
50%
40%
30%
20%
10%
0%
Registration Process
Poster Title Submission Process
Abstract/Poster/ Optional Video Submission Process
ForagerOne Symposium Site for Posters
Main Room Sessions
Breakout Sessions (other than poster sessions)
Student Poster Presentation Sessions
Opportunities to Network
Knowledge/Skills Gained
Technical Assistance
Very Dissatisfied
Somewhat Dissatisfied
Neutral
Somewhat Satisfied
Very Satisfied
N/A

Q4) For each session that you attended, please let us know how satisfied you were with that session.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Session	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Opening Session	1%	2	0%	0	12%	19	20%	31	41%	64	26%	40	100%	156
How and Why to Get Involved in Research While an Undergraduate	1%	2	2%	3	13%	20	13%	21	26%	41	44%	69	100%	156
Graduate School - The Real Story	1%	1	2%	3	9%	14	13%	21	26%	40	49%	77	100%	156
Student Lightning Talks	2%	3	1%	1	9%	14	22%	35	36%	56	30%	47	100%	156
Strategies for a Successful Research Experience	1%	1	3%	4	12%	18	13%	20	29%	45	44%	68	100%	156
Paired Research Talks	1%	1	1%	1	15%	24	15%	24	33%	51	35%	55	100%	156
Poster Sessions	4%	6	11 %	17	6%	10	25%	39	46%	72	8%	12	100%	156
Closing Session	2%	3	3%	4	15%	24	16%	25	38%	59	26%	41	100%	156



Q5) Please select your role.

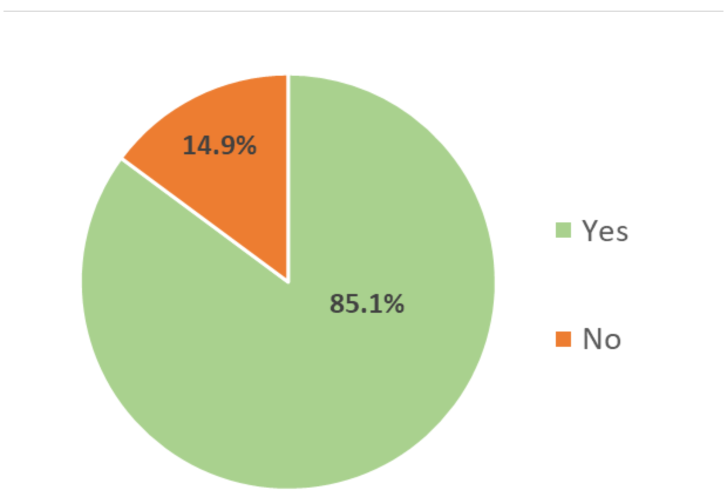


Answer	%	Count
Student	64.7%	101
Educator	26.3%	41
Other	9.0%	14
Total	100.0%	156

Q6) Other roles reported:

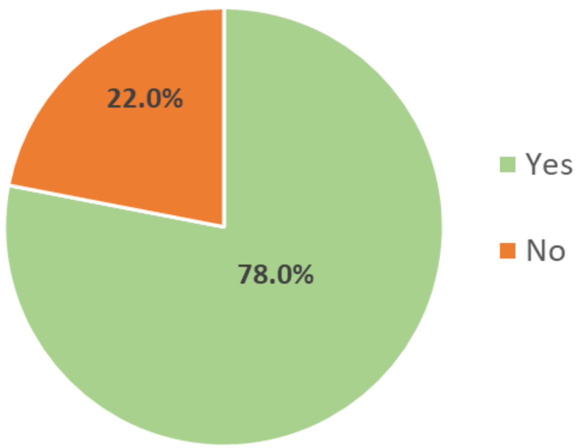
- Administrator
- Staff
- Mentor
- Panelist
- PI
- Program Director

Q7) Did you present a poster? (This question presented only to the respondents who selected "Student" as their Role.)



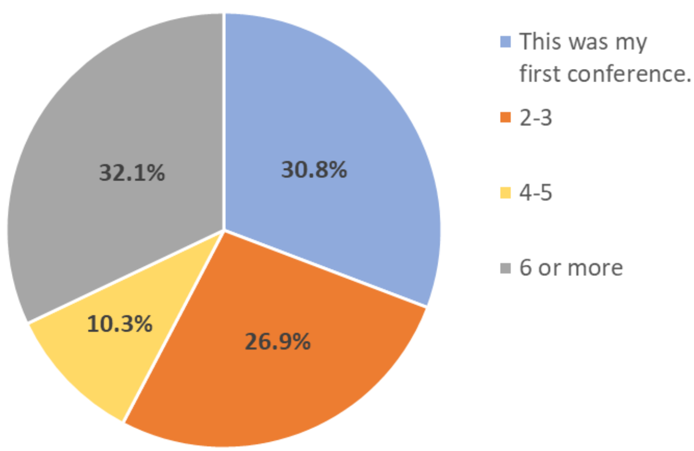
Answer	%	Count
Yes	85.1%	86
No	14.9%	15
Total	100.0%	101

Q8) Were you a mentor of a student researcher who presented a poster? (This question presented only to the respondents who selected "Educator" as their Role.)



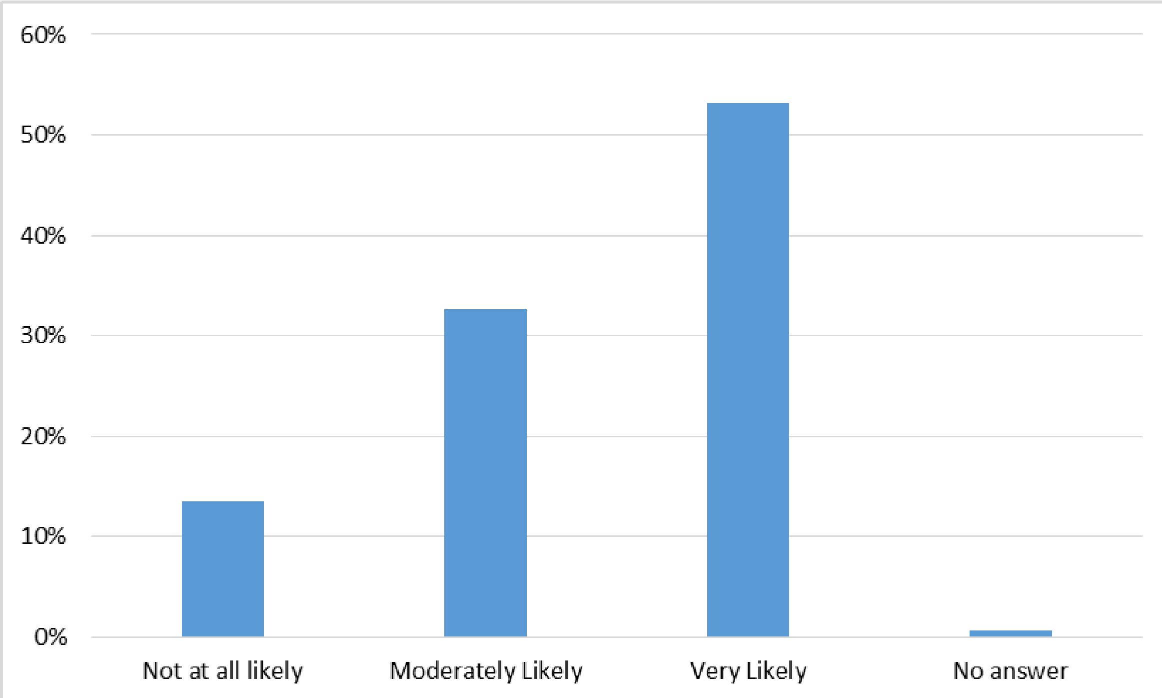
Answer	%	Count
Yes	78.0%	32
No	22.0%	9
Total	100.0%	41

Q9) How many conferences (technical and professional conferences) have you attended including this one?



Answer	%	Count
This was my first conference.	30.8%	48
2-3	26.9%	42
4-5	10.3%	16
6 or more	32.1%	50
Total	100.0%	156

Q10) How likely are you to attend ICUR next year?



Answer	%	Count
Not at all likely	13.5%	21
Moderately Likely	32.7%	51
Very Likely	53.2%	83
No answer	0.6%	1
Total	100.0%	156

Q11) What were your greatest lessons or take-aways from the conference?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 100 respondents answered to this question; some mentioned more than one take-away. The sum of the category counts is 139.

A criticism was received in response to this question and is indicated in red text.

CATEGORIES OF COMMENTS	COUNT
Learn about students'/others' research	28
Diversity of research	19
Opportunity to present/practice presenting my research/poster	10
Zoom conferences can be successful	6
Research during COVID-19	6
Ability and potential of students	6
Networking opportunities	5

Praise: Poster sessions	5
Lightning talks	5
Networking/interpersonal skills	4
Closing session	4
Gained confidence to present/conduct research	4
How to be a better researcher/succeed with research	4
Ability to support students	4
Students' enthusiasm	3
Research opportunities	3
Value of research	3
Graduate school info	3
New ways to get involved in UG research	2
Students' positive response to poster presentation experience	2
How to present research/posters	2
Praise: ICUR in general	2
Learn about fields and types of research	1
How to make the most of time as an undergraduate	1
Criticism: Inability to attend desired poster presentations via Zoom breakout rooms	1
Feedback on my research	1
Perseverance in research	1
Praise: Students and faculty	1
Advice from faculty	1
ForagerOne platform	1
Praise: ICUR organization	1

Strong responses:

- STUDENT: *"The most impactful aspect of ICUR for me was the sheer variety and diversity of subject matter and method of research. Before attending this conference, I had a singular view of what research was and now I believe there is a place for everyone within this community regardless of their discipline."*

- STUDENT: *"It felt nice to have people celebrate my accomplishments. I often down play my accomplishments and hearing the [encouraging] words from Dr. Tromp and other presidents made a world of a difference."*

    - The above statement is from a student who indicated they heard about ICUR through the LSAMP program.

- EDUCATOR: *"As always, the students were eager to get involved and had great questions. Their research was phenomenal."*

- STUDENT: *"I really liked the end of the first day session that discussed research during covid. I felt like that was a great thing to include and made me feel much better about the whole situation."*

- STUDENT: *"It was really exciting to see how much the professors advocated for the students and really seemed to want the best for them and their research."*

- STAFF MEMBER: *"Hearing about students who proceeded with research and remained flexible in how they approached their project was awesome. Any session where I could hear students share about their experiences was my favorite. Their resilience was inspiring!"*

The complete list of comments grouped by role follows, excluding "n/a" responses.

STUDENTS	
Student	All the research being done from students in many varying disciplines all over Idaho.
Student	Being able to freely talk to students about graduate school was really helpful and impactful for this point in my career. I also loved hearing from Dr. Bliss about what it takes to continue research and talking about how to make the most of our research experience.
Student	Being able to present
Student	Exposure to a wide range of research projects. It was heartening to see so many fields of study united under one "roof," even if just for one day.
Student	Finding new ways to get involved in undergraduate research.
Student	Getting to hear from the experienced people what they love most about research and learning about all the different kinds of research happening.
Student	Getting to see what other schools are working on, as well as building relationships within the scientific community.
Student	Having the opportunity to present my work to my peers of many different disciplines, as well as learn about other research from different disciplines.
Student	how diverse research can be
Student	Humans are extremely adaptable.
Student	I always enjoy the lightning talks and the diversity of the poster sessions. I definitely learn a lot from all of the presenters.
Student	I enjoyed seeing how diverse the research projects were and getting good feedback on my work (from people not in my discipline)!
Student	I feel like the range of research I now know about it extremely wide comparatively.
Student	I felt like I was more confident in myself and my research afterward.
Student	I found the breakout room that discussed how to succeed in undergraduate research very helpful. The tips for a successful research experience were my biggest takeaway from ICUR.
Student	I gained new information and I learned how other students conducted their research.
Student	I have gained more skills by talking to people that I do not know and who do not know anything about the subject of my research. Also, I liked the idea of exchanging the information between us it was something helpful for me.
Student	I learned that the lack of physical interaction makes presenting on Zoom less stressful, at least for me.
Student	I learned the existence of a research method course at Boise State that I am quite interested in attending!
Student	I liked the metaphor of a river being likened to research at the closing speech portion.
Student	I love research and we are all contributing pieces of a puzzle that will make this a better world
Student	I love the diversity in ideas and watching so many students researching exciting topics!
Student	I realized how important being able to present one's work is in the research community.
Student	I really enjoyed all the information about graduate school. Many of the questions I had were answered, as well as questions that I didn't know I had. I feel much more confident and informed about the entire process now.
Student	I really enjoyed networking and hearing about other student's research.
Student	I really enjoyed seeing what other research is done by undergraduate students.

Student	I really enjoyed the poster sessions and getting to hear about projects from a variety of fields that other student researchers were passionate about and to share my work.
Student	I really enjoyed the student lightning talks.
Student	I really liked listening to what undergraduates from disciplines other than my own were doing for their research.
Student	I really liked the end of the first day session that discussed research during covid. I felt like that was a great thing to include and made me feel much better about the whole situation.
Student	I was able to see what other students were working on during the summer from different fields.
Student	Importance of networking in the scientific community
Student	It felt nice to have people celebrate my accomplishments. I often down play my accomplishments and hearing the encoring words from Dr. Tromp and other presidents made a world of a difference.
Student	It helped me get a better feel for how to network and made me more convinced that I would like BioMedical research.
Student	It really helped me to see what kinds of specific research other undergrads were doing.
Student	It was great to see the variety of research projects that have been conducted in the state of Idaho. I was grateful to be apart of that group.
Student	It was really exciting to see how much the professors advocated for the students and really seemed to want the best for them and their research.
Student	Learned about various and interesting research outside my major
Student	Learning about other research being done.
Student	Learning about others research
Student	Learning about the research that others are doing.
Student	Learning about the variety of research that takes place in Idaho.
Student	Learning from other posters
Student	Learning from other students research and journeys
Student	Learning new things, experience presenting
Student	Listening to my Professor talk about research opportunities.
Student	Listening to other student's research was very eye-opening.
Student	Loved still being able to network with other researchers during these crazy times, and being reminded that we are all struggling with the impacts of this pandemic.
Student	Meeting new people
Student	My greatest take away was how significant it is to be able to effectively communicate research to an audience made up of individuals from a variety of fields.
Student	One of the most impactful parts of ICUR were being able to communicate and network using my research.
Student	presenting my lighting talk helped me learn how to succinctly communicate my research to a broad audience
Student	Research is not confined to just science.
Student	Research isn’t just the super sciency stuff in a lab. It can also be art or music or film.
Student	Seeing research done in other fields and all the other options there are was eye opening.
Student	That doing research is never easy but should always be aimed for.
Student	That we all face challenges in our research and that is okay. Another take away is that I learned to just stay motivated and stay passionate because that could take me far.
Student	The ability to hear a person briefly present their research, and then review the poster at my leisure anytime during the conference.
Student	The entire process of preparing for the poster sessions was very helpful in building my presentation skills and confidence.

Student	The importance of networking
Student	The main session talks about providing insight and tips on how to be a better researcher and succeed in your field.
Student	The most impactful aspect of ICUR for me was the sheer variety and diversity of subject matter and method of research. Before attending this conference, I had a singular view of what research was and now I believe there is a place for everyone within this community regardless of their discipline.
Student	The most impactful part of attending ICUR was seeing such a wide variety of research topics and learning about them from motivated students.
Student	The most impactful part was seeing all interest attend; including those outside of the STEM program.
Student	The overall experience.
Student	The poster sessions. I really enjoyed presenting my research to others.
Student	The practice of presenting a scientific poster at a professional event.
Student	The quality of research doesn't come out much in a one minute pitch, just the researchers excitement level.
Student	The student lightning sessions.
Student	The student presentations were fascinating and helped orient me to what I could expect for future research projects I may work on and present in conferences.
Student	There are many different areas of research that someone can go into
Student	We are all in this together.
Student	Will Hughes closing message really impacted me the most. Talk about a perfect message for wrapping up a 10 week rollercoaster of a research experience.
EDUCATORS	
Educator	As always, the students were eager to get involved and had great questions. Their research was phenomenal.
Educator	Being able to attend the conference successfully and support my students while not traveling. I wish that I had attended more sessions other than the poster sessions.
Educator	For ICUR 2020, that we can have attendance and participation from anywhere on the planet, and that students will participate if they knew and had opportunity. I think ICUR could advertise in a national or wider forum.
Educator	Frustration at not being able to select the poster presentations that I heard.
Educator	Great opportunity for students
Educator	I didn't realize how much great student research is taking place across the state! We should be very proud.
Educator	I loved getting some of the students who were sort of stuck in their own disciplines to answer much more basic questions by non-specialist audience members. In one case, the student struggled a bit, but then in round 2 of the poster breakouts, I ended up in the same room with him again and saw a much more audience-aware presentation the 2nd time! I also loved Will Hughes's moving, metaphorical comparison of students, scholarship, stages in a life, seasons, and rivers. Seriously brought tears to my eyes!
Educator	I missed the connections from the in person, but I really liked the breakout room as a way to try to replicate that.
Educator	I still enjoy the enthusiasm of the study students and the great breadth of research topics.
Educator	I was impressed with the students asking each other questions in the breakout sessions
Educator	I was very impressed at the polish the student lightning sessions.
Educator	Insight into the breadth and quality of undergrad research
Educator	My Students seemed to like the grad school panel.
Educator	Poster Sessions
Educator	Seeing students sharing what they've been working on all summer and gaining confidence.
Educator	student presentations.

Educator	Students learn from each other
Educator	Students presenting their research projects (poster sessions)
Educator	That our students are really doing great work!
Educator	The students manged to perform a great job during the pandemic.
Educator	To see so much support of undergraduate research, in ways I didn't receive when I was in college
OTHER ROLES	
Other	Diverse poster sessions and a fantastic keynote for the closing session.
Other	Hearing about students who proceeded with research and remained flexible in how they approached their project was awesome. Any session where I could hear students share about their experiences was my favorite. Their resilience was inspiring!
Other	learning that a zoom conference will work
Other	My greatest take-away is the value that research has on the student experience and how incredibly talented our staff and students are. Very impressive!
Other	Poster break-out sessions were great!
Other	This was an excellent substitute for an in-person meeting. Bravo to the organizers.

Q12) What changes in the ICUR would significantly improve the conference experience for you?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 84 respondents suggested a change; some made more than one suggestion. The total count of suggested changes/improvements is 100. 72 respondents either did not answer this question or indicated they had no suggestions for improvement.

CATEGORIES OF COMMENTS	COUNT
Poster sessions	55
Conference - general	27
Plenary/breakout/other talk sessions	8
Other logistics	6
Networking	3
Discipline focus	1

<u>Highlights:</u>

- Poster sessions
  - 21 people requested being allowed to choose which session/room to attend
  - 12 people stated students needed more time to present
  - 7 people made structure redesign suggestions for the suggestions
  - 5 people recommended better randomization of the participants in each room
    - 4 of these said they were in poster sessions with the same people more than once
- Conference - general
  - 13 people requested resuming an in-person conference
  - 2 people suggested better communication of submission/registration process

- 2 people mentioned challenges using the ForagerOne site
- Plenary/breakout/other talk sessions
    - 2 people made session structure redesign suggestions
- Other logistics
    - 3 people requested longer/more breaks between sessions
- Networking
    - 3 people suggested better/more networking opportunities*

**Repeat highlight from last year*

<u>Strong criticisms:</u>

- STUDENT: *"Better breakout room sessions with a longer break between session two and three. It would also be helpful if each room was conducted the same way. My favorite room had us each give our pitch and have 2 min of questions directly following my pitch. In The other rooms I didn't get any questions about my poster."*

- STUDENT: *"The only thing I can think of would be if there was some way we could choose which student presentations we listened to. I know we can leave comments on Foragerone, but its not the same as an "in person" interaction. Maybe even if there were just a few more poster sessions so you were more likely to see on of the presentations you were interested in. Or if one of the sessions was grouped by discipline so you could see other work in your field."*

- STUDENT: *"Setting up break out rooms for presenter/mentor pairs ahead of time might be beneficial. I know that some mentors would have liked to see their student present, however were unable to due to the random grouping. Having student/mentor pairs for one session would provide an opportunity for mentors to observe their student present so that additional feedback could be given after the conference."*

- STUDENT: *"I wish that we would get more time to present our posters. Actual poster presentations would actually be longer than 1-3 minutes. I feel that the short presentations don't prepare us to present at other conferences."*

- STUDENT: *"I found the random nature of the breakout rooms for the poster presentations frustrating. There were many presenters whose pitch I wanted to hear but wasn't able to. It felt inefficient and frustrating not to be able to hear from presenters I really wanted to while hearing from other presenters multiple times because we had been assigned to multiple breakout rooms together.*

  That said, I understand that hosting a conference online is difficult, and I really appreciate all the hard work that went into adapting the conference!"

- EDUCATOR: *"I noticed that in one of the sessions, when we were about to go into breakout rooms, the number of attendees dropped pretty noticeably. Maybe tell people they have the option to stay in the main room if they aren't in the mood to engage so that they don't leave altogether? It can feel like a lot for the introverts sometimes, especially as the day goes on."*

<u>Changes/Comments by Category</u> (sorted by the greatest number of mentions to the lowest):

CATEGORY > SPECIFICS	COUNT
Poster sessions	***55***
Allow choosing which session/room to attend	21
More time to present	12

Session structure redesign suggestion	7
Better randomization	5
Group by discipline	5
Preference for small, interactive sessions on Zoom instead of large, in-person room	1
Option to stay in main room	1
Not specified	1
Better/more communication of sessions and details before conference begins	1
More poster sessions	1
Conference - general	***27***
Resume in-person	13
Better communication of submission/registration process	2
ForagerOne challenges	2
Better/more communication of sessions and details before conference begins	1
Scheduling suggestion	1
Desires in-person / did not like virtual format	1
Session structure redesign suggestion	1
Technological fluency	1
Set a standard for projects to be included	1
Include graduate students	1
Too long	1
Intersect more visibly with federally-funded programs	1
More breakout groups	1
Plenary/breakout/other talk sessions	***8***
Session structure redesign suggestion	2
Not specified	1
Better talks/speakers - not specified	1
More interactive sessions	1
Option to stay in main room	1
More sessions for faculty/mentors	1
More time to present	1
Other logistics	***6***
Longer/more breaks between sessions	3
Not enough time for lunch	1
Better/more communication of sessions and details before conference begins	1
Extended deadline for submitting posters and abstracts	1
Networking	***3***
Better/more networking opportunities	3
Discipline focus	***1***
Include disciplines other than hard science	1

The complete list of comments grouped by role follows, excluding "n/a" and "none" responses that do not elaborate further.

STUDENTS	
Student	A better platform to be able to choose what posters you would want to see and listen to a presentation on. With it being on zoom we were not able to see talks on posters that we wanted to hear and on topics that we could more-so comprehend.
Student	Although this is dependent upon the audience itself, greater interaction between participants in the breakout sessions. Perhaps some sort of mediated "round table" discussion among the members might facilitate this?
Student	An extended deadline for abstracts and posters
Student	Aside from returning to an in-person conference, I would say workshopping the due dates.
Student	Being able to contact students I made connections with.
Student	Better breakout room sessions with a longer break between session two and three. It would also be helpful if each room was conducted the same way. My favorite room had us each give our pitch and have 2 min of questions directly following my pitch. In The other rooms I didn't get any questions about my poster.
Student	better more informative talks - learning about undergraduate research isn't helpful when we are already engaged in it; grad school info session was also pretty basic and not very informative
Student	For online conference: the ability to choose the topic of interest so that you have a chance to connect to the people from your field.
Student	Grouping poster sessions to more similar categories
Student	Have breakout rooms be based on subject matter.
Student	Having it in person.
Student	Having the conference on the weekend versus weekdays–we were still running experiments and could only attend sessions we were presenting in.
Student	Honestly, especially given the circumstances with Covid-19, I thought the organizers and participants did a fantastic job! The only complaint I had was the forager one poster presentation site. It was a little bit clunky to navigate. Being able to search specific meta data for a poster would have been very helpful (author, institution, etc). Not all posters had a poster number associated with them. It was difficult to easily display the poster in a full-screen manner so that you could read the small text.
Student	hopeful for an in person conference next year.
Student	I can't think of anything besides being able to be there in person which was out of anyone's control this year.
Student	I don't mean to be rude about this at all, but having attended the undergraduate research conference at BSU a couple of times, I know firsthand that having the thing in person works infinitely better. I understand that you guys were trying to put something on just so there could be a conference, and given the circumstances, I'd say you did about the best job you could, but I would've really preferred if we could've postponed until either the fall or next spring, whenever you could find a venue large enough to allow for an in-person conference.
Student	I don't necessarily have any recommendations besides meeting in person would be much more valuable than zoom. But circumstances were against us on that one.
Student	I felt like the poster breakout sessions need improvement, or going to in person.

Student	I found the random nature of the breakout rooms for the poster presentations frustrating. There were many presenters whose pitch I wanted to hear but wasn't able to. It felt inefficient and frustrating not to be able to hear from presenters I really wanted to while hearing from other presenters multiple times because we had been assigned to multiple breakout rooms together. That said, I understand that hosting a conference online is difficult, and I really appreciate all the hard work that went into adapting the conference!
Student	I just hope we have the opportunity to do it in person next year!
Student	I just miss impersonation interaction so much.
Student	I really liked the "roundtable" format from the small group poster sessions. I know the conference will likely not be virtual again but it was nice to have a small group to share our research with and ask questions rather than only poster presentations in a large room.
Student	I think getting to meet people in person would improve the experience hopefully for next year.
Student	I think taking more sessions for posters just because it was a really fun different way to present but I felt like I wanted to talk to more people and hear about more research.
Student	I wish that we would get more time to present our posters. Actual poster presentations would actually be longer than 1-3 minutes. I feel that the short presentations don't prepare us to present at other conferences.
Student	I would definitely recommend giving the student presenters more time in breakout rooms for presentations. Perhaps doing two rounds of break out rooms would make more sense so that there is more time. I also was disappointed that I did not get to see all of my peers present, but I know there were limitations to this Zoom conference.
Student	I would have liked the opportunity to see more of my peers research because I ended up in the same breakout groups as other student researchers several times.
Student	I would have liked to learn about research in my area or have had the ability for my mentor to sit in on one of my 1 minute talks. The conference primarily focused on biochem and although that is a part of STEM and research it isn't the only part.
Student	I would have the students have their posters ready and share their own screens, so the mediator doesn't have to waste time searching for the students' poster. I thought it was rude and ill prepared of students to ask the mediator to share their poster for them, because they were being lazy and reading a script from their own computer.
Student	I would like the ability to have my mentors watch my presentation. Although I understand there is great difficulty in setting up an online conference to accommodate the ability for a large group of people to choose their breakout rooms, I think finding a way to facilitate at least one poster session so this could happen would be great. That being said, I did like that the randomization of breakout rooms allowed me to listen to presentations that I might not have stopped at during an in-person conference.
Student	I would prefer to experience the conference in person it would have made it better for me.
Student	If ICUR were to continue on zoom I would encourage more attendee participation by using surveys and polls to interact with everyone.
Student	If this conference is held online next year, I would suggest changing the poster sessions. I was confused about how they were going to work right up until the very beginning of the first one. I feel that the 1 minute time limit for presenting the poster was slightly too short and most groups ended up giving people 3-5 minutes to talk which was much better. Overall, more information on how things were going to work would have made my experience much better.
Student	If using Zoom, create breakout rooms with more diverse topics. I found myself in rooms with people I was already conducting research with.

Student	If you will be online again use a system where the posters are viewed free form and not in breakout rooms. Cut the zoom aspect entirely as this made it chaotic and hard to focus in on one poster you enjoy. The comment section below each poster is sufficient for discussion and it lets researchers focus on presenting their work in its entirety rather than having a small spotlight in a small room full of people who are disinterested.
Student	In the future, add individual zoom links to each poster during an allotted time so those interested may go to that students breakout room and hear about their research. Similarly to an in person poster session.
Student	It was fine, but I got tired after the first two poster sessions and needed a longer break for lunch. It just felt long-winded with barely any time for breaks if you are the presenter.
Student	It will be great if it can be a physical conference, but only God knows what the future holds.
Student	Longer poster breakout room sessions; 30 minutes just wasn't long enough. Possibly determine the poster breakout room's prior to Friday so we can have time to look at our co-presenters posters and have questions ready for them. It felt like a lot of our time for Q&A was just spent asking really generic questions or no questions at all.
Student	Longer poster sessions (10-15 more minutes) for more time to ask questions and/or answer them.
Student	Longer time for breakout sessions when presenting the posters and answering questions.
Student	Longer time to explain our research, or divide it in two days.
Student	Moderators for all breakout rooms
Student	More breakout groups
Student	More breaks between poster sessions. More consistency in the Poster sessions.
Student	More poster sessions/more time for students to actually interact with each other. I feel like a lot of the time we were talking at each other. Also the majority of the non-poster-session talks were hard to sit through.
Student	More time involved in smaller groups.
Student	Opportunity to network with similar disciplines. This would also provide opportunities to our field and building relationships.
Student	Perhaps having participants create a video presentation to attach to their posters in case you don't get put into the same breakout room as some that are most interesting.
Student	Setting up break out rooms for presenter/mentor pairs ahead of time might be beneficial. I know that some mentors would have liked to see their student present, however were unable to due to the random grouping. Having student/mentor pairs for one session would provide an opportunity for mentors to observe their student present so that additional feedback could be given after the conference.
Student	Submission for title submission wasn’t advertised so I didn’t know when or how to do it.
Student	Technological fluency in main sessions.
Student	The 30 second elevator pitch was difficult for my first time around. I realize it needs to be short, but I would have preferred for it to be longer.
Student	The online breakout room research pitch was interesting.. I ended up being put into the same breakout room twice and saw about 10% of the same researchers present. I don't know how randomization into room could have been better made, but there were some repeat moderators and poster presentations that I sat through.
Student	The only thing I can think of would be if there was some way we could choose which student presentations we listened to. I know we can leave comments on Foragerone, but its not the same as an "in person" interaction. Maybe even if there were just a few more poster sessions so you were more likely to see on of the presentations you were interested in. Or if one of the sessions was grouped by discipline so you could see other work in your field.

Student	The only thing I might consider is having the posters presented by topic. My research was difficult to explain in a short time so during my "elevator pitch" I found I was only able to explain very introductory aspects of the research. I think it might help to have presented to people who were doing similar research because that way I wouldn't have had to introduce the topics my research was based on and i would have more time to talk about my research fully.
Student	There should probably be a higher bar for some work to be included - there were a couple people who presented research that wasn't particularly enlightening.
EDUCATORS	
Educator	Allow participants to select the talks / sessions they want to attend. This can be accomplished using Zoom. I have attended a 3 day meeting with over 80 sessions where we could could the sessions we wanted to attend and even change sessions as we wished.
Educator	Being able to attend talks given by my students and also connect more with other students doing similar research as in my lab (more networking, but I am aware that it is extremely which hard to pull off in a virtual setting).
Educator	Being able to request a breakout room by the Poster Number. I arrived late and missed the first session, so there was a chance that I would not see my students. I had to have my students text me their breakout room numbers, so I could be moved.
Educator	Besides being randomly selected for the poster session, it would be useful to be able to select for attending at least my students' presentations.
Educator	Break out poster session should have each room directly linked to title of poster on website page. Should not be randomized as spectator into the rooms. So you can choose to visit a room, thereby giving more emphasis to speaker.
Educator	Have posters on Day 1 and an opportunity for poster Q&A or "office hrs" so there can be more interaction.
Educator	I noticed that in one of the sessions, when we were about to go into breakout rooms, the number of attendees dropped pretty noticeably. Maybe tell people they have the option to stay in the main room if they aren't in the mood to engage so that they don't leave altogether? It can feel like a lot for the introverts sometimes, especially as the day goes on.
Educator	I wish we had graduate students as well.
Educator	I would have liked to be able to choose which student poster presentations I attended, but I understand that would be logistically challenging over Zoom.
Educator	I'd love to have been able to choose which poster sessions to attend, since there were some that I wanted to know more about, in actual interaction with the presenter. But I also understand that this way was much fairer to distribute audience members evenly. Is there a way to have 2 or 3 rounds of random distribution, like we did, plus one round, like the coffee break table at an in-person conference, where we could interact more informally with student presenters that we seek out specifically? Maybe even have the introduce-yourself breakout rooms AFTER the poster sessions, so that we could potentially talk to people whose posters we hadn't heard about?
Educator	If it were run online again it might be better to have attendees browse the posters in ForagerOne during the poster session and then click on one to join a breakout room type thing with the presenter and any other interested attendees.
Educator	In person again if that is an option next year
Educator	It is not so much ICUR as my own schedule and commitments. I would have liked to be at more events, and to interact more with the participants. There was one event that I found a bit anomalous ... switching to breakout room and back to the main session every few minutes - the times in the breakout room were a little short to let people get to know each other.
Educator	Knowing when students are presenting
Educator	Maybe more for faculty mentors, but not essential. The conference is for undergrads after all.
Educator	More awareness for others to join in.

Educator	More choice in which posters to "visit"
Educator	Poster intros were much too short. The students barely had time to state the research and then abruptly ended. Give students at least 2-3 minutes. There was plenty of time at the end of all poster sessions.
Educator	Searching posters on the online platform wasn't uniform. It only searched the text in the poster which made it hard to fine posters if the authors were in a graphic.
Educator	The coordination of the faculty presenters went pretty well. I felt there were perhaps too many emails and online documents, but I appreciated having the dress rehearsal for practice.
Educator	Themed poster sessions rather than the random assortment. This would vastly improve the potential for useful networking interactions, and increase the quality of the questioning and feedback for students.
Educator	virtual conference is not the way to go
OTHER ROLES	
Other	Back to in-person conference.
Other	Being virtual is always tough. On the one hand, randomizing attendees into breakout rooms allowed me to see diverse poster presentations I would not normally stop at. On the other hand, it would have been nice to see my students present. In all the poster sessions I attended, the moderators did a great job making sure everyone was asked a question. After talking to our SARE students, I think this experience was not consistent. One of my students reported that she was only asked one question across all four poster sessions, and was also locked with the same moderator for most sessions. Next time, better mixing with moderators would be helpful.
Other	Give general participants a choice of poster sessions (break room) to attend.
Other	Intersect more visibly with the large federally-funded programs that include undergraduate research/creative activity such as INRBE and EPSCor, and B2B.
Other	Two days was very long for me.

Higher Education Research Council
Undergraduate Research Supplemental Funding
Boise State University
Final Report

Academic Year 2019-2020

Donna Llewellyn, Executive Director, Institute for Inclusive & Transformative Scholarship
Catherine Bates, Assistant Director, Institute for Inclusive & Transformative Scholarship

Introduction

The Institute for STEM & Diversity Initiatives (ISDI) oversaw the HERC Undergraduate Research Fellowship at Boise State University Fall 2019, and Spring 2020. ISDI changed its office name to the Institute for Inclusive & Transformative Scholarship in the summer of 2020. HERC funds were used to support Boise State undergraduate students who had minimal research experience with a 10-week mentored research opportunity. Funds provided by the Higher Education Research Council supported a total of 27 students across 12 different STEM disciplines.

In addition, HERC funds made it possible to support 10 students with travel opportunities to attend professional STEM conferences in their field.

On behalf of the Institute for Inclusive & Transformative Scholarship, we thank the Higher Education Research Council for their generous support in helping build meaningful experiential learning experiences for Idaho students and supporting faculty research.

HERC Funding:

The Higher Education Research Council provided $55,000 in supplemental funding for STEM undergraduate research this year. Please see table below of how stipends and travel awards were dispersed.

Stipends	**Amount**
Boise State Research Stipends	$51,805
Student Travel to Professional Conference	**Amount**
Molecular Beam Conference (1 student)	$440.22
2020 Pacific Sociological Association Conference (4 students)	$1, 559.60
Undergraduate Women in Physics Conference (4 students)	$688.44
Applied Anthropology Conference (1 students)	$506.12
Total	**$54,999.38**

Note: Travel less than normal due to COVID

Boise State Research Fellows Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major
Holly Bossart	F	NonHispanic/Latino/a	Caucasian	Applied Mathematics
Antone Chacartegui	M	Hispanic/Latino/a	Hispanic	Mathematics
Grace Coughlin	F	NonHispanic/Latino/a	Asian	Chemistry
MJ Faris	F	NonHispanic/Latino/a	Caucasian	Elementary Education - Earth Science
Tessa Mei-lin Fong	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering
Maddelyn Jackson	F	NonHispanic/Latino/a	Caucasian	Chemistry
Julio Gonzalez Tempelta	M	Hispanic/Latino/a	Hispanic	Anthropology
Kate Grosswiler	F	NonHispanic/Latino/a	Caucasian	Geosciences
Ashely Leavell	F	NonHispanic/Latino/a	Caucasian	Biology
Crystal Lundgren	F	NonHispanic/Latino/a	Caucasian	Chemistry
Dalton Miller	M	NonHispanic/Latino/a	Caucasian	Health Sciences
Sabrina Moores	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering
Alyssa Romero	F	NonHispanic/Latino/a	Caucasian	Health Studies
Kyra Schroeder	F	NonHispanic/Latino/a	Caucasian	Geosciences
Kendall Swainston	F	NonHispanic/Latino/a	Caucasian	Biology
Rebecca Torres	F	Hispanic/Lantino/a	More than one race	Chemistry
Ellie Woerner	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering

Travel Awards

Student Name	Conference attended	STEM Major
Trent Garrett	Molecular Beam Conference	Physics
Bryant Hay	Applied Anthropology Conference	Anthropology
Madison Johnson	Undergraduate Women in Physics Conference	Physics
Isabelle Mais	2020 Pacific Sociological Association Conference	Sociology
Nathan McGregor	Undergraduate Women in Physics Conference	Physics
Stanford McConnehey	2020 Pacific Sociological Association Conference	Sociology
Alessia Molina	Undergraduate Women in Physics Conference	Physics
Jayanthi Pressana	Undergraduate Women in Physics Conference	Physics
Ann Snelgrove	2020 Pacific Sociological Association Conference	Sociology
Sam Savage	2020 Pacific Sociological Association Conference	Sociology

Fall 2019 HERC Fellow Boise State Student Abstracts:

Tessa Mei-lin Fong
Faculty Mentor: Dr. Zhangxian Deng, Department of Mechanical Engineering, Boise State University
Research Title: The Use Of Magnetostrictive Materials In Vibrational Energy Harvesting

Wireless devices have increased in the recent years. More technology means more products being charged. Recently, there has been a development of wireless charging because people need something convenient. Smart materials are being looked at, namely magnetostrictive materials. The energy harvester being designed will use mechanical energy (in the form of vibration) and convert that to electrical energy (in the form of voltage). This process can be used to create energy that can be applied to smart devices. The first objective was to develop a strong understanding of smart materials, especially magnetostrictive materials. The knowledge was then applied to learning about energy harvesting. This objective was met by reading and understanding research papers and reports from Dr. Zhangxian Deng. The two main reports included the "Review of magnetostrictive vibration energy harvesters" and "Magnetostrictive Devices", both by Dr. Zhangxian Deng and Marcelo J Dapino. [1], [2] The second objective was to develop skills in CAD and/or data acquisition software to allow a hands-on experience. This was done through the use of programs, such as SolidWorks and LabView. Hands-on experience was further demonstrated through the use of building the prototype. The last objective was to improve technical communication and writing. Technical communication of the problem was found with research papers provided by Dr. Zhangxian Deng, along with weekly meetings. Technical writing improved through the written final report due at the end of the corresponding semester. Fulfillment of these objectives helped the SMS Lab gain a system for future testing, along with a demonstration to model for those who may visit the SMS Lab.

Kate Grosswiler
Faculty Mentor: Dr. Mark Shmitz, Department of Geosciences, Boise State University

Research Title: Carbon Isotopic Analysis of Thaynes Formation Limestones: Using Global Carbon Cycle Perturbations to Explore the Temporal Correlation Between Early Triassic Ammonoid Biochronozones in North America and South China

The Permian-Triassic mass extinction, the most devastating mass extinction event in Earth history, was followed by a series of significant carbon cycle perturbations and climatic oscillations. Consequently, biotic diversity increased and decreased episodically. Because of their rapid speciation and preferential preservation, ammonoid fossils serve as key indicators of post-extinction marine faunal repopulation.

Previous work indicates Early Triassic ammonoid speciation was globally synchronous, yet radioisotopic age constraints on stratigraphic sections in Northeastern Nevada and South China that host identical ammonoid biochronozones exhibit a 1.5 Myr age offset. This age discrepancy illustrates the need for additional work to establish the temporal correlation between the North American and South China biochronozones.

We conducted carbon isotopic analyses on 63 limestone samples collected from the Early Triassic Thaynes formation in Southeastern Idaho and compared our results to carbon isotopic data from the Loulou formation in South China. Both formations host the same ammonoid biochronozones, making carbon isotope chemostratigraphy a useful calibration tool to determine whether the observed age incongruity is the result of erroneous biostratigraphic characterization or the result of flawed radioisotopic data from South China.

Ashley Leavell
Faculty Mentor: Dr. Marie-Anne de Graaff, Department of Biology, Boise State University
Research Title: TItle: Soil recovery after fire and invasion: implications for sagebrush reestablishment

The sagebrush steppe ecosystem has been heavily impacted by disturbance, including fires and the invasion of cheatgrass (*Bromus tectorum)*. Both fire and changes in the plant community can impact soil properties that reduce sagebrush (*Artemisia tridentata*) reestablishment success, but in the long-term, these soil properties may recover thus allowing for sagebrush re-establishment. With this study we ask: how do soil properties change in a recovering sagebrush ecosystem? To quantify soil properties and changes therein as succession progresses, I will investigate a 1983 fire on the Orchard Combat Training Center that is experiencing re-establishment of sagebrush. Soil samples have been collected from three areas: (1) areas of no sagebrush regrowth, (2) areas with sagebrush regrowth, and (3) unburned areas adjacent to the fire. I will measure physical, chemical, and biological soil properties that are critical to sagebrush re-establishment. These include soil structure, organic matter content, pH, nitrogen and carbon content, and microbial and arbuscular mycorrhizal fungi (AMF) communities. These results will allow us to evaluate the process of succession following fire and invasion, and the importance of recovery of soil properties in enabling this process.

Crystal Lundgren
Faculty Mentor: Dr. Michael Callahan, Department of Chemistry and Biochemistry, Boise State University.
Research Title: Synthesis and Characterization of Metallocyanides for Meteorite Analysis
Cyanide may have played an important role in prebiotic chemistry on early Earth including the synthesis of amino acids and nucleobases. Iron cyanocarbonyl complexes were recently discovered in meteorites (Smith *et al*., Nature Communications 2019); however, the complete characterization and quantification of these compounds in meteorites has not yet been performed. We synthesized *trans*-$(PPh_4)_2[Fe(CN)_4(CO)_2]$ and $(PPN)_3[Fe(CN)_5(CO)]$ using procedures modified from Contakes *et al.* (Inorganic Chemistry 2002) and characterized these compounds by electrospray ionization mass spectrometry. Mass spectral peaks corresponding to distinct isotopologues were found to be identical to those measured in meteorites. Future work will involve accurate quantification of iron cyanocarbonyl complexes in meteorites using our synthesized compounds as reference materials.

Kendall Swainston
Faculty Mentor, Dr. Ken Cornell, Department Chemistry & Biochemistry, Boise State University
Research Title: Toxicity testing of anti-parasitic MTN inhibitors against mammalian cells

Giardia intestinalis (GI) is the most common protozoan parasite in the U.S. It is contracted by consumption of cysts that are passed in the feces of humans, domestic animals, and wildlife and frequently contaminate watersheds in Western states. The cysts pass through the stomach and excyst to the form trophozoites that infect the proximal small intestine, where they cause severe flatulence, diarrhea, abdominal cramps, nausea, vomiting, dehydration, and weight loss. Drugs like metronidazole (MTZ), tinidazole, and nitazoxanide are usually prescribed, but there are increasing cases of treatment failure. Our prior work has shown that the parasite enzyme 5' Methylthioadenosine nucleosidase (MTN) is an excellent target for drug development as it is unique to the parasite and absent from humans. *In silico* screening of allosteric drugs against crystallographic models of the parasite MTN has identified 36 potential MTN inhibitors, a number of which show *in vitro* anti-parasitic activity. In an effort to demonstrate that the compounds do not show undesired off target effects in humans, we have performed preliminary *in vitro* cytotoxicity screening of these compounds against cultured normal human fibroblasts and human fibrosarcoma cells. Our initial studies show that most of the compounds show little effect against human cells, even at high (100 μM) concentrations. The results of these initial studies will be presented.

Rebecca Torres
Faculty Mentor: Dr. Owen McDougal, Department of Chemistry and Biochemistry, Boise State University
Research Title: Detection of Acrylamide in Coffee Using Near Infrared Spectroscopy, Liquid Chromatography-Mass Spectrometry, and Gas Chromatography-Mass Spectrometry

Acrylamide is a suspected carcinogen required to be listed on food labels in California. Certain foods that are cooked at elevated levels convert amino acids, such as Arginine, Asparagine, and Lysine, into acrylamide through the Maillard reaction. Foods such as potato chips, french fries, breakfast cereals, and coffee are required by Proposition 65 to be labeled as containing a suspected carcinogen. Near Infrared (NIR) spectroscopy, as well as Liquid Chromatography-Mass Spectrometry (LC-MS) and Gas Chromatography-Mass Spectrometry (GC-MS) will be used to analyze acrylamide levels in light, medium, and dark roast coffee.

Ellie Woerner
Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical Engineering, Boise State University
Research Title: Student Athletes in STEM

It is a rare combination for a Division 1 student-athlete to be pursuing a STEM degree owing to the rigor needed to pursue these degrees. Pursuing a STEM major is also very strenuous and often leaves limited time outside of their studies and has not been favored by athletes. Due to the rarity of this combination of individuals, there isn't a lot of information regarding how the experience of these student-athletes is during their college career. The study explores the support structures in place to help these student-athletes thrive both in the classroom and on the court, field, pool, or any other arena they are competing in. This study also reports on the skills that these individuals have that are enhanced through their sport and translate to the classroom to help them excel in their degrees. Finally, this study sheds light on how these individuals balance the roles of both student and athlete. The study results were obtained through surveys for the student-athletes and in-person interviews with staff in the athletic department, such as coaches and academic advisors.

Spring 2020 HERC Fellow Boise State Student Abstracts:

Holly Bossart
Faculty Mentor: Dr. Jaechoul Lee, Department of Mathematics, Boise State University
Research Title: Effective sample size calibrated multiple comparison methods for long memory US stock volatilities

Volatilities in stock prices often show long range dependence, representing significant autocorrelations even in large time lags. Multiple comparison methods can be used to identify different mean volatilities. However, the classical multiple comparison methods, including Fisher's least significant differences test, Tukey's honestly significant differences test, and Student-Newman-Keuls test, produce erroneously sensitive comparison results for long memory time series because these methods are developed for independent data. To accurately achieve the target significance level for long memory data, we propose using effective sample size (ESS) methods to calibrate these three popular multiple comparison tests. After using change point analysis to detect a sudden rise in mean stock volatilities of thirty prominent companies in January 2018, we analyze means before and after the changepoint using our ESS modified multiple comparison tests. With recent empirical evidence showing that low-volatility companies can outperform high-volatility companies, our methods help accurately identify which companies are low or high volatility.

Antone Chacartegui
Faculty Mentor: Dr. Donna Calhoun, Department of Mathematics, Boise State University
Research Title: Three Surprising Properties of Surface Curvature

Differential geometry is a branch of mathematics that studies local and global properties of curves and surfaces. Curvature plays a fundamental role in differential geometry. There are several different types of curvature described on a surface. For this research project, I investigated three surprising properties of *normal* curvature on smooth surfaces. The first property is a result of Euler's Theorem of principal curvature, which states that on any smooth surface, the principal curves at a point P are always orthogonal. The second property is the Mean Curvature theorem which states that, at a point P on a surface, the average curvature of all the normal curves passing through P is simply the arithmetic mean of the minimal and maximal curvature. The third property is that the mean curvature is related to the Laplacian.

How is it possible that the principal curves at a point P on a smooth surface are always orthogonal? Or that the average curvature is simply the arithmetic mean of the principal curvatures? How is the Laplacian operator, evaluated on the surface related to mean curvature? We will examine these questions and their answers.

Grace Coughlin
Faculty Mentor: Dr. Don Warner, Department of Chemistry and Biochemistry, Boise State University
Research Title: The Advancement of Breast Cancer Treatment by Developing Novel Cytokine Inhibitors

In the year 2020 the American Cancer Society estimates that 276,480 women will be diagnosed with invasive breast cancer and 42,170 women will die in the United States alone. The five-year survival rate plummets from 99% to 27% for metastatic breast cancer patients, making breast cancer the second leading cause of cancer deaths in women. An inflammatory cytokine (IC) plays a crucial role in activating cell signaling pathways that initiate the early stages of metastasis (i.e. detachment, migration, and intravasation), increasing the frequency of secondary tumors in vital organs. The aim of this research is to develop a small molecule inhibitor (SMI) that mediates IC-induced cell signaling. Previously, a high-throughput virtual screen of ~1.65 million compounds and a subsequent enzyme-linked immunosorbent assay (ELISA) identified SMI-26 as a lead compound. The three aryl groups of IC-SMI-26 have been synthetically modified to assess the steric, hydrophobic, and electrostatic interactions that contribute effective inhibition. Thus far, the incorporation of halogen substituents in aryl group 1, hydrophobic moieties in aryl group 2, and a strong electron withdrawing group in the para position of aryl group 3 increases SMI binding to the IC as determined by fluorescence quenching assays and ELISA experiments.

MJ Faris
Faculty Mentor: Dr. Karen Viskupic, Department of Geosciences, Boise State University
Research Title: Metacognitive Learning Strategies Used by Geoscience Students

Use of metacognitive learning strategies leads to better learning outcomes in college students (e.g. Dewey, 1933). This study sought to determine which metacognitive learning strategies are currently being used by geoscience students at Boise State University in order to see if students' metacognitive skills improve over time while in the geoscience program. Of the 43 students who completed the Learning Strategies portion of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991), 11.6% were undergraduate underclassmen, 32.6% were undergraduate upperclassmen, and 55.8% were graduate students. Participants identified as 55.8% female and 44.2% male. Total scores ranged from 173-332 (M=247, SD=33.36) out of a possible 350. Students' use of metacognitive learning strategies is correlated with both age and class standing. Correlations between gender and learning strategy use were inconsistent and statistically insignificant. Participants, on average, reported high use of Effort Regulation strategies and low use of Peer Learning strategies. Specific metacognitive and peer learning strategies are recommended to the faculty of the Boise State University Geoscience Department in order to improve student use of metacognitive learning strategies which we hypothesize will improve student success.

Julio Gonzaelz Tempetla
Faculty Mentor: Dr. Pei-Lin Yu, Department of Anthropology, Boise State University
Research Title: Archaeological Predictive Model: Orchard Combat Training Center

The objective of this research is to help protect cultural heritage resources on Idaho National Guard lands that are protected by law and are significant to Idaho Native Americans and historically associated communities. By utilizing a predictive model previously developed by Michael Bishop, a Boise State University alumnus, with variables specific to the Idaho National Guard's Orchard Combat Training Center (OCTC), a map was successfully produced that identifies areas of high probability for encountering archaeological sites. Working from the variables in Bishop's predictive model, we used ArcGIS mapping software to select only those areas within the area of interest with a specific distance to hydrological features, elevation, and angle to hydrology. This map will be field-tested by conducting pedestrian survey and based on the results, the model will be refined to increase accuracy in future applications. We hope our research facilitates the management of cultural heritage resources within the OCTC and provides further research opportunities.

Maddelyn Jackson
Faculty Mentor: Dr. Daniel Fologea, Department of Physics, Boise State University

Research Title: Lysenin Channel Selectivity for Monovalent Metal Cations

The ability of transmembranes to selectively transport ions and molecules across biological membranes is paramount for all cells. The functionality of excitable cells, such as the excitability from the brain and muscles, is unequivocally determined by the ability of ion channels to discriminate between ionic solutes. Selectivity, along with high transport rate and regulation, is fundamental for all ion channels. Following this line of thinking, we asked whether other protein channels, with regulatory functions, have similar selectivity to ion channels. Our investigations were focused on lysenin, a protein that self-assembles into a regulated, large-conductance channel in both artificial and natural lipid membranes. The ionic selectivity of lysenin channels of monovalent metal cations was estimated through transmembrane voltages measured after chemical gradients were produced across the membrane through successive ionic additions. Our results clearly demonstrated that lysenin channels present cation selectivity. However, the estimated ionic permeabilities were different for Na^+, K^+, Li^+, and Cs^+. This unusual feature, commonly shared by ion channels, may be further explored for controlling the electrochemical gradients across natural and artificial cell membranes.

Dalton Miller
Faculty Mentor: Dr. Ken Cornell, Department of Chemistry and Biochemistry, Boise State University
Research Title: Demonstration of Cold Atmospheric Pressure Plasma Biofilm Removal Using Profilometry

The CDC estimates that 128,000 people are hospitalized due to food-borne illness each year in the United States. The presence of bacterial biofilms in food-processing settings is a concern for the spread of disease, and is responsible for a significant number of the outbreaks that result in hospitalizations and food recalls. Although food-processing plants can be sterilized to some degree, the current means of doing so uses harsh chemicals and requires production to be halted for extended periods of time. To that end, we have developed a novel cold atmospheric-pressure plasma (CAPP) device to combat these types of biofilms in a more cost effective manner that requires no harsh chemicals. This biofilm removal can be imaged using fluorescence microscopy and quantified by profilometry, which measures the height of the biofilm before and after CAPP treatment. Here we demonstrate that even short (e.g. 1 minute) CAPP treatments could etch away biofilms in a time-dose dependent fashion. Our findings provide a proof-of-concept that a CAPP device is a viable potential alternative to classic food processing decontamination methods that rely on harsh chemicals.

Sabrina Moores
Faculty Mentor: Dr. Zhangxian Deng, Department of Mechanical and Biomedical Engineering, Boise State University
Research title: 3D-pringed and Wireless Piezoelectric Tactile Sensors

This research investigates the use of inkjet printing to manufacture wireless and flexible piezoelectric force sensors. The PVDF-TrFE polymer exhibits high piezoelectric response that can be measured by sandwiching it between two conductive electrodes. By investigating polymer ink preparation, curing, and drying times, a PVDF-TrFE ink that is compatible with a commercial inkjet printer was synthesized. Further investigation of printer settings and substrate treatments has resulted in a thin piezoelectric film for flexible force sensing. The newly-developed sensor has potential to be used for health monitoring, soft robotics, and wearable tech.

Alyssa Romera
Faculty Mentor: Dr. Cynthia Curl, Department of Community and Environmental Health, Boise State University
Research Title: Methodology to Assess the Effect of Exposure to Environmental Toxins on Reproductive Health and Birth Outcomes

The environmental exposures that women experience before and during pregnancy can impact reproductive health and birth outcomes. Our lab's goal is to understand pesticide exposure levels during pregnancy and, ultimately, to evaluate the potential long-term effects of that exposure. We are currently recruiting 40 pregnant women during their first trimesters and collecting a series of 36 biological samples from each woman, which we will analyze for pesticides. As part of this work, I am recruiting, consenting, and enrolling participants, conducting interviews, collecting urine samples, and analyzing data. I am also conducting a literature review to understand how similar environmental exposure assessment methods have been used in other populations. Specifically, I am conducting a search of relevant, peer-reviewed literature using Google Scholar and Academic Search Premier to investigate the relationship between use of personal care items and reproductive health before and during pregnancy. My literature review focuses on personal care items that contain known carcinogens and that have been detected in biological samples in populations such as pregnant women. My work compares the epidemiological methodology of our study with other studies published to determine the impact of both herbicide and personal care items with the reproductive system and birth outcomes.

Kyra Schroeder
Faculty Mentor: Dr. Matt Kohn, Department of Geosciences, Boise State University
Research Title: Pressure-Temperature Record From the Eastern Alps, Austria, Reveals Dynamics of Plate Collision

Metamorphic rocks form and evolve in response to changes in Pressure (P) and Temperature (T). Application of thermodynamics to mineral compositions is commonly used to calculate P-T histories of metamorphic rocks. Geologists use this information to detail and interpret Earth's mountain building events. Here, we test the accuracy of the P-T paths for the eastern Alps constructed 35 years ago (Selverstone et al., 1984, Journal of Petrology, v25, 501-531) using improved thermodynamic calculations.

We first used optical petrography to identify minerals, textures, and metamorphic facies. We then used back-scattered electron imaging on Boise State's Electron Probe Microanalyzer (EPMA) to verify minerals and assess chemical zoning within minerals. Lastly, we used the EPMA to collect individual chemical analyses and applied thermodynamic software to constrain P-T conditions. Whereas Selverstone et al. (1984) report P-T conditions of 7 ± 1 kilobars (25 km depth) and 550 ± 25 degrees °C, our calculations show an indistinguishable pressure of 7 ± 1 kilobars, but a higher temperature of 635 ± 25°C. The higher temperature implies that tectonic plates were warmer than once inferred. Because rocks become less brittle with increasing temperature, brittle phenomena such as earthquakes in the past would have occurred at shallower depths.

TO: Idaho State Board of Education, Higher Education Research Council
FROM: Deb Easterly, Assistant Vice President for Research
DATE: November 19, 2020

The ISU Office for Research would like to thank the Idaho State Board of Education Higher Education Research Council for the FY 20 Strategic Initiative Undergraduate Research funding that we received in the amount of $55,000.

Even though work slowed down in the spring of 2020 because of Covid-19, the funding was a very successful in growing our Undergraduate Research in the STEM fields.

With these funds we were able to support 10 research projects. The resulting grants provided funds for student wages, for fringe benefits, a small amount of materials and supplies and travel as needed for their research.

The research projects were each a collaboration of a STEM student and an ISU faculty member. The proposal application required the faculty member to develop and follow through on a mentoring plan, as well as assisting the student during a research project.

Several travel awards were made to students this year, but because of COVID-19 conferences were cancelled. As a result we only had three students attend virtual conferences. Twelve students were registered to attend and present at the National Conference on Undergraduate Research in Bozeman, MT, but the conference was cancelled.

This year $10,000 of these funds were again awarded to the ISU McNair program for travel. The McNair students' projects and reports are included with the rest of the reports. Because of COVID-19 the McNair program did not provide as many travel awards as they had planned. Those funds were returned to the Research Office and used to cover additional undergraduate STEM awards.

The application process for the travel funds was used as an opportunity to ask students for their thoughts on mentoring. We received answers that gave us valuable information to build our program. This information was important to us as we changed the focus of the FY 2021 program from past years.

One of the requirements to receive these funds was that the student present their findings at a conference. Unfortunately, most conferences were cancelled because of COVID-19. Conferences held virtually were an option for many, however. For example, many students had posters displayed on-line for the ISU Undergraduate Research Symposium. Another presentation option included the Idaho Conference on Undergraduate Research (ICUR), also held virtually. There were 19 posters presented by approximately 35 ISU students at the virtual ICUR, July 2020.

Posters for the ISU Symposium can be found at https://www.isu.edu/research/undergraduate-symposium/posters/. Abstracts for the posters presented at ICUR can be found at https://scholarworks.boisestate.edu/icur/2020/

The students have been very vocal in expressing their appreciation for the financial support and mentoring that has given them an opportunity to experience research and increase their knowledge about conducting research. Many of them have expressed that they will be continuing their education , seeking a Masters or PhD in a STEM field. When students participate in an opportunity such as these funds have provided it is quite the thing to see them grow in their education, skills, and confidence.

The student individual reports are attached. Posters and abstracts can be viewed at the links listed above.

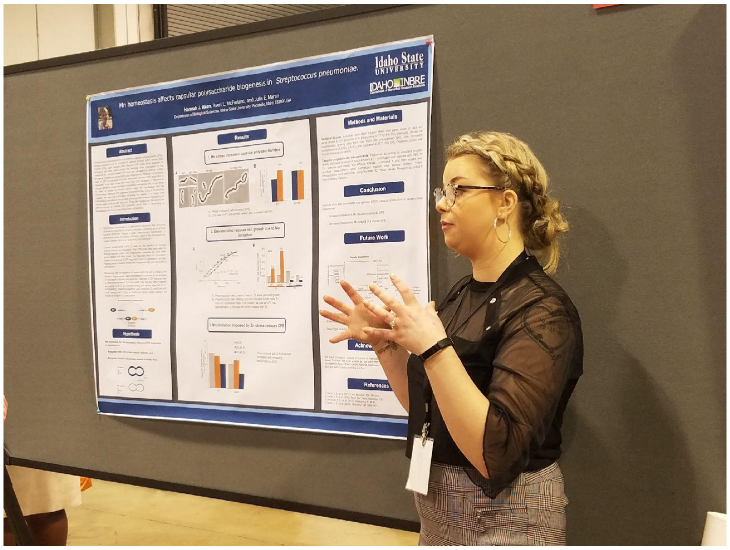
Rosemary Anibogwu

06 June 2020

Regrettably, the conference I planned on attending was canceled due to the current pandemic our world faces. Nonetheless, the process of submitting an abstract along with other aspects of the application process for the conference gave me a little insight on how to professionally and successfully organize an event. Communicating with the conference organizers through email enabled me to practice emailing professionally.

My education here at ISU is not merely confined to the teachings within a traditional classroom setting; it transcends that of the classroom setting and into a professional setting. As an undergraduate and a graduate student at Idaho State University, presenting at the 2nd Analytical and Bioanalytical Methods Conference (ANALYTICON 2020) would have been a wonderful opportunity to interact and connect with individuals within my chemical field of interest, analytical chemistry. This is especially valuable to me currently since I will be applying to Ph.D. programs in the Fall. This conference would have been a marvelous opportunity to apply my knowledge from the classroom to a highly professional setting. Such an experience would have exposed me to engaging questions about my research that I may not have considered.

Moreover, this travel experience would have been an indispensable opportunity to share my research experiences, challenges, and perspectives with like-minded individuals within and beyond my field of interest. ANALYTICON 2020 would have introduced me to the diversity of my peers and professionals in various fields whom I can learn from through presentations and various other interactions. These interactions may potentially lead to meaningful collaborations. Essentially, I would have received a deeper insight as to how the field I intend on being a member of truly operates on a professional level.


Idaho State
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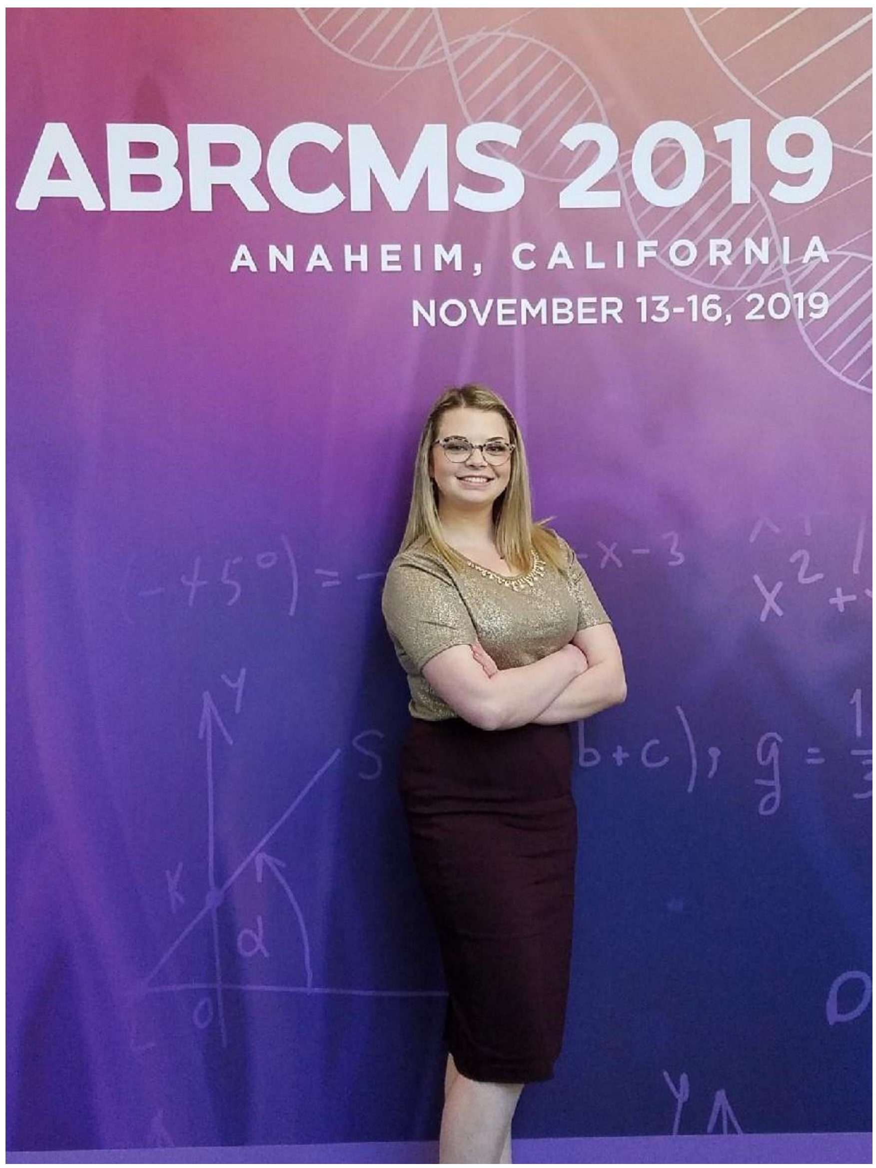
Mn homeostasis affects capsular polysaccharide biogenesis in Streptococcus pneumoniae.


ABRCMS 2019
ANAHEIM, CALIFORNIA
NOVEMBER 13-16, 2019

The funds provided by the Office for Research Outreach and Compliance allowed me to travel to Anaheim, California and present my research poster at the Annual Biomedical Research Conference for Minority Students (ABRCMS). While I was there, I learned about many different graduate programs all around the country. I also explored research happening in places outside of ISU. Without the help from TRIO McNair and the funds from the Office for Research Outreach and Compliance, I would not have been able to go to Anaheim to present my research. I come from a low-income family and I am a first-generation student and paying for travel to Anaheim just was not an option. The funds gave me the opportunity to learn more about myself as a researcher and explore the different research settings across the country. I was also able to secure a research internship for the summer. I understand more about biomedical research along with the different programs available to support me throughout my education. I also know more about what I want my career to look like in the future. Along with presenting my research, I was able to visit many booths for various graduate schools that each had different programs available. I was able to begin a list of graduate schools that I am interested in attending after earning my bachelor's degree. Without attending this conference, attending graduate school would feel like a shot in the dark. I am now more motivated to go to graduate school, be more productive, network as much as possible, and learn more about the research topics within my field.

Undergraduate Research Award
Reagan Badger

I am a B.S./M.S. student studying Biology (Biomedical Science). The undergraduate funds that I received have helped to support my research over the past year, which will eventually contribute to my graduate work and master's thesis project. I am currently working under Dr. Kinta Serve; I have worked in her lab as an undergraduate (and now graduate) student. We are investigating the therapeutic potential of a synthetic flaxseed lignan in an asbestos-induced model of inflammation. Specifically, we are interested in the anti-inflammatory effects of LGM2605 (a synthetic derivative of the flaxseed lignan secoisolariciresinol diglucoside) in the context of autoimmune disease induced by asbestos exposure. We are utilizing a murine model in order to explore these effects. Essentially, we are collecting tissues from asbestos-exposed mice (with and without LGM2605 treatment) and using them to measure various markers of inflammation (pro-inflammatory cytokines, immune cell recruitment/activation, etc.). My undergraduate work has focused specifically on the impacts of LGM2605 on gut microbiome composition and the resulting impacts on systemic inflammation. We previously collected cecums from mice (within a smaller pilot study) that had received LGM2605 treatment. We then extracted DNA from those samples using a Qiagen DNA extraction kit, and we performed 16S rRNA gene sequencing to identify microbial genera of interest. Next, we compared the relative abundance of microbial communities between the two treatment groups (LGM-treated v. control) in order to identify significant differences between them. We are also considering both α- and β- diversity measures; I am running statistics and generating figures using Phyloseq (a program in R). My next step will be to research specific microbial genera that were significantly influenced by LGM2605 treatment in order to draw inferences regarding their roles in inflammation, autoimmune disease, etc. We are planning on publishing a paper on our work (once completed) by the end of the summer; I am working on writing this now.

The funds that I received allowed me to perform the DNA extraction and sequencing that were such a central focus of this project, and to continue working and analyzing within the lab. Using these funds, I was able to begin research that will eventually contribute to my master's thesis project, as well as gain valuable experience in a lab setting. Having this experience will greatly improve my academic resume as I begin applying to medical schools. My background in research, furthermore, will both complement and strengthen my clinical work as a future physician. Besides working in the lab, I also recently had the opportunity to present my project (concerning the influence of LGM2605 on the gut microbiome) within the Undergraduate Research Symposium at ISU. Putting together posters is always a great experience in itself; doing so has allowed me to share my work and build valuable communication skills that will carry forth into my graduate work and career thereafter. I am incredibly grateful for the opportunities I have had so far at ISU. Being able to perform research as an undergraduate student is, in part, what will allow me to finish both my undergraduate and graduate degrees in just 4 total years. It has also challenged and stimulated me beyond the level of my normal coursework.

(see next page for copy of poster)

Talia Cahoon

Undergraduate Research Award 2020

Sequencing the Great Salt Lake for Publication

Over the past few months, I have revisited my project of sequencing the DNA of all microorganisms in the Great Salt Lake (GSL). This time I used a newer GSL sample and did three replicates so we have three results to compare, calculate error from, and do statistical analyses on. I am working with the Molecular Core Research Facility (MRCF) who is sequencing the samples and will give me the raw data which I will then process to determine what organisms are present. My mentor and I contacted Dr. Mike Lee, a bioinformatician at NASA who is familiar with extreme environments like the Great Salt Lake. He has been helping us design our new sequencing experiment and he has been guiding me through data processing.

Dr. Lee showed us a new way of processing data that provides better resolution and accounts for error in the sequencing data. To do this, I need to learn a programming language, R, and apply it in a software package called Dada2. I have actually been advised multiple times in the past to learn R since it is a major language used for statistical analysis in biology, but I was never able to take a class for it. I am excited that I am now learning this language and applying it to experimental data under the direction of Dr. Lee who can make sure I use it correctly according to the specifications and nuances of our experiment. Through these improvements, we expect our results to be much more robust and publishable.

These funds allowed me to work from home and dedicate time to learning one of the most commonly used programming languages in biology which will be sure to pay off in the future. Sequencing and bioinformatics are tools employed in most microbiological or biochemical labs and can either be done by the researcher or can be sent off to be done elsewhere. As I continue to develop these skills, I will be able to process my own data in the future, saving both time and money. I am very grateful for the opportunities this Undergraduate Research award has provided. It has opened many doors for me and will continue to do so as I meet more of the scientific community and present my research.

Daniel Gray

Although in-class simulations are a valuable and necessary part of the learning process, the importance of real-world training cannot be overstated. Thanks to the project funding provided by this grant, I was able to gain experience in a non-curated setting while contributing to departmental research. The awarded grant thus benefitted both myself and ISU's Psychology department as a whole by furthering research work.

The project, whose presentation at ICUR will be titled "Caffeine Consumption and Beliefs Regarding Caffeine's Effects in an Online U.S. Sample," was originally envisioned as an in-lab experimental study. This study would have recruited approximately sixty participants who would complete a beliefs questionnaire and, after being administered either caffeine or a placebo, then complete a series of tasks designed to measure metacomprehensive accuracy. The goal of this study was to examine both the relationship between caffeine consumption and cognitive processes and the potential effect of subjective beliefs regarding caffeine upon objective performance. While caffeine's effects upon alertness, reaction time, and sustained attention are widely documented, very little research has been done upon stimulant effects on metacognition. Metacognition (commonly described as monitoring and regulation of cognitive processes) plays a vital role in a wide range of environments, from the academic realm (especially pertaining to effective study habits) to the professional. Caffeine being a widely used stimulant, the interplay between it and metacognition could have significant effects, thus making this an important avenue of research.

In preparation for this study, I was involved in questionnaire design, literature review, acquisition of needed materials, and the crafting of experimental protocols (interaction scripts, format of in-lab engagements, timing assessments). For the online version of this project (detailed below), I scheduled participants, credited them for their work, examined collected data for adherence to criteria (completed assignments and compliance with required attention checks), and participated in data cleaning prior to analysis.

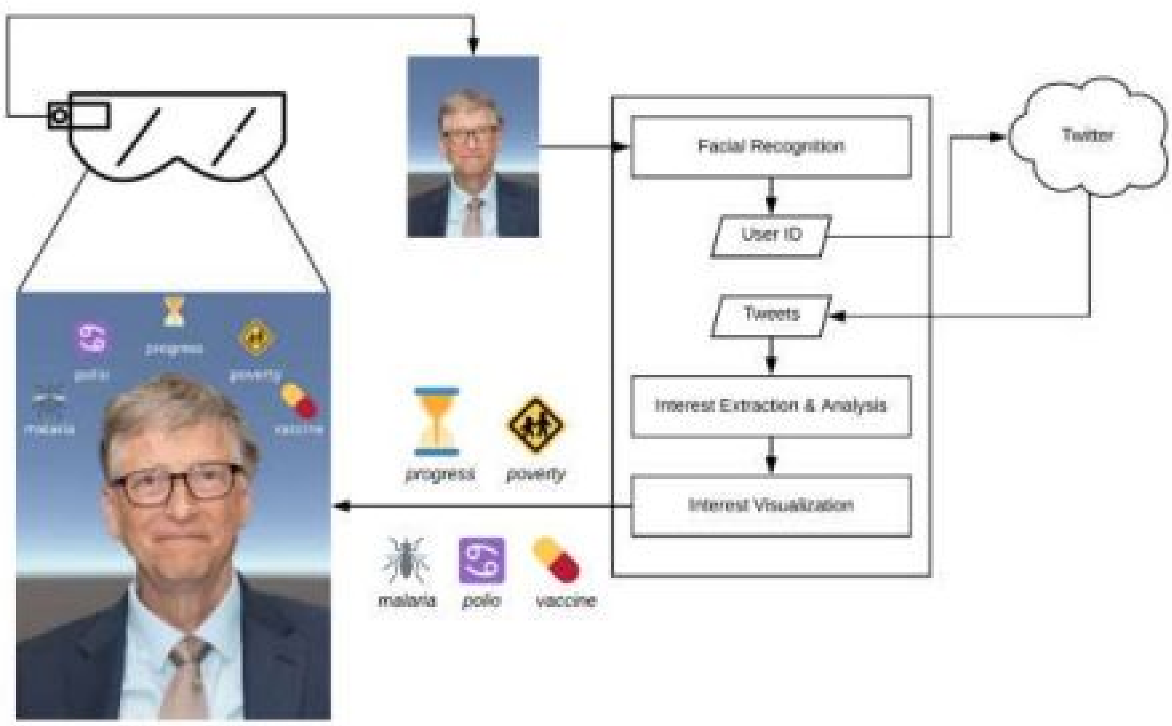
Due to the onset of COVID-19, we were prevented from in-person data collection beyond our initial pilot studies. Fortunately, we were able to adapt to an online format that allowed us to collect data from a sample of 368 participants. These participants completed a questionnaire administered through the Amazon MTurk platform. This consisted of several modules examining demographic characteristics, caffeine consumption patterns, and beliefs or conceptions regarding caffeine's effects on various social and cognitive functions. These functions included executive functioning (e.g. memory and reasoning), interpersonal communication and comprehension, spatial awareness, and creativity/divergent thinking. The analysis of this data will hopefully illustrate how beliefs about certain aspects are correlated with each other. The acquisition of data from a larger sample size (roughly six times that of the original projected number of participants) will also enhance the generalizability of the findings.

Validation of this survey through this sample will also provide benefits to later studies, especially experimental studies akin to the original plan. Being able to establish expected patterns of both belief and consumption will allow construction of further projects designed specifically for those patterns. These future projects could also provide multiple opportunities for further research, both for myself and others, increasing scholarship on an area of study that this far has yet to be fully explored.

-Daniel F. Gray, 29 June 2020.

Undergraduate Research Award Report and Results | Hunter Harris

The funds awarded to me and my mentor opened a great opportunity for me. As a direct result of the funds, I had the chance to design and construct a working computationally creative system that suggests conversation cues and represents them with emoji all by using a given user's tweets. Following the implementation of our system, my mentor and I were able to get two academic papers accepted to a conference: one to IETC in Orem, Utah, and the other to ICCC in Coimbra, Portugal. We were also able to submit posters to ISU's Undergraduate Research Symposium and the Idaho Conference on Undergraduate Research. I will attach the submitted posters and papers along with this report. Participating in this research has taught me several valuable things. I have learned how to code more efficiently and with better quality, and I am now proficient in using the Python programming language. I learned how to work on a large scale project without becoming deterred by its size and how to break down the things I needed to do into smaller tasks. Doing research has also made me consider going to graduate school and becoming a professor myself. Having multiple publications under my belt will also give me an edge in getting into graduate school and starting my masters. Overall, this has been a wonderful experience for me, and I have learned a great deal from it.



System Overview of HeyLo

Makayla Linnastruth

Undergraduate Research Grant

This grant has allowed me to be able to experience research at the undergraduate level, which has allowed me to gain momentum in performing future research. I have learned methods for writing research papers, and methods for creating a system that explores how technology can aid in interpersonal communication through shared interests. The system which we created selects user interests based on a user's twitter account and uses these interests to find a connection to an emoji. The goal in this research is to enable people to be able to communicate more effectively by comparing user interests and communicating them through the use of an emoji.

The grant has allowed me to fund time to participate in this research and ultimately co-author two research papers which have been accepted into two separate conferences. This knowledge of the research process, along with help from my advisor and another student/advisor team has helped me to write another paper which was also accepted into a conference. I feel truly fortunate to have three co-authored papers published so far as a student. This grant was the stepping stone needed to pursue research and give me an advantage as an undergraduate student looking toward graduate school. I believe this program to be very helpful to jump-start a student's academic career and am thankful to have been given this opportunity.

Callan Norby

How this project has benefitted my education

Being awarded funds from the State Board of Education has allowed me to work exclusively in a lab rather than acquiring another job over the summer. I was able to work 25 hours per week only concentrating on research which allowed me to make enough progress in my project to be able to present at ICUR where there is great networking. I was also able to improve upon my presentation skills and gain a better understanding of contemporary research being conducted within all fields of chemistry. My career goal is to become a professor, and the ability to articulate information in a manner conducive to learning is a trait I am constantly trying to improve upon. I will also be able to attend ICUR in July and the Great Scientific Exchange (SciX) in October where I hope to have similar experiences. I have also become much more knowledgable about my research area, chemometrics, due to being around lab cohorts who are all working on projects that pertain to different aspects of the field. This research experience has allowed me to hone my ability to critically think and learn. Enhancing both of these abilities will assist me in all future classes, graduate school eduation, future career, and life in general. Lastly, I was able to enhance my understanding of the MATLAB sofware and its utilities. In doing so, I have gained a serious passion for software programming and have begun to learn three new programming languages (Python, R, and Julia) on my own time.

Summary of accomplishments / research results

Over the course of the summer, I have been able to advance my research project in many ways. Using only spectral similarity measures, we were able to tune the ISU algorithm to have satisfactory least square fits when calculated ISU values are plotted against relative prediction errors for several data sets. The following plot and tabulated results are for one particular data set measured over several temperatures.

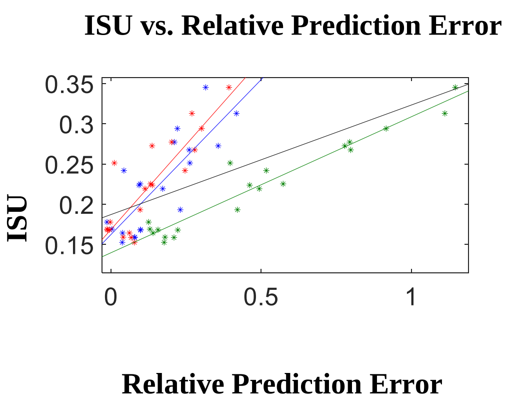


Figure 1. ISU vs. relative prediction error for all prediction properties in Temperature

Prediction Property	R^2	Intercept
Isopropanol	0.7383	0.1688
Water	0.6565	0.1625
Ethanol	0.9351	0.1398
Composite	0.4078	0.1872

Table 1. Least squares values for Figure 1.

These results will be presented in Boise at the Idaho Conference on Undergraduate Research (ICUR) in July. Although the results look promising for this data set, we were not able to reproduce similar trends for several other data sets. We are currently adjusting the ISU algorithm to have consistency for multiple data sets.

Presentations
1. Callan Norby, John H. Kalivas, Fusion of similarity measures to assess data set uniqueness, Idaho Conference for Undergraduate Research (ICUR), Boise, ID, July 2020

Melissa Rivas

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Biological Sciences

Biology Major

Undergraduate Research Funds Application: Social Instability and Stress Hormones in the bluebanded goby, *Lythrypnus dalli*.

In February 2020, I joined Dr. Devaleena Pradhan's laboratory in the Department of Biological Sciences as a volunteer. Dr. Pradhan's research deals with understanding the physiological mechanisms of behavioral plasticity in organisms. I have assisted two graduate students on their research questions on trout. I have been able to get hands-on experience with data collection, instead of just processing samples without understanding the origin of the data. I continued learning how to use new methods and improving my critical thinking in Dr. Devaleena Pradhan. During the short time I had in her lab, I found the opportunity to learn more about the stress mechanism in animals. I was very interest in the applying in their scientific method to Behavioral endocrinology. The physiological stress response entails an elevation of the hormone cortisol that is a hormone that controls stress-induce responses in all vertebrates. The role of cortisol can change phonotype plasticity that will allow to adaptation. I found interesting about the stress response in species of hermaphroditic fish like the bluebanded goby, *Lythrypnus dalli*, their behavioral phenotype is regulated by social structure. The stress response the bluebanded goby presents its due to an elevation of circulating cortisol. We could observe, the blubanded goby's relationship between social status it depends on the cortisol levels, that regulates metabolic demands during stressful periods. Adding and changing their already social hierarchy will produce stress. Waterborne hormones were collected after 24 hours of the application of either of the treatment. Samples will dry down and resuspend in 7.5% and 95% EIA buffer. Then to quantify cortisol levels it will be perform another method enzyme immunoassay. I plan to continue my research in her lab in a project that investigates social instability and stress hormones in the fish, blue-banded goby, Lynthrypnus dalli. In my short time in Dr. Pradhan's Lab, I have experienced the process of scientific discussions and critical thinking –what I felt I lacked all this time, about how to design an experiment and prepare for it.

I've been learning a lot of lessons. One of the important is writing protocols for each procedure that I can refer back of them if I need to. Dr. Pradhan highlight the importance to write your own procedure and asking questions about it. Learning things for the first time is difficult but building a solid foundation on basic lab techniques can help to reinforce knowledge gain in the protocols and make no mistakes during the experiment.

Based on my short experience in Dr. Pradhan's Lab. I've improved in my lab etiquette knowing and using new instruments in Dr. Pradhan's lab. I've been learning a lot of lessons too. One of the important is writing protocols for each procedure that I can refer back of them if I need to. Dr. Pradhan highlight the importance to write your own procedure and asking questions about it. Learning things for the first time is difficult but building a solid foundation on basic lab techniques can help to reinforce knowledge gain in the protocols and make no mistakes during the experiment. This new knowledge impact in motivate me more discipline and keep me engage. The other major challenge that I encountered is being organized and ask questions. Being vocal about the research projects allowed me to get more involved in their experiments and help me to interpreted data.

Undergrads, like me often help to make or update the inventory because its important familiarized with the lab and the materials. Knowing where is the material storage in lab will help the lab team to operate more effectively and provide a high performance, its important to keep a tracking of the laboratory material. Controlling inventory will save time and work.I had a positive experience observing how Grad students design their experiments. I'm looking forward to understand insight and problems with the stress hormones and discussing more articles that revealed new gaps that had not been previously described using the bluebanded goby. I feel like I'm growing as a researcher and I wan to continue improving and learning.

Garrett Stouffer
SBOE Report
6/23/2020

This research project is about solving partial differential equations using fenics which is a mathematical programming language based on python. Everything I've learned from this project is useful information for me because I am majoring in mathematics. I've learned about the Finite Element Method which was developed for solving partial differential equations. The information I've been taught or found out on my own as a part of this project will help me succeed academically and career wise. Academically I've further developed the skill of learning on my own and covered mathematical/programming topics that may be very useful in future classes. Beyond that I've learned problem solving and communication skills that last forever and will definitely come in handy in future careers.

This project has been very challenging for me to understand at times. It really forces me to think long and hard in order to understand what I'm learning. I can't actually remember ever finding learning and studying as difficult as this project. Typically school has been easy for me to understand, but this project forces me to think critically and work hard. I believe that that is the best case scenario for a student, because without being challenged academically you could lose the love for learning. I am very grateful for this project and for the funds that supported it because it allowed me to get a headstart academically and career wise.

Jacob Tolman

This project was focused on writing software implementations of the finite element method to apply to the Eastern Snake Plain Aquifer Model (ESPAM). We obtained some initial information about the model when we visited the Henry's Fork Foundation, and learned about how the model is used to solve important problems related to water law. They use a finite-difference approach to solve the partial differential equations involved, which is far from efficient. Using the finite element method for approximating the solution of the equations involved would greatly reduce the computational cost of simulating the aquifer, and allow for a much higher-resolution model to be used.

We also spent time learning and implementing recent variation of the finite element method, called the Weak Galerkin method. This method is currently very popular, as ithas been shown to be much simpler and more efficient than most other variations of the finite element method. In the future, we plan to use the Weak Galerkin method and standard finite element method to solve the aquifer model, and comparing the efficiency and results with each other, and with the current finite-difference method.

This funding has greatly benefited me this semester. Without it, I would probably have to work a job not as focused on math or research. So it has given me the opportunity to focus more on learning and research than I would otherwise be able to. This is particularly useful for me, since I plan to pursue a PhD in mathematics. It is important for me to get any extra preparation for graduate school that I can. Also, this project has helped me apply some of the skills I have learned throughout my undergraduate studies in a practical setting. I learned a lot, and I look forward to continuing the project next semester. All papers and posters related to this project will be completed then.

FY20 HERC Undergraduate Research: *LEWIS-CLARK STATE COLLEGE*

Student(s)	Major(s)	Project Summary	Project Amount	Stipend(s)	Supplies	Travel	Faculty Mentor	Dissemination
Mari Carillo	Biology/Social Sciences:Anthropology Emphasis	Medical Pluralism: Shifts in traditional knowledge and practice amoung Sobadores and medical practitioners	3,039	2,460		579	Kerensa Allison	Presented at the ICUR virtual conference.
Rhiana Fox	Math & Psychology	Using Data Analytics to study the psychological effects due to long-term illness.	3,510	3,510			Heather Moon	Presented at the ICUR virtual conference.
Gary McEwen	Exercise Science	Effects of Bio-Electro-Magnetic-Energy-Regulation (BEMER) on recovery and performance in Anaerobic Exercise Tests	1,000	1,000			Collin Fehr	Presented at the ICUR virtual conference and the ACSM meeting in Boise, Idaho.
Tristan Olsen	Mathematics and Chemistry	Using Parametric Linear Programming to approximate phase state curves	3,510	3,510			Heather Moon	Presented at the ICUR virtual conference and the ACSM meeting in Boise, Idaho.
Abbey Roy	Biology	Studying long-term biological consequences of Blm-deficient embryonic development in Drosophila.	2,560	2,560			Eric Stoffregen	Presented at the ICUR virtual conference.
Judy Boozer	Biology	Use of Amphioxus as a model for Regenerative Medicine.	1,624	1,176	448		Leigh Latta	Presented at the ICUR virtual conference.
Dylan Miller	Biology, Chemistry	Method Development for the Determination of Uptake Rates used in Passive Sorbent Tube-Type Sampling.	1,440	1,440			Nancy Johnston	Presented at the ICUR virtual conference.
Eli Moser	GeoChemistry	Collection and analysis of mobile sulfer compound data around a pulp papermill in northern-central Idaho.	1,440	1,440			Nancy Johnston	Presented at the ICUR virtual conference.
Elias Pukkila	Chemistry/Biology	Analysis of multiple anions in the water supply and surrounding natural water deposites of North Idaho.	1,480	1,080	400		Nancy Johnston	Presented at the ICUR virtual conference.
Ryan Glimp and McKenzie Malm	Kinesiologgy:Exercise Science (Glimp) Kinesiology:Health & Fitness (Malm)	Body Dysmorphia Occurrence in College Athletes versus College Students	1,482	1,344	138		Clay Robinson	
Totals		**Payments**	**21,085**	**19,520**	**986**	**579**		
		FY21 HERC Undergraduate funding received	**20,000**					
		# undergrads participating in research	11					

8/5/2020

Dear Provost Stinson:

Hello, my name is Eli Moser. This summer I had the privilege to be funded by the State Board of Education Higher Education Resource Council and Provost Stinson to conduct research on sulfur dioxide (SO_2) in the air in the Lewis-Clark Valley. Sulfur dioxide in our valley is partially responsible for the noxious odor that hangs in the valley. It is emitted by industry such as the local paper mill. SO_2 is a criteria pollutant monitored by the EPA but has never been monitored constantly for a significant amount of time in the area. SO_2 is known to cause irritation of the skin and respiratory system and increases the symptoms in people with preexisting respiratory issues. SO_2 also has corrosive environmental effects such as acid rain and the reduction on growth in foliage existing in high concentration areas.

My project goals were to measure SO_2 constantly and find trends temporally, spatially, and seasonally. To achieve this, we sampled 24 hours a day since June 2019, and continue to sample from the lab and on a mobile platform. We analyzed the data and found that temporally there was a spike in concentration through the morning and has been a constant increase in concentration for the past year. Spatially, from the few sampling runs we have done agree that there is an increase in concentration with an increase in elevation. The title of my project was *Collection and analysis of mobile sulfur compound data around a pulp papermill in northern-central Idaho.* As the project developed the final poster title that was presented at the Idaho Conference of Undergraduate Research (ICUR) was *Analysis of Sulfur Dioxide Emissions in the Lewis-Clark Valley.*

Similar to the project itself, I developed as a scientist and a person over the course of this project. I have learned more of the chemistry of SO_2 in the atmosphere and instrumentation than I previously had exposure to in classes or normal lab procedures. I had the opportunity to be exposed to the grant writing process as well as method development and all of its trial and error. Perseverance is an essential element of conducting research and has taught me many lessons like better communication and time management. I believe that future projects will be vastly improved by the experience that I have gained while taking on this project. I am very thankful for the opportunity and hope to assist more students in the future to have a similar research experience.

Sincerely,

Elijah Moser

Analysis of Sulfur Dioxide Emissions in the Lewis-Clark Valley

Moser, E.P.; McGarry J.K; Johnston, N.A.C. Ph.D.
Division of Natural Sciences and Mathematics
Lewis-Clark State College

Introduction

- Sulfur dioxide (SO_2) is produced as a byproduct of burning fossil fuels or chemical reactions used by industries such as kraft paper mill production.
- A kraft paper mill is a major industrial pollution source in the Lewis-Clark Valley; a community that rests at the confluence between the Snake and Clearwater Rivers and includes parts of Southeastern Washington and North central Idaho.
- SO_2 is a criteria pollutant that is monitored by the EPA because in the atmosphere because it is an indicator of other sulfur species SOx concentration and
  - It creates acid rain and while gaseous can damage plant growth and foliage
  - accelerates respiratory issues such as asthma
- The goal of this study is to discover:
  - How SO_2 pollution varies in a water gap valley
  - Diurnal variation of concentrations including
  - Plume movement throughout the day morning to noon versus noon to dusk
  - Daily / weekly / monthly averages or seasonal variation
  - Spatial variation of concentrations throughout the valley
- SO_2 was monitored using a Teledyne T102, UV fluorescence-total reduced sulfur analyzer.
- Sampling was done in both a stationary location (LCSC instrument lab) and on a mobile platform that was driven around the valley

Methods and Materials

- A Teledyne T102, UV fluorescence-total reduced sulfur analyzer was used in SO_2 mode during mobile operation and in SO_2 and TRS (Total Reduced Sulfur) mode switching every 10 minutes during stationary operation.
- While conducting stationary sampling the analyzer was calibrated with NIST traceable 5.0 ppm +/- 10% sulfur dioxide gas cylinders as standards controlled via a T700 dilution calibrator and a T701 zero air generator.
- Calibration checks were conducted while sampling in the field with a Metronics Dynacal 140 ng/min +/- 25% wafer permeation tube.
- Sampling sites seen in Figure 1 were chosen to bisect the paper mill and explore different elevation gradients.
- SO_2 was sampled continuously from the LCSC instrument lab from June 2019 to present, while Mobile operations took place in a Chevy Volt on 7/1-7/1/2020.
- During mobile sampling the relative humidity, atmospheric pressure, temperature, wind speed and direction both locally and on a valley wide average as well as times were recorded while in the field.
- Data analysis of raw 1-minute data was streamlined by using Python to create data files and statistics.

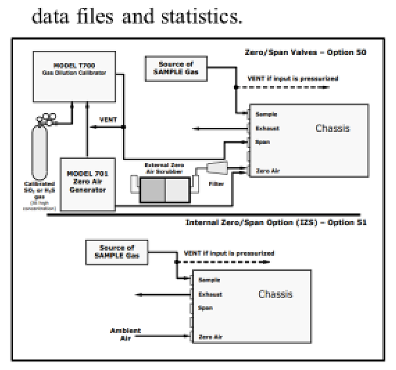

Figure 1. diagram of the setup that was used to calibrate and sample SO_2 in the lab.[1]

Figure 2. Eli Moser calibrating the T102 sulfur analyzer.

Figure 3. Chevy Volt housing the sulfur analyzer and sampling via an intake tube out of the back window.

Results

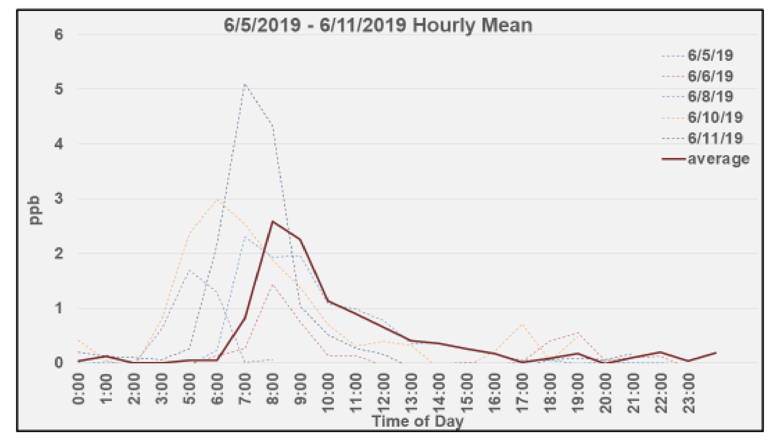

Figure 4. The hourly average measured in ppb for 7 days in June and the average of all the days in series displaying a peak from hours of 6:00 to 12:00 at LCSC site.

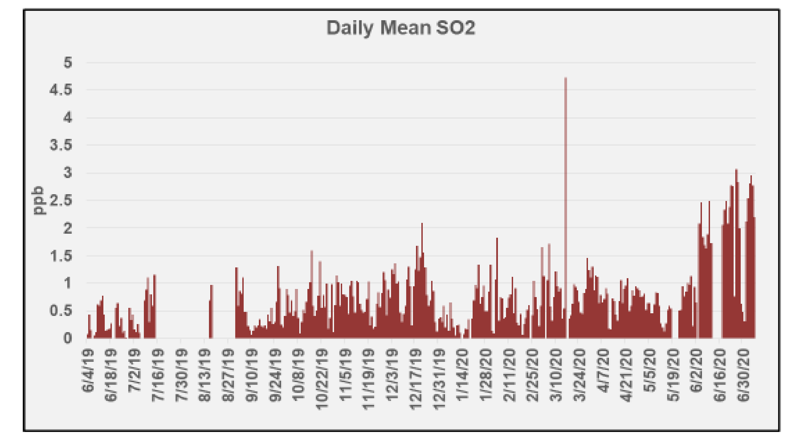

Figure 5. The daily average SO_2 for June at LCSC site 2019-2020 with concentrations in ppb.

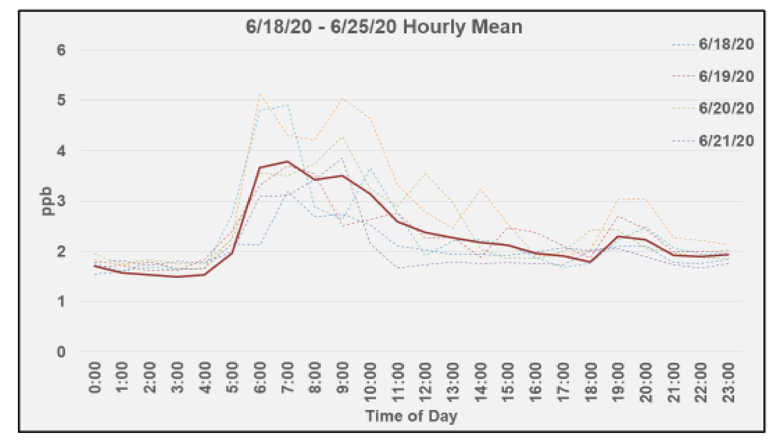

Figure 6. The hourly average measured in ppb for 8 days in June and the average of all the days from series displaying a peak from 7:00 to 12:00 at LCSC site.

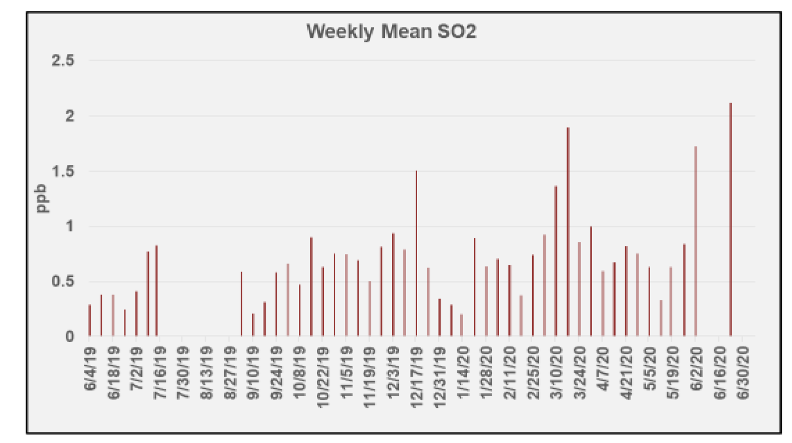

Figure 7. The weekly average for 2019-2020 at LCSC site and SO_2 concentrations in ppb.

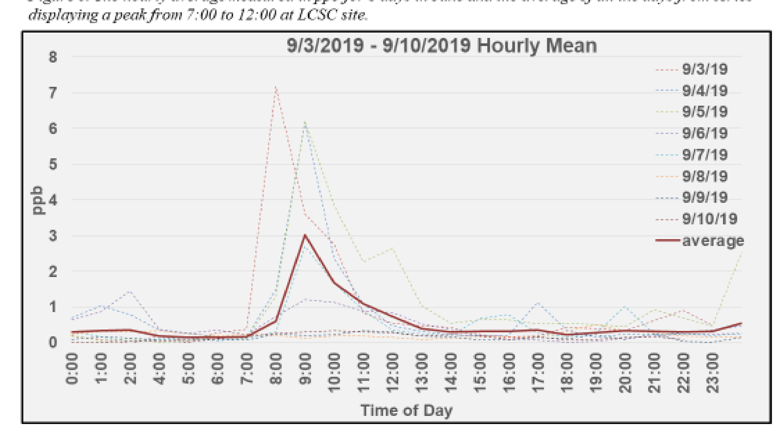

Figure 8. The hourly average measured in ppb for 8 days in September and the average of all the days displaying a peak from 5:00 to 18:00 at LCSC site.

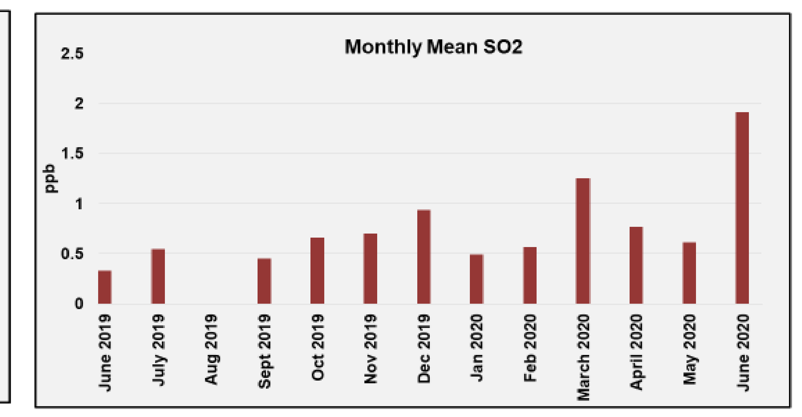

Figure 9. The monthly average for 2019-2020 at LCSC site and SO_2 concentrations in ppb.

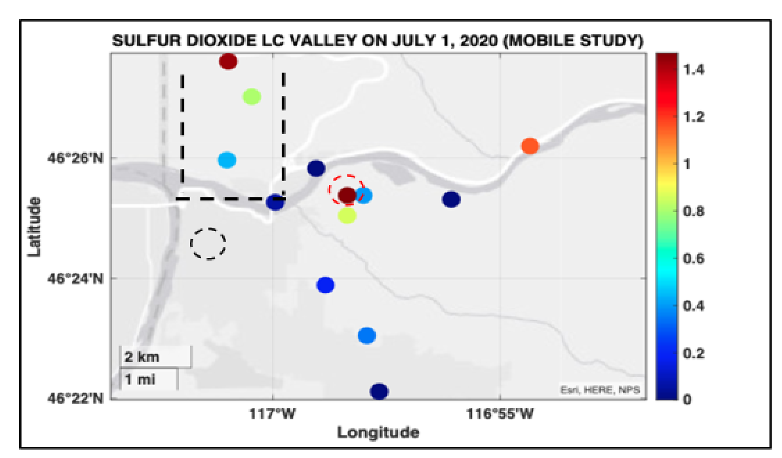

Figure 10. Mobile sample sites in the Lewis-Clark valley and SO_2 concentration in ppb on July 1, 2020. Red circle marks the Paper Mill location. The black circle indicates the stationary site at LCSC.

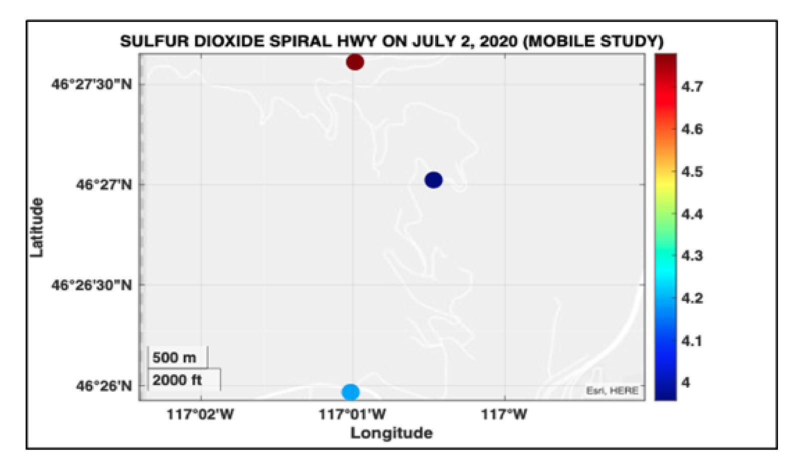

Figure 11. Mobile sample sites in the Lewis-Clark Valley and SO_2 concentration in ppb. These sites are from insert on Figure 10.

Conclusions

- There is a consistent peak SO_2 from about 6:00 AM to 12:00 PM during the day and otherwise the days and nights are low.
- SO_2 appears to be rising throughout the year at a slow rate. This could be coincidence, weather related or increased emissions.
- There may be certain months that have higher concentrations however more data is needed to confirm.
- Although data is limited (two sample runs on 7/1/20-7/2/20), the mobile sampling suggests an increase in SO_2 concentration with an increase in elevation. This could be from the heat released causing the SO_2 to rise in a column and then disperse with the inversion layer.
- We also see low concentrations of SO_2 directly beside the mill although the smell is distinctly stronger meaning the odor may be other compounds in addition to SO_2
- In the future we plan to sample in a stationary position at different locations and attempt to track plume movement as it correlates to temperature and elevation.
- SO_2 levels in LC Valley are considered at or below attainment.[2]

Figure 12. A photo of the Clearwater Paper Mill on the Clearwater River . Photo taken by Nancy Johnston.

References

1. Teledyne API. (2012, June 11). Model T102 Total Reduced Sulfur Analyzer with Model 501 TRS Thermal Analyzer. San Diego, CA.

1. United States Environmental Protection Agency. (2017, January 19). *Sulfur Dioxide (SO2) Pollution*. Retrieved from EPA.gov: https://www.epa.gov/so2-pollution

Acknowledgements

- This research was sponsored by a Higher Education Research Council Grant, Idaho State Board of Education's Higher Education Research Council, This publication was made possible by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under Grant #P20GM103408 and Lewis-Clark State College.
- Additional assistance that made this research possible was provided by Gabrielle Dickenson and Timbre Durbin.
- Contact: Elijah Moser (epmoser@lcmail.lcsc.edu)

IDAHO INBRE
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Idaho State Board of Education

30-Jul-20

Provost Lori Stinson, Ph.D., RN
Lewis-Clark State College
c/o Office of the Provost
500 8th Avenue
Lewiston, ID 83501

Dear Dr. Stinson,

I want to thank you for facilitating my Summer 2020 Idaho HERC award. As this component of my project comes to a close, I reflect on the results we have achieved from a very positive outlook. The HERC grant I received was instrumental in initiating our study of diffusive uptake rates for use with passive air sampling. I'm so grateful for the steps forward these funds have allowed me to take as a student researcher and critical thinker.

At the Idaho Conference on Undergraduate Research this month, I presented the poster entitled "Determination of Diffusive Uptake Rates for VOCs on Passive Thermal Desorption Air Samplers". This was the first public sharing of my work with uptake rates. Our preliminary results indicated confidence in the method conducted and relevant literature comparison showed commensurate data with derived uptake rates. Attached is a copy of the presented material. For the remainder of the summer and throughout the coming academic year, our goals for the project will include the expansion of our data sets including uptake rates of up to two weeks working toward eventual publication in a scientific journal.

Again, thank you so much for your support of this research!

With Gratitude,

Dylan Miller

Determination of Diffusive Uptake Rates for VOCs on Passive Thermal Desorption Air Samplers

Dylan D. Miller and Nancy A.C. Johnston, Ph.D.
Division of Natural Sciences and Mathematics, Lewis-Clark State College, Lewiston, ID

LEWIS CLARK STATE COLLEGE
NATURAL SCIENCES & MATHEMATICS

Background

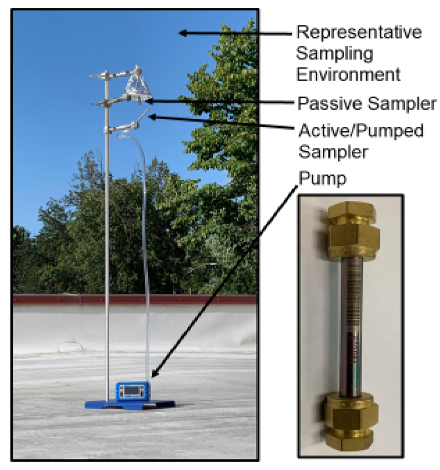
- The LCSC VOC air research group is conducting ongoing studies on air pollutants and wildfire emissions with pertinence to human heath risk.
- Thermal desorption tube-type samplers are a common method for air sampling. This can be done actively by pumping air through the sampler or passively by the diffusion of compounds onto sorbent.[1]
- Sampling passively offers an average concentration of compounds over the sample period, which is important in human health risk assessment.[2]

Introduction

- Passive sampling requires the use of an uptake rate (UTR), the rate at which compounds diffuse into the sampler and onto the sorbent.[3]
- UTRs published in the scientific literature are lacking.[4]
- The purpose of this research is to expand the literature of established UTRs via a synchronized active/passive sampling technique.

Methods

- Necessary components of UTR calculations were obtained by parallel active and passive samples.
- Two sampling trials of 24-hour duration with one duplicate were conducted using this technique.
- Experimentation was performed in outdoor ambient environments.
- Active samples were taken for 4 hours with a flow of 20 mL/min to accompany passive sampling.



- Blank correction was accomplished by the subtraction of all trials' averaged field blanks from both passive and active samples.
- All Samples were analyzed using TD-GC-MS and chromatograms were individually verified for quality.

Figures 1A and 1B: Sampling Apparatus and Sorbent Tube.

Methods (cont.)

Thermal Desorption - Removes compounds of interest from the sampler with high temperatures → Gas Chromatography – Separates sampled compounds into pure species by their physical properties → Mass Spectrometry – Identifies compounds based on the mass of their fragments after ionization

Calculations

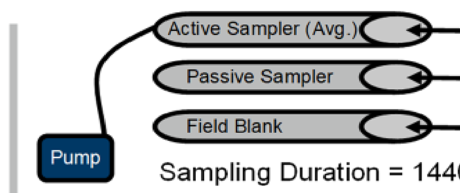
- Algebraic manipulation of a concentration equation for passive samplers derives the equation for uptake rate calculation.

$$C = \frac{(m_{passive\ sampler} - m_{blank}) \times 1000}{UTR \times t}$$

$$UTR = \frac{(m_{passive\ sampler} - m_{blank}) \times 1000}{C_{active\ sampler} \times t}$$

- To calculate uptake rates (UTR), $C_{active\ sampler}$ (concentration) was provided by active samplers, m (sorbed mass on sample) was provided by passive samplers, and t (time) is duration of the sample.
- Active sample concentrations were averaged to provide the mean concentration over the sample period (24-hr).

Sample Calculation: Benzene (24-hr UTR)



0.3199 ng/L = $C_{active\ sampler}$
0.2454 ng = $m_{passive\ sampler}$
0.1040 ng = $m_{field\ blank}$
Sampling Duration = 1440 min.

$C_{active\ sampler}$ calculated with: $(m_{active\ sampler} - m_{field\ blank})$/ Volume Sampled

$$UTR = \frac{(0.2454\ ng - 0.1040\ ng) \times 1000\ \frac{mL}{L}}{0.3199\ \frac{ng}{L} \times 1440\ min}$$

$$= \frac{141.4\ ng\ mL}{460.7\ ng\ min}$$

$$UTR = 0.3060\ \frac{mL}{min}$$

Results

Compound	24-hr Trial 1 UTR (mL/min)	24-hr Trial 1 Duplicate UTR (mL/min)	24-hr Trial 2 UTR (mL/min)	24-hr Trial Averages (mL/min)	Literature comparison (7-day period)[2] (mL/min)
Benzene	0.31	0.21	0.80	0.44 (+/- 0.26)	0.30
Toluene	0.25	0.22	0.74	0.40 (+/- 0.24)	0.35
Ethylbenzene	0.29	0.27	0.81	0.46 (+/- 0.25)	0.35
m,p-Xylene	0.21	0.19	0.70	0.37 (+/- 0.24)	0.39

Figure 2: 24-hour uptake rates (mL/min) averaged from all trials and compared to related literature data (1-week rates). There are no directly comparable 24-hour rates in the published literature.

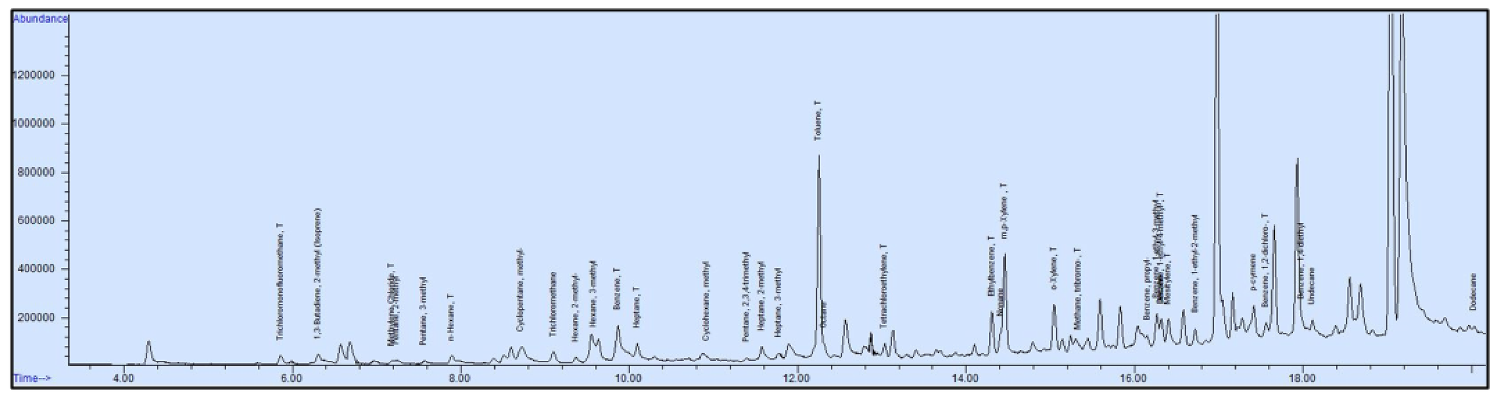


Figure 3: Chromatogram showing a normal response for actively sampled air samplers.

Conclusions

- Agreement between experimental data and comparable published uptake rates is observed.
- Preliminary data suggests confidence in the method due to these agreements.
- Fewer uptake rates than expected were calculated. This is due to the fact that compounds whose uptake rates are derived are quantified on both active and passive samplers. This experimentation yielded a phenomenon in which many more compounds were quantified on active samplers in comparison to passive samplers. This may be resolved with longer sample durations.
- With the measurement of additional uptake rates, LCSC VOC 2019 data set from our participation in NASA/NOAA FIREX-AQ will be retrospectively evaluated for human health risk.

References

1. US EPA. (2019). Method 325A—Volatile Organic Compounds from Fugitive and Area Sources. Retrieved from https://www.epa.gov/sites/production/files/2019-08/documents/method_325a.pdf.
2. Walgraeve, Christophe, et al. "Diffusive sampling of 25 volatile organic compounds in indoor air: Uptake rate determination and application in Flemish homes for the elderly." Atmospheric environment 45.32 (2011): 5828-5836.
3. Walgraeve, Christophe, et al. "Uptake rate behavior of tube-type passive samplers for volatile organic compounds under controlled atmospheric conditions." Atmospheric environment 45.32 (2011): 5872-5879. (2).
4. Brown, V.M., et al., Long term diffusive sampling of volatile organic compounds in indoor air, Environmental Technology,(1993), 14: 771–777, http://dx.doi.org/10.1080/09593339309385348.

Acknowledgements

- This research was supported by an Idaho Higher Education Research Council Grant and an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under Grant #P20GM103408, Idaho State Board of Education's Higher Education Research Council and Lewis-Clark State College.
- This research was assisted by Gabrielle Dickinson, Elias Pukkila, Timbre Durbin, Elijah Moser, Aakriti Bajracharya, and William Bruchard.

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Analysis of Nitrate and Other Anions in Natural Water Sources of North Central Idaho

LEWIS-CLARK STATE COLLEGE

Elias J. Pukkila and Nancy A. C. Johnston

Division of Natural Sciences and Mathematics, Lewis Clark State College, Lewiston, Idaho

IDAHO INBRE
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Abstract

Nitrates in the water supply may cause cancer and birth defects when ingested. Nitrates are introduced to the water supply when farmers use fertilizer for their crops. The fertilizer contains high concentrations of nitrates. These nitrates are then able to enter various water sources via runoff from rain. Water samples from various water sources in North Central Idaho during early summer were collected. Nitrates and six other anions (Fluoride, Chloride, Nitrite, Bromide, Phosphate, and Sulfate) were analyzed using ion chromatography. Only Fluoride, Chloride, Nitrate, and Sulfate were detected in any of the samples. No amounts of nitrate analyzed exceeded the EPA MCL (maximum contaminant level) except for one site located in a small creek located in a valley between two farms. Therefore, analysis shows little risk of health danger for most water sources in North Central Idaho.

Introduction

- Runoff from farmland can cause high concentrations of nitrate to flow into different water sources which can be harmful to biological systems when ingested.
- Sites were chosen based on the EPA's nitrate priority areas. These are areas which have had high nitrate levels that need to be monitored.[1]
- One of these areas is located to the east of the Lewis-Clark valley. Sites were picked along the river to observe any change in anions as creeks located in these nitrate priority areas were deposited into the river.
- Two samples were taken from each site on different days during the beginning of Summer.

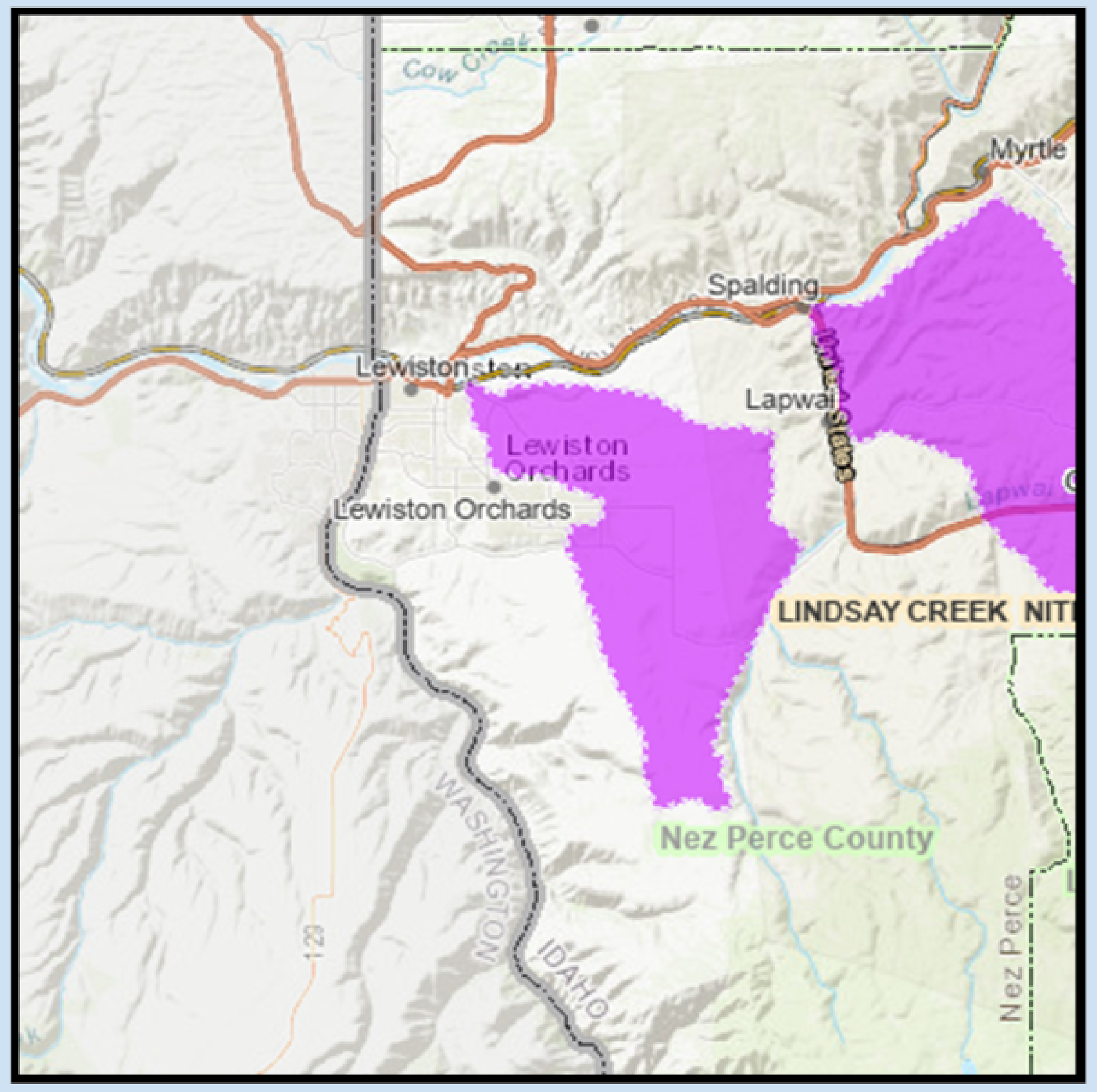

Figure 1: EPA Nitrate Priority Map

Results/Discussion

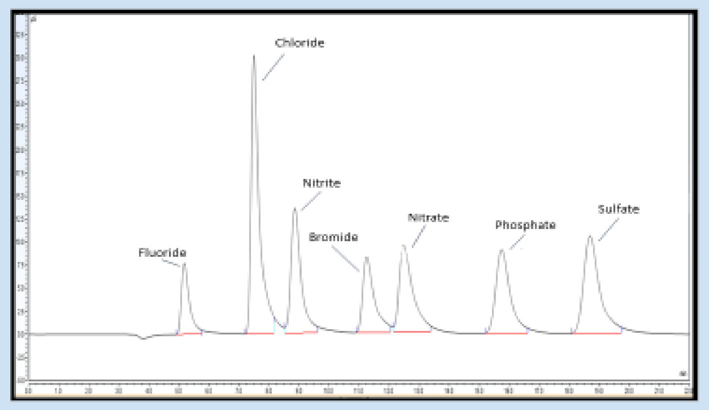

Figure 2: 50 ppm 7 Anion Standard Chromatogram

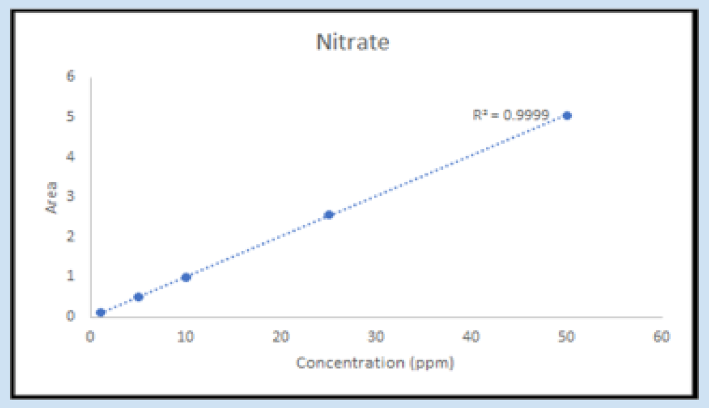

Figure 3: Nitrate Calibration Curve

Day 1 - Day 2 -

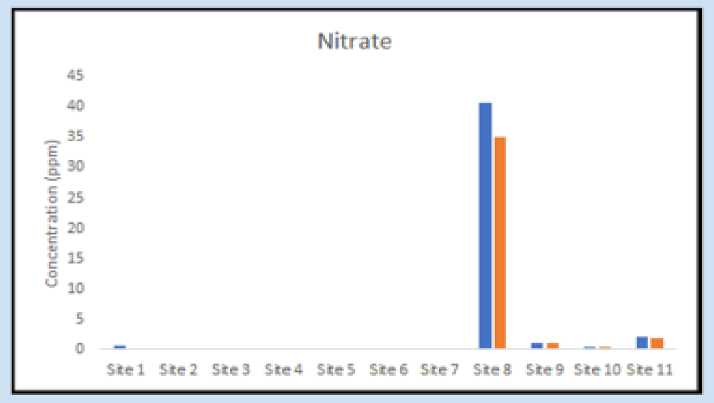

Figure 4: Source Water Nitrate Concentrations

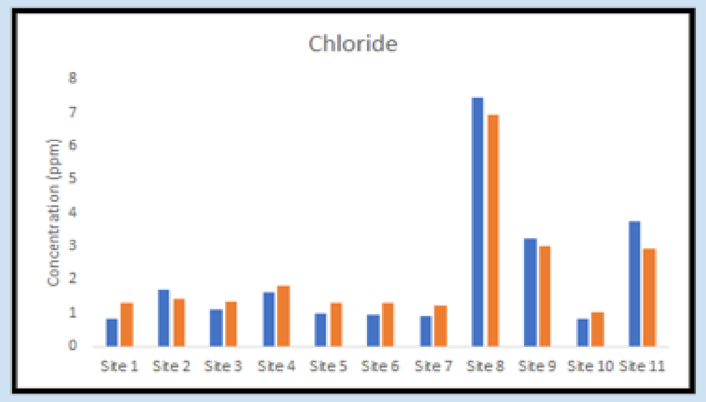

Figure 5: Source Water Chloride Concentrations

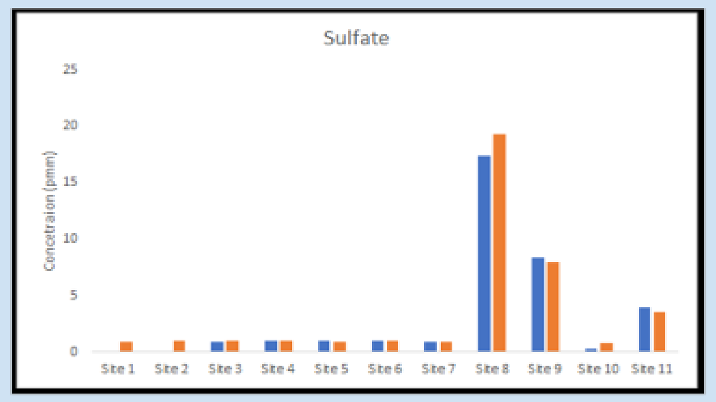

Figure 6: Source Water Sulfate Concentrations

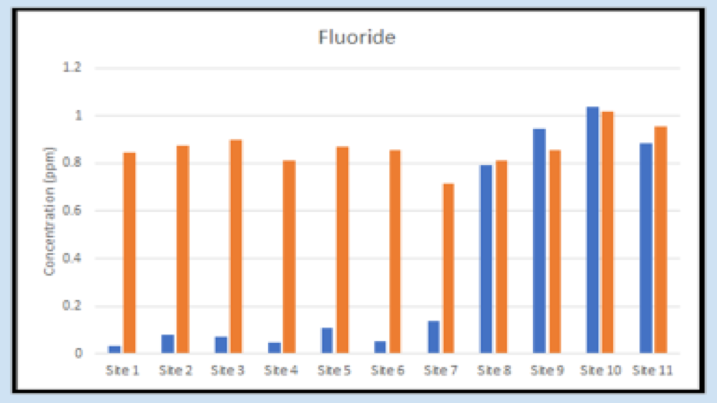

Figure 7: Source Water Fluoride Concentrations

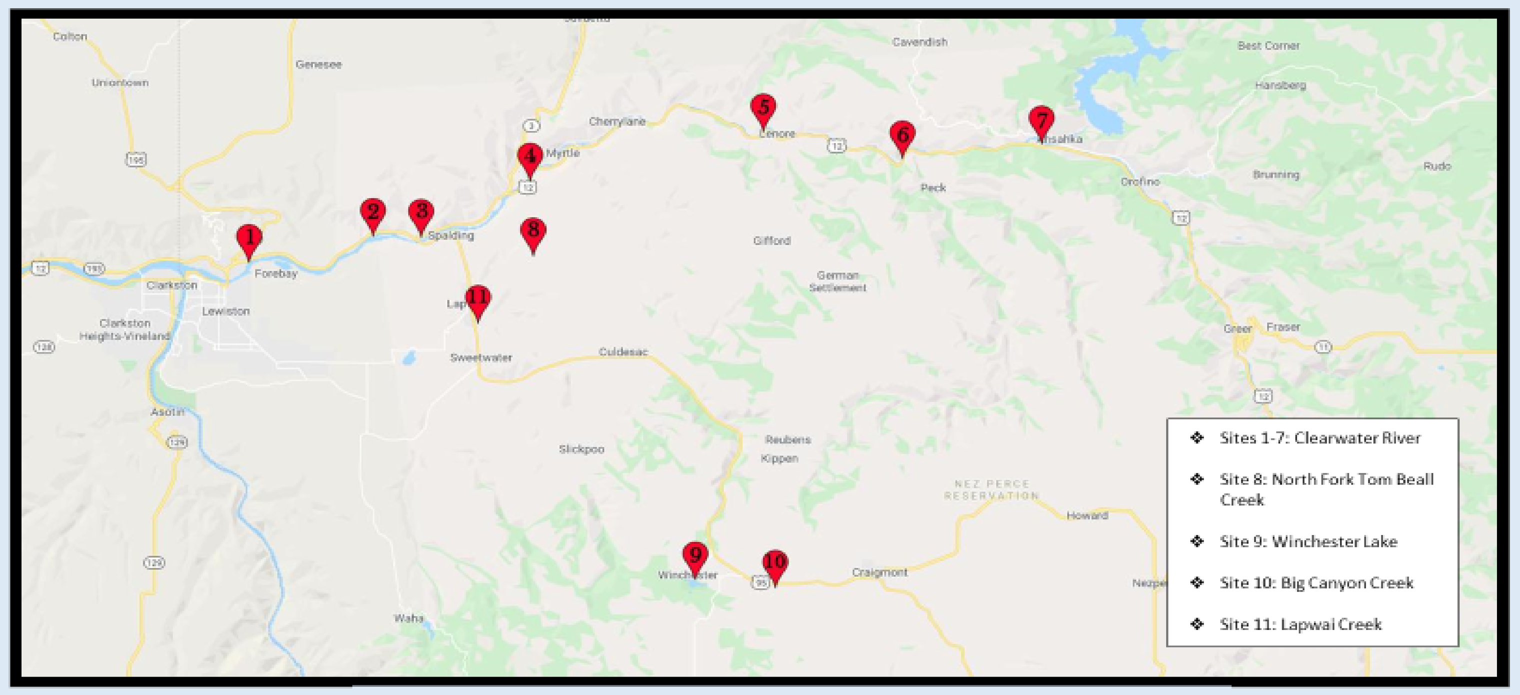

Figure 8: Map of Source Water Sampling Sites

Methods

- Water samples were retrieved from the several locations provided in *Figure 2*. 500 mL PTFE bottles were used to store the liquid before analysis.
- The samples were analyzed no later than 48 hours after they were extracted and were syringed through 0.46 um filter before injection into the ion chromatogram.
- Standards were prepared using a Thermo standard stock solution containing the 7 anions being analysed. 5 different concentration levels were made to create a calibration curve (50 ppm, 25 ppm, 10 ppm, 5 ppm, and 1 ppm)

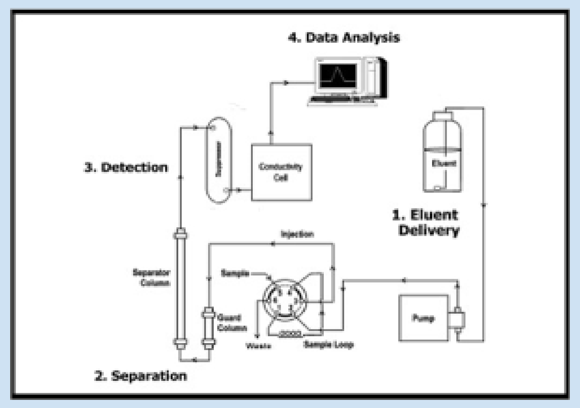

Figure 9: Ion Analysis Process

IC Parameters

- Column: Dionex IonPac AS 14A
- Suppressor: Dionex AERS 500 14mm
- Flow: 0.7 mL/min
- Current: 30 mA
- Eluent: 8 mM Carbonate/ 1mM Bicarbonate
- Run time: 22 min

Conclusions

- No amounts of Nitrite, Bromide, or Phosphate were detected in any source water sample. Concentrations for these anions may have been under the LOD for the experiment.
- Chloride and Sulfate concentrations of all samples stayed well below the EPA's set MCL of drinking water of 250 ppm.[2]
- The source of the Fluoride in the drinking water is possibly from the addition of fluoride to drinking water.
- Sampling site 8 was the only site to show Nitrate concentrations exceeding the EPA's established MCL of 10 ppm.[3] This is possibly due to the farmland to both sides of the creek.
- All other sampling sites were well below the MCL for nitrate.

References

1. Idaho Department of Environmental Quality, 2014 Nitrate Priority Areas, retrieved from https://mapcase.deq.idaho.gov/npa/
2. Idaho Department of Environmental Quality, National Secondary Drinking Water Regulations (NSDWRs), retrieved from https://www.epa.gov/sdwa/drinking-water-regulations-and-contaminants
3. Idaho Department of Environmental Quality, National Primary Drinking Water Regulations, retrieved from https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Acknowledgements

- This publication was made possible by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under grant #P20GM103408 and the Idaho State Board of Education Higher Education Research Council

Idaho State Board of Education

STRATEGIC INITIATIVE
Undergraduate Research Funding for STEM Majors at the University of Idaho

FINAL PROJECT REPORT

Submitted to:

Higher Education Research Council
Idaho State Board of Education
P.O. Box 83720
Boise, Idaho 83720-0037

Submitted by:

University of Idaho
Office of Undergraduate Research

875 Perimeter Drive
Moscow, ID 83844

September 30, 2020

Table of Contents

Executive Summary

Undergraduate research is recognized as a high-impact educational practice that increases the rates of student retention and engagement. At the University of Idaho, it is practiced throughout all units on campus and it is centrally placed in the institution's strategic plan. The Office of Undergraduate Research is tasked with taking the lead in enabling research opportunities for undergraduates at the U of I. Among its roles, it manages various competitive student grant programs that directly support student research.

During FY2020, generous funding from the State Board of Education/Higher Education Research Council permitted the U of I to continue its Summer Undergraduate Research Fellowship (SURF) Program. This intensive 10-week summer research experience actively engages undergraduates in faculty-mentored, independent research. Each student is provided with a $4,000 stipend in the form of a fellowship which allows them to devote full time effort to their projects. Each student is also provided with $1,000 to help offset materials and supplies and other project-related expenses. Selection of student participants is a competitive process in which students submit research proposals to the Office of Undergraduate Research. State Board of Education funding supported eleven SURF awards during the summer of 2020. These awards were managed by the U of I Office of Undergraduate Research.

Of the eleven student projects funded by the State Board of Education award, all but one student/mentor team fully spent out project-related funds as planned. The one exception involved a student project where the final cost of project supplies came in just under the original estimated amount. This left an unspent amount of $90.25 after the project had been completed. This unspent money is being returned to the State Board of Education.

All of the U of I students supported by State Board of Education funds attended and presented the results of their projects at the Idaho Conference on Undergraduate Research (ICUR) in July 2020. With the exception of those students who will be graduating this fall, all of our students also will present posters of their work at the U of I Undergraduate Research Symposium in April 2021.

End of project feedback from students and their mentors was overwhelmingly positive. Significantly, none of the undergraduate research projects described here would have been possible without the support provided by the State Board of Education. We sincerely thank the Higher Education Research Council and the Idaho State Board of Education for making these experiences possible for our students.

This final project report combines all of the student project reports funded by the SBoE awards into a single document.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Evan Allen, University of Idaho
Faculty Mentor: Dr. Michael Maughan, Department of Mechanical Engineering
Project Title: Determining Residual Stress Fields and Plastic Zone Sizes Surrounding Fatigue Cracks Using Nanoindentation

Project Description:

A plastic zone forms at the tip of a growing fatigue crack. In this zone, residual stresses are created as the crack travels, thereby relieving the load and hindering crack growth. The size of the residual stress area or "plastic wake" can be measured in a new way by combining nanoindentation and atomic force microscopy (AFM) to measure material upheaval around an indent. The magnitude of the residual stress field is related to the elastic modulus and Poisson's Ratio of the tested material, as well as the indenter angle, flow stress, and residual stress (Larson 2017). The coupled method of nanoindentation and AFM can determine the magnitude and location of the residual area around the tip of a crack. The data found through performing this research can also help predict the plastic zone size at different crack lengths.

The specimen my mentor and I studied is an alloy 709 stainless steel that has undergone fatigue crack growth testing. Fatigue is a critical failure mode in almost all components; therefore, it is important to improve our understanding of crack propagation. The goal of this project was to provide a comparison between new experimental measurements and the Irwin model, which predicts the zone size from the yield strength of a material and the applied stress intensity factor (Stephens 2001). Another project goal was to determine how the stress field varies from the tip of the crack to locations outside the plastic zone. This project was conducted in order to refine our understanding of fatigue crack models to better predict and prevent system failure.

Expanding our knowledge of crack propagation is critical in determining when components are approaching fracture. This fracture due to crack growth, if not analyzed properly, can sometimes be catastrophic and can put lives in extreme danger. That is why the understanding of the area around a growing crack is an absolute necessity. The project procedure was to first obtain an Alloy 709 fatigue crack growth sample, indent the surface, measure indent upheaval around the indents, and then compare the data with the plastic zone size estimations with the Irwin model. This procedure was the foundation for the project.

Project Accomplishments:

I was able to obtain an Alloy 709 Stainless Steel fatigue crack growth sample that was heated to 700°C. I took the sample to the machine shop and milled down one side so the material could be indented. This was my first experience using the manual mill in the machine shop. Once the sample was machined to the proper specifications, I polished the surface to prepare it for nanoindentation. I then indented the specimen with a gradient pattern as can be seen in Figure 1a along four different crack lengths along the specimen. Fig. 1b shows the Alloy 709 surface indentation lines at 17.8mm and 20mm crack lengths. Fig. 1c depicts the loading parameters used for the indentations.

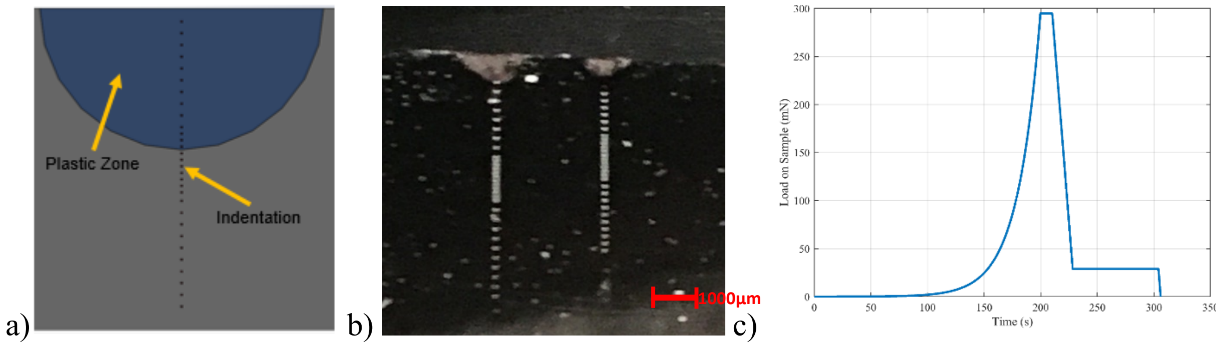

Figure 1: a) Indentation gradient technique applied to all measured crack lengths on the surface of the specimen b) Alloy 709 FCG specimen indents taken along 17.8mm and 20mm crack length c) Indentation Load vs. Time Curve (typical for all indents)

The indentation data can be used to provide estimations of the plastic zone size based on the hardness. Below in Table 1, the estimated plastic zone size comparison between the Irwin model and solely indentation data is shown. The nanoindentation estimation of the plastic zone radius is estimated at the point where the highest change in hardness occurs between any two indents. As seen in table 1, the indentation estimations of the plastic zone size are closely related to the Irwin model values.

Table 1: Plastic zone sizes found using the Irwin model and indentation changes in hardness. Nanoindentation estimation values are the distances from the crack tip where the greatest change in hardness occurs.

Plastic Zone Size Comparison		
Crack Length (mm)	**Irwin Model r_y(mm):**	**Nanoindentation Estimation of r_y (mm):**
17.8	2.416	2.28 - 2.38
20	3.024	3.04 - 3.14
25	5.247	5.13- 5.23
30	10.226	10.39 - 10.49

More results for the indentation data can be seen in the poster that I made for ICUR 2020. Unfortunately, the AFM machine that I was looking to use still does not work. A few faculty members and I spent quite some time trying to get the machine to work, but we were unsuccessful. Currently, my mentor and I are looking into other methods to find the surface topography so I can measure the residual stress field and compare the results with those displayed in Table 1. I am performing scanning electron microscopy on the sample to hopefully retrieve data that will lead to another estimate of the plastic zone size.

Discussions and Conclusions:

This project has taught me many new research skills, and my mentor and I have been able to accomplish many of our goals. I was able to estimate the plastic zone, and I learned quite a bit more about fatigue testing, nanoindentation, AFM, and scanning electron microscopes. I will be able to carry the skills I developed while performing this project through graduate school and the next phases of my academic and professional career. I had many challenges to overcome and I am proud that I was able to put forth my best effort to overcome the obstacles I experienced. I will continue this research, and I plan on determining the residual stress field. I am hopeful that I will be able to complete this aspect of the project soon and hopefully be able to publish my findings.

I would like to sincerely thank Idaho State Board of Education for the support provided that made my SURF award possible.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Lydia M. Druin, University of Idaho
Faculty Mentor: Dr. Lisette Waits, Fish & Wildlife Department
Project Title: Assessing Relationships between Predator and Prey Distributions in the Central Volcanic Cordillera Region of Central Costa Rica

Abstract

Predators are a focus of conservation efforts, especially in the tropics, where there are high levels of disturbance on the landscape. Prey availability plays an important role in predator abundance, and predator-prey relationships are extremely complex. Pumas (*Puma concolor*) and jaguars (*Panthera onca*) are the largest mammalian predators in Central America and have been the focus of range-wide conservation efforts promoting habitat connectivity. In Costa Rica, the Central Volcanic Cordillera Jaguar Conservation Unit (CVC JCU) is a critical link for connectivity within Costa Rica and from Panama into Nicaragua. This region has experienced disturbance and has low densities of felid predators and their prey. We evaluated potential predator-prey relationships between species distributions via camera trapping and hypothesized that prey distributions would serve as a predictor of puma distributions in the CVC JCU area. Species occupancy was modeled using four main covariates: forest cover, minimum distances to roads and towns, and the Human Footprint Index. We found only six models returned significant p-values, all the null models of the following species: agouti, armadillo, coati, puma, rabbit, and tamandua. The low levels of significance in the dataset may be attributable to a small overall dataset, which accumulated over a 14-week sampling period, or due to low numbers of detections per species sampled.

Background & Project Summary

Predator species have long been considered a major focus of conservation initiatives. These organisms are believed to have multiple community- and ecosystem-level effects; understanding and delineating these effects is critical for evaluating their impacts on landscapes and their value to conservation (Finke & Snyder 2010). Furthermore, large predators typically occupy the top trophic levels and are at a higher risk of extinction as a result (Finke & Snyder 2010). In addition to predator species, global biodiversity is under increasing threat due to agricultural expansion, especially in tropical countries (Tscharntke *et al.* 2012; Laurance *et al*. 2014). Food resource availability plays a central role in large predator abundance: decline in prey abundance can produce a five-fold loss or greater in large predators (Carbone *et al.* 2010). Relationships between large carnivores and their prey are complex and vary extensively. Low densities of prey may cause a myriad of effects on carnivores, including low predator abundances, higher energy expenditures and metabolic rates, and reduced survival and reproduction rates (Carbone *et al*. 2010).

Jaguars (*Panthera onca*) and pumas (*Puma concolor*) are the largest terrestrial predators in the tropics of Central America. Jaguars specifically have been the subject of range-wide conservation initiatives for roughly two decades. Biologists described Jaguar Conservation Units (JCUs), areas hypothesized to be able to support self-sustaining jaguar populations (Sanderson *et al.* 2002), and corridors, which seek to connect nearby JCUs; together these units work to provide functional connectivity for jaguars range-wide (Zeller *et al.* 2013). In Costa Rica, 27% of the country is considered protected, but some of these areas have some degree of fragmentation. Corridors connecting these protected areas often have experienced high rates of deforestation and human disturbance such as agriculture (Sanchez-Azofeifa *et al.* 2003).

The Central Volcanic Cordillera (CVC) JCU was previously assumed to be a stronghold for jaguars; however, recent studies have reported little evidence of jaguars in the area (Salom-Perez 2019; Velado-Cano 2019). This JCU is a critical link in a chain of refuges in Costa Rica seeking to provide jaguar habitat connectivity from Panama into Nicaragua (Salom-Perez 2019), and the reason behind the jaguars' absence is unclear. Consequently, pumas are the main predator in the area. A nearby evaluation uncovered that puma habitat use was positively correlated to prey species richness, and that forest cover was the most important habitat covariate for habitat use. Low species richness was observed in areas with high human disturbance or fragmentation (Salom-Perez 2019).

With this project, I built upon Salom-Perez's (2019) work by investigating relationships between puma and prey species occupancy in the CVC JCU. I addressed the following objectives: 1.) assess prey occupancy of puma prey species, 2.) assess puma occupancy, and 3.) determine relationships between these species´ distributions in this area. I hypothesized that prey distributions would serve as suitable predictors of puma distributions and predicted that areas with higher levels of human disturbance or encroachment would have lower species occupancy.

The study area is the Central Volcanic Cordillera Jaguar Conservation Unit (CVC JCU) (*Figure 1*). This area is composed of protected lands with 75% primary and secondary forest cover, serves as the origin of several rivers, and is roughly 1,100 km^2. Forty-two camera traps were deployed for 14 weeks in a 16 km^2 grid from October 2018 to January 2019 (*Figure 1*). Camera trap photos were reviewed using Panthera's Integrated Data Systems in 2019 to generate detection histories by species. For my analysis, I selected prey species only if they were documented as puma prey, following Salom-Perez's (2019) review. Camera data was combined to the 16 km^2 grid cell level and at weekly observation periods.

I utilized program R package *unmarked* for data analysis (R Core Team 2019; Fiske & Chandler 2011). Via *unmarked*, I estimated each species' detection probability and occupancy at each grid cell across the 14-week sampling period. I selected four site covariates: forest cover (FONAFIFO 2012), Human Footprint Index (WCS & CIESN 2018), minimum distance to road (Ortiz-Malavasi 2009), and minimum distance to town (Ortiz-Malavasi 2009) and composed models where site covariates impacted or served as predictors of species occupancy only. Models were selected based on Akaike's Information Criterion (AICc) scores corrected for small sample size. Prey species occupancies were then scaled as site covariates and combined with the four original site covariates to determine the best model in predicting puma occupancy across the sites.

Summary of Project Results

In addition to pumas (*Puma concolor*), the qualifying observed prey species were agouti (*Dasyprocata punctata*), armadillo (*Dasyphus novemcintus*), coati (*Nasua narica*), red-brocket deer (*Mazama temama*), opossum (*Didelphis marsupialis*), paca (*Cuniculus paca*), peccary (*Pecari tajacu*), rabbit (*Sylvilagus brasiliensis*), raccoon (*Procyon lotor*), tamandua (*Tamandua mexicana*), and tayra (*Eira barbara*), for a total of 11 prey species. After generating models to estimate species occupancy, relating to the four covariates and a null model, I reviewed these results for significance and found only six models were supported across all species, as described in *Table 1.* Six species had supported models, each being the null model; however, the null model was not the leading model for all six species. Agoutis and tamanduas instead were best supported by the town model and forest model, respectively. In this case, the agouti minimum distance to town model was extremely close to the null model (town deltaAICc = 0.00, null deltaAICc = 0.06), despite not being significant (p-value = 0.127). The tamandua forest cover model was also close to the null model (forest deltaAICc = 0.00, null deltaAICc = 0.35) but was not significant (p-value = 0.153). For the four remaining species listed in *Table 1* with significant models, no other model was reasonably close (deltaAICc <2) to the leading null model, nor were any other significant.

Because of these results, I was unable to generate species occupancy estimates to then relate the 11 prey species occupancies with puma occupancy across the study site, and only ran puma models with the four site covariates and null model. The null model was the top model for pumas (*Table 1*). The low observed significance (six models of total 60) could be due to a small dataset. Data was gathered over only a 14-week sampling period; this may not have been a lengthy enough period to accumulate enough data to suitably complete the planned analysis. Furthermore, the lack of significance found could be attributed to a low number of detections by species. Species that returned with significant models did have more detections when compared to others; for example, there were 69 total detections of armadillos over 42 cameras but only 5 detections of raccoons. However, this was not the rule—pumas had only 7 detections, while species such as red-brocket deer had 39 and peccaries had 34 detections. It is also possible that there are other factors that were not considered (e.g. elevation, slope, hunting) that could have an influence over species distributions.

This study has continued funding from the Adele Berklund Undergraduate Research Scholar Award in cooperation with the University of Idaho, and we plan to continue this project by incorporating additional site covariates and testing for significance. Further directions with this project include determining puma habitat use probability based upon prey species occupancy or abundance and distribution of prey, which extends Salom-Perez's (2019) analysis as pictured in *Figure 1*. Additionally, further investigation into prey species abundance in this area may provide more insight on jaguars' absence from the area, a critical geographic link.

Appendix

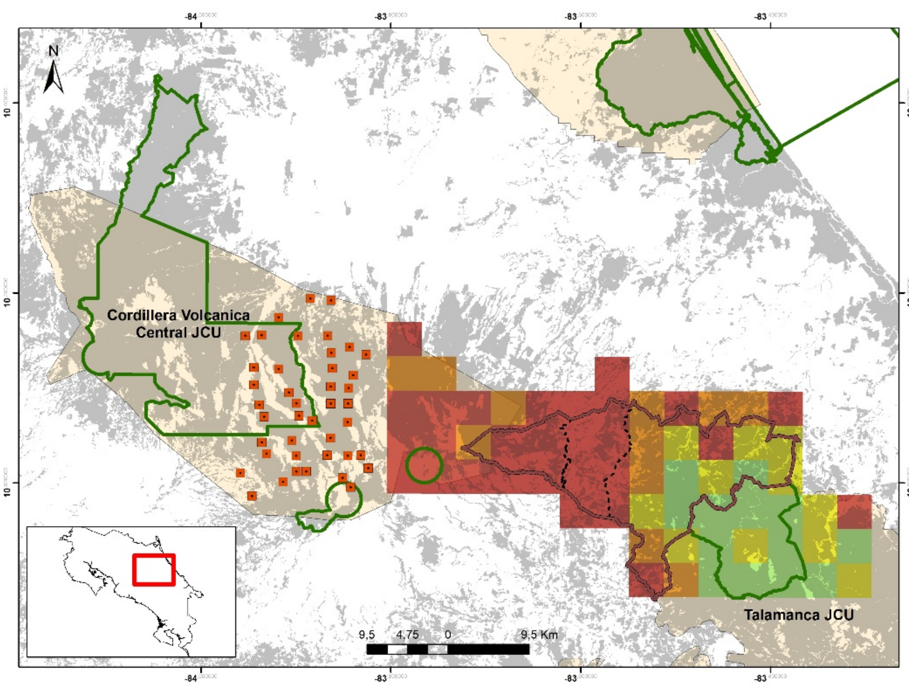

Figure 1: The study site, the Central Volcanic Cordillera JCU, is in shaded yellow in addition to the camera trap locations in the study site denoted with red squares. The colored grid cells indicated predicted jaguar habitat use, ranging from good (green) to poor (red) as evaluated by Salom-Perez (2019). National Parks are outlined in green.

Table 1: The six significant models are listed below in order of species. The top model is denoted in the second column. In cases where the top model was not significant, it is starred. The null model was the only supported model in this study.

Species	Top Model
Agouti	Town*
Armadillo	Null
Coati	Null
Puma	Null
Rabbit	Null
Tamandua	Forest*

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Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Audrey Duncan, University of Idaho
Faculty Mentor: Dr. Deborah Stenkamp, Department of Biological Sciences

Project Title: Nuclear hormone signaling and regulation of cone photoreceptor gene expression in the zebrafish

1. Abstract:

Vertebrate color vision requires spectrally selective opsin-based pigments that are expressed in separate cone photoreceptor populations. The regulation of cone opsin expression is poorly understood. The common model used to describe regulation of tandemly-replicated opsin genes in humans suggests that locus control regions (LCR) interact with each of the tandemly replicated opsin genes at random. However, it has been found that in human retina there are topographic gradients in red: green cone ratios which suggests that a trans-regulatory mechanism is involved in their expression. Publications from the Stenkamp lab have shown that thyroid hormone (TH) is involved in the endogenous regulation of *lws* (long-wavelength sensitive, red-sensing) opsin expression in zebrafish larvae and juveniles; more recently, research was conducted on adult zebrafish with TH treatments showing similar results. With this project, further research was done to better understand the regulation and expression of *lws1* and *lws2* cone opsin genes in response to TH in larvae and adult zebrafish. This included determining the effects of TH on a transgenic reporter line that has had elements deleted from the regulatory region of the *lws* array and further characterizing the effect of TH on adult zebrafish cones.

3. Project Description:

i. Background

The retina is the light-sensitive layer of the eye containing photoreceptor cells called rods and cones. Cone cells in our eyes express photopigments consisting of a chromophore together with a protein called opsin, which play an important role in color vision. Human long wavelength-sensitive (*LWS*) and medium wavelength-sensitive (*MWS*) genes are arranged in tandem and share a single locus control region (LCR) (Wang et al., 1999). An independent evolutionary phenomenon (tandem replication) is also seen in the orthologous *lws* array present in zebrafish (Tsujimura et al., 2010).

The current model of opsin regulation in humans suggests that a locus control region (LCR) interacts with each of the tandemly replicated opsin genes at random (Wang et al., 1999). However, in human retina it has been discovered that there are topographic gradients in red: green cone ratios, this suggests that a trans regulatory mechanism is involved in their expression. In support of this hypothesis, recent publications from our lab, investigating the *lws* array of zebrafish have shown that thyroid hormone (TH) promote the expression of *lws1* at the expense of *lws2* in larvae and juveniles (Mackin et al., 2019). This suggests that TH serves as an endogenous trans regulator of the *lws* genes array.

ii. Significance:

The significance of this study is to ultimately further scientific understanding on how human *LWS* and *MWS* genes and other tandemly replicated genes are regulated. A better understanding of cone plasticity can inform gene-regulating therapeutic intervention for diseases caused by opsin mutations and other retinal disorders. Elucidating the mechanism of regulation in tandemly replicated opsin play an important role in photoreceptor-replacement approaches to vision restoration.

4. Summary of Project Accomplishments:

The goal of this study was to assess the expression and regulation of *lws1* and *lws2* cone opsins. Research previously conducted in this lab has shown that retinoic acid and thyroid hormone are involved in the expression and regulation of *lws* cone opsins (Mitchell et al., 2015; Machin et al., 2019). At other institutions, LWS and other cone opsins have been implicated in human color blindness and cone degenerative diseases (Kuchenbecker et al., 2011).

Using transgenic line constructs, we wanted to determine what regions of the LWS locus are involved in the expression and regulation of lws1 and lws2 cone opsins. Two transgenic line constructs were created by our collaborators, using the *lws* Locus. The first construct lacked the 1.8kb region upstream of *lws2* and the second construct lacked the 2.6kb region upstream of *lws1*. By removing these regions in each construct, we were hoping to determine how the removal of the sections alters *lws1* and *lws2* expression in zebrafish, particularly the response to thyroid hormone. GFP+ is used to report the expression of these genes and allows for the visualization of the cones within the eyes. Using confocal images obtained by a graduate student in the Stenkamp lab following these TH treatment experiments, I quantified GFP+ cones in these samples. It was determined with the first construct that the proximal 2.6kb region upstream of *lws1* contains elements sufficient for TH- mediated upregulation of *lws1*. With the second construct, the LAR and 1.8kb intergenic region together do not contain the elements necessary to reduce *lws2* in response to TH. In fact, somewhat unexpectedly, the LAR and 1.8kb intergenic region together contain an element(s) that serves to promote the expression of *lws2* in response to TH, when other proximal regions upstream of *lws1* are missing. This shows that additional research is needed to fully understand how expression is regulated and anticipate responses to TH.

Our experiment using HCR v3.0 in situ processes on whole mounted larvae were used to test our probes to make sure they were working properly. The reason for this was because when first trying an HCR treatment on adult cryosectioned slides it was unsuccessful. To better narrow down the issue with the adult experiment, we wanted to confirm whether or not it was the probes themselves causing the issue. In the past experiments done on larvae whole mounts have been successful. The whole mount treatments were successful and the probes labelled correctly. This indicates that there are non-probe-related issues present.

The experimental design of adult TH treatments begins with two groups of wild type fish being treated with either NaOH or T4, one group is the control and the other is the treated respectively. Both groups were treated for five days and after the treatment period their eyes were dissected out of the body. One eye from each fish was used for qPCR and the second eye was used for cryosectioning. As mentioned before, the first trial of HCR protocol on adult cryosectioned slides were unsuccessful. Moving forward it may be possible to optimize HCR v3.0 in situ protocol on sections. Some other alternatives include using dig-labeled probes (normal in situ protocol), or collecting whole retinas from adults rather than using cryosections.

5. Summary of Budget Expenditures:

1. Pipette calibration- 90.00
2. Superfrost slides- 427.00
3. Probe wash buffer- 253.00
4. Proteinase K- 136.00
5. Hard drive- 93.37
6. **Total (as of 08/10/2020) - 999.37**

6. Literature/references:

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Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Anna Findley, University of Idaho
Faculty Mentor: Dr. Diana Mitchell, Department of Biological Sciences

Project Title: Analysis of apoptotic cell clearance by microglia in zebrafish mutants lacking havcr1, a putative phosphatidylserine receptor

Abstract

The retina is made functional by complex interactions of various cell types unique to the central nervous system. While neurons and glia are well appreciated in this context, the microglia, a lesser understood cell type, has emerged as an important player. Microglia are resident phagocytes that colonize the central nervous system (brain and retina) early in vertebrate development. Recent work indicates that microglia have a variety of functions in development and homeostasis, but the genes and pathways that are involved, and therefore molecular mechanisms, are poorly understood. A well described function of microglia is the phagocytic clearance of apoptotic cells during normal development as well as in contexts of tissue damage or degeneration. However, the genes required for this function remain to be fully elucidated. Recent transcriptome analysis published by our lab has shown zebrafish microglia express high levels of the gene *havcr1*. Sequence and genomic comparisons indicate *havcr1* is a receptor for Phosphatidylserine (PS), which is exposed on the surface of dying cells. Therefore, we hypothesize that *havcr1* has a function in the recognition and clearance of apoptotic cells by microglia. We propose to use the zebrafish to reveal the function of *havcr1* in the vertebrate retina, by the following objectives: (1) Demonstrate that microglia express *havcr1* using in situ hybridization, and (2) Determine if clearance of apoptotic cells during development is reduced in *havcr1* mutants. This work will increase mechanistic understanding of apoptotic cell clearance by microglia and will provide a novel genetic tool for future experiments.

Project Description

The overall goal for this project was to gain a better understanding of the function of expression of the *havcr1* gene by microglia. We did this through our two objectives which were: **(1)** Demonstrate that microglia express *havcr1* using in situ hybridization, and **(2)** Determine if clearance of apoptotic cells during development is reduced in *havcr1* mutants. To demonstrate our objectives, we used wildtype zebrafish for **Objective 1** and a CRISPR-generated line of zebrafish for **Objective 2**.The original proposal was to study two genes, *havcr1* and *lgals3bpb*, but we decided to focus only on *havcr1* for the summer to be most efficient.

To achieve **Objective 1**, we used HCR in situ technology to detect *mpeg1*, a microglia marker, and *havcr1* transcripts in retinas of wildtype zebrafish embryos at 3 days post fertilization. In situs are an effective method for analyzing transgene expression at the cellular level because it enables the detection of precise localization of a specific nucleic acid sequence in an individual cell (1). Expression of microglia was marked and *havcr1* transcripts were also co-labeled to indicate if microglia express *havcr1* in the developing zebrafish retina. We also included a probe set for the gene *lgals3bpb*, which was also of interest and included in the original proposal. These results indicated co-expression of *lgals3bpb* by microglia as well.

To achieve **Objective 2**, we crossed heterozygous *havcr1* (+/-) parents, which carried a predicted loss of function mutation in the *havcr1* gene, to produce offspring (wildtype, heterozygous, and mutant). The offspring were then collected at 3 days post fertilization (dpf) and dissected for DNA extraction (tails) and TUNEL staining (heads/bodies). The DNA extraction was used for genotyping with an established protocol to identify the genotype of individual fish using a PCR/Restriction Enzyme assay. A 3 dpf time point was chosen because microglia are present in the developing central nervous system by 3 dpf and developmental apoptosis is also detected. TUNEL staining was used for detection of apoptosis in the developing zebrafish retina. During the later stages of apoptosis, DNA becomes highly fragmented by nucleases. These enzymes are activated by caspases, which are a family of proteins that execute programmed cell death. dUTP is recruited when there is a breakdown of DNA (2). dUTP is what gets stained during TUNEL staining and fluorescence, so we can see which cells are apoptotic. Confocal spinning disk microscopy was used to image the samples. The numbers of apoptotic cells in the retinas were then quantified for wildtype, heterozygous, and mutant embryos to see if there was a significant statistical difference between the different genotypes. Given that microglia are the main cell type responsible for apoptotic cell clearance in the developing zebrafish retina (3) and *havcr1* is predicted to code for a PS receptor (4), we would expect that *havcr1* mutants will have higher numbers of uncleared TUNEL stained cells.

Project Accomplishments

For **Objective 1**, we found *havcr1* transcripts (and *lgals3bpb* transcripts) co-labeled with *mpeg1* transcripts are indeed expressed by microglia in the developing zebrafish retina by 3 dpf, indicating that *havcr1* could play a role in the clearance of apoptotic cells in the developing zebrafish retina.

For **Objective 2**, the CRISPR-generated mutant line of zebrafish appeared to have more apoptotic cells in the retina than heterozygous and wildtype embryos. However, our sample size was insufficient for proper statistical analysis and to make strong conclusions. From our sample size, we had 29% (10) *havcr1* mutants, 59% (20) heterozygous fish, and 12% (4) wildtype fish. Our sample sizes slightly differ from the expected Mendelian inheritance patterns. The uneven sample sizes we had with the genotypes is another reason we could not form a strong conclusion with the data obtained thus far. We are currently working on repeating the experiments to further quantify and statistically analyze our data as we continue to increase our sample size.

The future direction of this project may include live imaging techniques to analyze the rate at which microglia function to remove apoptotic cells in the developing retinas of *havcr1* mutant compared to wildtype and heterozygotes. In addition, we may use this as a genetic system to study apoptotic cell clearance in the context of retinal regeneration in zebrafish, and to determine how phagocytosis shapes microglial function.

Each objective is significant because we can explore the expression and function of this gene in the retina to better understand microglial functions on a molecular level. This will help us gain a better understanding of how this gene might be important in microglial behaviors, in proper development and homeostasis of the vertebrate retina, or if these genes might have a function in regeneration of the zebrafish retina. Because microglia are dysregulated in a variety of neurodegenerative diseases, this knowledge could assist in informing potential treatments, for human retinal degenerative disorders.

Budget Expenditures

Source/Vendor	Item	Price
Molecular Instruments	HCR in situ probe sets and reagents for *havcr1* and *lgals3bpb* transcript detection	$1000.00
		TOTAL: $1,000.00

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4. Márquez- Ropero M. et al. Microglial Corpse Clearance: Lessons from Macrophages. Frontiers in Immunology. 2020; doi.org/10.3389/fimmu.2020.00506

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Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Keggan Georgeson, University of Idaho
Faculty Mentor: Dr. Jessica Stanley, Department of Geological Sciences
Project Title: Dating South African rifting events via apatite helium thermochronology

Abstract
Despite many years of study, the topographic evolution of the south African plateau is still poorly understood. Thermal histories and cooling dates obtained from rocks that compose the area may give an idea to the progression of continental rifting and plateau development. Our goal is to constrain the <70°C thermal history from samples in the Algoa and Gamtoos basin using (U-Th)/He Thermochronology dating. We began the process to acquire the data necessary by selectively picking and packing apatite grains that meet several quality requirements. 64 apatite grains from 13 sedimentary rock samples have been selected for analysis, packaged, and sent to the University of Colorado Thermochronology Research and Instrumentation Laboratory (CU TRaIL) to be analyzed. After analysis we will examine our data for spatial patterns using Geographic Information System (GIS) software. In addition, a forward and inverse thermal history models will be conducted using a software called HeFTy (Ketcham, 2005). This software will allow for the exploration of thermal histories that can explain data well while taking into consideration of other geologic information and previously published geo- and thermochronology from the region that constrain the possible histories. Preliminary cooling dates for samples 1059-61 and 1059-62 are 90 ± 11 and 103 ± 14 Ma. These dates are substantially younger than the depositional ages for the samples and rifting in the region. Theses dates would suggest a major cooling phase 90 – 100 Ma that may be associated with plateau development.

Project description
The objective of this study is to constrain the <70°C thermal history from the Algoa and Gamtoos basins, on the SE edge of the S. African plateau. These basins contain some of the only sediments from southernmost Africa that were deposited during and after continental breakup. Knowing how deeply they were buried and have since been exhumed can provide unique clues to the topographic evolution in this region. Green et al. (2017) suggested a more recent phase of cooling in some parts of the southern coast of S. Africa, however lacking the resolution to detect it in the Algoa and Gamtoos Basins that we are looking for evidence of how widespread the cooling phase is. The samples used have been provided by Professor Jessica Stanley by Dr. Paul Green. These samples are from the Uitenhage Group containing Kirkwood Sandstone, Sunday River Formation, and Enon Conglomerate (Green et al., 2017). Sample location can be seen in Figure 1.

Summary of accomplishments
To complete this project, I have carefully selected 63 apatite grains from 13 rock samples to be sent to the University of Colorado Thermochronology Research and Instrumentation Laboratory (CU TRaIL) for (U-Th)/He analysis. Using this data, we have compiled a map of sample locations with thermal color-coded points. To do this, I have learned the basics of the QGIS geographic information systems software to plot sample locations. I have also been working on adding in fission track dates (Green et al., 2017) to the map to see if there are any visible trends in sample cooling date. Dr. Stanley and I met regularly in the summer to discuss papers we had read related to the Algoa and Gamtoos Basins, southern African topography, and continental breakup. We have received data for 2 preliminary samples and are currently awaiting the data from the rest of the samples. We have also made thermal models samples 1059-61 and 1059-62 showing all possible paths the samples could have taken and highlighted the best fit path (Figure 2). These models will be important for understanding the history of the apatite grains within the samples and help date

cooling rates. To do this, I used literature to define the major geologic events in the region, and use the HeFTy software to model what thermal history paths conform to these events and the apatite (U-Th)/He cooling dates that I acquired (Fig 2). I have also had the pleasure to present at ICUR this year and have learned a lot about other research and how to present my own research. The hope is to do thermal models for the rest of the samples once we receive the rest of the data and to present this at the undergraduate research symposium in the spring.

Figure 1. Map created in QGIS showing sample locations.
Figure 2. Thermal history models created using HeFTy.

The boxes inside this figure set constraints for the program to plot around. These samples tried 10,000 different paths in attempt to find the best fit. The line in dark blue is the best direct fit and the black line is the best fit. the colored areas are envelopes, the pink is paths deemed as a good fit and the green is paths that were acceptable. These models overall show the potential paths that each sample could have taken based upon data we received. These events started with a high temperature event <200 ma indicated by fission track dates, then cooled to the surface around 150 ma and finally another heating event based on our U-Th/He analysis around 100 ma.

Summary of budget expenditures
The cost to send in our samples for U-Th/He analysis totaled to $850.00 and any extra was funded by Dr. Jessica Stanley. We needed 63 Niobium tubes to package apatite grains, these totaled to $123.20. In order to maintain a sanitized, clean, and contaminate free workplace we needed 5 boxes of kimwipes and 5 1L bottles of Ethanol, these totaled to $26.50. The overall cost of everything came out to be $999.70, a cost chart can be seen below. We are still awaiting the invoice for analytical costs from CUTRaIL, should it not arrive in the next week Dr. Stanley will cover these costs and the remainder of the budget will be spent on relevant lab supplies.

Acknowledgement:
I truly appreciate the generous support provided by the State Board of Education in the form of this undergraduate research grant. This was an incredible experience which greatly enhanced my education at the University of Idaho. This grant enabled me to participate in research on a level that otherwise would not have been possible. Thank you again for your generosity.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Cody Gibson, University of Idaho
Faculty Mentor: Dr. Jessica Stanley, Department of Geological Sciences
Project Title: Evaluation of a testing apparatus for high temperature/high pressure in nuclear pressure vessel conditions.

Project Description

Stress corrosion cracking (SCC), fatigue, and fatigue crack growth (FCG) of structural materials has occurred since the early operation of boiling water reactors (BWR), pressurized water reactors (PWR) and other light water reactors (LWR) and high-temperature water systems [1]. The Department of Energy-Nuclear Energy is looking to increase reactor service live and reliability through the development of new materials that exhibit higher strengths and better fatigue and stress corrosion cracking resistances. Proper characterization of these materials is of upmost importance due to the harsh environments inside of nuclear reactors.

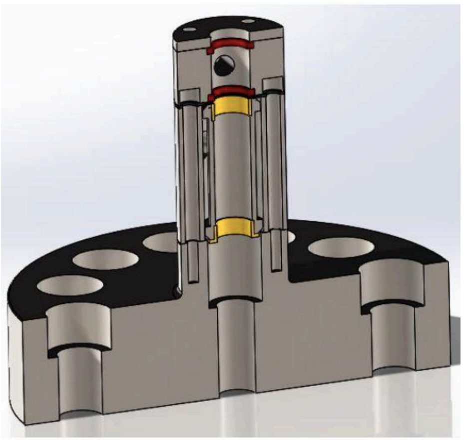
Recently the University of Idaho was awarded a DOE Infrastructure grant to enhance the viability and competitiveness of the Nuclear/Mechanical Engineering/Material Science Programs. With this infrastructure grant the University was able to sponsor a Mechanical Engineering Senior Design Project that designed and built a testing apparatus capable of testing materials in the same environment seen in nuclear reactors (high temperature, high pressure, and corrosive environment). Implementation and proofing of this system was not completed however, so the testing apparatus was left in an unfinished state. I was tasked to complete the coupling of this testing apparatus and prove out the system, so that it would be ready in the event that the University received a grant to test new materials under the above conditions.

Project Accomplishments

The autoclaves cooling jacket is one of the most critical parts in the autoclave/circulation loop system. It needs to cool down the loading rod while maintaining a dynamic seal between the loading rod and seal housing. During initial validation testing of the autoclave/circulation loop system the previous cooling jacket designs were not able to keep the seals cool enough resulting in complete system failures. A new design was required before any loading, temperature or pressure tests could be performed. My new cooling jacket design in figure 1 moved the seal further away from the autoclave lid and implements a second seal. A chamber between the upper and lower seal is designed to be monitored by a pressure transducer so that a lower seal failure can be detected during testing making it a fail-safe design. My new design also implements a Viton seal which has a melting temperature that is 100oC higher than the original Urethane seals.

After manufacturing and assembling the new cooling jacket I conducted a load test without a specimen in the load grips to determine the friction forces on the loading rod. Loading in tension resulted in a force of 21 lbf while loading in compression resulted in a force of 9 lbf. Because the seals are a directional u-cup design it was assumed that the compression and tension forces measured by the load cell would be different and the initial test proved the assumption to be correct. After determining the friction forces on the loading rod, I conducted an in-air temperature test to determine the cooling capabilities of the new cooling jacket. In this test I placed five thermocouples in different locations to monitor the heater, CT specimen, autoclave lid, loading rod between seals and loading rod above top seal temperatures.

Figure 2 is a temperature vs time graph representing the temperatures measured at the above locations. In this test, the cooling jacket was able to cool the loading rod from 325oC inside of the autoclave to 22oC next to the lower seal which validates the new cooling jacket design capabilities. The last test I was able to conduct tested the ability of the cooling jacket and new seals to hold solution at pressure. After coupling the autoclave and circulation loop systems together I was able to pressurize water in the autoclave to 1500 psi without a seal failure validating the ability of the new cooling jacket design and seals to maintain desired pressure.



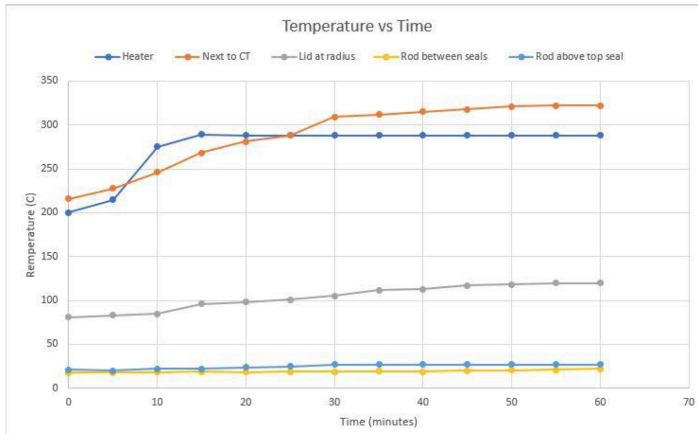


Figure 1) 3D model section view of cooling jacket and autoclave lid. Figure 2) Temperature vs Time graph of temperature validation test.

Discussions and Conclusions

This project has given me a great insight to undergraduate research and has allowed me to use my knowledge as an undergraduate mechanical engineering student to solve a real-world problem. The redesign of the cooling jacket was a critical part of this project and required me to develop better communication skills when working with different seal manufacturers. Testing of the new cooling jacket system and upgraded seals under high temperature and later under high pressure was a big step forward in validating the autoclave/circulation loop system. The circulation loop system is functional but requires five of the high-pressure valves to be replaced. Replacement of theses valves is necessary so that the fluid filtration loop within the system can remain isolated from the autoclave loop. Direct Current Potential Drop (DCPD) is the method used in determining crack length within the autoclave. I was not able to test the DCPD method within the autoclave due to setbacks with manufacturing the cooling jacket. However, I was able to learn how to properly conduct an FCG test using DCPD on a separate load frame in Dr. Stephens lab to ensure that I could validate the method within the autoclave later.

During the Fall 2020 semester I will continue to work on coupling and validating the autoclave/circulation loop system. The next test I conduct will require the cooling jacket and seals to handle water at 1000 psi and 250oC. When successful I will begin testing the DCPD system within the autoclave in first air and then in water. The final validation test will be to perform an FCG test using DCPD to monitor crack growth while the specimen is submerged in water at 1000 psi and 250oC.

References

1. Proc 1st - 15th Internat Symp Environ Degradation of Materials in Nuclear Power Systems-Water Reactors, Houston, TX, Warrendale, PA: NACE/ANS/TMS, 1983-2011.

Acknowledgement: I truly appreciate the generous support provided by the State Board of Education/HERC in the form of a Summer Undergraduate Research Fellowship from the UI Office of Undergraduate Research. This was a tremendous experience for me. Without this support from the SBOE, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Kaitlyn Harvey, University of Idaho
Faculty Mentor: Dr. Nathan Schiele, Department of Biological Engineering
Project Title: Exploring the impact of macrophages on the tenogenic differentiation of stem cells

Abstract Tendon is a collagenous tissue that transfers mechanical forces from muscle to bone. Tendon injuries are associated with significant disruptions in mechanical function and are difficult to treat clinically. During the healing process, interactions between inflammation and mesenchymal stem cells (MSCs) may play a role in tendon tissue regeneration. Macrophages influence inflammation, and MSCs may differentiate toward tendon (i.e., tenogenesis) to regulate regeneration. However, more research is needed to determine how macrophages directly interact with MSCs and impact tenogenesis. We hypothesized that macrophages impact tenogenesis. To test this hypothesis, macrophages and MSCs were co-cultured. Tenogenesis of mouse MSCs was induced using transforming growth factor (TGF)β2, and directly co-cultured with mouse macrophages. Additional experiments were conducted to evaluate how macrophage growth was influenced by both TGFβ2 and the ratio of MSCs-to-macrophages in co-culture. To evaluate the impact that the macrophages have on tenogenesis, both MSCs and macrophages were imaged and cell growth was evaluated. In future experiments, MSCs will be stained to visualize actin cytoskeleton morphology and western blots will be used to determine the protein levels of the tendon marker proteins, scleraxis and tenomodulin. Results will provide new information for how macrophages impact tenogenesis, which has a significant implication for understanding tendon healing and regeneration.

Central Problem and Project Description Tendon is very prone to injury and lacks adequate intrinsic healing properties. After injury, tendon never regains its full original tensile strength. This provides motivation to develop tissue engineering and regenerative medicine techniques to promote better tendon healing. The inflammatory response, which is involved in the tendon healing process, is thought to be regulated by macrophages and stem cells. So, in order to better understand the tendon healing response, this project aims to explore how macrophages impact the differentiation of stem cells into tendon tissue cells (tenogenesis). To accomplish this objective, macrophages and mesenchymal stem cells (MSCs) were directly co-cultured with different seeding density ratios to determine their co-culture viability. To induce tenogenesis, cells were treated with a tenogenic biochemical, transforming growth factor (TGF)β2. Control groups were standard culture medium (i.e., no TGFβ2 supplementation) and monocultures of either macrophages or MSCs. After determining that both cell types were viable in direct co-culture, they were directly co-cultured and supplemented with TGFβ2 and imaged to determine morphological changes in the stem cell structure.

Procedure and Summary of Project Accomplishments
<u>Macrophage Culture:</u>
Initially, cell-seeding densities needed to be determined. Therefore, mouse macrophages were first cultured with densities of 5000, 1667, 833, and 500 cells/cm2 in 12 well plates with standard cell culture medium (Dulbecco's Modified Eagle's Medium (DMEM), 10% fetal bovine serum (FBS), and 1% Penicillin/ Streptomycin) for 24 hours and three days. Images were taken at the 24 hour and three day time points. Further experimentation cultured the macrophages with densities of 7600, 4750, and 1900 cells/cm2 in 24 well plates with 10% FBS for 24 hours, then switched to a low serum cell culture medium (1% FBS) for 24 hours and three days. These cell densities were supplemented with sterile water, as a vehicle control, or TGFβ2, as the treatment, after 24 hours in 10% FBS and 24 hours in 1% FBS. Images were taken at the 24 hour and three day time points.

Macrophage and Mesenchymal Stem Cell (MSC) Direct Co-Culture:
Macrophages and mouse MSCs (C3H10T1/2) were directly co-cultured in 24 well plates at ratios of 1:1, 1:3, 1:5, 1:6, 1:10, 5:1, and 10:1 macrophages to MSCs, maintaining a total density of 5000 cells/cm2 in each well. Cells were co-cultured in 10% FBS for 24 hours, then switched to 1% FBS for 24 hours before being supplemented with sterile water, as a vehicle control, and TGFβ2, as the treatment. Images were taken at the 24 hour, three day, and seven day time points.

Macrophage and MSC Direct Co-Culture with TGFβ2 Supplementation:
After running the direct co-culture experiments without TGFβ2 supplementation, it was determined that macrophages have a greater viability when cultured at an equal or slightly higher density than the MSCs. Thus, we then used the macrophage to MSC seeding ratios of 1:1 and 5:1 to evaluate the viability of co-culturing these cell types with TGFβ2 supplementation. Cells were co-cultured in 10% FBS for 24 hours, then switched to 1% FBS for 24 hours before being supplemented with sterile water, as a vehicle control, and TGFβ2, as the treatment. Images were taken at the 24 hour, three day, and seven day time points.

Project Accomplishments:
The results from the images of the macrophage and TGFβ2 cultures determined that macrophages were viable after supplementation with TGFβ2, which can be seen in poster Figure 4 (ICUR 2020). It was also determined that macrophages generally have a greater viability when cultured at higher densities. As for the co-cultures between the macrophages and the MSCs, both cell types were viable after direct co-culture, seen in poster Figure 5 (ICUR 2020). In this case, we also found that macrophages had a greater viability when cultured in the 1:1 and 5:1 macrophage to MSC ratios. Further supplementation with TGFβ2 seemed to have no significant impact on the viability of the direct co-cultures. These results have provided us with new information that will further allow us to understand how macrophages impact tenogenesis, which will contribute to our overall understanding of tendon healing and regeneration.

Future Directions:
Through the results of this project, we have seen that macrophages and MSCs are viable in co-culture, and that both macrophages and macrophage co-cultures with MSCs are viable after supplementation with TGFβ2. This information provides us with a basis to perform both long-term direct and in-direct co-culture experiments, as well as perform further analysis of MSC tenogenesis using western blots to look for the production of tenogenic markers, scleraxis and tenomodulin, as well as staining for actin cytoskeleton morphology of the MSCs.

Summary of Budget Expenditures
The consumable lab supplies required to complete this project were as follow: Transwell plates, $244.79; Mouse macrophages (RAW 264.7), $471.60; Transforming growth factor beta 2, $380.00. TOTAL: $1,096.36 (Dr. Schiele covered the amount that was in excess of $1,000).

Acknowledgment:
I truly appreciate the generous support provided by the State Board of Education in the form of a SURF award from the UI Office of Undergraduate Research. Without this support from the SBOE/HERC, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant – Summer 2020

Grant Recipient: Madi Thurston, University of Idaho
Faculty Mentor: Dr. Margrit von Braun, Department of Chemical and Environmental Engineering
Project Title: Quantifying human exposure to heavy metals in artisanal gold mining communities impacted by severe lead poisoning

Abstract
In 2010, an unprecedented lead poisoning in Nigeria resulted in the death of over 400 children. The outbreak was caused by artisanal processing of gold ores inside rural village homes, where incidental ingestion of contaminated soils resulted in geomean blood lead levels (BLLs) of 149 µg/dL. Soil lead concentrations in villages averaged 300-4,143 mg/kg, regularly exceeding the United States Environmental Protection Agency safe soil lead level of 400 mg/kg. The Nigerian government partnered with international organizations, including TerraGraphics International Foundation (TIFO) and Médecins Sans Frontières (MSF) to remediate residential areas and deliver life-saving medical treatment for poisoned children. Archived *in situ* x-ray fluorescent spectrometer (XRF) soil lead data from the environmental response provides an opportunity to develop a better understanding of heavy metal exposures that can be applied to other artisanal mining and indigenous communities.

This study demonstrates the influences of neighborhood size and compound location on child lead exposure. To assess spatial variability in soil lead concentrations, an attribute database for compound lead levels was built in ArcGIS™ for pre-remediation data. Household, neighborhood, and community means were calculated for each compound. Neighborhood concentrations consist of a mean of all compounds and public areas within a radius of each home. The appropriate radius value (e.g., 200’, 300’, 400’) should reflect a child’s independent mobility and is likely influenced by several factors, including age and gender. This study demonstrates that neighborhood size, contamination variability, and compound location within the neighborhood have a significant impact on child’s exposure to contaminated soil.

Project description
During the 2010 lead poisoning tragedy in Zamfara State, Nigeria, TIFO partnered with the Nigerian government to assess environmental soil contamination and to remediate the most affected areas of the villages. Remediation methodologies included using a handheld X-ray fluorescent spectrometer (XRF) to measure the amount of lead and other heavy metals in the soil. XRF results were recorded on hand-drawn maps of homes and public areas. All XRF data was recorded on field sheets and later entered into Microsoft Excel by unique household identifying numbers in each village resulting in >10,000 soil lead concentrations collected for the >800 households.

The goal of this SURF project was to utilize existing XRF soil lead concentration data to quantify variability in soil lead exposures for children using spatial analysis. To assess various exposure scenarios in the Zamfara crisis, the XRF data was characterized over for the pre-remediation time period for each household, each household’s associated neighborhood, and each community for a total of five villages thus far. To accomplish this, I input village data into the mapping program ArcGIS™ to utilize spatial analysis tools. Village data consisted of a GIS layer of individual compounds and an attribute table including a unique ID for each compound and a matching mean soil lead concentration. Soil lead data for compounds was entered manually from a separate spreadsheet containing XRF arithmetic mean soil lead concentrations. The GIS layer with compounds and exterior areas was checked for accuracy against existing hand drawn maps from 2010 remediation efforts and missing buildings were inserted by hand.

Once all buildings and soil lead data are verified, the result is three separate layers to input into the neighborhood analysis model: exterior areas, compounds, and a combination of exteriors and interiors.

In ArcGIS™, I created a neighborhood analysis model by combining existing spatial analysis tools. The model iterates through each compound of a village to find all the mean soil lead levels of buildings and exterior areas surrounding that house withing a designated radius and outputs a table of summary statistics. Neighborhood area radii included lengths of 100', 200', 300', 400', or 500'. Multiple radii were used to prepare for future analyses in which an appropriate radius will be chosen for a child's exposure based on independent mobility, age, and gender using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model for lead. Repeating the neighborhood analysis for different variations can help determine if mean soil lead concentrations are influenced more by nearby compounds or exterior areas. This neighborhood analysis is repeated at each of the five radius lengths for the following variations:

Finding neighborhood summary statistics of interior buildings by examining surrounding
- o Public exterior areas and interiors
- o Only public exterior areas
- o Only interiors

Summary statistics for exterior areas by examining surrounding
- o Public exterior areas
- o Interiors

In addition to creating the neighborhood analysis model, for each village I built a heat map by using a gradient based on average soil lead concentration for the home. I also used a multitude of spatial analysis tools in ArcGIS™ for each village to provide statistical results and reveal patterns of soil lead concentrations in different contexts. The most helpful tools were the Cluster and Outlier Analysis test and the Hot Spot Analysis tool in ArcGIS™. The Cluster and Outlier Analysis tool determines four statistically significant variables: significantly high soil lead concentration compounds in relatively high soil lead areas, really low lead concentration houses in low areas, high spots in low areas, and low spots in high areas. The Hot Spot Analysis tool finds significant high or low compound soil lead concentrations relative to nearest neighbors. These tools reveal patterns that can't be seen by just looking at the map.

Accomplishments

Over the course of 10 weeks, I completed the neighborhood analysis for pre-remediation data for five villages, including the largest village with over 425 houses. These villages now have a compound, neighborhood, and village mean soil lead concentration for each individual household. From using spatial analysis tools, I was able to confirm results from a past paper. Villages from Phase I (remediated in 2010) have a significantly higher soil lead exposure than in a Phase II village (remediated in 2011), meaning that a child's exposure in a Phase I village is high regardless of residential location. I also found that neighborhood concentration has a significant impact on a child's exposure. This means that for Phase II and Phase III (remediated in 2013) villages, if a child's home has a high soil lead concentration, but they live in a low concentration neighborhood, their exposure is lowered and vice versa for a low soil lead home in a high soil lead neighborhood. Finally, the neighborhood data showed variability in lead concentrations depending on radius length. Each child's exposure to lead is unique depending on their independent mobility which directly relates to the size of their neighborhood.

These findings help answer questions about exposure and point towards important factors for determining a child's lead exposure. By understanding the relationships between lead exposure from compounds versus neighborhoods, future analysis can help determine what soil lead weighted average of home, neighborhood, and community determines the most meaningful exposure estimate. In addition to these findings, I presented my research at the Idaho Undergraduate Research Conference and submitted an abstract to present at the 2021 International Conference on Soil, Water, Energy, and Air conference next spring.

Budget expenditures

My original budget was $875 for project expenditures related to travel to Moscow, ID. Due to unforeseen circumstances, my laptop crashed and had to be replaced in order to use the software required for the project. I was reimbursed $847.99 for the laptop purchase. This was necessary as my work was remote and required high computing power for large data files and mapping software such as ArcGIS. Due to conditions during the pandemic, travel was limited. The remaining budget was applied toward travel between Boise and Moscow, ID.

Future works

During the 10-week period, I produced several fascinating results that bring up new questions for future work. After this summer, I will continue to work with TIFO on additional investigations for this project. With the neighborhood analysis model, I will finish conducting the soil lead analyses on the remaining three villages. Afterward, I will begin the next steps of finding the most appropriate radius value for a child's exposure varying by age. When neighborhood analysis is completed for all villages, a weighted mean of the soil lead means from the home, neighborhood, and community can be calculated. For children aged 6 months to 8 years, a predicted BLL can be calculated for each individual depending on their location and assumptions about mobility using the IEUBK model. In the future, predicted BLLs will be compared against the actual BLLs collected by MSF during emergency response efforts to adjust exposure factor variables.

Acknowledgment: I greatly appreciate the generous support provided by the SBoE/HERC that made my SURF award this experience possible for me. It was a truly great experience.

2020 SURF 2-page final report

Abstract

Propelled by the recent revolution in genome editing, gene drives—selfish genetic units which spread preferentially in wildlife populations—have been celebrated in recent years as a means to *eradicate* vector-borne diseases like malaria, which continue to claim millions of lives each year. While some proponents have argued for the use of 'lethal' drives to depress vector populations, others support a more nuanced approach: the suppression of parasite transmission, at no cost to the host. Lethal or not, genetic interventions against disease will likely prove *spatially imperfect*—leaving pockets in which parasite persistence and evolution are possible. In order to probe how spatial structure affects such genetic interventions, we built and analyzed multi-strain metapopulation model(s) of vectored disease characterized by distinct functional forms of transmission together with movement of humans between patches. We found that differences in mosquito ecology and the softening of spatial structure, shape the nature of infection globally. This work culminated in a manuscript submitted to *Evolution, Medicine, and Public Health* this summer. Using a stochastic formulation of the model, we have begun studying evolution of the parasite in discrete space. In particular, we are interested in if and/or when the strength of movement between patches and standing genetic diversity of the parasite can save a pathogen from extinction or allow it to expand its initial range. Altogether, our results illustrate the nuanced reality of interventions, both genetic and not, against vector- borne disease: population structure, mosquito biology, and evolution together determine where eradication is possible, and where it isn't.

Project description

Using two metapopulation models of vectored disease—a system of ordinary differential equations, and the other an analogous stochastic process—we sought to answer a couple key questions. How do differences in mosquito biting (as reflected in density- versus frequency-dependent transmission) affect the long-run outcomes of disease in a two-patch, single-strain setting as the degree of spatial structure changes? In a many-patch setting, how does the strength of movement between neighboring patches change the evolution, transmission, and spread of a parasite in discrete space? How does the degree of standing genetic diversity of the parasite affect the adaptive dynamics? Can mutation save a pathogen headed for extinction? Can a parasite accumulate successive mutations at the boundaries of patches where transmission is (initially) suppressed to expand its initial range?

Our first model is deterministic and tracks densities of susceptible and infected humans and mosquitoes in patches $k = 1, 2, \ldots, n$ with strains $j = 1, \ldots, m$. The equations describing densities of individuals in a given patch k *infected* with strain j are included below.

$$\dot{H}_{I_j}^{(k)} = \underbrace{\left(H^{(k)} - H_S^{(k)}\right)\left[\sum_{i=1}^{n} c_{ki} \cdot a_{HM}^{(i,j)} \cdot M_{I_j}^{(i)} \cdot b_i\right]}_{\text{infection of susceptible humans with strain } j} - \gamma_j \cdot H_{I_j}^{(k)} - \mu_H \cdot H_{I_j}^{(k)}$$

$$\dot{M}_{I_j}^{(k)} = \underbrace{b_k \cdot a_{HM}^{(j)} \cdot M_S^{(k)} \cdot \left[\sum_{i=1}^{n} c_{ik} \cdot H_{I_j}^{(i)}\right]}_{\text{infection of susceptible mosquitoes with strain } j} - \delta \cdot M_{I_j}^{(k)} - \mu_M \cdot M_{I_j}^{(k)}$$

This model has been updated since applying for OUR funding: we now track multiple strains and mutational dynamics (characterized by red terms).

Our second model is a continuous-time stochastic process $(\vec{X})_{t\geqslant 0} = (H_{I_j}^{(k)}, M_S^{(k)}, M_{I_j}^{(k)})$ defined on a discrete state space and such that probabilistic rates and transitions are defined as in the deterministic setting. We used τ-leaping to simulate realizations of the process.

Project accomplishments & budget expenditures

With the support of the Office of Undergraduate Research, we have been able to complete the following over the summer months:

- Reviewed literature in mathematical epidemiology, especially that having to do with the spread of vector-borne diseases in structured populations.

- Studied Gillespie's direct method for stochastic simulation. Implemented this method, as well as the τ-leaping approximation, to study the effect of stochasticity in the basic SIR model and in other settings. An R Markdown file with code to complete stochastic simulations for this model with the direct method is attached.

- Finalized study of the model in the two-patch, one-strain setting. While the submitted manuscript does not reflect some of the work done (simulations solving the system of ODEs to steady state for various combinations of parameters), a pre-print can be found here: https://www.biorxiv.org/content/10.1101/2020.07.16.207464v1.

- Wrote code (included in another R Markdown file) to complete simulations of the stochastic m-strain and n-patch model with mutation, in which n and m can be chosen arbitrarily. We have begun using this code to answer questions laid out in the project description, as well as in a poster (attahced) presented at the 2020 ICUR.

We spent the funds provided by the OUR for Mathematica on a year-long licence in July.

Determining Residual Stress Fields and Plastic Zone Sizes Surrounding Fatigue Cracks Using Nanoindentation

Evan Allen and Dr. Michael Maughan

Department of Mechanical Engineering, University of Idaho

University of Idaho College of Engineering

I. Abstract

Crack propagation is typically observed in systems that experience cyclic loading, often resulting in critical failure (fatigue). Compressive residual stresses induced in a material contribute to stunting crack growth and can increase the fatigue life or prevent failure. The tensile loading of cracks creates a plastic zone at their tips, and growth of the crack leaves a "plastic wake" region adjacent to the newly created surface wherein the material has been strained. While some models and validation techniques to describe and measure the plastic zone size are available, the plastic zone has not previously been measured using nanoindentation. Nanoindentation is the process of inducing compressive plastic deformation at a micrometer length scale, typically using a pyramidal indenter probe. Data analysis of the force vs. displacement data can be used to determine the specimen's material properties. By coupling nanoindentation with atomic force microscopy (AFM) to measure material upheaval around the impression, the residual stress field can be determined at the tip and the wake surrounding a crack. These data can also be used to model the plastic zone around the tip of a crack. This research will provide a comparison between the nanoindentation method and a mathematical model in the literature. Ultimately, results from these experiments can help us to understand crack propagation and potentially provide a non-destructive fatigue damage prediction.

II. Background

Figure 1a

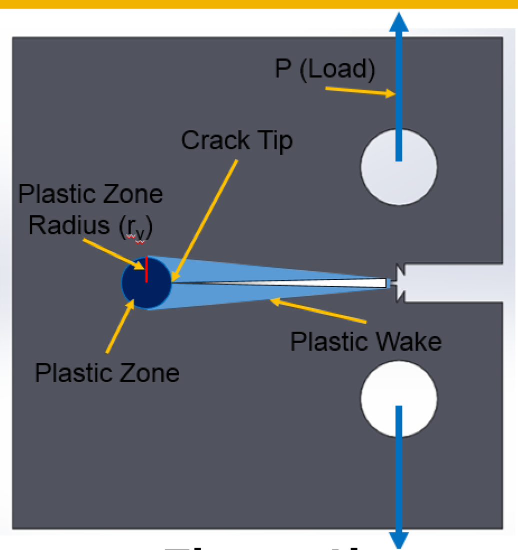


Figure 1b

Figure 1: a) Alloy 709 Stainless Steel compact tension specimen **b)** Specimen characteristics during fatigue testing

- The Irwin model for finding the plastic zone size, r_y , is shown in Equation 1. This equation is for plane stress conditions and is commonly used in fatigue crack growth (FCG) applications.

$$2r_y = \frac{1}{\pi}\left(\frac{\Delta K}{2S_y}\right)^2 \qquad (1)$$

- The plastic zone size can be determined by finding the changes in the residual stress magnitude at different points on the surface of the specimen. Equation 2 Shows the formula for determining the magnitude of the residual stress field, Λ.

$$\Lambda = \frac{\mathrm{E}*\tan(\beta)}{(\sigma_y(1-\nu^2))} \qquad (2)$$

E = Young's modulus
β = Angle between sharp indenter and undeformed surface
σ_y = Flow stress
ν = Poisson's ratio

- By performing indentation to an FCG specimen's surface and AFM to determine the indented surface topography, the residual stress field can be determined along with the plastic zone size.

III. Methods

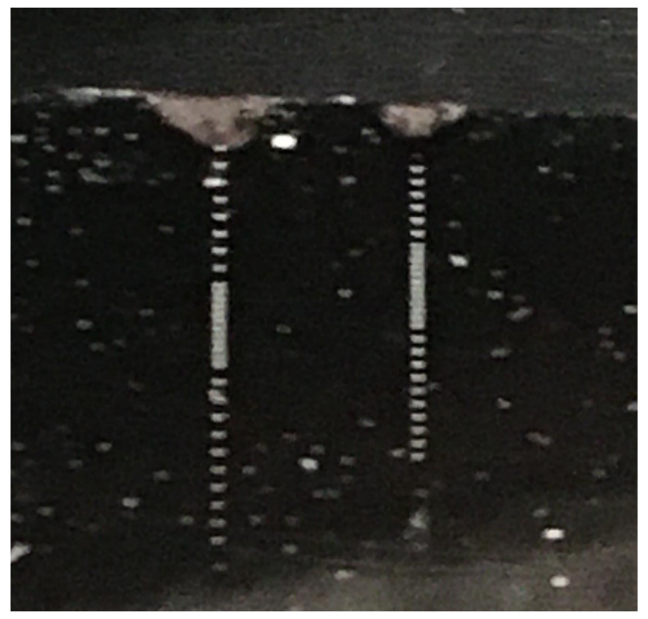


Figure 2a

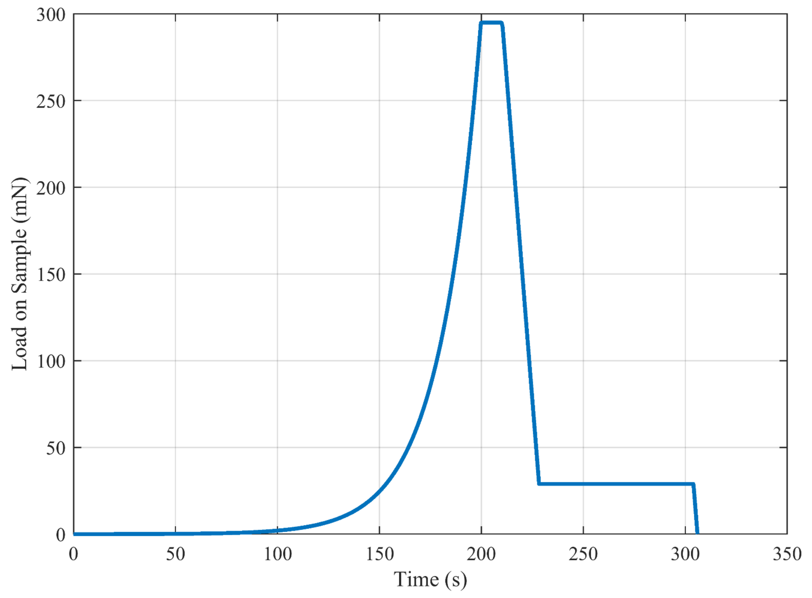


Figure 2b

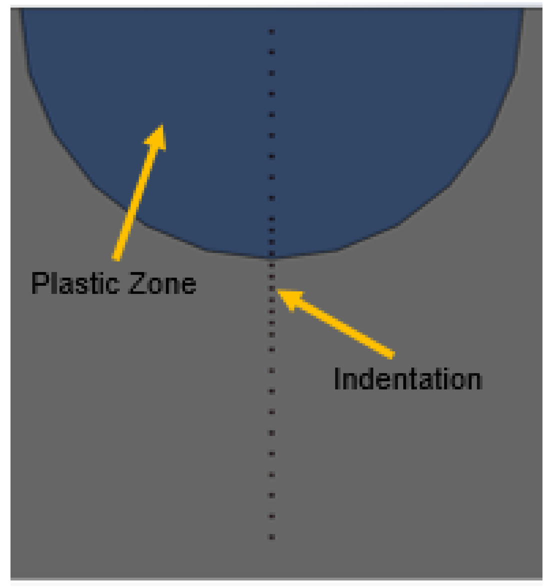


Figure 2c

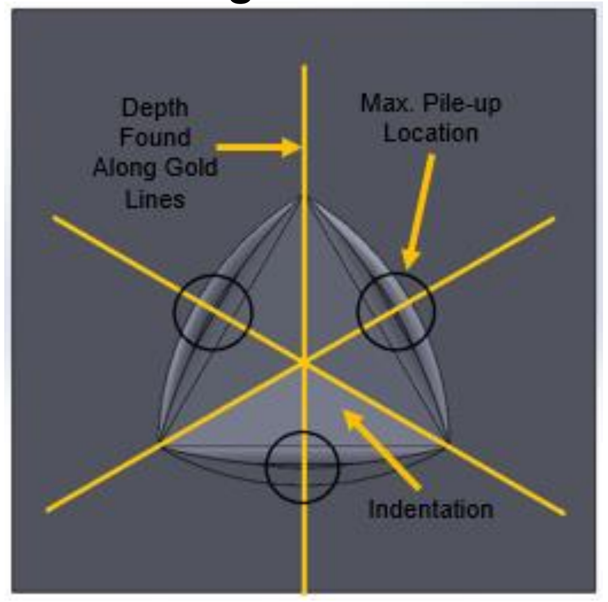


Figure 2d

Figure 2: a) Alloy 709 FCG specimen indents taken along 17.8mm and 20mm crack length **b)** Indentation Load vs. Time Curve **c)** Indentation technique applied to different crack lengths **d)** AFM strategy to determine amount of sink-in/pile-up for indents

- Four different crack lengths were tested on an Alloy 709 Stainless Steel specimen: 17.8mm, 20mm, 25mm, and 30mm
- Gradient Indent Pattern used to test the surface of specimen
- AFM used to measure the amount of pile-up around indents
- An average of the max pile-up of each side of indents calculated on the lines shown in Fig. 2d

IV. Experimental Testing

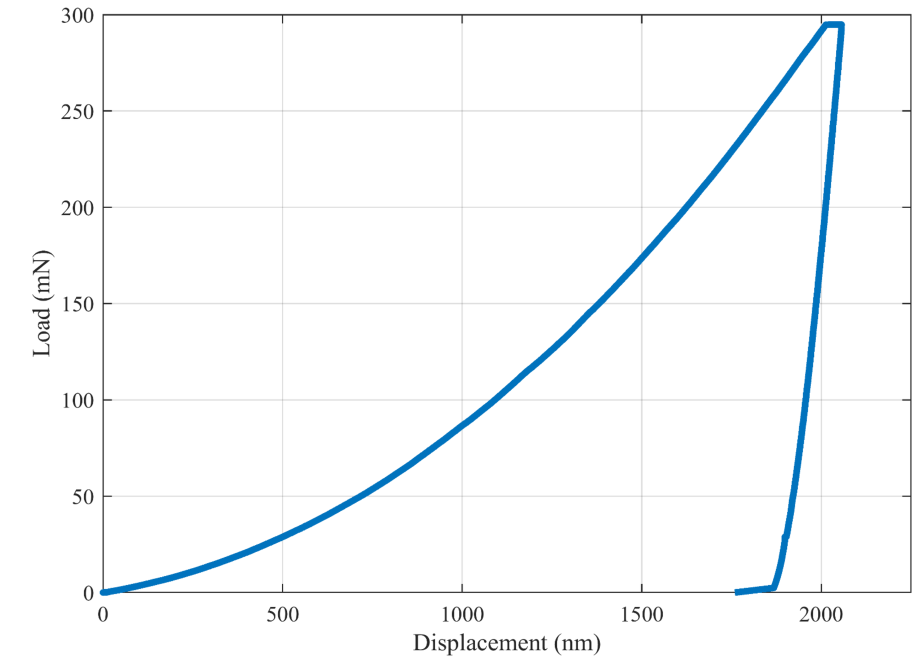


Figure 3: Indentation Load vs. Depth Curve

- Strain-controlled testing used for indentation, each indent set to a target depth of 2000nm

V. Results

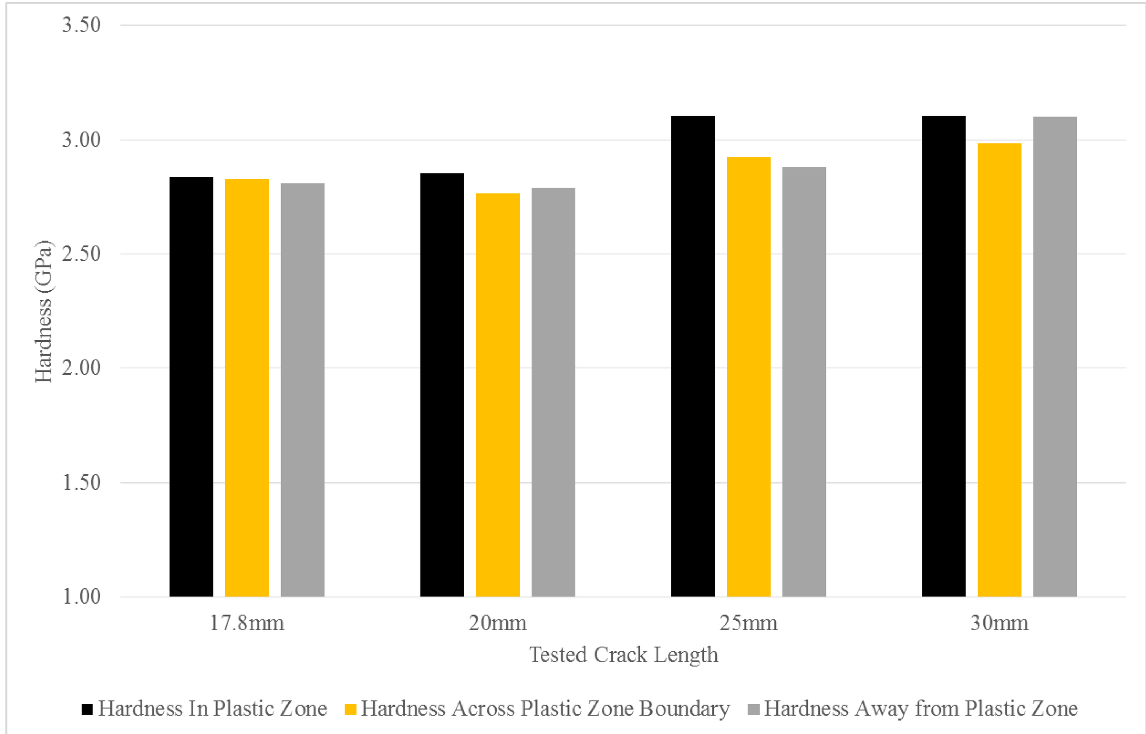


Figure 4: Average hardness values at tested crack lengths among three different areas along the specimen

Table 1: Plastic zone sizes found using the Irwin model and indentation changes in hardness. Nanoindentation estimation values are the distances from the crack tip where the greatest change in hardness occurs

Crack Length (mm)	Irwin Model r_y (mm)	Nanoindentation Estimation of r_y (mm)
17.8	2.416	2.28 - 2.38
20	3.024	3.04 - 3.14
25	5.247	5.13- 5.23
30	10.226	10.39 - 10.49

- Hardness varies slightly among tested regions along specimen
- Both the regions near the plastic zone boundary and away from the zone have lower hardness values than found in the plastic zone for all tested crack lengths
- Plastic zone size estimations using solely indentation are closely related to the Irwin model calculations

VI. Discussion & Future Work

- The indentation technique provides similar values to those calculated using the Irwin model
- Retrieve AFM data and use values to calculate residual stress field and plastic zone size
- Run methods on more samples to further improve confidence in results

VII. References

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VIII. Acknowledgements

- The project described was supported by a student grant from the UI Office of Undergraduate Research
- We are grateful to Dr. Robert Stephens for supplying the Alloy 709 samples

Estimated Ancient Volcanic Characteristics from Modern Spatter

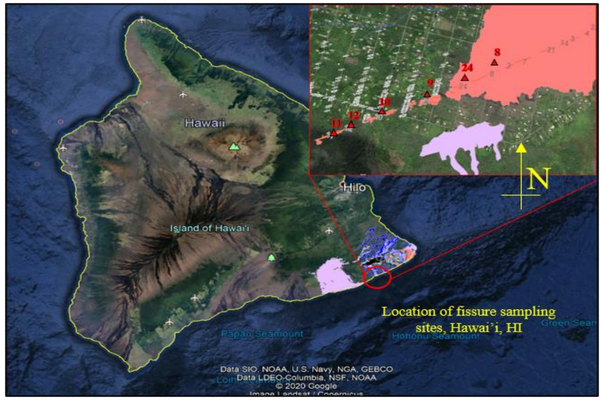
David Cavell (University of Idaho, Geology)

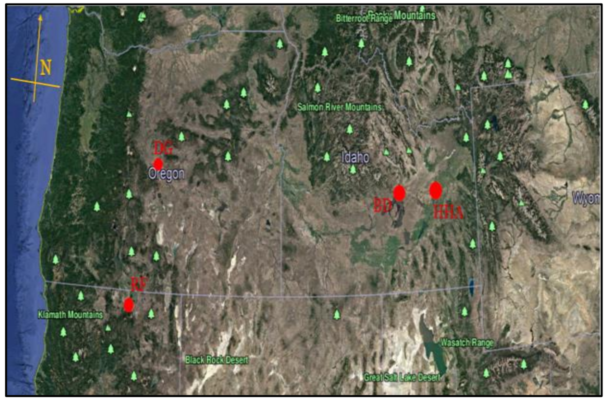
Hypothesis

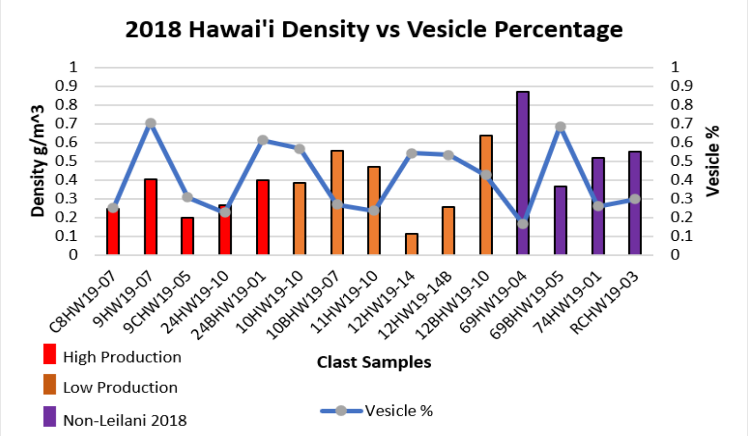
Analyzing spatter deposits and their vesicles from recent eruptions, such as the 2018 Hawai'i eruption, can be used to determine relative degassing and potential lava fountaining height through vesicle percentage and shape.

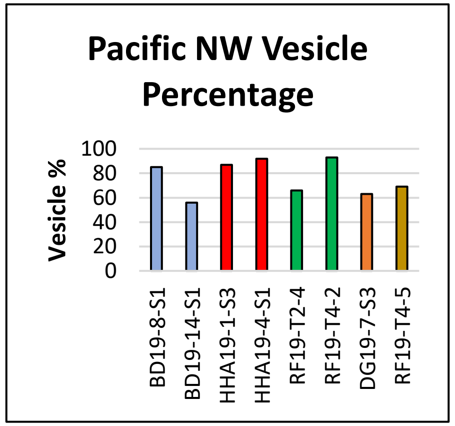
Methods

- Spatter clast were collected from the 2018 Hawai'i eruption and several ancient sites from throughout the Northwest, USA.
  - Samples collected from the Northwest USA were collected from lava flows and fissure sites from Hell's Half Acre, Blue Dragon, Devil's Garden, and Ross Flow
- Thin sections were created for each clast
- Each thins section was thin scan to have an image of the whole thin section
- These scanned images were then inputted into ImageJ for a vesicle percentage in the thin section
- The thin sections are then imaged with backscatter SEM at varying magnifications and locations on the slide
  - At 29x, 50x, and 100x magnifications following the guidelines set in Shea et al., 2009.
- The SEM images are processed in FOAMS for analyses of the vesicles size and sphericity





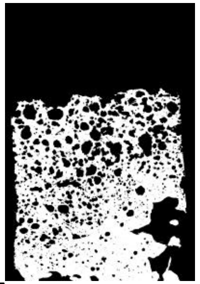




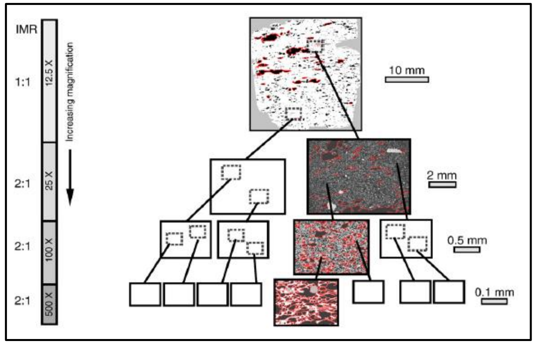
Looking Forward

- Using the outlined methods, it is hoped that we can locate eruptive fissures that displayed relatively high degassing, potentially resulting in higher fountaining of erupted lava. In Parcheta et al. 2013, it is shown that fissures with higher fountaining resulted in a higher percentage of vesicles and smaller in size and consisting of high sphericity. Through analyzing the 2018 Hawai'i eruption's spatter from sites with varying fountain heights and rate of degassing, we hope to see correlations to ancient volcanic events. This can lead to knowing the way in which the lava was erupted and how it affected the landscape and eruption. We can see that fissures with higher vesicle percentage tend to be from high production vents.
- Completion of Northwest samples in ImageJ and both sets of samples in Backscatter SEM, and then process and interpret the collected data and present all findings.

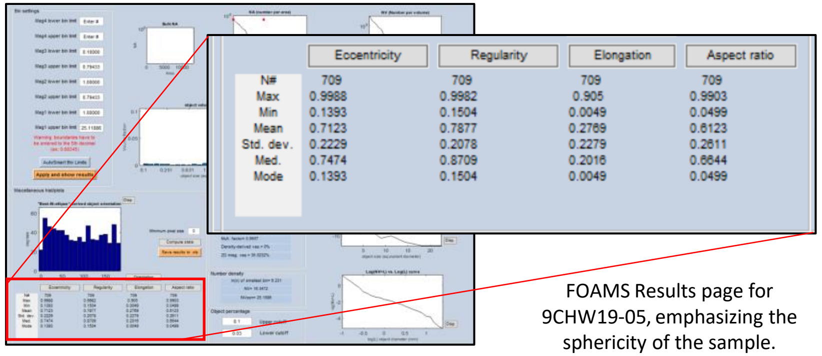
Scanned thin section of 9CHW19-05



ImageJ vesicle image thin section of 9CHW19-05



15 image "Exponential" Nest as outlined in Shea et al. for its ability to get broad clast vesicle data with limited images to increase amount of processed clast samples



FOAMS Results page for 9CHW19-05, emphasizing the sphericity of the sample.

Acknowledgements

Dr. Erika Rader (University of Idaho, Geology)
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OUR Undergraduate Research Programs

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Assessing Relationships between Predator and Prey Distributions in the Central Volcanic Cordillera Region of Central Costa Rica

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Background

Pumas (*Puma concolor*) are one of the largest mammalian predators in Central America
- They have many complex effects on ecosystems.
- Pumas are a species of conservation need due to a high extinction risk in some areas 2
- Predator abundance, survival, and reproduction rates are closely tied to prey availability and density1

In Costa Rica, 27% of land is protected, but some areas have a degree of fragmentation5
- Corridors often have high rates of deforestation and human disturbance5
- The Central Volcanic Cordillera Jaguar Conservation Unit (CVC JCU) has low jaguar density, despite previously being viewed as a stronghold4
  - Provides habitat connectivity from Panama to Nicaragua
  - A 2019 study in a nearby JCU and corridor evaluated prey species richness as a means of predicting jaguar and puma habitat use4

Evaluating species distributions in the CVC JCU could provide insight on the relationships pumas have with prey in this critical protected area
- Similar studies observed predator distributions were best explained by prey distribution7
- Puma-prey relationships are unknown in this area; reason for jaguars' absence is unknown

Research Questions & Objectives

Can prey occupancy serve as a predictor for puma occupancy? If so, which species?

Objectives:
- Predict occupancy for species with four main covariates (minimum distances to road and town, Human Footprint Index, and forest cover)
- Predict puma occupancy, including predicted prey occupancies as additional covariates

Figure 1: Camera trap deployed by Panthera Costa Rica.

Figure 2: Puma as captured on a camera trap by Panthera Costa Rica.

Methods

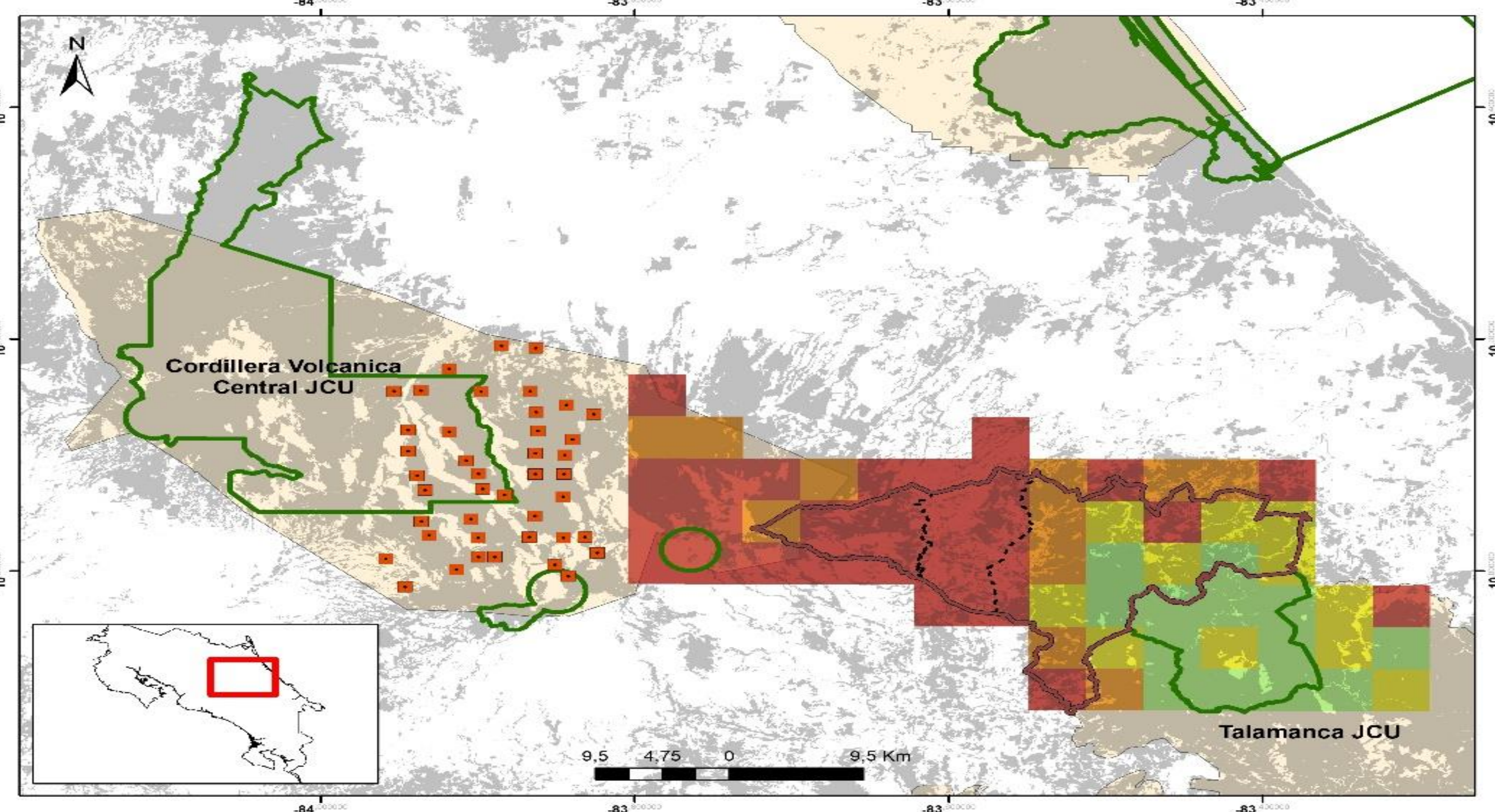

Figure 3: Camera trap locations in the study site are denoted with red squares. The colored grid cells indicated predicted jaguar habitat use, ranging from good (green) to poor (red)4

1. **Camera Trapping**
   - 42 camera stations deployed across study area (*Figure 3)* for 14 weeks from Oct. 2018 to Jan. 20194
   - Generated detection histories per species
   - Species were included if they were a documented prey item of pumas4
   - Selected covariates include forest cover, Human Footprint Index, minimum distance to road, and minimum distance to human town
2. **Data Analysis**
   - Data analyzed with R package *unmarked*3
   - Predicted occupancy based on leading model (by AIC scores) for each prey species
   - Puma occupancy was modeled with predicted prey occupancies as influencing factors in addition to 4 site covariates
   - Leading puma occupancy model was then used to predict puma occupancy across the 42 sites

Results Summary

Puma occupancy was best predicted by rabbit (*Sylvilagus brasiliensis*) occupancy, minimum distance to road, and red-brocket deer (*Mazama americana*) occupancy as the top models (*Table 2,* deltaAIC < 2).

Puma occupancy across the study site ranged from 0.003 (std error=0.01) to 0.602 (std. error=0.27)
- Rabbit occupancy varied from 0.009 (std. error=0.02) to 0.416 (std. error=0.21)
- As rabbit occupancy rates increased, so did puma occupancy rates
- Pumas were also linked to minimum distance to road (decreasing occupancy with increasing distance) and red-brocket deer (decreasing occupancy with increasing red-brocket deer occupancy)

Table 1: Species included in the analysis and the best model. The effect of the covariate on occupancy is summarized by trend; null models indicate that species occupancy does not vary across site and therefore no trend was identified.

Species	Top Model	Trend
Agouti	Forest	Increases with increasing Forest Cover
Armadillo	Town	Decreases with increasing Minimum Distance to Town
Coati	Null	None
Red-brocket Deer	Road	Increases with increasing Minimum Distance to Road
Opossum	Null	None
Paca	Human	Increases with increasing Human Footprint Index
Peccary	Town	Increases with increasing Minimum Distance to Town
Puma	Rabbit	Increases with increasing Rabbit Occupancy rates
Rabbit	Road	Decreases with increasing Minimum Distance to Road
Raccoon	Null	None
Tamandua	Null	None
Tayra	Forest	Decreases with increasing Forest Cover

Table 2: Model ranking summary for all models evaluated in predicting puma occupancy. Models are listed in order of best to poorest fit based on AIC scores.

Model	AIC	delta AIC	AICwt	Rsq	cumltv Wt
Rabbit	47.41	0	0.24	0.24	0.24
Road	47.48	0.08	0.23	0.24	0.46
Red-brocket Deer	47.52	0.11	0.22	0.24	0.69
Tayra	50.57	3.17	0.05	0.10	0.74
Null	50.67	3.27	0.05	0.00	0.78
Armadillo	51.70	4.29	0.03	0.05	0.81
Town	51.99	4.58	0.02	0.04	0.83
Agouti	52.07	4.66	0.02	0.03	0.86
Peccary	52.20	4.79	0.02	0.02	0.88
Forest	52.54	5.13	0.02	0.01	0.90
Human	52.63	5.22	0.02	0.00	0.91
Paca	52.64	5.23	0.02	0.00	0.93
Tamandua	52.67	5.27	0.02	0.00	0.95
Coati	52.67	5.27	0.02	0.00	0.97
Opossum	52.67	5.27	0.02	0.00	0.98
Raccoon	52.67	5.27	0.02	0.00	1.00

Discussion and Implications

Our results indicate that pumas in the Central Volcanic Cordillera may follow prey in the area
- In this case, pumas were best predicted by rabbit and red-brocket deer occupancy (of prey models where deltaAIC < 2)
- However, deer and pumas were inversely related – deer may be avoiding pumas, or other, unmeasured factors may be contributing (such as elevation or distance to water)
- More investigation is necessary to confirm results

Four of 11 prey species evaluated had some anthropogenic disturbance as the main covariate impacting occupancy
- Showed higher occupancy rates when disturbance was less or a greater distance away

Caveat:
- Selected #1 model of prey species to conduct puma occupancy analysis—often, species had more than 1 model with deltaAIC < 2
- In future, can combine these top models for more complete summary of the system

Further Research

- Can perform further analysis by combining models where deltaAIC < 2 for more refined results

Mitigating cat-cattle conflict is of high importance in the country and a main focus of Panthera4
- We can build upon Salom-Perez's 2019 evaluation (*Figure 3)* of the neighboring protected areas and determine puma habitat use probability based on prey species abundance and distributions
- This can identify potential conflict hotspots between cats and humans

Further examining prey species abundance and distributions may help provide insight on why there is little to no evidence of jaguars in the CVC
- This area is a critical link for jaguars4
- Can extend Salom-Perez's 2019 work into the CVC and predict jaguar habitat use using our data and occupancy analyses

Acknowledgements

This research was funded by a Summer Undergraduate Research Fellowship from the University of Idaho's Office of Undergraduate Research. For research support, we would like to thank Panthera Costa Rica, Panthera's field teams in camera trap deployment and collection, and Maryory Velado-Cano at the Centro Agronomico Tropical de Investigacion y Ensenanza, Costa Rica, in data collection. Without these contributions, this work would not have been possible.

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Nuclear Hormone Signaling and Regulation of Cone Photoreceptor Gene Expression in the Zebrafish

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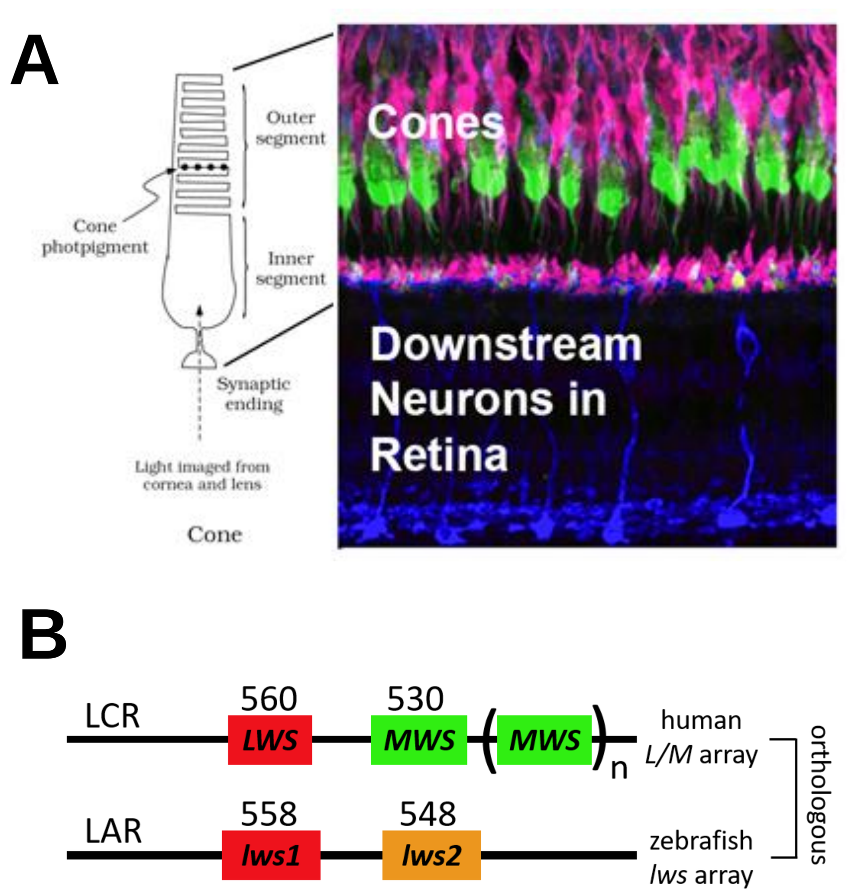
Introduction

Vertebrate color vision requires the expression of cone visual pigment proteins (opsins), with different peak spectral sensitivities in separate cone populations (Fig. 1A). In primates and in teleost fish, some opsin genes have been tandemly-replicated, with the opsins encoded by the replicates having divergent spectral sensitivities (Fig. 1B). The current model for the regulation of tandemly-replicated opsin genes in humans is described as a stochastic event[1]. However, in human retina it has been discovered that there are topographic gradients in red: green cone ratios[2] (Fig. 1C), this suggests that a trans regulatory mechanism is involved in their expression. In support of this hypothesis, recent publications from our lab, investigating the orthologous long wavelength sensitive (*lws*) array of zebrafish (Fig. 1B; D) have shown that retinoic acid and thyroid hormone (TH) promote the expression of *lws1* at the expense of *lws2* in larvae and juveniles [3,4]. Preliminary data from experiments in which adult zebrafish were treated with TH, suggest a similar response takes place in adults. The goals of the current project are to better understand the regulation and expression of *lws* cone opsins when larvae and adult zebrafish are treated with TH, as well as demonstrate that *lws* expression is plastic in cones of adult zebrafish.



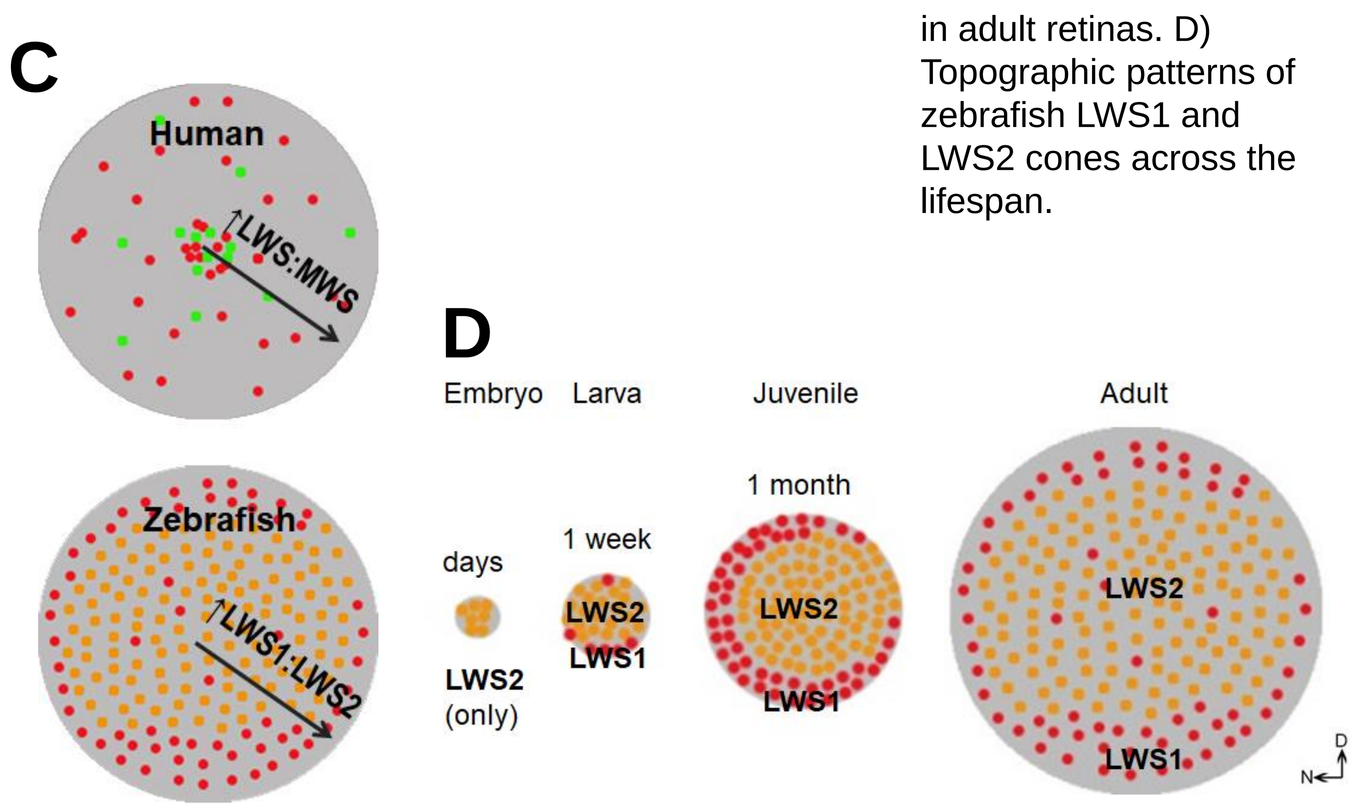
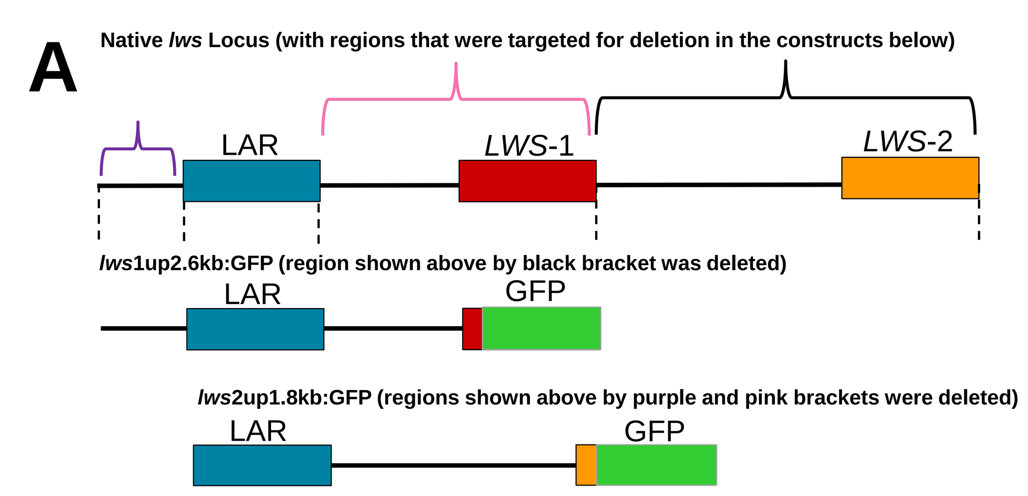


Fig 1: A) Diagram of cone photoreceptor, and image of (fluorescently-labeled) cones and downstream neurons in zebrafish retina. B) Human *L/M* cone opsin array and zebrafish *lws* cone opsin array. LCR = locus control region. LAR = *lws* activating region. Numbers above genes indicate the corresponding peak spectral sensitivity (in nm) of the encoded visual pigments.[5] C) Topographic patterns of human LWS:MWS (=L/M) and zebrafish LWS1:LWS2 cone ratios in adult retinas. D) Topographic patterns of zebrafish LWS1 and LWS2 cones across the lifespan.

Results

Cis-regulatory regions involved in response to TH



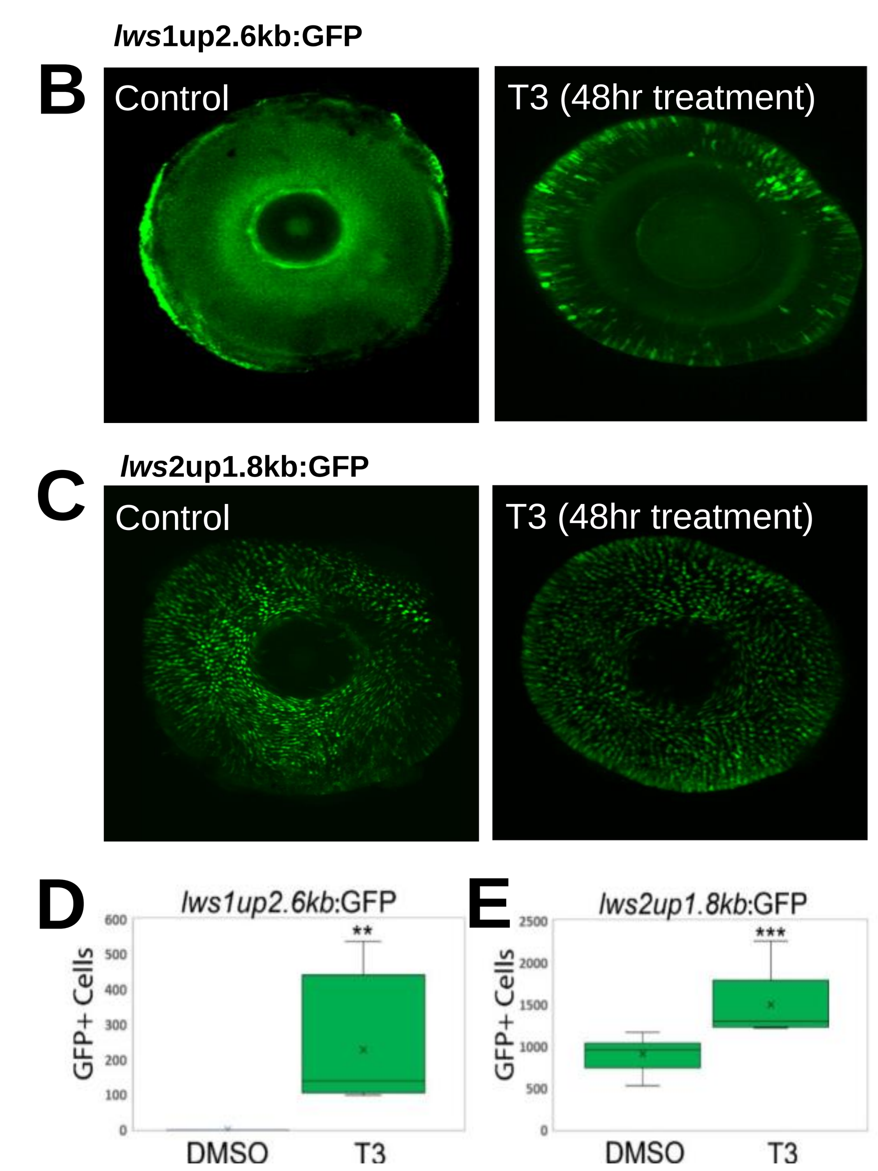


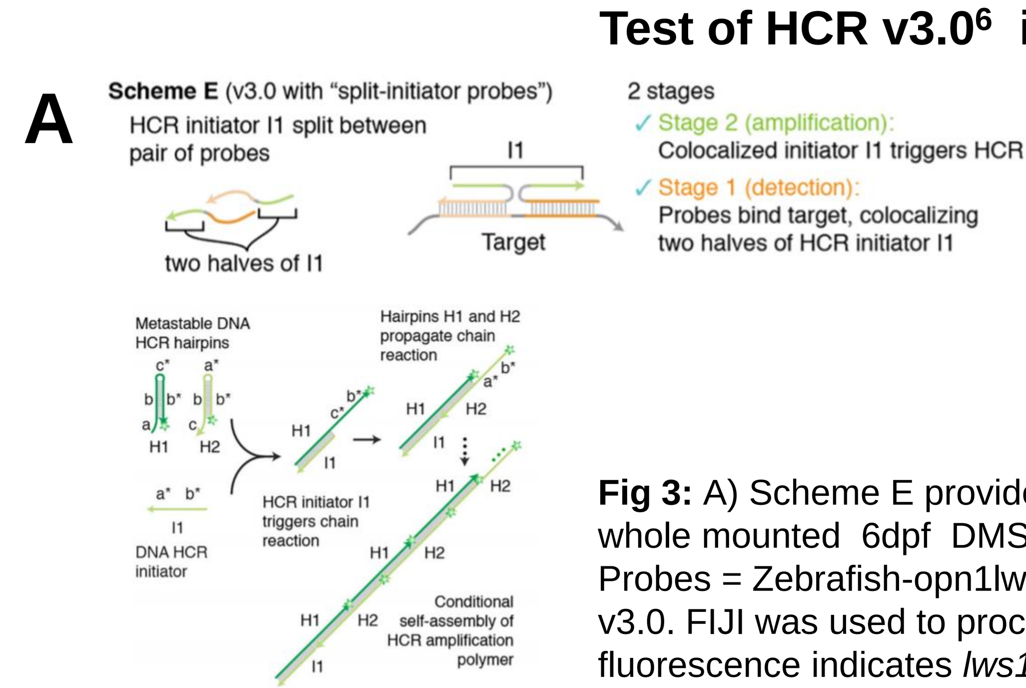
Fig. 2. A) Transgenic constructs generated to evaluate roles for cis-regulatory regions that may be important for the response to TH. The native locus responds by upregulating *lws1* and downregulating *lws2*[5]. B) Left: a whole mounted 4dpf DMSO-treated (control) eye; Right: a whole mounted 4dpf T3-treated eye. Both eyes are from the transgenic reporter line *lws*1up2.6kb:GFP C) Left: a whole mounted 4dpf DMSO-treated (control) eye; Right: a whole mounted 4dpf T3-treated eye. Both eyes are from the transgenic reporter line *lws*2up1.8kb:GFP. All eyes were imaged using the confocal microscope. D) Numbers of GFP+ cones for DMSO vs. T3 treated line *lws*1up2.6kb:GFP P=0.00512. E) Numbers of GFP+ cones for DMSO vs. T3 treated line *lws*2up1.8kb:GFP P=0.00094. The Mann-Whitney test was used to quantify the comparison between GFP+ cones from the control vs. treated group, resulting in the above P values. Statistical notation: $^{**}P \leq 0.001$, $^{***}P \leq 0.0001$.

•The proximal 2.6kb region upstream of *lws1* contains elements sufficient for TH-mediated upregulation of *lws1*.

•The LAR and 1.8kb intergenic region together do not contain the elements necessary to reduce *lws2* in response to TH.

•Somewhat unexpectedly, the LAR and 1.8kb intergenic region together do contain an element(s) that serves to promote expression of *lws2* in response to TH, when other proximal regions upstream of *lws1* are missing.

Test of HCR v3.0[6] in situ to detect *lws* transcription.



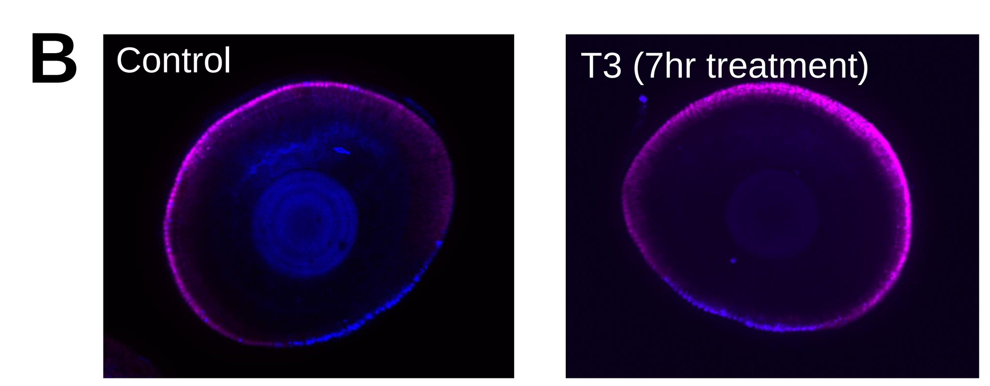


Fig 3: A) Scheme E provides the basis for *in situ* HCR (Hybridization Chain Reaction) v3.0.[6] B) Left is a whole mounted 6dpf DMSO-treated (control) eye and right is a whole mounted 6dpf T3-treated eye. Probes = Zebrafish-opn1lw-B3 (*lws1*), and Zebrafish opn1lws2-B4 (*lws2*) were used when undergoing HCR v3.0. FIJI was used to process the images following imaging on the confocal microscope. Blue fluorescence indicates *lws1* expression, and magenta fluorescence indicates *lws2* expression.

•The HCR procedure was successful; 7h T3 may not be sufficient to upregulate *lws1*.

Experimental design for experiments using adult zebrafish.

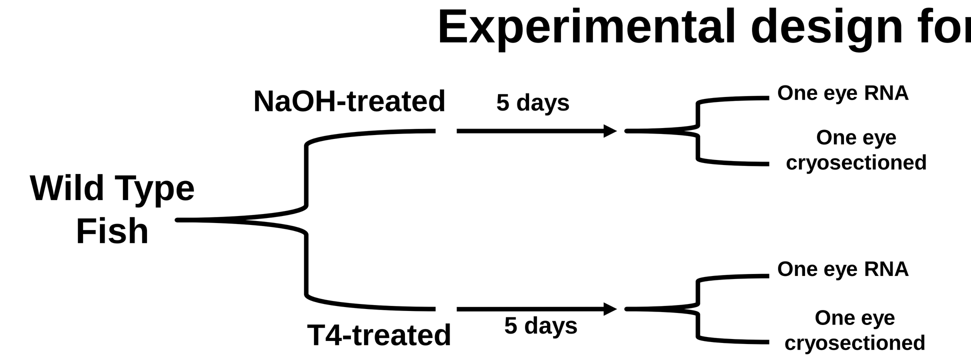


Fig 4: Flow chart of adult thyroid hormone treatment. 10,000x stock T4 was added to the fish beakers to result in a final concentration of 386nM (NaOH was at a final concentration of 0.01%), Treatments lasted 5 days and solutions were refreshed every 24 h.

•HCR in situs are in progress.

Discussion

- Regulation of *lws1* vs. *lws2* opsin gene expression by TH is a complex process.
  - We characterized regions of the *lws* locus that are important for TH mediated opsin expression.
- The HCR v3.0 in situ process, and the probes available, appear useful for detecting specific transcripts in whole mounted tissues.
  - Initial attempts to perform HCR using these probes, on sectioned adult retinas, were not successful. A non-probe-related issue needs to be resolved, including adjustments to reduce autofluorescence.

Future Directions

- Determine expression patterns and response to TH in adult *lws*1up2.6kb:GFP and *lws*2up1.8kb:GFP transgenic fish.
- More work needs to be done to better optimize HCR v3.0 in situ use on adult retinal cryosections.
- Alternatives include the standard use of dig-labeled probes, or the collection of whole retinas from treated vs. untreated adults.

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Analysis of Apoptotic Cell Clearance by Microglia in Zebrafish Mutants Lacking *havcr1*, a Putative Phosphatidylserine Receptor

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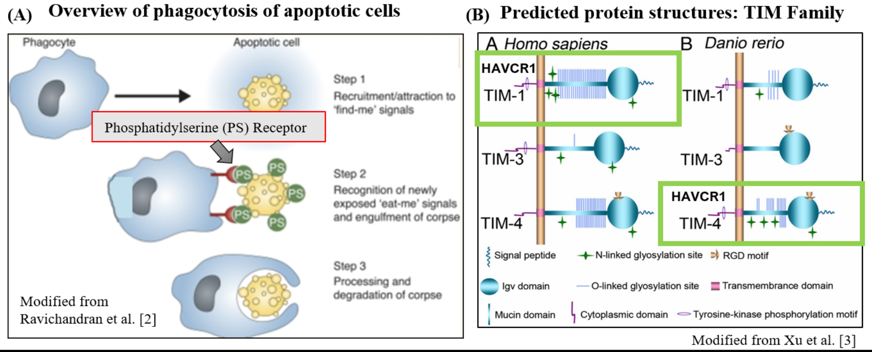
University of Idaho

Abstract

The retina is made functional by complex interactions of various cell types unique to the central nervous system. While neurons and glia are well appreciated in this context, the microglia, a lesser understood cell type, has emerged as an important player. Microglia are resident phagocytes that colonize the central nervous system (brain and retina) early in vertebrate development. Recent work indicates that microglia have a variety of functions in development and homeostasis, but the genes and pathways that are involved, and therefore molecular mechanisms, are poorly understood. A well described function of microglia is the phagocytic clearance of apoptotic cells during normal development as well as in contexts of tissue damage or degeneration. However, the genes required for this function remain to be fully elucidated. Recent transcriptome analysis published by our lab has shown zebrafish microglia express high levels of the gene *havcr1*. Sequence and genomic comparisons indicate *havcr1* is a receptor for Phosphatidylserine (PS), which is exposed on the surface of dying cells. Therefore, we hypothesize that *havcr1* has a function in the recognition and clearance of apoptotic cells by microglia. We propose to use the zebrafish to reveal the function of *havcr1* in the vertebrate retina, by the following objectives: (1) Demonstrate that microglia express *havcr1* using in situ hybridization, and (2) Determine if clearance of apoptotic cells during development is reduced in *havcr1* mutants. This work will increase mechanistic understanding of apoptotic cell clearance by microglia and will provide a novel genetic tool for future experiments.

Figure 1: Dynamics of phagocytosis and the predicted structure of HAVCR1: a phosphatidyl serine receptor.



(A) Overview of apoptotic cell clearance. "Find-me" signals are released from apoptotic cells, which attract phagocytes to the site of death within tissue. "Eat me" signals are exposed on the surface of apoptotic cells and promote recognition by the phagocyte and subsequent internalization of the dying cell. The best known "eat me" signal is phosphatidyl serine (PS) [1]. In healthy cells, PS is located on the inner plasma membrane, but during apoptosis, becomes exposed on the surface of the apoptotic cell. Phagocytes express receptors that recognize and bind to PS. Binding of PS receptors to PS on apoptotic cells provide a signal that triggers cell engulfment [2]. **(B)** Humans and zebrafish have orthologous genes in the TIM family that act as PS receptors [3]. In this diagram (modified from Xu et al. [3]), the protein called TIM-1 in humans is coded by the human *HAVCR1* gene. The protein called TIM-4 in zebrafish is coded by the zebrafish *havcr1* gene. The predicted structures of the proteins are shown.

Acknowledgements

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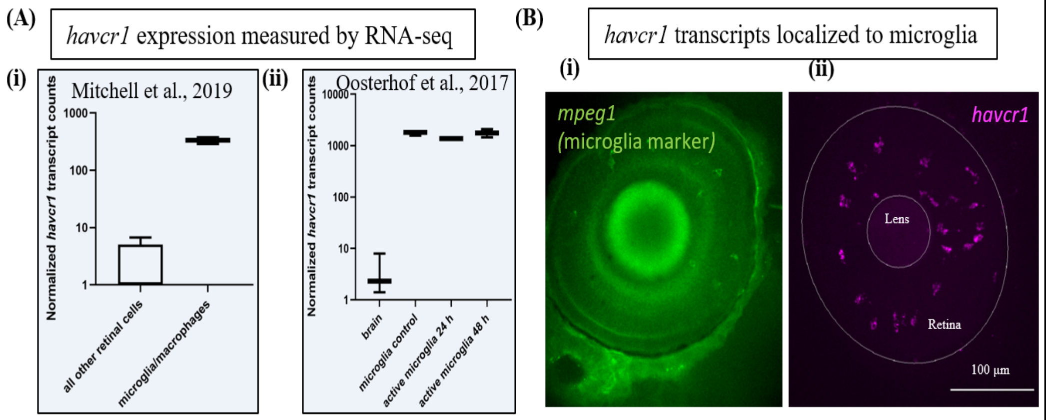
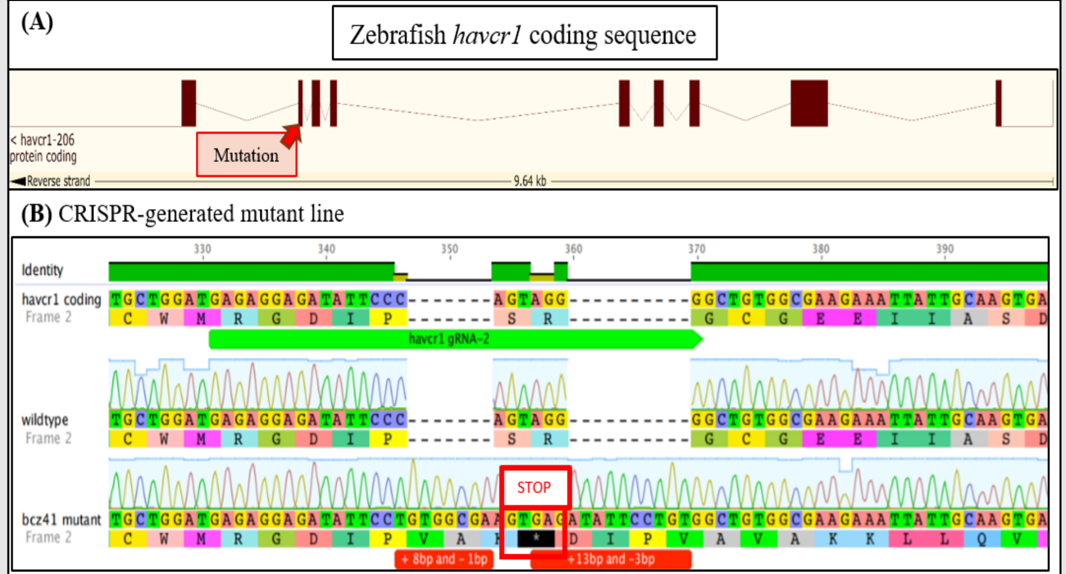
Figure 2: Microglial expression of *havcr1*



(A) Shows *havcr1* expressions in microglia compared to other cell types, measured by RNA-seq in two published studies using adult zebrafish [4,5] **(B)** We used HCR in situ technology [6] to detect *mpeg1* and *havcr1* transcripts in retinas of fixed zebrafish embryos at 3 days post fertilization. **(i)** Shows the expression of microglia using *mpeg1* in a singular section of an embryonic retina, while **(ii)** shows a retina of a different embryo with *havcr1* transcripts labeled. The labeling pattern of the *havcr1* transcript indicates that *havcr1* is indeed expressed by microglia in the developing zebrafish retina.

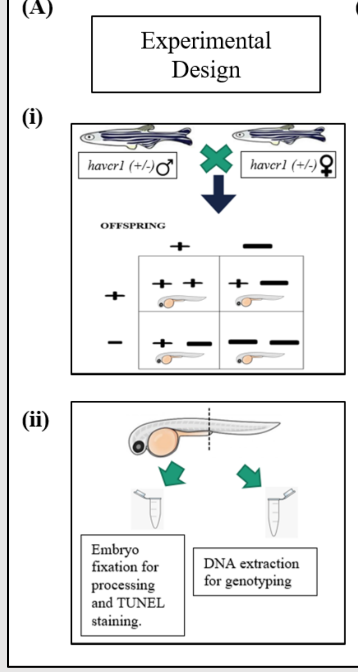
Figure 3: Mutation in zebrafish *havcr1* introduced by CRISPR gene editing.

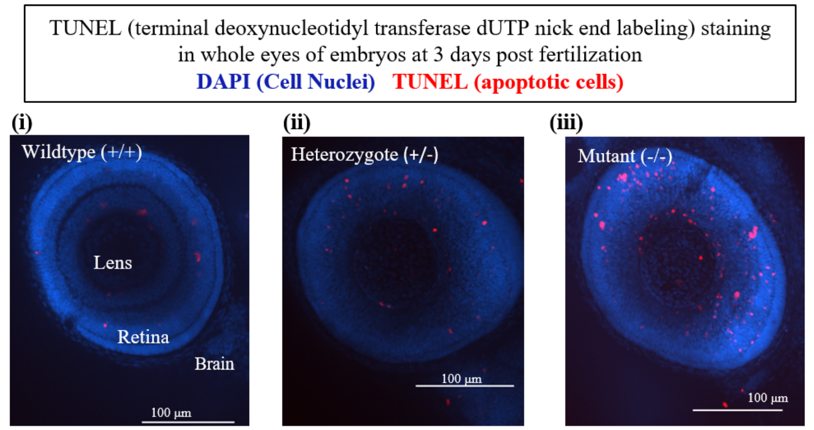


(A) Diagram of the coding sequence for zebrafish *havcr1*, showing exons. The location of the mutation in *havcr1* in the bcz41 zebrafish line is shown with a red arrow. The mutation is located in the second exon. **(B)** Shows the region targeted by the gRNA and containing the CRISPR-generated edits to *havcr1* in zebrafish compared to the wildtype gene sequence. The CRISPR-generated mutant line was gifted to our lab by Dr. Celia Shiau (UNC). The mutant allele introduces a premature STOP codon (red box), which occurs early in coding sequence. The mutation is predicted to be a null mutation, meaning the altered gene product lacks the molecular function expected from a wildtype gene. Since the HAVCR1 protein is likely a receptor for PS, we would then expect to see a higher number of apoptotic cells in *havcr1* mutants due to the lack of recognition and clearance of apoptotic cells by microglia.

Figure 4: Analysis of apoptotic cell clearance during retinal development in *havcr1* mutant zebrafish.

Hypothesis: Loss of *havcr1* leads to failure of microglial clearance of apoptotic cells during development.
Justification: The results from Figure 2 present evidence that *havcr1* is highly expressed by microglia. Microglia are the main cell type responsible for apoptotic cell clearance in the developing zebrafish retina [7]. Since *havcr1* is predicted to code for a PS receptor (Figure 1), it is predicted that *havcr1* mutant retinas will have higher numbers of TUNEL stained cells.





(A)(i) Heterozygous *havcr1* (+/-) parents were crossed to produce offspring (wildtype, heterozygous, and mutant). **(ii)** The offspring were then collected at 3 days post fertilization (dpf) and dissected for DNA extraction/genotyping (tails) and TUNEL staining (heads/body). This timepoint was chosen because microglia are present in the developing central nervous system by 3 dpf and developmental apoptosis is also detected [7]. **B.** TUNEL staining is used for detection of apoptosis. Images show TUNEL+ apoptotic cells (red) in whole eyes of 3 dpf embryos from each genotype. Quantification and statistical analysis of numbers of apoptotic cells will next be performed, to determine if the *havcr1* mutation results in an accumulation of apoptotic cells.

Conclusions

- We have shown that *havcr1* is expressed by microglia in the developing zebrafish retina by showing that *havcr1* transcripts localize to microglia and not other cell types.
- The CRISPR-generated *havcr1* mutant line of zebrafish appears to have more uncleared apoptotic cells than heterozygous and wildtype embryos, although quantification and statistical analyses are still pending.

References

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Evaluation of a Testing Apparatus for High Temperature/High Pressure in Nuclear Pressure Vessel Conditions

University of Idaho College of Engineering

Cody Gibson and Dr. Robert Stephens

Department of Mechanical Engineering, University of Idaho

Abstract:

Mechanical components that operate under high temperatures and pressures in a corrosive environment while being cyclically loaded are prone to the effects of environmental cracking. Dr. Stephens along with other faculty members at UI have submitted several proposals to various agencies with the hope of being awarded a grant that would allow them to begin testing new materials under these conditions. Recently Dr. Stephens was a Co-PI on an NEUP Infrastructure Grant in which the team was awarded the grant to purchase and assemble couple a testing frame / autoclave / circulation loop / controller for material testing. As a result, there is a lot of complex and complicated coupling of the equipment necessary to make it operate correctly and safely. Over the summer I will be tasked with coupling the key components together so that they will be fully functional in the event one of the submitted grants is awarded. I will be performing validation tests that include fatigue and stress corrosion cracking using a candidate stainless steel alloy used in nuclear power plant applications. Initial tests will include room temperature validation followed by high temperature and pressure within the testing apparatus.

Introduction:

Stress corrosion cracking (SCC), fatigue, and fatigue crack growth (FCG) of structural materials has occurred in numerous types of high temperature and pressure water reactors used in the Nuclear Energy Industry. The Department of Energy-Nuclear Energy is looking to increase reactor service life and reliability though the development of new materials that exhibit higher strengths and better fatigue and stress corrosion cracking resistances. Proper characterization of these materials is of upmost importance due to the harsh environments inside of nuclear reactors. Recently the University of Idaho was awarded a DOE Infrastructure grant to enhance the viability and competitiveness of the Nuclear / Mechanical Engineering / Material Science Program. With this infrastructure grant the University was able to sponsor a Mechanical Engineering Senior Design Project that designed and built a testing apparatus capable of testing materials in the same environment seen in nuclear reactors. Implementation and proofing of this system was not completed however, so the testing apparatus was left in an unfinished state. I have been tasked to complete the coupling of this testing apparatus and prove out the system so that it will be ready in the event that the University receives a grant to test new materials under the above conditions.

Methods

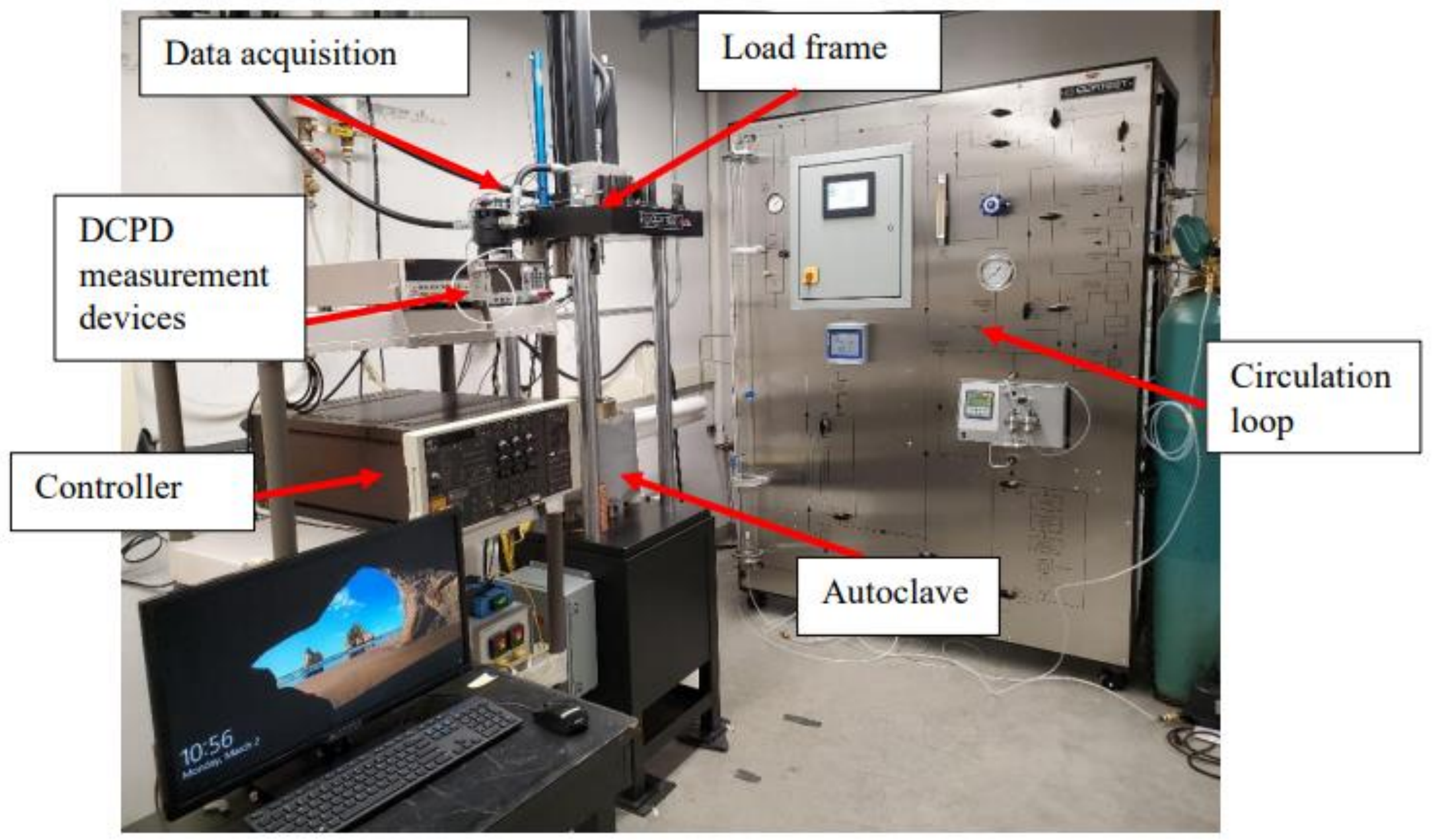


Figure 1. Primary components of experimental testing apparatus. Includes data acquisition, controller, load frame, autoclave, DCPD devices, and circulation loop.

- LabVIEW software has been downloaded to the desktop
- Data acquisition system has been connected to LabVIEW
- Nano voltmeter and power supply for DCPD measurement have been connected to the DAQ
- Controller with micro profiler has been connected to the load frame and is fully functional
- Autoclave heater is connected and has been tested

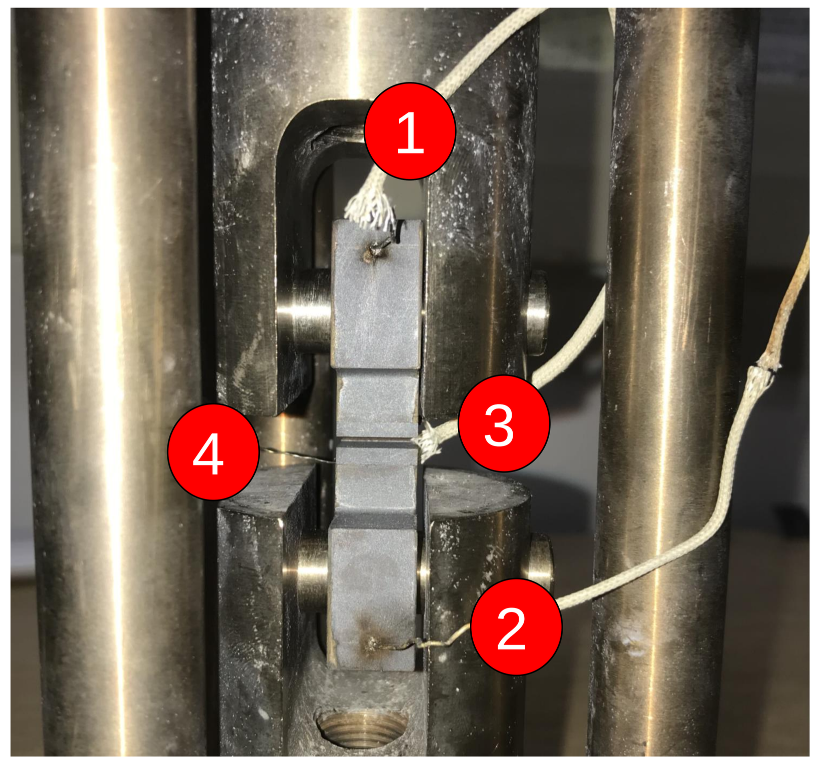


Figure 2. Side view of a compact tension specimen wired for DCPD measurement inside of the load frame grips. Wires 1 and 2 are connected to the power supply, wires 3 and 4 are connected to the nano voltmeter.

Direct Current Potential Drop (DCPD) is the method used for monitoring crack growth. A constant amperage of 2 amps runs through the specimen. As the crack grows there is a change of resistance in the material. The nano voltmeter monitors the voltage change due to the change in resistance. That data is collected and converted into a physical measurement corresponding to crack length.

Results

Figure 3. Old cooling jacket system

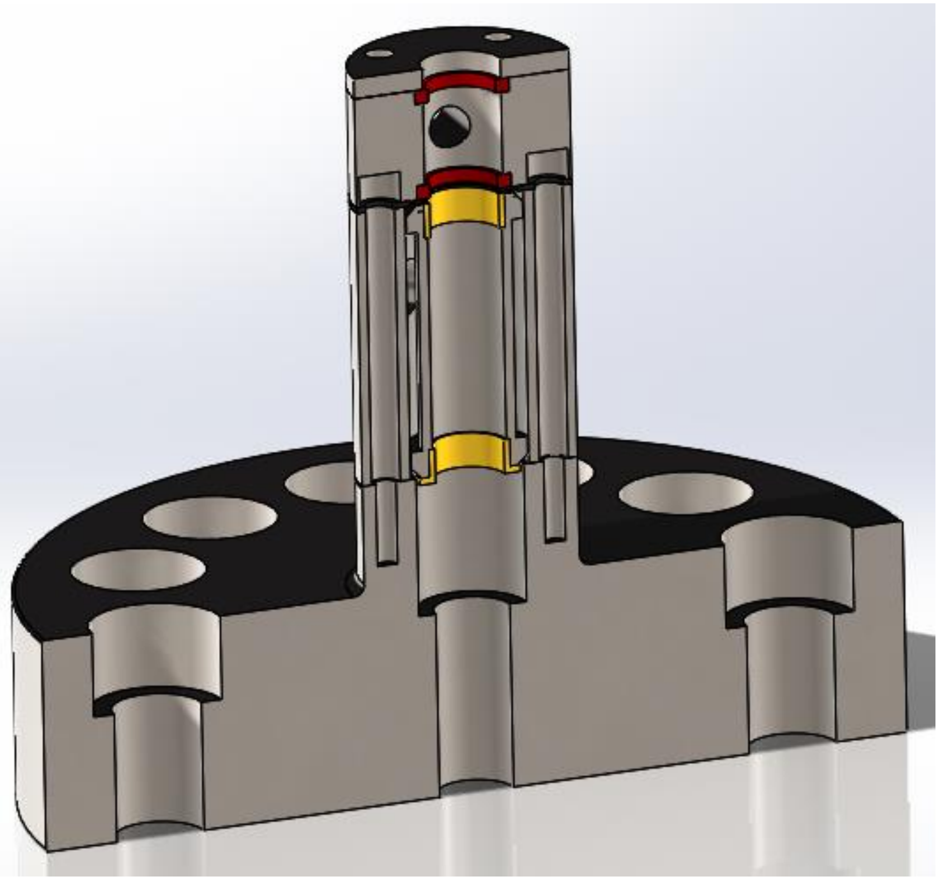


Figure 4. Solidworks model of new cooling jacket system.

While testing the high temperature capabilities of the autoclave a seal failure was found in the cooling jacket that mounts to the lid of the autoclave. Before proceeding to pressure testing in the autoclave a new cooling jacket design was required. The new cooling jacket implements a fail-safe design. There are now 2 rod seals (seen in red in figure 4) and a second chamber between the rod seals. The second chamber will be monitored using a pressure sensor. A significant pressure change in this chamber will indicate a lower seal failure and will let the operator know to stop the test.

Future

- Perform validation tests that include fatigue crack growth and stress corrosion cracking using a candidate stainless steel alloy used in nuclear power plant applications. Testing will be conducted at room temperature for initial validation followed by high temperature and pressure within the testing apparatus.

Acknowledgements

- The project described was supported by a student grant from the UI Office of Undergraduate Research

Exploring the Impact of Macrophages on the Tenogenic Differentiation of Stem Cells

University of Idaho Department of Biological Engineering

Kaitlyn J. Harvey[1], Sophia K. Theodossiou[1], Jett B. Murray[1], and Nathan R. Schiele[1]

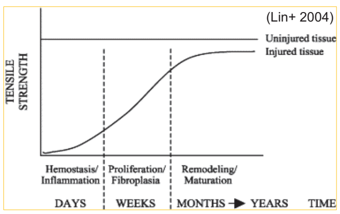
[1]Department of Biological Engineering, University of Idaho, Moscow, ID,

University of Idaho Office of Undergraduate Research

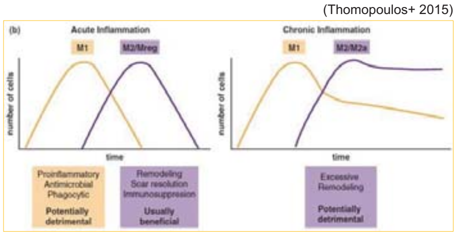
Background

Background:

- Tendon is a soft, flexible, and strong collagenous tissue that connects muscle to bone
- After injury, tendon tissue does not regain the original tensile strength of the uninjured tendon (Lin+ 2004)
- TGFβ2 is linked to tendon cell growth and induces tenogenesis in stem cells
- Inflammatory response is involved in the wound healing process and causes dysfunctional healing in the collagen structure of tendon
- The two stages of the inflammatory response are the pro-inflammatory stage (induces inflammation) and the anti-inflammatory stage (reduces inflammation)
- Macrophages differentiate into different types (M1, M2) that are involved in the different stages of the inflammatory healing response (Thomopoulos+ 2015)
- Inflammation might be regulated by macrophages, but more research needs to be done to determine how macrophages directly impact tenogenesis



(Thomopoulos+ 2015)



Motivation and Hypothesis

Current Problem:
Tendon is prone to injury and has very poor intrinsic healing properties, thus, creating a need for healing approaches that involve tissue engineering.

Objective and Hypothesis:
The overall objective of this research proposal is to *determine the effect of macrophages on tenogenically differentiating MSCs.* This will be done by evaluating how macrophages in co-culture impact the tendon markers produced by tenogenically differentiating MSCs. *We hypothesize that macrophages impact tenogenesis.*

Long-Term Goal:
We would like to learn more about the role of macrophages in tenogenesis so we can better understand the regenerative properties of tendon, allowing us to engineer specific and practical approaches to improve tendon regenerative medicine.

Experimental Plan

Task 1

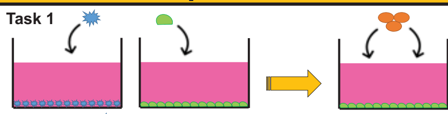


Fig. 1 MSCs and RAW 264.7 macrophages are cultured separately. Macrophages are supplemented with TGFβ2 to test if they are impacted by the growth factor.

Task 2

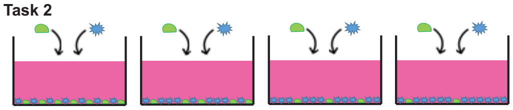


Fig. 2 MSCs and macrophages co-cultured directly at different densities (1:1, 3:1, 6:1, and 10:1) to determine the viability of a co-culture.

Task 3

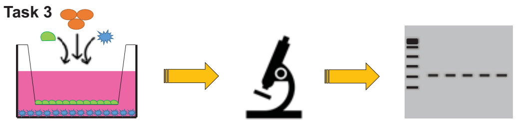


Fig. 3 MSCs and macrophages are indirectly co-cultured in Transwell plates and supplemented with TGFβ2. Samples are stained and imaged using Dapi and Phalloidin staining. Western Blot analysis is used to determine protein levels of scleraxis and tenomodulin.

Macrophages are Viable in TGFβ2

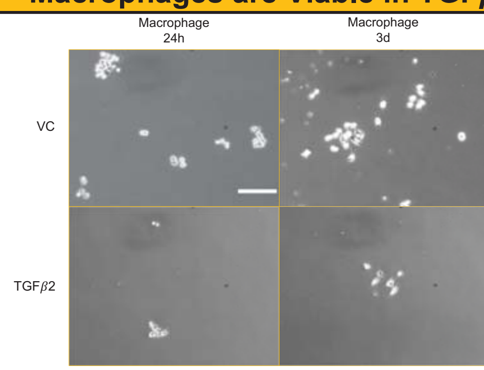


Fig. 4 Macrophages were seeded at a density of 500 cells/cm^2 (Dakin+ 2017). Vehicle control (VC) was sterile water and treatment was TGFβ2. After 24 hours and 3 days of TGFβ2 treatment, the macrophages were still viable in culture. Images were taken from the same VC well and the same treatment well. Scale bar = 250μm

Preliminary Seeding Densities

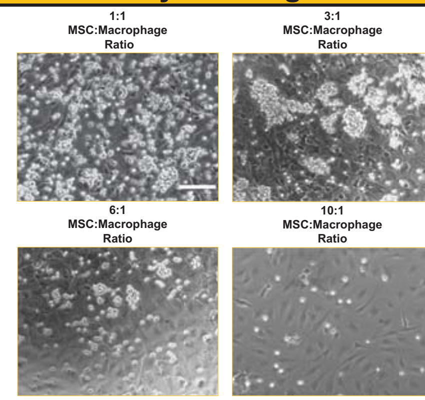


Fig. 5 MSC and Macrophage Direct Co-Culture. MSCs, seeded at 5000 cells/cm^2, and macrophages, seeded at 5000, 1667, 833, and 500 cells/cm^2, were directly co-cultured and imaged after 3 days. Both MSCs and macrophages survived in co-culture for each seeding density. The 10:1 ratio was chosen for further experimentation with macrophage and MSC co-culture with TGFβ2. Scale bar = 250μm

MSC to Macrophage Ratio	MSC Seeding Density (Cells/cm^2)	Macrophage Seeding Density (Cells/cm^2)
1:1	5000	5000
3:1	5000	1667
6:1	5000	833
10:1	5000	500

Table 1. Breakdown of MSC and macrophage seeding ratios and their corresponding seeding densities.

Conclusion & Future Directions

- RAW 264.7 macrophages and MSCs survive in direct co-culture
- RAW 264.7 macrophages are viable after TGFβ2 supplementation
- *Future experiments will further explore what the macrophages are producing to potentially impact tenogenesis (pathways, signaling molecules, etc.)*
- This will better inform tissue engineering practices on in-vivo tissue environments

Acknowledgements

This project was supported by the Summer Undergraduate Research Fellowship (SURF) through the Office of Undergraduate Research (OUR) at the University of Idaho.

Milk Processing by Nonthermal Liquid Plasma Discharge Technology

Elisabeth Nickell, Yuan Yuan, Sarah Wu, Jordan Ommanney, and Celiannie Rivera

Department of Biological Engineering, University of Idaho, Moscow, ID

Introduction

In 1938, 25% of all disease outbreaks associated with contaminated food and water stemmed from milk-borne outbreaks hence high temperature short time pasteurization was developed [1-2]. This method does not effectively eliminate of heat-resist pathogens, requires large cost-intensive energy inputs, results in losses of 33% of thiamine and 50% of vitamin B12 in raw milk, and leads to a reduction in milk quality by decreasing vitamin E content and enzymes [3]. This has led to additional research into the application of nonthermal technologies to improve milk quality with novel milk processing methods.

Nonthermal liquid plasma discharge (NTLPD) is a promising nonthermal technology that inactivates microorganisms under more mild conditions, while meeting microbial safety standards and preserving bioactive compounds that are essential to the quality and composition of milk. Utilizing high voltage power in contact with liquid to produce a plasma discharge reaction from and electron avalanche, NTLPD has been shown to microbicidal and promising in industrial applications [4-5].

The purpose of this study is to further the research on the inactivation of microorganisms using nonthermal liquid plasma technology for milk pasteurization while focusing on the impact of product quality nutrient composition.

Objectives

1. Determine the feasibility of utilizing nonthermal liquid plasma discharge for milk processing
2. Optimize the NTLPD reactor based on the effect of milk flow rate and carrier gas flow rate on the total bacteria inactivation
3. Investigate physical and nutritional qualities of the NTLPD treated milk that pass FDA Grade A Pasteurized Milk Ordinance
4. Determine if NTLPD technology is an energy efficient option for milk processing

Materials and Methods

Materials

- Raw milk was used to develop the procedure and efficiency of the system for preliminary testing.
- During the major experiments, pasteurized milk inoculated with bacteria isolated from raw milk will be treated to characterize microbial inactivation.
- Samples are stored at 4°C and plated on TSA medium and incubated at 37°C for 72 hours, with CFUs (colony forming units) recorded every 24 hours. Serial dilutions were performed, and the microbial inactivation will be reported in log reduction of total bacteria.

Experimental Set Up

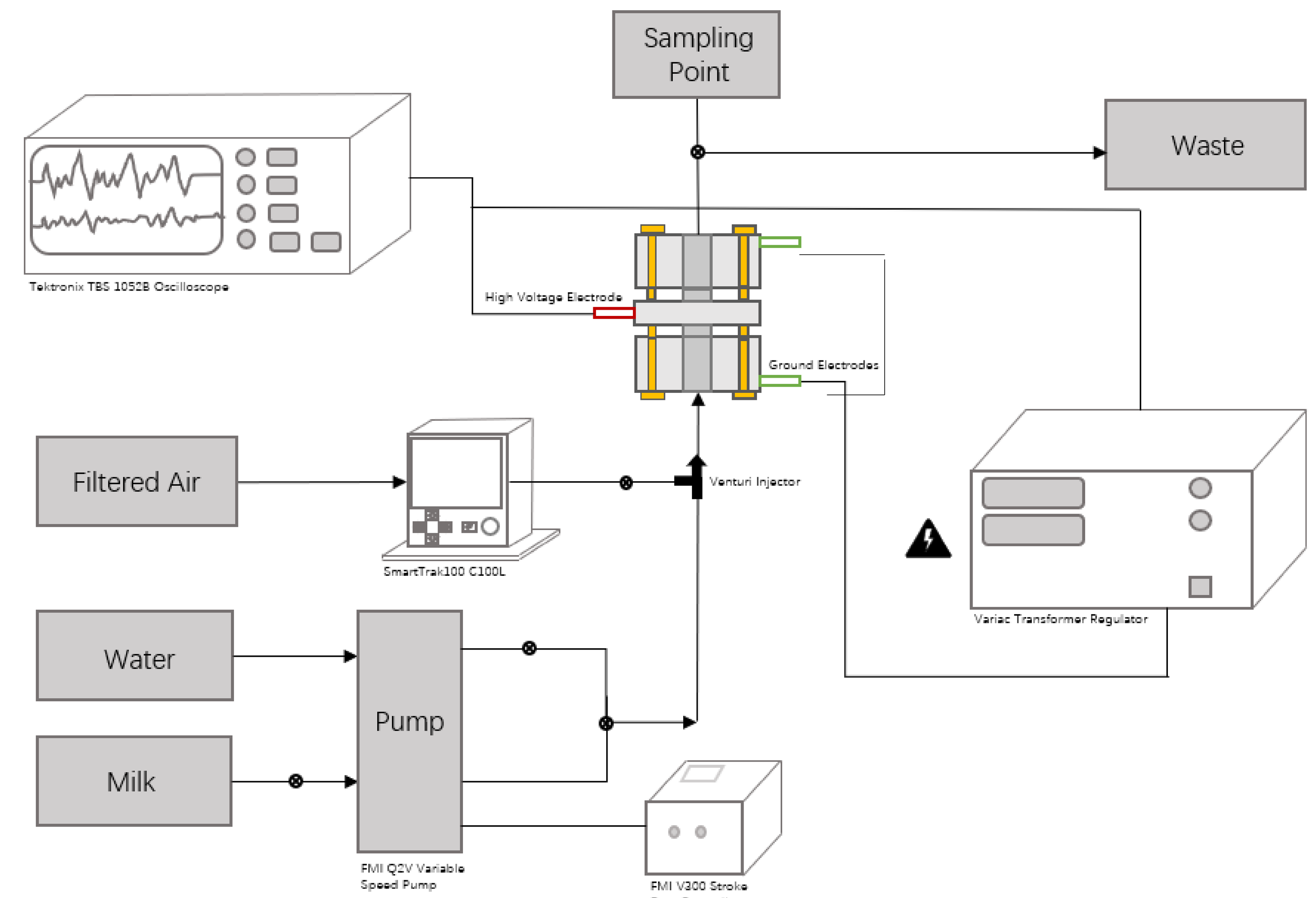


Figure 1. System diagram.

Experimental Design

The preliminary testing stage will be determining the influential factors and feasible variable input ranges using Design-Expert® software. Air flow rate, milk flow rate, and power were used as input variables and pH, conductivity, applied voltage, as well as total bacteria log reduction rate were placed in the software as responses. Further testing will determine optimum variable parameters and assess the quality of the NTLPD treated milk on top of satisfying microbial inactivation. Lastly an energy assessment will be conducted to determine the energy efficiency of the system as compared to other nonthermal milk processing techniques found in literature.

Preliminary Results

Initial results suggest that the non-thermal liquid plasma discharge technology in this novel two-phase water priming design decreases the risk of bacterial contamination with 100% bacterial inactivation achieved at the power input of 200-watt, milk flow rate at 40 mi/min, and air flow rate controlled at 1 L/min.

This provides a basis to meet the project objective #1 by showing that NTLPD technology could be a feasible option for fast and efficient milk processing.

Future Directions

The aim of this project is to determine the feasibility of milk processing using NTLPD technology and optimize the system and procedures. The accomplish this, we will:

- Use inoculated pasteurized milk for testing to determine parameter values that optimize microbial inactivation in log reduction of total bacteria.
- Assess the quality of the treated milk and analyze comprehensive milk quality breakdowns from laboratory screened samples.
- Analyze the viability of NTCLD technology for and industrial scale milk process by determining the energy efficiency of the process.

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University of Idaho
Office of Undergraduate Research

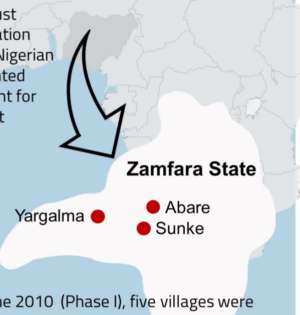
Acknowledgements

Funded by Undergraduate Research Grant from the OUR at University of Idaho.

Spatial Analysis of Soil Lead Exposures from Lead Poisoning Tragedy in Artisanal and Small-Scale Gold Mining Villages of Zamfara, Nigeria

Madison Thurston[1], Margrit von Braun[1,2], Ian von Lindern[2], Casey Bartrem[2]
1. University of Idaho
2. TerraGraphics International Foundation

Background



In 2010, several remote northern Nigerian villages experienced unprecedented mass lead poisoning resulting in the death of over 400 children in three months.[1] Artisanal gold ore processing resulted in severe lead exposures via incidental soil/dust ingestion. TerraGraphics International Foundation (TIFO), Médecins Sans Frontières (MSF), and Nigerian health and environmental agencies implemented emergency remediation and medical treatment for exposed children. Handheld X-ray Fluorescent Spectrometer (XRF) was used to assess contamination before and after remediation, resulting in a database of >10,000 soil lead concentrations. The interdisciplinary project team remediated eight villages in Zamfara State, including 820 homes, reducing exposures for nearly 3000 children and 16,000 community members.[2] Two villages were assessed and remediated from May-June 2010 (Phase I), five villages were addressed from Sept 2010-March 2011 (Phase II), and one village was remediated in 2013 (Phase III). Pre-remediation residential *in-situ* XRF soil lead levels averaged 1,113 mg/kg (range 19 - 35,380 mg/kg), and decreased to average 94 mg/kg post-remediation.[3] Geometric mean blood lead levels decreased from 149 µg/dL pre-remediation to <30 µg/dL post-remediation.[2,3]

Figure 1. (Left to right) Incidental ingestion of soil and dust is a significant source of children's exposure to environmental contaminants; remediation crew removing contaminated soil in a compound; Zamfara Environmental Sanitation Agency using XRF to measure lead in compound soil.

Objectives

1. Use XRF database to quantify spatial variability in *in situ* soil lead concentrations for each home, neighborhood, and village
2. Determine spatial factors with potential impact on children's exposure

Methods

1. Organize and geolocate data
   Compare XRF data to compound (home) and exterior (common) area maps to confirm correct soil lead concentration for each location. Import soil lead data into ArcGIS™
2. Compute summary geo-statistics for compounds, exteriors, and neighborhoods
   Use three-step spatial model to determine neighborhood means for each compound, inclusive of exteriors, at radius lengths of 100-500' at 100' increments

3a. Find exterior effects
   Repeat step 2 by examining neighborhood means of exteriors and neighborhood means of interiors, excluding surrounding exteriors

3b. Neighborhood analysis
   Use the Cluster and Outlier Analysis ArcGIS® tool and Anselin Local Moran's I statistic to identify compound outliers and clusters

Results

- Compared to the Phase I village (Yargalma), Phase II villages (Sunke and Abare) have lower community means and greater variability in lead concentrations, resulting in clusters of high or low areas (Fig 4a-c)
- Depending on a child's independent mobility, children from the same home may have different exposure severity (Fig 5a-c)
- Children in Phase II compounds with low soil lead concentrations can experience high exposure if living in a high neighborhood (and vice versa) (Fig 6a-c)
- Exterior areas with wells and where grinding occurred have higher concentrations of lead than other types of exteriors (data not shown)

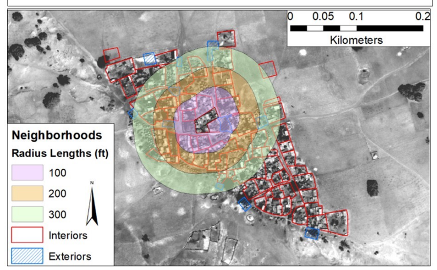


Figure 2. Yargalma village map showing the radius areas of 100', 200', and 300' used to calculate the neighborhood means (400' and 500' not shown)

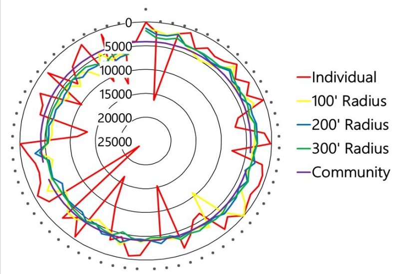
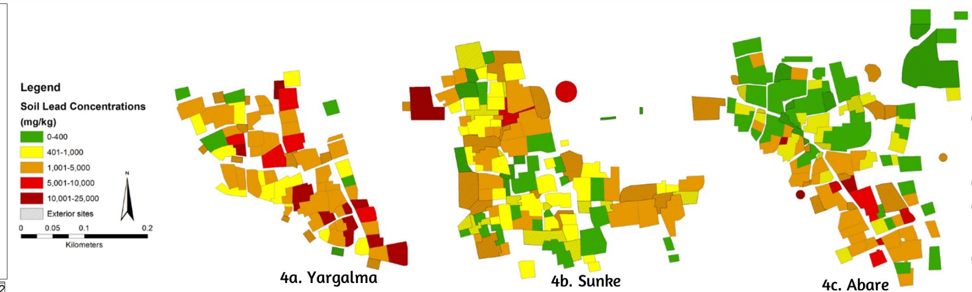
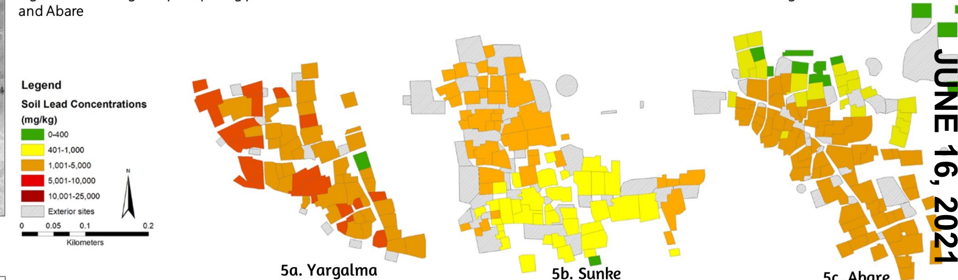


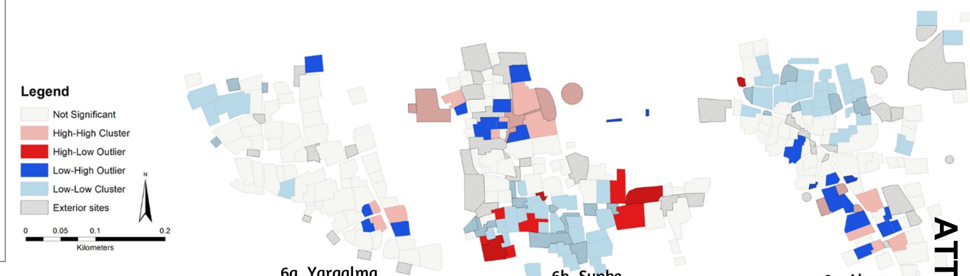
Figure 3. Radar graph of Yargalma showing pre-remediation soil lead concentrations for individual homes, neighborhood areas at radius lengths of 100', 200', and 300', and the overall community mean. Each dot around the outer circle represents one compound.



Figures 4a-c. Village maps depicting pre-remediation mean soil lead concentrations of individual homes and exteriors for Yargalma, Sunke, and Abare



Figures 5a-c. Village maps depicting the neighborhood pre-remediation mean soil lead concentrations for each home using a radius of 200 feet



Figures 6a-c. Village homes grouped by hot and cold spots relative to surrounding homes. Low-low and high-high homes are significant among similar nearby concentrations (low home in a low surrounding area or high home in a high surrounding area, respectively). Low-high and high-low homes are significantly different from nearby areas (low home in a high area and high home in a low area, respectively)

Discussion and Conclusions

This study demonstrates the influence of neighborhood size and compound location on child lead exposure. To account for the wide variation of contamination between homes, neighborhoods, and communities, a combination of soil lead concentrations from each is important in predicting exposure. The Nigeria lead poisoning tragedy provides a unique opportunity to better understand heavy metal exposures in low-income, subsistence communities, where environmental health crises are seen with increasing frequency.[4] Eighty-two percent (82%) of lead poisoning deaths occur in low and middle-income countries and children under the age of five are at the highest risk.[5] Analysis of XRF data from the Zamfara crisis can be applied to other artisanal mining communities.

Future Analyses

- Complete pre-remediation radius analyses for remaining Zamfara villages and look for patterns among phases, neighborhoods, etc.
- Examine proximity to high-concentration exterior areas as a potentially significant exposure variable
- Complete similar analyses using post-remediation and Remedial Effectiveness Evaluation (REE) soil lead data; assess differences between pre, post-rem, and REE spatial results
- Use existing geo-located blood lead level dataset and the Integrated Exposure Uptake Biokinetic (IEUBK) model to determine the best fitting radius value for a typical child's neighborhood

University of Idaho
TIFO TERRAGRAPHICS INTERNATIONAL FOUNDATION

Acknowledgments

This project was funded by a SURF award from the U of I Office of Undergraduate Research. The analysis was supported by TerraGraphics International Foundation (TIFO). Data were generated during emergency response activities and collected by Zamfara State Environmental Sanitation Agency (ZESA), Anka Local Government Area (LGA), and Anka Emirate, with the support of Médecins Sans Frontières (Doctors Without Borders, MSF) and TIFO.

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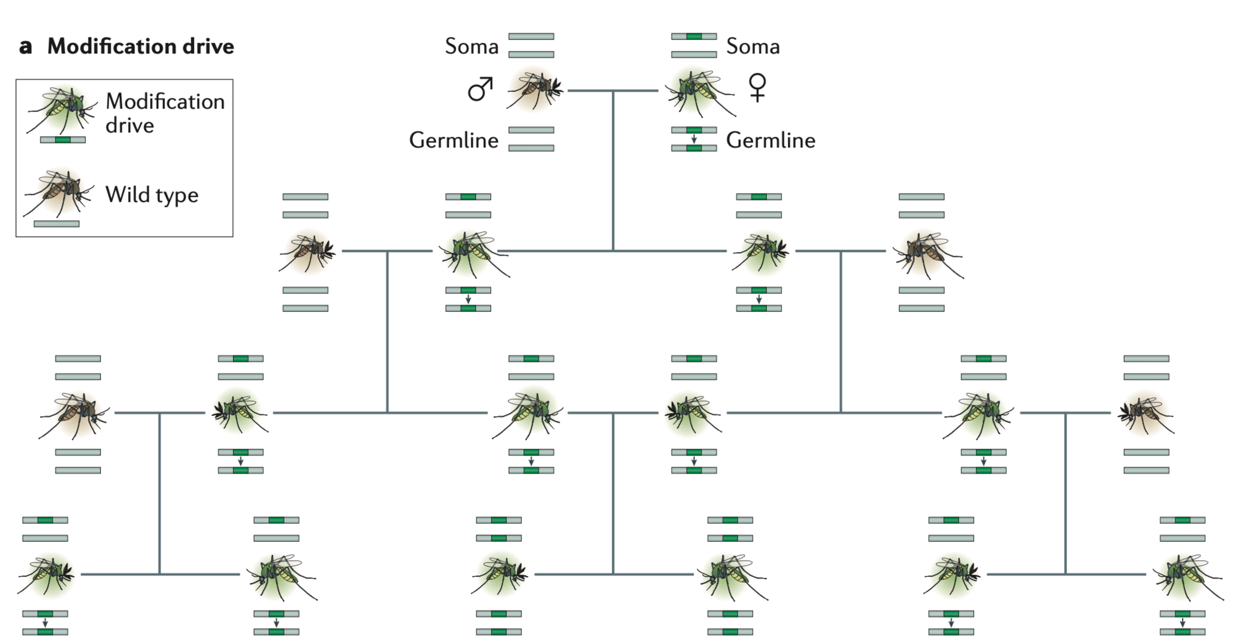
Population Structure Affects Outcomes of Gene Drive Interventions Against Vector-borne Diseases

Mete K. Yuksel (1), Christopher H. Remien (1), Bandita Karki (1), James J. Bull (2), Stephen M. Krone (1) — University of Idaho Departments of Mathematics (1) and Biological Sciences (2)

Abstract. Proponents of so-called "gene drives" promise freedom from some of the most pressing public health and ecological challenges of the day, arguing that genetic engineering and similar technologies could be used to eliminate vector-borne diseases like malaria. However, genetic interventions against disease will likely prove imperfect—leaving pockets in which parasite persistence and evolution are possible. To understand the effect of such imperfections on genetic interventions against disease and the role of space in interventions more generally, we build and analyze metapopulation models of vectored disease characterized by distinct functional forms of transmission. We find that movement of humans between localities, as well as differences in mosquito ecology, shape the nature of infection globally. Further, we hypothesize that discrete spatial structure has profound evolutionary implications, allowing for a parasite to accumulate successive mutations and expand its initial range. Altogether, our results illustrate the nuanced reality of interventions, both genetic and not, against vector-borne disease: population structure, mosquito biology, and evolution together determine where eradication is possible, and where it isn't.

Background: genetic interventions against disease

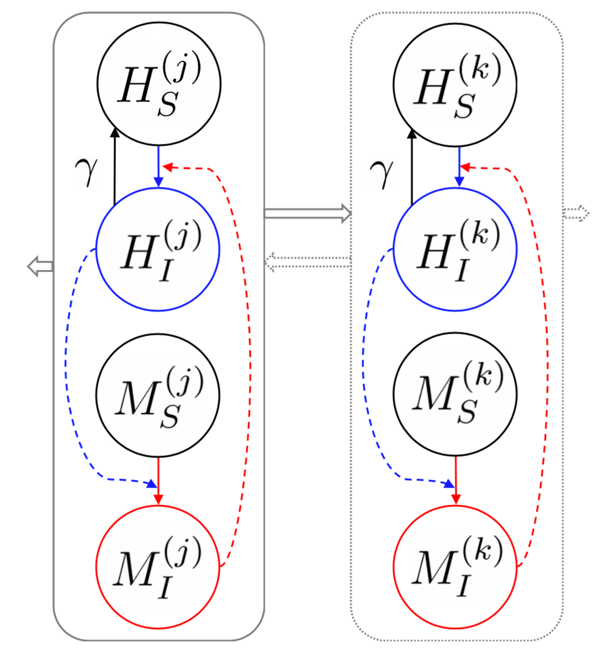
Champer, J., Buchman, A., & Akbari, O. S. (2016). Cheating evolution: engineering gene drives to manipulate the fate of wild populations. *Nature Reviews Genetics, 17*(3), 146–159.



- Two kinds of "gene drives" to control vectored diseases
  - 'Lethal' drives reduce vector population sizes
  - Drives carrying genetic 'cargo' to depress parasite transmission (from vector to human)
- Introducing the bacterial symbiont *Wolbachia* suppresses parasites in the vector population
- Population and spatial structure have been shown to affect outcomes of gene drive interventions
  - Example: inbreeding reduces the number of heterozygotes in population, prevents spread of drive
  - Earlier work predicted that softening spatial structure facilitates parasite eradication

Mathematical model: patch structure and transmission assumptions

Model tracks susceptible and infected humans and mosquitoes in *n* patches



- Transmission dynamics
  - Susceptible humans become infected from the bite of an infected mosquito
  - Susceptible mosquitoes become infected from the bite of an infected human
  - Mosquitoes are infected for life; humans are susceptible again following recovery
- Movement between patches
  - Mosquitoes do not move
  - Humans identified with a home patch, spend a fraction of their time in other patches

$$\dot{H}_I^{(k)} = \underbrace{H_S^{(k)} \cdot B(\alpha) \cdot \left[\sum_{j=1}^{n} \left(\tilde{H}^{(j)}\right)^{-\alpha} \cdot c_{kj} \cdot a_{MH}^{(j)} \cdot M_I^{(j)}\right]}_{\text{infection of patch } k \text{ humans}} - \underbrace{\gamma \cdot H_I^{(k)}}_{\text{recovery}}$$

(density of infected patch *k* humans)

$$\dot{M}_I^{(k)} = \underbrace{\left(\tilde{H}^{(k)}\right)^{-\alpha} \cdot B(\alpha) \cdot a_{HM} \cdot M_S^{(k)} \cdot \left[\sum_{j=1}^{n} c_{jk} \cdot H_I^{(j)}\right]}_{\text{infection of patch } k \text{ mosquitoes}} - \underbrace{\delta \cdot M_I^{(k)}}_{\text{death}}$$

(density of infected patch *k* mosquitos)

Notation	Description
γ	recovery rate (i.e., 1/mean duration of disease)
α	$\alpha = 0$ gives density-dependent transmission $\alpha = 1$ gives frequency-dependent transmission
B	mosquito biting rate, function of α
λ_k	mosquito birth rate in patch k
δ	mosquito death rate (i.e., 1/mean mosquito lifetime)
c_{kj}	fraction of time patch k humans spend in patch j
a_{HM}	human-to-mosquito transmission probability
$a_{MH}^{(k)}$	patch k mosquito-to-human transmission probability

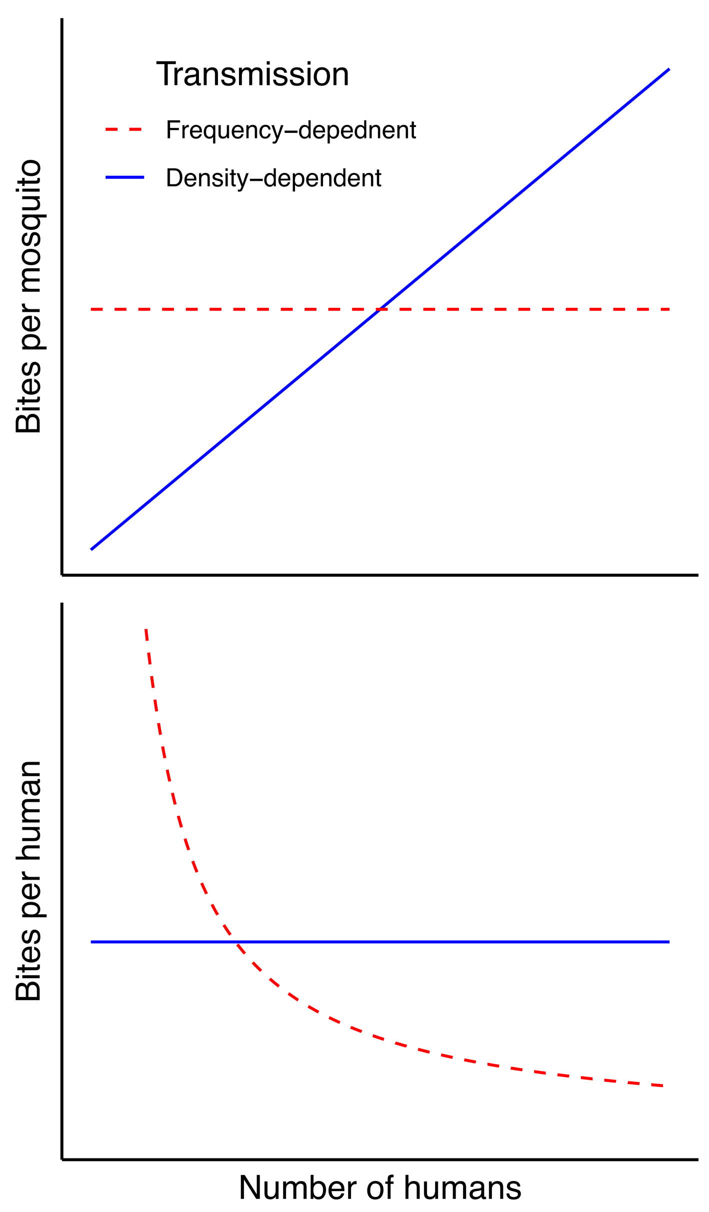
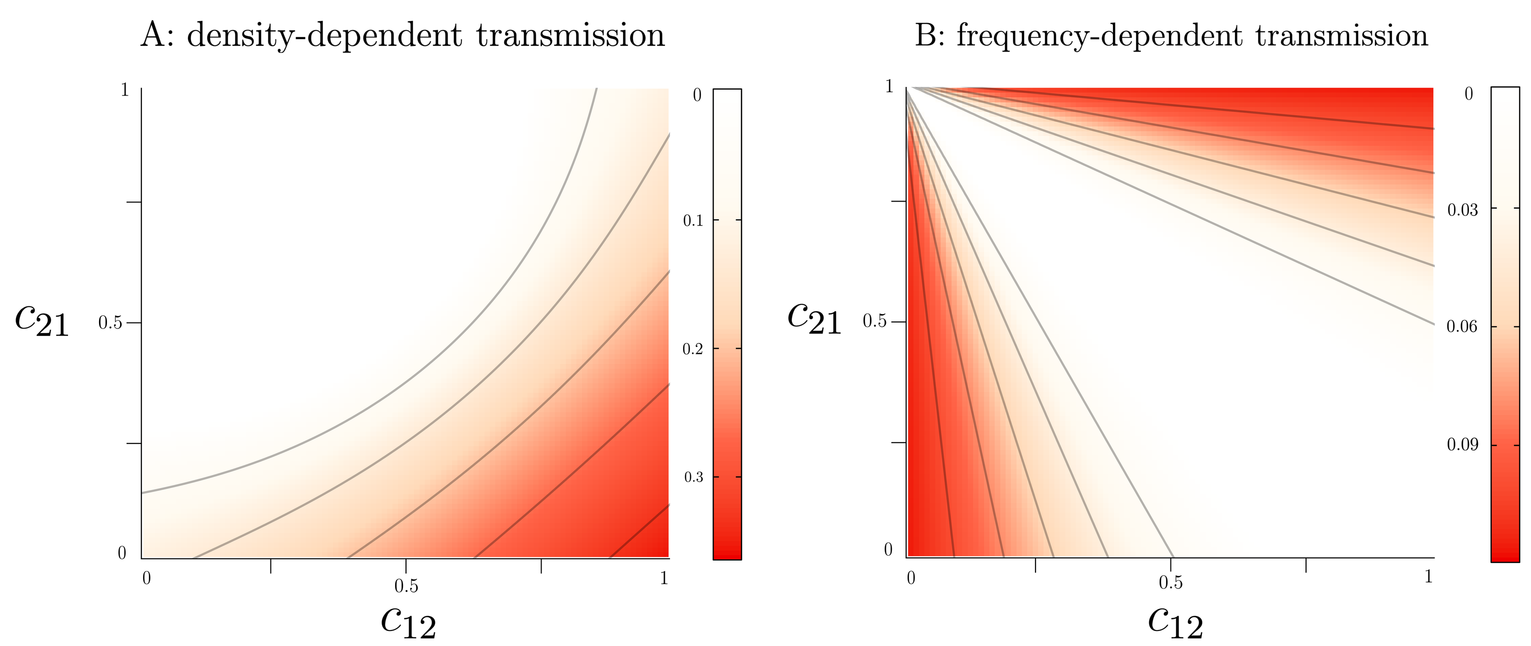


Figure 1. Two models of mosquito ecology and transmission dynamics.
- In the density-dependent model, the mosquito-human transmission rate is proportional to the density of infected humans. This means that mosquitoes work harder to dole out bites as more humans enter a given patch.
- In the frequency-dependent model, the mosquito-human transmission rate is proportional to the frequency of infected humans. This means that mosquitoes dole out fewer bites per human as more humans enter the patch.

Characterization of steady states and the basic reproduction number



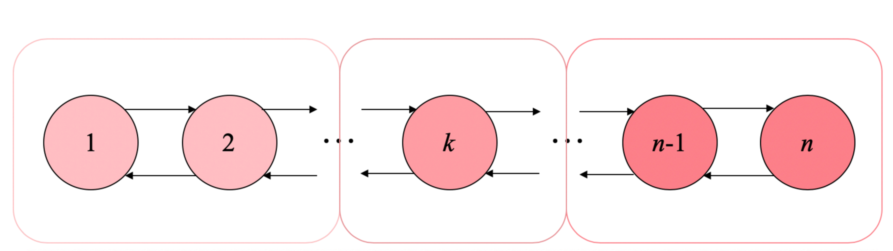
- In a given patch, the basic reproductive is the expected number of mosquitoes infected by a single infected mosquito in a completely susceptible population.
- Mathematically, the basic reproduction number of the metapopulation is the leading eigenvalue of the matrix *R* whose entries are:

$$R(m,l) = \frac{1}{\gamma \cdot \delta} \cdot B^2 \cdot \left(\tilde{H}^{(m)} \cdot \tilde{H}^{(l)}\right)^{-\alpha} \cdot a_{HM} \cdot a_{MH}^{(l)} \cdot M^{(m)} \sum_{j=1}^{n} c_{jm} \cdot c_{jl} \cdot H^{(j)}$$

- Depends on transmission assumptions, as well as visitation
- Simulations confirm the basic reproductive number gives the correct the threshold for stability of the disease-free steady state

Figure 2. Contour plots of the steady-state fraction of infected humans as a function of the visitation parameters reveal a fundamentally different effect of human movement under density dependence (left) than under frequency dependence (right).
- The density-dependent equilibrium fraction of infected increases as more humans move from the drive-protected patch (1) to the unprotected patch (2). Conversely, the infection diminishes as humans spend more of their time in the protected patch.
- This effect is reversed in the frequency-dependent case: travel to the unprotected patch reduces infection (because the addition of humans results in a "swamping effect" which insulates the unprotected patch), while travel into the protected patch amplifies infections elsewhere.

Future work: spatial evolution of the parasite—when can mutants invade drive-protected patches?



$$a_{MH}^{(1)} < a_{MH}^{(2)} < \cdots < a_{MH}^{(k)} < \cdots < a_{MH}^{(n-1)} < a_{MH}^{(n)}$$

Figure 3. Schematic of the model with (i) linear ordering of patches by drive efficiency, (ii) nearest-neighbor movement, and (iii) mutation illustrates how the parasite may evolve in space.
- Patches where the wild-type pathogen can successfully invade are colored light red; patches colonized by mutants spawned over the course of the epidemic are colored increasingly darker shades of red.
- We aim to characterize if/when the wild-type pathogen can accumulate mutations and invade initially-protected patches. A parallel approach would be to study if mutation could save the parasite from extinction.

Conclusions

- Spatial structure and mosquito behavior together shape long-run disease outcomes—there is no universal effect of softening spatial structure.
- Travel to and from sources of infection have global consequences, with the effects reversed between the density- and frequency-dependent models.

Acknowledgements

- MKY thanks the Office of Undergraduate Research at the University of Idaho for financial support, as well as Courtney Schreiner and Samuel Johnson for useful discussions on the topic of this work.

HERC/IGEM Project

Yr 2: Annual Progress Report

Project Title: Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management

Principal Investigator: Dr. Karen Humes

Institution: University of Idaho (lead) with subcontracts to Boise State University and Idaho State University

Grant Number: IGEM19-001

Award Amount: $700,000

Fiscal Period: July 1, 2019 – June 30, 2020

Progress Report Submitted to SBOE: June 30, 2020

Reporting Period: July 1, 2019 – June 30, 2019

Table of Contents

1) Summary of project accomplishments for reporting period and Plans for Yr 3:

The accomplishments and plans for the four primary tasks identified in the original proposal are summarized here (Tasks A-D). A summary of accomplishments for the overall project management and coordinated stakeholder engagement activities are also summarized below, listed as Task E.

The team would like to stress that our partnerships with producers, processors, municipal treatment personnel and water management entities (private and public) are fundamental to all of our tasks and our project as a whole. Our Yr 2 activities have been influenced and enhanced by interactions with our Stakeholder Advisory Board (described in more detail under Task E below) and interactions with other stakeholders as well.

Task A) Recovery of energy, nutrients, water and bioproducts from waste streams: bench to place-based pilot projects

Team: Erik Coats (UI, environmental engineering/molecular biology; emphasis on resource recovery from waste streams); Armando McDonald (UI, biomass conversion and bioproducts); Kevin Feris (BSU, algae-based resource recovery and microbial ecology))

Team background and overall goals:

This team collaborated for 10+ years and has the required multidisciplinary experience to integrate biological, chemical, physical and thermal approaches to the recovery of energy, bioproducts and nutrients from multiple waste streams. The team is leveraging investments made by the INL, CAES, HERC, and the IGEM incubation fund. Over the last 10 years our efforts have resulted in multiple extramurally funded awards, student training opportunities, scientific publications and a pending patent. We have worked across bench and pilot scales. Recent support from SBOE HERC allowed us to build a pilot scale system to convert dairy waste to value added products (biogas, bio-plastic, algal biomass); previous HERC funding supported construction of two pilot systems at UI by Dr. Coats–one located at the Moscow WWTP, designed for municipal wastewater and one mobile system (24 ft. trailer) designed for dairy manure resource recovery. We are engaged in testing, validating, and extending these systems to evaluate opportunities to recover high-value products (bioplastics, algae, biofuels) from industrial/municipal wastewater while achieving treatment. Research is focused on further understanding/optimizing our integrated system to maximize utility across input streams and demonstrate “real-world” applicability. Research objectives will further technology interrogations and advance wastewater as an economic resource. Ultimately, research will advance solutions that can be applied in Idaho agricultural and food processing sectors; producing economic value from waste will enhance Idaho-based industries by diversifying product portfolios.

Accomplishments this reporting period:

The following provides detail of progress in the first half of Year 2, building from Year 1 successes, towards the aims described in the original proposal.

i. Bench scale: Assess and evaluate nutrient recovery, energy reduction, bioplastics production, and algal production strategies to inform pilot scale operations.

a) Assessment of optimal process sequences (biological, chemical, physical, thermal) to recover energy, bioproducts (biofuels; bioplastics) and nutrients from mixed waste.

- (Coats) Bench-scale EBPR bioreactor operations continue to be operated and evaluated. One current focus is analysis of process "success" vs. "failure." Stable operations of any resource recovery system at full scale demands intrinsic knowledge on what constitutes stable operation, and how unstable, or "failed," operations might be recovered. Investigations are being conducted using macro- and molecular-level methods.
- (Coats) Phosphorus recovery from wastewater is most sustainably and reliably achieved through a process known as enhanced biological phosphorus removal, EBPR. Bench-scale EBPR operations are ongoing, with a focus on ascertaining the effects of key process operational criteria on maximal P recovery. Building from past research efforts, current investigations are focused on two operational scenarios that integrate a new operational strategy. One operational scenario feeds all wastewater to the bioreactor at one time (beginning of the cycle), while the 2nd strategy feeds a more targeted, controlled wastewater (VFA-rich fermenter liquor) at the beginning of the cycle and then the raw wastewater stream at the end of the anaerobic period. The former operational strategy is identified as the A/O process, while the latter is known as the Westbank process. A central question relates to understanding the effect of adding VFAs outside of the anaerobic period. In Y2 research was expanded to incorporate a new operational strategy that involves oxidation-reduction (redox) control of the anaerobic period. Research suggests that "deep anaerobic" conditions can enhance and stabilize EBPR; we are utilizing real-time redox process control to further evaluate this operational strategy and its impact on operational "success" vs. "failure." Results will ultimately inform pilot (2020) and full-scale operations.
- (Coats) Another current focus is on achieving stable nitritation in an activated sludge wastewater treatment system achieving carbon, ammonia-N, nitrite-N, nitrate-N, and phosphorus removal. Nitritation is a biological process whereby ammonia-N is oxidized only to nitrite. Process success will result in significant energy savings in wastewater treatment. Process success was realized at both bench and pilot scale in late Y1 and in Y2; results are being reviewed to inform 2020 pilot operations, and also to generate a peer-reviewed publication
- Complementing the nitritation research are efforts to understand and better characterize denitritation, with the aim to further optimize the EBPR process for energy efficient nutrient recovery. Nitrate is a contaminant of concern in drinking water, and often must be removed from wastewater prior to discharge to the water environment. A primary concern with conventional EBPR processes that integrate nitrite/nitrate reduction is the potential production of nitrous oxide, which is a very potent greenhouse gas (300X CO_2). Bacteria exhibit variable metabolic pathways to reduce nitrate vs. nitrite; some bacteria cannot reduce nitrate to nitrite, which requires a more complex microbial culture to successfully eliminate nitrate from the wastewater. Ongoing efforts by one of Coats' PhD students is

centered on better understanding the metabolic capabilities of bacteria and how they reduce nitrate vs. nitrite.

- One of Coats' PhD students conducted intense evaluations of the dairy-based PHA pilot in Y1/Y2, with very successful results. Ongoing efforts are focused on finalizing and submitting a peer-reviewed journal manuscript that details the results from these investigations; the publication will be submitted in June 2020. The manuscript includes numerous team members, including McDonald's research team. Coats' PHA pilot also went into operation in spring 2020; a primary focus is to couple Coats' PHA pilot with his EBPR pilot to evaluate broader process integration for enhance waste resource recovery.
- Algal cultivars were used throughout year 2 for routine experimental deployment. On-going experiments continue to be focused on cultivation at both bench and pilot scales employing wastewaters from multiple sources (e.g. currently dairy and municipal provided by the Coats lab and the City of Boise, respectively) to maximize nutrient capture and algal biomass production as well as production of high-value PUFA enriched algal biomass. Bench scale experiments have identified which strains produce optimal levels of biomass under various cultivation conditions and have been translated to pilot-scale operations of our greenhouse-based algal cultivation systems. Current bench scale experiments continue to assess the utility of municipal sourced struvite to cultivate high value algal biomass under controlled conditions, while simultaneously capturing struvite sourced nutrients (e.g. nitrogen (N) and phosphorus (P)). We are continuing to work with three algal strains known to produce high concentrations of omega-3 fatty acids under the proper cultivation conditions (i.e. *Chlamydomonas reinhardtii*, *Nannochloropsis oculata*, and *Paeodactylum tricornutum*). Initial experiments suggested that certain modifications to the cultivation conditions were required to obtain significant levels of growth when using struvite as the primary nutrient source. These experiments not only direct future work for optimization of algal cultivation on municipal struvite, but are also potentially applicable to struvite produced from agricultural resource recovery systems. As we hone our understanding of what cultivation media factors and growth conditions are required to maximize growth and high value biomass production we will then scaled these experiments up to pilot scales to evaluate high-value algae production at these larger scales.

  We also initiated greenhouse/pilot-scale cultivation experiments during Fall 2019 and Spring 2020 that are pursuing mixed-culture approaches for the capture of nutrients from liquid wastewaters. Produced algal biomass from these experiments has been dewatered and preserved for HTL processing by the McDonald lab. During year 3 nutrients captured from the HTL processing of algal biomass will then be tested as inputs to a struvite production system (either via modeling or bench scale struvite production). Struvite produced in this way will then either be tested similar to the municipal struvite experiments described above or analyzed for mineral content to allow accurate estimate of the utility of the algae-capture nutrients purified by struvite production. Based on this suite of experiments we will determine the most appropriate mechanism for algal cultivation and nutrient source in our integrated system. Initial greenhouse cultivation results suggest we can generate high levels of algal biomass on PHA reactor effluents. However, we need to continue this work to determine stability of the production system (i.e. in terms of growth rates, yields, and nutrient capture rates) and repeatability of the HTL processing outputs.

We initially expected to have some biomass characteristics data acquired during the second half of year 2. However, due to experimental delays induced by the COVID-19 pandemic this effort will continue into year 3. We will build on these experiments in year 3 to enhance our focus on the quality of the produced algal biomass in the context of potential economic returns of a commercialized system and/or the influence of the nutrient capture on the potential to reach a "Net zero" status for a given agricultural system. These goals are informed by our discussions with our stake holder advisory group, as noted below.

ii. Pilot scale assessments: Conduct pilot scale evaluations from mixed waste streams; implement/evaluate treatment resource recovery processes.

- Both Coats' pilot systems were operational in Y1, and have been re-started for Y2, to continue into Y3. Coats' research team was fully trained on systems operation.
- Completed 2019 operations of Coats' pilot operations at the UI dairy (PHA pilot) and at the city of Moscow, Idaho (EBPR/nitritation pilot). Former efforts were intensively focused on collecting data to facilitate ultimate transition to a full scale system; ongoing data interrogation is informing and being integrated into a journal manuscript. Moreover, PHA pilot data greatly informed potential future scale-up to commercial operations, and the team is evaluating potential new funding opportunities to make the transition to commercialization. Latter efforts focused on preliminary assessment of integrated EBPR-nitritation, with an emphasis on integrating ammonia-based aeration control (ABAC) to enhance nitritation over nitrification. Successful nitritation was achieved for the entire month of August 2019 (early Y2); data evaluation is ongoing, with the aim to inform 2020 pilot operations.
- The initial pilot scale greenhouse systems have been constructed at the Boise State research greenhouse and were validated for suitability for cultivation of multiple algal strains. We purchased, installed and tested a new 20L flow through centrifuge for rapid collection and concentration of the algal biomass produced in our pilot-scale greenhouse cultivation experiments. Installation and safety checking of the centrifuge took longer than expected slowed the rate of optimization of operational conditions in the first half of year 2. However, final installation and testing of the centrifuge was completed prior to December 2019. In Jan 2020 we initiated our greenhouse scale experiments, employing both controlled media and effluent sourced from the pilot-scale PHA system operated by the Coats lab. Initial cultivation experiments were successful and produced significant quantities of algal biomass for testing in our HTL process development (McDonald lab). Although the full suite of proposed greenhouse scale experiments for year 2 may not be completed in year 2, the majority of the experimental operation and sample collection will likely occur in year 2. However, completion of data collection and analysis will most likely be delayed until the start of year 3. This additional delay is due to the COVID-19 pandemic and associated temporary closures of research facilities at Boise State University. During the last month of year 2 and first months of year 3 we will do our best to accelerate the rate of these experiments to facilitate our ability to inform decisions about which types of algal

cultivation systems to couple with the AD/PHA aspects of our integrated system. We will continue to operate the pilot scale algal cultivation systems through 2020 in collaboration with the Coats and McDonald labs at UI.

iii. Produce prototype products (bioplastic mulch film, biochar, biofuel) for evaluation.
- One PhD student in McDonald's lab has been working on extracting and isolating pure PHA bioplastic generated from eight trials on the pilot plant over 84 days of operation. Each batch of PHA was produced under slightly different operating conditions (see section ii). The eight batches of the purified PHA bioplastic are being characterized for their thermal and rheological properties in order to determine their suitability for producing bioplastic films. We have been evaluating different extraction and purification methods to improve the recovery of PHA from biomass and the purified PHAs are being characterized.
- With the on-ramping of the greenhouse scale experiments in Fall 2019/Spring 2020 in the Feris lab we will begin to produce suitable quantities of algal biomass for use in HTL experiments by the McDonald lab. Primary outputs of HTL processing of algal biomass will include biofuel (i.e. biooil), biochar, and aqueous phase nutrients. The aqueous phase will be recycled to the algal cultivation system to enhance algal biomass production.

iv. Partnerships with producers, processors and municipal treatment personnel are fundamental to all of these tasks. Team will build on existing relationships with Twin Falls wastewater treatment facility, Food Northwest, Chobani, Amalgamated Sugar, J.R. Simplot, Idaho Dairymen's Association, and Glanbia, and expand to new partners throughout this project

a. A second SAG meeting was held virtually on December 17th, 2019. This meeting focused on providing research updates to our SAG committee members and inquiring with them on where they felt we should focus our efforts over the remainder of year 2. SAG members were supportive of the direction of the research but provided feedback that the team should continue to focus on potential routes towards commercialization of the technologies under investigation. SAG members renewed their commitments to help the team pursue potential routes for commercialization as opportunities arise. Additionally, the SAG provided additional detail on how to best help move portions of our work towards commercialization. These included suggestions to focus interpretation and analyses of experimental outcomes in the context of typical or example real world systems. Specifically, to look into how our technology would translate to implementation at a 1500 head dairy (the typical dairy size in ID). The SAG also suggested we look into how implementation of our technology would help Idaho Dairies reach a net zero status. One means by which the team could achieve these goals would be to engage students and faculty from the Business schools in our respective universities.
b. Additionally, our SAG engagement resulted in leadership from the Idaho Dairymen's Association inviting two members of our team (Feris, Coats) to the joint Idaho/Utah Dairymen's association meeting in Salt Lake City, UT in July 2019. This meeting provided an opportunity to further develop relationships with regional dairy producers and to introduce them to the potential outcomes of our project. Additionally, the Idaho Dairymen's Association networked Coats/Feris with Newtrient LLC (Steve Rowe, CEO). Newtrient is advancing an integrated set of technologies focused on achieving 'net zero' emissions from dairies. Discussions will continue with Newtrient to i) potentially ascertain how the PHA

technology might be integrated, and ii) potentially collaborate on future commercialization funding.

c. Research plan adjustments in response to our Stakeholder Advisory Group (SAG): SAG feedback from the mid-year meeting in December 2020 continued to support our focus on the utilization of struvite as a nutrient source for algal cultivation for production of high value biomass. Further, current algal cultivation experiments are being planned within the context of potential future application at a typically sized ID dairy and in the context of net economic return. We are also investigating the effect of our integrated technology on the ability of an agricultural system to achieve net zero status, however this work is in its early stages and will require more effort during year 3 to make significant progress. The Feris lab also intends to seek out a suitable and interested business student to help us translate our algal productivity data to economic value projections during year 3.
d. Another recommendation from our December 2019 SAG meeting was to evaluate i) the greenhouse gas footprint of Coats' PHA process, and ii) evaluate the potential of Coats' PHA process to remove phosphorus. These evaluations are ongoing.
e. One of our goals for year 2 of this project was to continue to build on our budding Stakeholder relationship with the hopes that they will blossom into partnerships for seeking pre-commercialization funding in year 3. We continue to work towards this goal and during year 3 we will focus our data collection efforts on system development and scale up as well as communication of research findings with our stakeholder group.

f. **Research plan adjustments in response to the COVID-19 pandemic:** Research facilities at the University of Idaho and Boise State University were shut down for a significant component of the second half of year 2 of this project. During the facility shut down research activities were focused on data analysis, literature reviews, and planning for experiments once facilities were reopened. Although some delays in data collection were experienced due to the COVID-19 pandemic, as of early June 2020, research facilities at both institutions are re-opening and we hope to make significant progress towards our year 2 research goals in the last month of FY20. Travel to and attendance at conferences/meetings that were planned were halted during this period and delivery of presentations impeded. Additionally, Dr. Feris' sabbatical plans were interrupted by the COVID-19 outbreak and corresponding limitations on travel around the state. However, we plan to utilize our team's stakeholder meetings to enhance our relationships with local municipalities and regional agricultural representatives.

Goals/Plans for Year 3 (Task A):

i: Bench scale

- In year 3 nutrients captured from the HTL processing of algal biomass will then be tested in a secondary stage algae production system for high value commodity production either directly as aqueous nutrients or via production of struvite. Based on these experiments and those of the primary stage algal cultivation we will determine the most opportune mechanism for algal cultivation in our integrated system as a primary nutrient capture stage and a secondary high value biomass production stage or as a single primary or secondary stage system. Our evaluation will be based on the algaes growth rates, yields, biomass characteristics, and economic potential when grown in the different wastewater nutrient sources.

- Advance new knowledge on operational criteria to discern between process "failure" and "success" for enhanced biological phosphorus removal. Generate a publication.
- Advance new knowledge on achieving shortcut nitrogen removal in biological wastewater treatment. Emphasis will be both on reactors performing enhanced biological phosphorus removal and on reactors just performing ammonia-nitrogen removal. Generate a publication.
- Finalize a metabolic model for producing biodegradable plastics from fermenter dairy manure. Generate a publication.

ii: Pilot scale:

- Operate and analyze performance of Dr. Coats' bioplastics pilot system at the UI dairy.
  - Refine and evaluate operational criteria based on successes from Y2 operations.
  - Produce quantities of bioplastic material from Coats' pilot scale system for McDonald's ongoing polymer characterization work.
  - Undertake blown film trials using pilot scale produced bioplastics
- Operate and analyze performance of Dr. Coats' municipal enhanced biological phosphorus removal system located at the city of Moscow wastewater treatment system. Focus on translating/assessing operational criteria from Coats' bench scale reactors to his pilot scale systems. Specific focus will be:
  - Achieve and assess shortcut nitrogen removal
  - Evaluate the impacts of the return activated sludge flow rate on process stability and performance
  - Evaluate the impacts of integrating effluent from Dr. Coats' bioplastics pilot on overall wastewater treatment and resource recovery
- We will continue to operate the pilot scale algal cultivation systems through 2020-2021 in collaboration with the Coats and McDonald labs at UI.

iii: Producing prototype products:

- Ongoing experiments in the Feris lab will begin to produce suitable quantities of algal biomass in year 2 and 3 for use in HTL experiments by the McDonald lab. Primary outputs of HTL processing of algal biomass will include biofuel (i.e. biooil), biochar, and aqueous phase nutrients. The aqueous phase will be recycled to the algal cultivation system to enhance algal biomass production.
- Produce bioplastic blown films for assessment

iv: Training:

- Conducting training for the city of Moscow, Idaho wastewater treatment staff, focused on the basics of biological wastewater treatment and integrating knowledge on the operation of their enhanced biological phosphorus removal system.

Task B) Decision-support tools for industry and community leaders to quantify and visualize trade-offs among water, energy, land use and municipal growth

Team: Jae Ryu, UI, systems dynamics modeling, water resources; Karen Humes (UI, water/energy nexus, geospatial analysis

Overall Goals:

The goal of this task is to integrate energy components into an updated version of a pre-existing system dynamics model for water supply, use and flows in the region of the Eastern Snake Plain Aquifer. The model which will serve as a decision-support tool for stakeholders (including the food producers, food processors, irrigation districts, water and energy providers and municipal communities/citizens). The tool will quantify and provide users with visuals on the linkages between water, energy, land use and municipal growth, to be used for planning and decision-making by producers, water users, businesses, utilities, state agencies and communities.

Accomplishments this period:

- Evaluated the existing model to determine how to implement water management options (e.g., managed aquifer recharge) given the existing data types available
- Interacted with IDWR on their newest ESPAM (Eastern Snake Plain Aquifer Model) model version and updated data needs
- Evaluated the feedback from IDWR and Surface Water User's Association at the stakeholder meetings in May 2019 and Dec 2019 and how the model could be more useful for stakeholders
- Incorporated new features that are available in Stella Architect into the system dynamics model and user interface.
- Performed a quality analysis of the most recent data available from IDWR and completed the integration process to bring the model up to date.
- Completed data placeholders for the updated water data from the ESPAM ground model
- Explored available data on energy use in irrigation, including interactions with IDWR and collaboration with experts on energy use in irrigation at Idaho Power.
- Further evaluation of spatial patterns in energy use for irrigation in the ESPA and controlling factors in order to identify key variables to relate water and energy use in irrigation (i.e., crop type, irrigation system characteristics, water source, etc.). Data analysis nearly complete, with publication to be submitted in August 2020.

Plans for Yr 3 (Task B):

- We will update available water and energy data for Stella Architect once the latest version of ESPAM model becomes available to the public
- We will continue exploring management options to incorporate into the model, such as water conservation, managed recharge, etc.
- We will be developing system evaluation criteria associated with new data inputs and potential uses for the expanded and update model, such as system reliability, vulnerability, resilience, etc.
- We will complete our analysis of available data on energy use in irrigation

- We will complete the development of a module for the system dynamics model that quantifies energy use in irrigation for two meteorological scenarios (average and above average demand in a growing season) and number of acres with other key variable combinations (eg., crop type, irrigation source/type)
- We will begin incorporating supply side scenarios to quantify the linkages between water, energy and land use and address the uncertainty of the water/energy nexus in the Eastern Snake Plain Aquifer.
- Submit draft of journal article describing the linkages between water and energy use in Idaho
- We will continue to seek input from our Stakeholder Advisory Board and other water and energy providers, managers and community leaders on how to make the tool/model most useful to them.
- We will explore water supply uncertainties driven by climate variability in the ESPA, particularly the impacts of more frequent drought conditions.

Task C) Technical innovations/sensing systems to reduce water/energy/nutrient use in targeted production systems:

Primary team members: Donna Delparte, (ISU, drone and satellite-based sensing systems) and partners among growers and crop consultants.

Accomplishments this period:

Progress in the following task area has been made through the subcontract award to Idaho State University and included:

- **Goal 1 – Decision Support Systems**
    - Decision support online tool prototype for sustainable agriculture decisions making: https://avalanche.geology.isu.edu/i2i/osgood.html
    - This decision support tool was developed by working with stakeholders and our Advisory Board member (Brandon Vining, ProGro) to provide remote sensing data/tools to aid decision making that is relevant to business decision making and operations
    - Stakeholders are excited about the potential of the tool to improve ROI, reduce fertilizer inputs and improve precision farming techniques for sustainable agriculture

- **Goal 2 - Pilot projects to use drone-based, other field-based and satellite sensors to reduce water/nutrient/energy use in production of targeted crops**
    - Conducted remote sensing analysis to forecast yield for potato growers based on a growing season of high-resolution satellite imagery (submitted for publication in 2019 to *ASPRS Pecora Conference Proceedings* by Masters student)
    - Conducted thermal camera surveys of irrigated cropland using UAS in the 2019 growing season to assess efficiency and support water reduction efforts. Data collected and analysis in progress.
    - Hyperspectral camera data collection during the 2019 growing season of potato crops to detect crop threats

- PhD student conducted experiment to determine essential spectral signatures required to detect individual unhealthy plants in a growers field that leverages machine learning of hyperspectral imagery – thus offering the opportunity to reduce inputs for control and mitigation of disease.
- New thermal and hyperspectral data acquired in the first portion of the 2020 growing season, as well as more training/testing with growers on the effectiveness of the satellite-based tool for monitoring emerging crops
- Co-I Delparte launched a new Idaho based spin-off company (I2IGeo) to provide growers with technological innovations and decision support to assist their operations, leveraging the research outcomes from this grant.

Plans for next reporting period:

For the next reporting period, the team will focus on the continued development and testing of UAS platform and sensor combinations for data collection in the 2020 growing season and the first part of the growing season in 2021, again in partnership with growers and crop consultants. Dr. Delparte will also continue to work actively toward commercialization of the most promising technologies from this research through her new Idaho company (I2IGeo).

Task D) Engaging the present and future workforce in the adoption of new technologies

Team members for training (primary): Karen Humes, Erik Coats, Kevin Feris, and partners at CSI, UI Idaho Falls and professional organizations such as Food Northwest, *Primary team member for drone outreach activities:* Jae Ryu (Idaho Drone League (I-Drone), Founder).

Overall goals:

The overall goals in this task are two-fold: 1) to provide direct support to our stakeholders in the near-term by identifying workforce development needs that universities could plan and implement, together with partners at community colleges and professional organizations (resourced primarily in Yrs 2 and 3) and 2) contribute to longer-term workforce needs by holding outreach events designed to engage the future workforce in STEM activities that will serve the food industry in Idaho in the future, such as drone operations and the analysis of data from sensors onboard drones.

Accomplishments this period:

- Goal 1: Current/near-term workforce development needs
    - Engaged with a stakeholder (IDEQ) that approached us about workforce development needs and added a representative to our Stakeholder Advisory Board
    - Discussion and initial planning for training sessions we could hold in coordination with the rural water treatment association meetings later in Yr 2 and in Yr 3.
    - Due to Covid-19 and the cancellation of the rural water treatment association, some of
    - the outreach planned for the end of Yr 2 had to be postponed to Yr 3.

- Goal 2:
    - Hosted a hands-on education program known as "Idaho Drone League(iDrone)" in the Treasure Valley in Fall 2019 to promote STEM pipelines and skills important to the Idaho food industry in the future.
    - There was a Drone League event planned for June 2020 in Twin Falls, which unfortunately had to be postponed due to Covid-19 closures and restrictions.

<u>Plans for Yr 3:</u>

- Training sessions to be held in conjunction with the Rural Water Treatment Association meeting and similar venues. If travel and in-person meetings continue to be problematic, we will hold virtual training sessions.
- Three Idaho Drone League events will be scheduled in Year 3. These event will include a table highlighting how drones can be used in food production (from Task C of this research). If COVID-19 continues in Yr3, we will adopt a hybrid option (e.g., virtual meeting for drone building/coding/programming + hands-on flight experience outdoor with social distancing and PPE).
- Continue to engage with our Stakeholder Advisory Board and professional organizations such as Food Northwest to identify and implement professional development needs in food, water, energy and waste and how the universities can catalyze and facilitate these.
- Continue to engage with other stakeholders such as the IDEQ on needs and opportunities in professional development on pollution control and management.

Task E) Project Management/Stakeholder Engagement

Background: An important element of our project management was to put together and meet regularly with an advisory board comprised of stakeholders in the food production and processing industries, water user groups and state agencies. In Year 1 we formed this advisory and had a very successful 1st meeting in person in Boise in early May 2019. As noted in the technical progress reports (earlier sections of this report), the board feedback influenced our research plans in Year 2, as planned. The board agreed to meet in it's entirety once/yr in person (Apr/May), once/yr via videoconference (Nov/Dec) and have specialized meetings between specific sub-groups of team and advisory board members in between.

<u>Accomplishments this period:</u>

- We held a 2nd meeting of our full Stakeholder Advisory Board (SAB) on Dec 17, 2019. As planned and discussed at our May meeting, the meeting was held by video, with 4-5 attendees in one conference room in The following SAB members attended and those listed with a (*) were invited and had hoped to attend but were not able to do so:
    - Jeff Bohlscheid, Senior Principal Scientist, J.R. Simplot Company
    - Shawn Moffitt, Regional Business Manager, Jacobs Engineering (contractor for City of Twin Falls and Chobani water treatment plants)

- Bob Naerebout, Government Affairs and former Exec Director, Idaho Dairyman's Association and and Megan Satterwhite, Environmental Programs Director, IDA
- Ben Nydegger, Biosolids Program Manager, City of Boise
- Sean Vincent, Hydrology Section Manager, Idaho Dept of Water Resources
- Ben Jarvis, Pollution Prevention Projects Coordinator, Idaho Department of Environmental Quality
- Brian Olmstead*, President, Surface Water Appropriators and General Manager, Twin Falls Canal Company
- Brandon Vining*, ProGro Consulting

- The primary goal of this second meeting of our SAB was to update the SAB on our previous 6 months activities, particularly those things that had been prioritized or tweaked as a result of their feedback in May, and to gain more insight from them as to how we could make our research as useful to them as possible.
- PI Karen Humes and Co-I Erik Coats met individually with Ben Jarvis in Oct 2019 to discuss workforce training opportunities that could "piggyback" along with existing IDEQ events and/or professional meetings such as the Idaho Rural Water Association
- As described in some detail under our "Task A" Technical progress section above, two of our Co-Is (Coats and Feris) have done considerable outreach to the dairy industry in both Idaho and Utah, including presentations at the Utah Dairyman's Association in July 2019.
- We also established a cloud file storage space for our project (and shared it with the SAB) in which all presentations and notes from our SAB meetings are stored, along with our progress reports to the SBOE/HERC.
- PI Humes has begun a new stakeholder relationship with the Association of Idaho Cities
- In the way of other team management and organization among Co-Is at the multiple institutions, we have continued our monthly team meetings via videoconferencing.
- We had planned to hold a second SAB meeting in May 2019 but postponed it in the hope that meeting at a later date would allow face-to-face meeting. However, in late June we began preparations to hold another SAB meeting via Zoom in early July.

<u>Plans for YR 3:</u>

- Hold two SAB meetings (Dec 2020 and June 2021)
- Continue to build on existing relationships with Twin Falls wastewater treatment facility, Food Northwest, Chobani, Amalgamated Sugar, J.R. Simplot, Idaho Dairymen's Association, and Glanbia, and expand to new partners throughout this project
- Continue to hold monthly team meetings to monitor progress and facilitate coordination of all project tasks and stakeholder engagement activities. In coming months these meetings will focus on student presentations of research.

2. Summary of budget expenditures for Yr 2 (July 1, 2019 – June 30, 2020)

A detailed expenditure is provided in Section 6 at the end of the report, but the table below summarizes the spending in the major budget categories, relative to the budgeted amounts for Year 2. The expenditure report was run on June 30, 2020, but expenses for the last pay period in June, which ended on June 27, are not yet reflected in the amounts remaining. There are also a few operational expenses that are still working their way through the approval queue and have not yet posted. Our subcontractors final estimated invoices sent on June 15 indicated that all but $267 of the funds allocated to them would be spent. We anticipate that all of the funds in the budget for UI investigators will be expended after all June expenses clear the system.

	Budget	Expenses Cleared	Remaining*
Salaries:	$ 181,768	$ 179,629	$ 2,139
Fringe Benefits:	$ 25,901	$ 22,957	$ 2,944
Irregular Help:	$ 53,023	$ 40,965	$ 12,057
Travel:	$ 10,912	$ 10,511	$ 401
OE:	$ 65,760	$ 63,284	$ 2,477
Subcontracts:	$ 287,435	$ 287,168	$ 267
$5K > Capital:	$ 18,245	$ 18,245	$ -
$5K < Capital:	$ 2,522	$ 2,522	$ -
Trustee/Benefits:	$ 54,435	$ 55,533	$ (1,098)
Total:	$ 700,000	$ 680,813	$ 19,187

*Payroll has not yet cleared for the last pay period in June, as well as a few other expensed amounts in approval queues.

3. Demonstration of economic development/impact

- Patents, copyrights, Plant Variety Protection Certificates received or pending

Co-I Dr. Donna Delparte has formed a private company in Idaho called ***I2IGeo*** and is working to develop a commercialization pathway for her research on this grant related to the use of satellite and drone technology to assist growers in the application of nutrients, herbicides, pesticides and water.

- Private sector engagement

Because every aspect of our work involves considerable private sector engagement, we have noted those engagements in each of our five tasks described in Section 1, particularly under *Task E: Project Management/Stakeholder Engagement.*

- Jobs created

Several of the research assistant and all of student research assistantship positions described in the next section were newly created in Year 1 of this grant.

4. Numbers of faculty and student participation

In the Yr 2, the numbers of faculty, students and other researchers participating are as follows:

Faculty: 6 (4 UI, 1 BSU, 1 ISU)
Graduate Students: 11 (7 UI, 2 ISU; 2 BSU (both of whom are from groups underrepresented in STEM fields)
Undergrad Students: 5 (UI)
Research Scientists: 2 (1 UI, 1 ISU, both partially supported by this grant)

More details on staffing, by Task:

Task A: Recovery of energy, nutrients, water and bioproducts from waste streams

Coats staffing: 2 PhD students in Environmental Engineering; 2 MS student in Environmental Engineering; 2 undergraduate students in Environmental Engineering; 2 undergraduate students in Environmental Science; 1 research scientist. 4 women, 4 men.

McDonald staffing: 1 PhD student in Environmental Science. 1 woman.

Feris staffing: Current staffing includes 2 male graduate students (both from underrepresented groups in STEM). Both graduate students were previously employed as research technicians on this project, however, by Jan 2020 both transitioned to the MS graduate program in the Biological Sciences with a Spring 2020 start date. Both students will participate in experimental development, data collection, and data analysis. We had originally targeted recruitment of additional undergraduate students (1 or 2) for the second half of year 2 to assist with laboratory and greenhouse scale experiments. However, due to the COVID-19 pandemic we decided to postpone recruitment of additional undergraduate team members. We are planning to recruit additional undergraduate team members in year 3, assuming conditions are favorable for such recruitment.

Task B: Quantifying Water/Energy Linkages

- 2 PhD students (1 in Geography, 1 in Water Resources)

Task C:

- 1 PhD students in Geosciences
- 2 summer Masters students in Geoscience
- 1 research/programming technician

5. Description of future plans for project continuation or expansion

- PI Karen Humes is a Co-Lead on the newly formed CAES Focus Area group in the Energy-Water Nexus arena. Being a CAES Focus Area lead provides some access to CAES resources, including program development funds, to build a team of CAES researchers in pursuit of establishing CAES as a global leader in research, education, and innovation related to the energy-water nexus. Team members of this project are looking forward to leveraging our current work to pursue future opportunities. The coupling of food, water and energy is exceptionally strong in southern Idaho, from both a national and international standpoint, making a compelling case for other funding sources. Our integrated approach to water, energy and waste is also unique among teams studying the food-energy-water nexus. She and Co-I Erik Coats organized and attended a workshop at CAES in Idaho Falls on Nov 25, 2019 and are now involved in developing proposals.

- Team members are also actively writing grants to other agencies for related work, such as the NSF, USDA and NASA. This includes a current effort led by PI Karen Humes and involving Co-I Erik Coats and 6 other UI faculty) for a graduate student training grant to NSF (the NSF Research Training Grant progam, or NRT) related to water quality and public health, with emphasis on Idaho (proposal was submitted to NSF in Feb 2020 and is currently pending). This effort includes also stakeholder partners such as IDWR, IDEQ, and the City of Boise Dept of Public Works. The NSF-NRT program is highly competitive and it would be very unusual for the proposal to be funded on the first attempt; however, if not funded, the team is dedicated to strengthening the proposal (particularly the partnerships with stakeholders) and resubmit in Feb 2021.

- PI Karen Humes submitted a proposal to UI Presidential Initiative on Water and Sustainability for seed funding to begin discussions with stakeholders for the possible formation of an Industry-University Cooperative Research Center on topics studied in this IGEM grant. The NSF supports the development of these with a process that involves a planning grant and then a full proposal the following year. The NSF goal for this program is as follows: *"The IUCRC program generates breakthrough research by enabling close and sustained engagement between industry innovators, world-class academic teams and government agencies."* We would see this as a way to institutionalize and sustain the research and industry relations developed in this grant. If successful in a full proposal, the NSF provides up to 10 yrs of base funding to establish and maintain such a center. We will also discuss this program at our SAB meeting in early July 2020.

- Co-I Erik Coats (and team leader for Task A of this grant) is a Co-I on the recently awarded 5-yr $10M grant funded by USDA, led by the College of Agriculture and Life Science, that has among its goals the recovery of byproducts from dairy waste. Dr. Coats will ensure that progress made in the IGEM grant will be brought to bear on the USDA grant and vice-versa.

6. Expenditure reports

The expenditure reports presented in Appendix B (detailed first, then a summary by category) details the expenditures at the University of Idaho, including the amounts for paid invoices from our two contracting institutions (Idaho State University and Boise State University). Please note that that this report was run on June 30, 2020 and not all expenses from June 2020 have cleared the system, including the last payroll period that ended on June 27, 2020.

7. Commercialization Revenue

None to report yet, but the company I2IGeo (Co-I Delparte as Founder) has been formed.

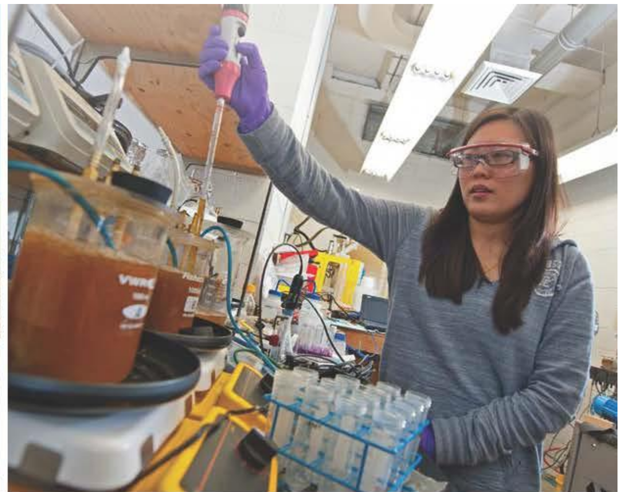
Appendix A: Project Brochure Prepared for Stakeholder Engagement

WATER, ENERGY, and WASTE Management

for FOOD PRODUCTION, PROCESSING, and RESOURCE RECOVERY

WHO we are: Consortium of scientists and engineers from University of Idaho, Boise State University, Idaho State University, and Center for Advanced Energy Studies

University of Idaho · Boise State University · Idaho State University · CAES Center for Advanced Energy Studies

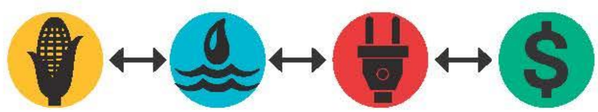


WHY ARE WE ASKING YOU TO
ENGAGE WITH US?

- You are among the leaders in Idaho food production, processing, and associated services such as water and waste treatment
- To gain your perspective and input on issues, challenges, and pathways for your industry
- To better understand both single-user solutions and longer-term visions for applied research on regional solutions, including efficiencies to be gained through collaboration.
- To learn about workforce preparedness gaps and how we can help fill them

WHAT we are:

- Team conducting applied research funded by Idaho State Board of Education
- Research activities focused on creative solutions in water, energy, and waste management that enhance economic and environmental bottom line for Idaho agro-industry and rural communities.



TEAM EXPERTISE -
FOR DAIRIES AND FOOD PROCESSING:

- Wastewater treatment: operations,energy efficiency, nutrient recovery, and water recycling
- Minimizing management of waste products or any other outputs parasitic to the economic bottom line
- Assisting stakeholders to diversify economic portfolio via resource recovery and retrieval of other value-added products

TEAM EXPERTISE -
FOR CROP PRODUCTION:

- Tools for utilizing satellite and drone data for optimal application of nutrients and water

TEAM EXPERTISE -
FOR ALL STAKEHOLDERS, INCLUDING STATE AND COUNTY/MUNICIPAL PLANNING:

- Quantifying the interconnection of water, energy, and waste streams in southeastern Idaho region
- Useful for planning and identifying synergies/ partnerships among stakeholders in the future

For more information, please contact Project Director Karen Humes, *khumes@uidaho.edu* or 208-885-6506.

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FWRITEM                        University of Idaho
                      Itemized Expenditures by Grant Code
                         From 01-JUL-2019 To 30-JUN-2020

Grant: SG3587 - ISBOE IGEM FY20 Sustain Food Ind-KH         30-Jun-2020 12:04 PM
--------------------------------------------------------------------------------
Salaries
   E4106 Staff
         Brinkman, Cynthia                                              16040.32
             884.25 hours
   E4108 Summer Salary
         Humes, Karen                                                   17647.20
             240.00 hours
         McDonald, Armando                                              11513.60
             160.00 hours
         Ryu, Jae                                                        3711.40
              70.00 hours
   E4109 IA/GA Salary
         Abbasi, Maryam                                                 20030.00
            1000.00 hours
         Alfaro Salmeron, Glenda                                          750.00
              40.00 hours
         Deyo, Brent                                                    21500.00
             860.00 hours
         Mellin, Jason                                                  36410.00
            1000.00 hours
         Smoot, Lindsey                                                  8250.00
             440.00 hours
         Thompson, Emily                                                22228.40
            1000.00 hours
         Walters, Riveraine                                             19497.00
             780.00 hours
   E4175 Overtime - Covered by FLSA
         Brinkman, Cynthia                                                 74.83
               8.25 hours
                                                                      ----------
                                                                     $ 177652.75

Temporary/Irregular Help
   E4135 Temporary Student
         Brouillard, Nicolas                                             2163.00
             180.50 hours
         Crites, Willow                                                  2664.75
             242.25 hours
         Deyo, Brent                                                     2800.00
             112.00 hours
         Ekness, Tayler                                                   474.38
              43.75 hours
         Gibson, Joseph                                                  3515.88
             326.25 hours
         Guho, Nicholas                                                 23446.32
             848.00 hours
         McCormack, Roslyn                                                595.38
              54.75 hours
         McLean, Carly                                                    569.25
              51.75 hours
         Shaber, Jonathon                                                1369.50
             124.50 hours
         Smoot, Lindsey                                                  2811.88
             258.25 hours
                                                                      ----------
                                                                     $  40410.34
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Fringe Benefits			
E4280 Faculty CFR Benefit Expense			10157.50
E4281 Staff CFR Benefit Expense			6526.59
E4282 Student CFR Fringe Expense			5748.64

			$ 22432.73
Travel			
E5360 Personal Vehicle - In-State			
20-SEP-19	I2095733	Ryu, Jae H.	5.00
18-OCT-19	I2101059	Humes, Karen S..	48.09
10-DEC-19	ZT913239	Parking 11112019	10.00
13-DEC-19	I2110710	Ryu, Jae H.	147.69
E5365 Personal Vehicle - Out-of-State			
07-AUG-19	I2087973	Coats, Erik Robert.	42.28
22-OCT-19	I2101614	Coats, Erik Robert.	96.82
22-OCT-19	I2101614	Coats, Erik Robert.	55.00
E5367 Rental Vehicles - In-State			
12-AUG-19	ZT407009	Car Rental Fuel 07202019	60.55
12-AUG-19	ZT407009	Car Rental Fuel 07242019	44.04
12-AUG-19	ZT407009	Car Rental Fuel 07292019	26.72
12-AUG-19	ZT407009	Car Rental Fuel 07302019	37.88
12-AUG-19	I2088874	Ryu, Jae H.	520.99
20-SEP-19	ZT534237	Car Rental Fuel 08102019	27.36
20-SEP-19	ZT534237	Car Rental Fuel 08102019	60.55
20-SEP-19	ZT534237	Car Rental Fuel 08132019	63.74
20-SEP-19	ZT534237	Car Rental Fuel 08142019	27.90
20-SEP-19	ZT534294	Car Rental 09032019	230.06
20-SEP-19	ZT534294	Car Rental Fuel 08302019	64.79
20-SEP-19	ZT534294	Car Rental Fuel 08312019	29.63
20-SEP-19	ZT534294	Car Rental Fuel 09022019	16.02
20-SEP-19	I2095733	Ryu, Jae H.	53.87
20-SEP-19	I2095733	Ryu, Jae H.	604.78
18-OCT-19	I2101059	Humes, Karen S..	181.16
18-OCT-19	I2101059	Humes, Karen S..	2.02
10-DEC-19	I2109969	Humes, Karen S..	252.00
E5380 Airfare - In-State			
18-OCT-19	I2101059	Humes, Karen S..	58.30
18-OCT-19	I2101059	Humes, Karen S..	284.50
10-DEC-19	ZT913239	Airfare 11112019	521.51
E5381 Airfare - Out-of-State			
23-JUL-19	I2085705	Coats, Erik Robert.	478.20
23-JUL-19	I2085707	Coats, Erik Robert.	1280.00
08-OCT-19	I2098846	Ryu, Jae H.	125.00
18-DEC-19	I2111627	Ryu, Jae H.	213.10
25-MAR-20	Z1002936	McDonald A- Airfare to GA- GOT CANC	299.40
E5391 Ground Transportation - In-State			
18-OCT-19	I2101059	Humes, Karen S..	38.00
E5392 Ground Transportation-Out-of-State			
07-AUG-19	I2087973	Coats, Erik Robert.	17.72
22-OCT-19	I2101614	Coats, Erik Robert.	278.80
18-DEC-19	ZT905632	RyuJa 905632 Uber Jae traveled to S	13.95
18-DEC-19	ZT905632	RyuJa 905632 Uber Jae traveled to S	15.26
E5396 Lodging & Per Diem ? In State			
20-SEP-19	I2095776	Ryu, Jae H.	49.00
20-SEP-19	I2095776	Ryu, Jae H.	23.00
20-SEP-19	I2095776	Ryu, Jae H.	49.00
18-OCT-19	I2101059	Humes, Karen S..	26.00
18-OCT-19	I2101059	Humes, Karen S..	42.00
18-OCT-19	I2101059	Humes, Karen S..	42.00
18-OCT-19	I2101059	Humes, Karen S..	33.00
18-OCT-19	I2101059	Humes, Karen S..	30.00
18-OCT-19	I2101059	Humes, Karen S..	164.02
18-OCT-19	I2101059	Humes, Karen S..	433.07
10-DEC-19	I2109969	Humes, Karen S..	26.00

10-DEC-19	I2109969	Humes, Karen S..	49.00
10-DEC-19	ZT913239	Hotel - Lodging 11132019	185.00
10-DEC-19	ZT913239	Hotel - Lodging 11142019	178.71
13-DEC-19	I2110710	Ryu, Jae H.	49.00
E5397 Lodging & Per Diem ? Out of State			
22-JUL-19	F0168715	GRT226540-CIVIL&ENV ENGINEERIN	-1526.56
23-JUL-19	I2085705	Coats, Erik Robert.	147.96
24-JUL-19	ZT335285	Hotel - Lodging 07032019	2289.84
07-AUG-19	I2087973	Coats, Erik Robert.	56.00
07-AUG-19	I2087973	Coats, Erik Robert.	43.00
08-OCT-19	ZT599870	Hotel - Lodging 08142019	76.61
08-OCT-19	I2098846	Ryu, Jae H.	50.00
08-OCT-19	I2098846	Ryu, Jae H.	38.00
08-OCT-19	I2098846	Ryu, Jae H.	37.05
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
18-DEC-19	I2111627	Ryu, Jae H.	33.00
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	568.54
18-DEC-19	I2111627	Ryu, Jae H.	56.00
25-MAR-20	Z1002936	McDonald A, hotel in GA for Swanapa	381.66

			$ 10510.58

Operating Expenses

E5045 Photocopy Service			
03-FEB-20	J1263308	DS; UIB copier charge Jan 2020	0.06
02-MAR-20	J1265005	DS; UIB copier charge Feb 2020	0.18
E5049 Journal Publication Costs			
25-SEP-19	ZT574740	Professional Services 09042019	25.00
E5070 Conference/Registration Fees			
24-JUL-19	ZT335285	Conference Registration 07012019	615.00
24-JUL-19	ZT335285	Conference Registration 07092019	-570.00
24-JUL-19	ZT335285	Conference Registration 07092019	725.00
24-JUL-19	ZT335285	Conference Registration 07092019	570.00
26-SEP-19	ZT568130	Memberships / Subscriptions / Regis	180.00
01-NOV-19	ZT748634	Memberships / Subscriptions / Regis	-725.00
18-DEC-19	I2111627	Ryu, Jae H.	630.00
11-FEB-20	Z1000753	AAG 2020 conference registration fo	175.00
25-MAR-20	Z1002876	RyuJa 367212 Registration Grant res	5.00
07-APR-20	Z1003527	McDonald A-FPS International Confer	415.00
09-APR-20	Z1003603	2020 AAG conference cancellation fo	-175.00
E5210 R&M Svcs - Work Orders			
26-MAR-20	I2126584	Oppenheimer Development Corporation	195.97
21-APR-20	J1267705	ef/CT from 826742 to 826867	-195.97
E5307 Analytical Services			
02-OCT-19	J1252563	MJ/GRC 1811977_Forney	860.00
16-DEC-19	J1260582	bf ASL Invoice EOCT19-003	46.00
E5320 Software/Applications - Individual			
27-AUG-19	ZT406541	Supplies 07272019	129.00
26-JUN-20	I2138310	Oregon Education Technology Consort	107.88
30-JUN-20	B1835767	Oregon Education Technology Consort	0.00
E5330 Software/Applications - College/Dep			
24-JUL-19	I2086054	Ryu, Jae H.	799.00
14-AUG-19	ZT401299	Supplies 07032019	19.15
14-AUG-19	ZT401299	Supplies 07172019	15.99
12-SEP-19	ZT511342	Supplies 08032019	19.99
12-SEP-19	ZT514946	Supplies 08272019	129.00
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	31.71
29-MAY-20	Z1005499	RyuJa 746498 Verizon Data storage s	166.90

E5410 Office and Administrative Supplies			
04-DEC-19	ZT859061	Supplies 11122019	88.34
17-JAN-20	ZT159595	Charge for tonor cartridge. Linda M	120.64
E5430 Consumable Water			
08-AUG-19	I2088020	Culligan Water Conditioning	29.95
E5465 Gasoline			
14-AUG-19	ZT401299	University Vehicle Expenses 0701201	42.34
14-AUG-19	ZT401299	University Vehicle Expenses 0715201	40.31
E5560 Technology - Supplies			
09-AUG-19	I2088550	Ryu, Jae H.	476.96
04-SEP-19	ZT498840	Supplies 08122019	62.99
30-OCT-19	ZT730095	Supplies 10152019	33.99
18-FEB-20	Z1001008	Charge for power cord for SC 200 Co	12.14
E5710 Tools			
14-AUG-19	ZT401299	Supplies 07042019	107.25
14-AUG-19	ZT401299	Supplies 07112019	38.03
E5724 Research Supplies			
18-JUL-19	ZT303097	Supplies 07032019	1613.10
18-JUL-19	ZT303097	Supplies 07052019	11.94
18-JUL-19	ZT303097	Supplies 07062019	98.17
18-JUL-19	ZT303097	Supplies 07072019	11.74
18-JUL-19	ZT303097	Supplies 07092019	396.00
18-JUL-19	ZT303097	Supplies 07092019	18.00
18-JUL-19	ZT303097	Supplies 07102019	166.30
18-JUL-19	ZT303097	Supplies 07112019	91.62
23-JUL-19	I2085701	Ryu, Jae H.	271.08
02-AUG-19	ZT335026	Supplies 07032019	420.44
02-AUG-19	ZT335026	Supplies 07102019	1704.66
02-AUG-19	ZT335026	Supplies 07102019	69.54
02-AUG-19	ZT335026	Supplies 07122019	75.80
02-AUG-19	ZT335026	Supplies 07132019	52.28
02-AUG-19	ZT335026	Supplies 07162019	169.80
02-AUG-19	ZT335026	Supplies 07162019	30.26
02-AUG-19	ZT335026	Supplies 07172019	13.75
02-AUG-19	ZT335026	Supplies 07222019	29.98
02-AUG-19	ZT335026	Supplies 07242019	320.62
02-AUG-19	ZT335026	Supplies 07242019	327.90
02-AUG-19	ZT335026	Supplies 07252019	701.46
07-AUG-19	ZT381455	Agriculture and Medical Supplies 07	18.08
14-AUG-19	ZT401299	Supplies 06262019	5.99
14-AUG-19	ZT401299	Supplies 06272019	94.80
14-AUG-19	ZT401299	Supplies 07022019	92.91
14-AUG-19	ZT401299	Supplies 07022019	9.24
14-AUG-19	ZT401299	Supplies 07082019	39.94
14-AUG-19	ZT401299	Supplies 07112019	189.74
14-AUG-19	ZT401299	Supplies 07142019	217.28
14-AUG-19	ZT401299	Supplies 07192019	156.86
15-AUG-19	ZT402367	Supplies 07192019	61.57
15-AUG-19	ZT402367	Supplies 07272019	69.54
15-AUG-19	ZT402367	Supplies 07272019	48.02
15-AUG-19	ZT402367	Supplies 08012019	185.84
15-AUG-19	ZT402367	Supplies 08012019	53.10
15-AUG-19	ZT402367	Supplies 08022019	-53.10
15-AUG-19	ZT402367	Supplies 08052019	28.45
15-AUG-19	ZT402367	Supplies 08062019	13.94
15-AUG-19	ZT402367	Supplies 08072019	32.44
15-AUG-19	ZT402367	Supplies 08082019	13.98
15-AUG-19	ZT402367	Supplies 08082019	250.82
15-AUG-19	ZT402367	Supplies 08082019	334.67
27-AUG-19	ZT406541	Supplies 07292019	7.41
27-AUG-19	ZT406541	Supplies 07292019	28.93
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	36.10
04-SEP-19	ZT498840	Supplies 08072019	9.65
12-SEP-19	ZT511342	Supplies 08032019	4.55
12-SEP-19	ZT511342	Supplies 08032019	217.94

12-SEP-19	ZT511342	Supplies 08052019	5.29
12-SEP-19	ZT470567	Supplies 08102019	113.20
12-SEP-19	ZT470567	Supplies 08132019	197.90
12-SEP-19	ZT470567	Supplies 08132019	79.82
12-SEP-19	ZT470567	Supplies 08142019	65.08
12-SEP-19	ZT470567	Supplies 08142019	54.04
12-SEP-19	ZT470567	Supplies 08152019	149.99
12-SEP-19	ZT470567	Supplies 08162019	32.26
12-SEP-19	ZT470567	Supplies 08172019	1046.30
12-SEP-19	ZT470567	Supplies 08182019	1700.00
12-SEP-19	ZT470567	Supplies 08182019	82.51
12-SEP-19	ZT470567	Supplies 08212019	38.35
12-SEP-19	ZT470567	Supplies 08212019	55.97
12-SEP-19	ZT470567	Supplies 08222019	216.16
12-SEP-19	ZT470567	Supplies 08272019	188.66
12-SEP-19	ZT514946	Supplies 08202019	89.90
12-SEP-19	ZT514946	Supplies 08222019	229.00
12-SEP-19	ZT514946	Supplies 08262019	241.38
18-SEP-19	ZT536932	Supplies 09032019	487.72
18-SEP-19	ZT536932	Supplies 09042019	182.70
18-SEP-19	ZT536932	Supplies 09052019	456.23
25-SEP-19	ZT574740	Supplies 09032019	88.77
25-SEP-19	ZT574740	Supplies 09082019	81.80
25-SEP-19	ZT574740	Supplies 09092019	62.95
25-SEP-19	ZT574740	Supplies 09102019	51.94
25-SEP-19	ZT574740	Supplies 09102019	28.39
25-SEP-19	ZT574740	Supplies 09102019	49.69
25-SEP-19	ZT574740	Supplies 09112019	211.89
25-SEP-19	ZT574740	Supplies 09132019	102.25
01-OCT-19	I2097494	Ryu, Jae H.	3120.00
07-OCT-19	I2098295	Culligan Water Conditioning	29.95
07-OCT-19	ZT582328	Supplies 09092019	75.00
07-OCT-19	ZT582328	Supplies 09092019	1.42
07-OCT-19	ZT582328	Supplies 09092019	4.50
07-OCT-19	ZT582328	Supplies 09092019	28.26
07-OCT-19	ZT582328	Supplies 09112019	166.30
07-OCT-19	ZT582328	Supplies 09122019	157.46
07-OCT-19	ZT582328	Supplies 09132019	21.60
07-OCT-19	ZT582328	Supplies 09132019	81.64
07-OCT-19	ZT582328	Supplies 09132019	66.68
07-OCT-19	ZT582328	Supplies 09202019	173.07
07-OCT-19	ZT582328	Supplies 09212019	75.80
09-OCT-19	ZT631422	Supplies 09212019	3244.50
09-OCT-19	ZT631422	Supplies 09242019	283.86
09-OCT-19	ZT631422	Supplies 09272019	2154.25
09-OCT-19	ZT631422	Supplies 09272019	-3244.50
09-OCT-19	ZT631422	Supplies 10012019	17.40
09-OCT-19	ZT631422	Supplies 10022019	396.00
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	18.50
25-OCT-19	ZT638339	Supplies 09192019	56.82
25-OCT-19	ZT638339	Supplies 09232019	7.40
25-OCT-19	ZT638339	Supplies 09232019	4.79
01-NOV-19	ZT748634	Supplies 10082019	446.27
01-NOV-19	ZT748634	Supplies 10182019	377.25
01-NOV-19	ZT748634	Supplies 10222019	266.80
06-NOV-19	I2103978	Culligan Water Conditioning	29.95
18-NOV-19	ZT811408	Supplies 10282019	70.56
18-NOV-19	ZT811408	Supplies 10292019	41.98
18-NOV-19	ZT811408	Supplies 10302019	147.50
18-NOV-19	ZT811408	Supplies 11012019	187.34
04-DEC-19	ZT900954	Supplies 11042019	8.99
04-DEC-19	ZT900954	Supplies 11072019	6.63
04-DEC-19	ZT900954	Supplies 11132019	461.22
04-DEC-19	ZT900954	Supplies 11152019	137.09
04-DEC-19	ZT900954	Supplies 11152019	1096.36

04-DEC-19	ZT900954	Supplies 11162019	91.62
06-DEC-19	I2109475	Culligan Water Conditioning	29.95
09-DEC-19	J1260116	KRE-H; Phys Mchn shp wrk A McDonald	87.79
11-DEC-19	ZT907694	Supplies 11032019	77.15
11-DEC-19	ZT907694	Supplies 11112019	178.17
18-DEC-19	ZT030436	McDonald A purchased o-rings and co	12.88
18-DEC-19	ZT030436	McDonald, A purchased research supp	40.32
18-DEC-19	ZT852583	McDonald A purchased lab supplies.	24.92
18-DEC-19	ZT852583	McDonald A purchased lab supplies:	13.60
18-DEC-19	ZT852583	McDonald A purchased lab supplies:	6.78
18-DEC-19	ZT852583	McDonald Armando purhcased CHECK IN	254.41
18-DEC-19	ZT852583	McDonald purchased instrument pans	230.00
18-DEC-19	ZT987942	Charge for aluminum dish fluted 144	101.50
18-DEC-19	ZT987942	Charge for high pressure and specia	54.60
18-DEC-19	ZT987942	Charge for new digital ORP sensor,	1123.63
20-DEC-19	ZT923142	USB drives for data backup on the S	65.97
03-JAN-20	ZT080545	Charge for Tryptic Soy Broth 25 Gal	44.87
10-JAN-20	I2113862	Culligan Water Conditioning	29.95
15-JAN-20	J1262127	KRE-H; Phys Mchn Shp: evap dishes	225.72
17-JAN-20	ZT000328	RyuJa 000328 Amazon Grant research	181.14
17-JAN-20	ZT000328	RyuJa 000328 Amazon Grant research	74.18
17-JAN-20	ZT000328	RyuJa 000328 Amazon Grant research	102.56
17-JAN-20	ZT000328	RyuJa 000328 Amazon Grant research	158.99
17-JAN-20	ZT104789	MCDonald A purchased sleeve for res	105.44
17-JAN-20	ZT104789	McDonald A purchased Dimethyl carbo	157.51
17-JAN-20	ZT104789	McDonald A purchased flow restricto	18.94
17-JAN-20	ZT104789	McDonald, A purchased a spooler for	28.65
17-JAN-20	ZT159595	Charge for chemicals for research l	57.42
17-JAN-20	ZT159595	Charge for cylinders, specialty gas	47.40
17-JAN-20	ZT159595	Charge for new (used) controller fo	135.40
24-JAN-20	ZT225464	McDonald A purchased BETAINE, ANHYD	90.07
24-JAN-20	ZT225464	McDonald A purchased CENT BOTTLE 25	204.69
05-FEB-20	I2118261	Culligan Water Conditioning	29.95
05-FEB-20	Z1000337	Charge for a new HACH controller fo	599.99
05-FEB-20	Z1000337	Charge for fuses for lab pumps used	7.79
06-FEB-20	Z1000416	RyuJa 182074 Amazon Grant research	13.08
06-FEB-20	Z1000416	RyuJa 182074 Amazon Grant research	161.38
06-FEB-20	Z1000416	RyuJa 182074 Amazon Grant research	242.74
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	60.16
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	103.68
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	244.55
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	51.77
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	11.65
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	9.57
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	117.25
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	9.56
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	84.59
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	-44.51
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	192.95
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	5.67
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	10.39
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	21.73
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	93.21
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	25.43
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	9.53
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	23.58
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	76.30
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	-242.74
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	119.44
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	50.31
10-FEB-20	Z1000606	RyuJa 231435 Amazon Grant research	18.95
10-FEB-20	Z1000606	RyuJa 231435 Home Depot Grant resea	157.57
10-FEB-20	Z1000606	RyuJa 231435 Home Depot Grant resea	43.82
10-FEB-20	Z1000606	RyuJa 231435 Paypal Grant research	217.56
18-FEB-20	Z1000988	Armando: 25mL autoclave reactors fo	70.00

18-FEB-20	Z1000988	McDonald: Fuses for lab instruments	6.49
18-FEB-20	Z1001008	Charge for PC primers to evaluate b	36.38
18-FEB-20	Z1001008	Charge for cylinders, specialty gas	461.23
18-FEB-20	Z1001008	Charge for new syringes for Erik's	964.58
18-FEB-20	Z1001008	Charge for nitrile exam gloves, pip	1498.11
18-FEB-20	Z1001008	Charge for reagent set ammonia and	1759.50
18-FEB-20	I2120138	McDonald, Armando Gabriel.	9.90
02-MAR-20	B1825956	McDonald, Armando G.	-9.90
04-MAR-20	I2123028	Ryu, Jae H.	1796.52
05-MAR-20	Z1001838	Charge for new caps for ammonia/nit	1733.49
05-MAR-20	Z1001838	Charge for pipette tips used to pro	82.80
05-MAR-20	Z1001838	Charge for silicone treadmill belt	12.25
12-MAR-20	Z1002318	Charge for 96 well plates for qPCR	455.44
12-MAR-20	Z1002318	Charge for adhesive qPCR film, alum	229.81
12-MAR-20	Z1002318	Charge for connective wire, groundi	16.76
12-MAR-20	Z1002318	Charge for cylinders, specialty gas	195.63
18-MAR-20	Z1002545	McDonald A, Chemical Resistant O-ri	22.85
18-MAR-20	Z1002545	McDonald A, pump head for research	96.27
18-MAR-20	Z1002545	McDonald, A- vacuum pump for lab an	649.00
18-MAR-20	Z1002545	McDonald: PTFE STIRRER ANCHOR 500L	58.58
18-MAR-20	Z1002571	McDonald: STANDARD TRNS PIPETS 5ML	13.53
18-MAR-20	Z1002571	McDonald: VIAL SCINT 20ML GLASS 500	230.27
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	17.16
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	144.06
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	227.88
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	37.48
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	185.46
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	22.03
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	232.27
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	8.22
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	21.19
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	25.42
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	10.59
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	164.79
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	211.99
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	8.94
25-MAR-20	Z1002876	RyuJa 367212 Amazon Grant research	8.94
25-MAR-20	Z1002876	RyuJa 367212 Facebook Grant researc	23.82
25-MAR-20	Z1002876	RyuJa 367212 Home Depot Grant resea	36.72
25-MAR-20	Z1002876	RyuJa 367212 USAQUADCOPT EBAY Grant	73.62
25-MAR-20	I2126495	Ryu, Jae H.	697.94
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	77.73
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	55.07
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	124.00
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	20.13
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	234.95
01-APR-20	Z1003304	RyuJa 400924 Amazon Grant research	26.81
01-APR-20	Z1003304	RyuJa 400924 Home Depot Grant resea	73.80
01-APR-20	Z1003304	RyuJa 400924 Paypal Grant research	140.00
01-APR-20	Z1003304	RyuJa 400924 Paypal Grant research	168.32
01-APR-20	Z1003304	RyuJa 400924 Paypal Grant research	100.00
01-APR-20	Z1003357	RyuJa 514304 Amazon Grant research	8.25
01-APR-20	Z1003357	RyuJa 514304 Amazon Grant research	16.78
01-APR-20	Z1003357	RyuJa 514304 Amazon Grant research	17.96
01-APR-20	Z1003357	RyuJa 514304 Amazon Grant research	44.86
01-APR-20	Z1003357	RyuJa 514304 Amazon Grant research	57.91
01-APR-20	Z1003357	RyuJa 514304 Home Depot Grant resea	131.24
01-APR-20	Z1003357	RyuJa 514304 Home Depot Grant resea	139.85
01-APR-20	Z1003357	RyuJa 514304 Home Depot Grant resea	74.79
01-APR-20	Z1003357	RyuJa 514304 Paypal Grant research	226.80
01-APR-20	Z1003357	RyuJa 514304 Verizon Grant research	166.85
07-APR-20	Z1003527	McDonald A- 3V power supply for re	6.35
07-APR-20	Z1003527	McDonald A- LCD display for researc	6.39
07-APR-20	Z1003527	McDonald A- Mini reflector bulb gua	7.07
07-APR-20	Z1003527	McDonald A- PTFE stirrer anchor for	54.13

07-APR-20	Z1003527	McDonald A- bread board for resear	5.99
07-APR-20	Z1003527	McDonald A- breadboard jumper cable	7.99
07-APR-20	Z1003527	McDonald A- clamp assembly for rese	68.00
07-APR-20	Z1003527	McDonald A- hands on primer-monitor	15.99
07-APR-20	Z1003527	McDonald A- lab supplies for resear	43.35
07-APR-20	Z1003527	McDonald A- pi4 touchscreen for res	19.99
07-APR-20	Z1003527	McDonald A- sensor board for resear	6.99
07-APR-20	Z1003527	McDonald A- sensor for research	6.48
07-APR-20	Z1003527	McDonald A- soil sensor for researc	14.87
07-APR-20	Z1003527	McDonald, A- CO2 gas sensors for re	296.59
07-APR-20	Z1003527	McDonald, A- Mega v-3 shield for la	27.00
07-APR-20	Z1003527	McDonald, A- clamps for lab researc	35.51
07-APR-20	Z1003527	McDonald, A- cuvette for research	34.50
07-APR-20	Z1003527	McDonald, A- data logging equipment	23.97
07-APR-20	Z1003527	McDonald, A- data logging equipment	11.99
07-APR-20	Z1003527	McDonald, A- data logging equipment	70.26
07-APR-20	Z1003527	McDonald, A- data logging for resea	7.50
07-APR-20	Z1003527	McDonald, A- electric motor replace	16.67
07-APR-20	Z1003527	McDonald, A- pellet die for researc	319.12
07-APR-20	Z1003527	McDonald, A- replacement GC column	602.37
07-APR-20	Z1003527	McDonald, A-replacement motor resea	7.77
10-APR-20	I2128570	Culligan Water Conditioning	29.95
14-APR-20	Z1003781	Charge for cylinders, specialty gas	57.00
14-APR-20	Z1003781	Charge for pack of 1000 filters, re	880.16
14-APR-20	Z1003781	Charge for reagents to test for nit	1002.52
14-APR-20	Z1003781	Charge for reagents to test for nit	136.84
06-MAY-20	Z1004558	McDonald A- Masks for research.	36.98
06-MAY-20	Z1004558	McDonald A- digital thermometer for	12.98
06-MAY-20	Z1004558	McDonald A- refund for 4 CO2 sensor	-296.59
06-MAY-20	Z1004558	McDonald A- research supplies	29.15
19-MAY-20	Z1004937	Charge for purchase of PCR test pla	116.55
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	149.68
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	7.41
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	190.79
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	19.15
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	14.98
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29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	37.49
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	10.06
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	203.06
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	158.87
29-MAY-20	Z1005467	RyuJa 689859 Amazon Grant research	46.50
29-MAY-20	Z1005467	RyuJa 689859 Home Depot Grant resea	49.21
29-MAY-20	Z1005467	RyuJa 689859 Office Depot Grant res	43.66
29-MAY-20	Z1005475	RyuJa 764722 Amazon Batteries neede	20.99
29-MAY-20	Z1005475	RyuJa 764722 Staples Storage boxes	62.97
29-MAY-20	Z1005499	RyuJa 746498 Amazon Batteries and r	95.96
29-MAY-20	Z1005499	RyuJa 746498 Amazon Brushless motor	33.89
29-MAY-20	Z1005499	RyuJa 746498 Amazon Electronic spee	156.66
29-MAY-20	Z1005499	RyuJa 746498 Amazon Metal dispenser	44.99
29-MAY-20	Z1005499	RyuJa 746498 Amazon Metal sealer to	27.99
29-MAY-20	Z1005499	RyuJa 746498 Amazon Plastic bags ne	52.00
29-MAY-20	Z1005499	RyuJa 746498 Amazon Plastic bags ne	35.99
29-MAY-20	Z1005499	RyuJa 746498 Amazon Plastic bags th	29.99
29-MAY-20	Z1005499	RyuJa 746498 Amazon Raspberry pi he	5.99
29-MAY-20	Z1005499	RyuJa 746498 Amazon Small boxes tha	23.71
29-MAY-20	Z1005499	RyuJa 746498 Amazon Zip ties that a	4.39
29-MAY-20	Z1005499	RyuJa 746498 Staples File storage a	101.93
29-MAY-20	Z1005531	RyuJa 680904 Amazon Grant research	30.89
29-MAY-20	Z1005531	RyuJa 680904 Amazon Grant research	7.41
29-MAY-20	Z1005531	RyuJa 680904 Amazon Grant research	84.53
29-MAY-20	Z1005531	RyuJa 680904 Amazon Grant research	138.43
29-MAY-20	Z1005531	RyuJa 680904 Home Depot Grant resea	46.94
29-MAY-20	I2134640	Ryu, Jae H.	254.99
03-JUN-20	Z1005709	McDonald A- 2 angle plate 2" webbed	37.04

03-JUN-20	Z1005709	McDonald A- 4 CO2 sensors for resea	279.80
03-JUN-20	Z1005709	McDonald A- gloves for research lab	54.76
03-JUN-20	Z1005709	McDonald A- lab supplies for resear	15.97
03-JUN-20	Z1005709	McDonald A- lab supplies for resear	7.95
03-JUN-20	Z1005709	McDonald A- masks for lab research	119.96
03-JUN-20	Z1005709	McDonald A- stand for research.	114.80
03-JUN-20	Z1005709	McDonald A- supplies for research	98.58
03-JUN-20	Z1005722	Charge for 250 pk small nitrile exa	334.46
03-JUN-20	Z1005722	Charge for Great Stuff hornet spray	24.97
03-JUN-20	Z1005722	Charge for for purchase of material	1470.70
03-JUN-20	Z1005722	Charge for grease gun, grease hose,	33.47
03-JUN-20	Z1005722	Charge for plastic welding kit, res	74.19
03-JUN-20	Z1005722	Charge for purchase of new peristal	220.50
09-JUN-20	Z1006053	Charge for BASE PAIR 50 NMOL SCALE,	48.56
09-JUN-20	Z1006053	Charge for nitrile exam gloves, res	167.23
18-JUN-20	J1271165	ef/CT from 826742 to 826744	-400.98
29-JUN-20	Z1007007	Surge Protector with extension cord	50.38
29-JUN-20	I2138724	Humes, Karen S..	43.67
E5741 Med Lab & Tech Supplies			
08-JUL-19	U0132495	Chemstores/Alfaro	16.51
10-JUL-19	U0132527	Chemstores/Guho	3.04
10-JUL-19	U0132530	Chemstores/Guho	8.65
24-JUL-19	U0132644	Chemstores/Abbasi	8.18
25-JUL-19	U0132646	Chemstores/Abbasi	30.02
25-JUL-19	U0132647	Chemstores/Abbasi	21.53
26-JUL-19	U0132658	Chemstores/Abbasi	134.58
26-JUL-19	U0132659	Chemstores/Dikshyapokhrel	61.69
07-AUG-19	U0132748	Chemstores/Alfaro	72.00
08-AUG-19	U0132758	Chemstores/McDonald	10.89
13-AUG-19	U0132773	Chemstores/Abbasi	9.91
14-AUG-19	U0132781	Chemstores/Pokhrel	8.18
23-AUG-19	U0132870	Chemstores/Abbasi	214.26
26-AUG-19	U0132881	Chemstores/Pokhrel	9.91
26-AUG-19	U0132882	Chemstores/Pohkrel	29.72
27-AUG-19	U0132894	Chemstores/Abbasi	39.63
29-AUG-19	U0132924	Chemstores/Abbissa	80.97
29-AUG-19	U0132925	Chemstores/Abbisa	61.47
29-AUG-19	U0132926	Chemstores/ReturnU132924	-61.70
03-SEP-19	U0132965	Chemstores/Pokhrel	61.47
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	47.17
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	43.99
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	213.00
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	9.90
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	30.04
06-SEP-19	U0133005	Chemstores/Abbasi	91.48
11-SEP-19	U0133072	Chemstores/Abbasi	34.02
13-SEP-19	U0133135	Chemstores/McDonald	23.13
17-SEP-19	U0133169	Chemstores/Abbasi	87.88
17-SEP-19	U0133186	Chemstores/Abbasi	44.84
19-SEP-19	U0133228	Chemstores/Abbasi	72.56
23-SEP-19	U0133262	Chemstores/Guho	9.91
24-SEP-19	U0133284	Chemstores/Guho	25.56
25-SEP-19	U0133296	Chemstores/Abbasi	38.16
02-OCT-19	U0133354	Chemstores/Brower	43.50
03-OCT-19	U0133365	Chemstores/Pokhrel	72.35
22-OCT-19	U0133570	Chemstores/Pokhrell	23.33
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	299.99
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	178.08
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	17.65
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	105.69
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	226.85
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	21.98
04-NOV-19	U0133705	Chemstores/Abbasi	23.73
21-NOV-19	U0133885	Chemstores/Pokhrel	30.00
20-DEC-19	U0134294	Chemstores/Alfaro	19.68

06-JAN-20	U0134306	Chemstores/Abbasi	47.03
14-JAN-20	U0134369	Chemstores/Abbasi	19.53
21-JAN-20	U0134419	Chemstores/Abbani	30.00
24-JAN-20	U0134463	Chemstores/Abbasi	53.97
27-JAN-20	U0134467	Chemstores/Abbasi	30.00
30-JAN-20	U0134555	Chemstores/Return-U134463	-53.97
10-FEB-20	U0134652	Chemstores/Alfaro	2.00
14-FEB-20	U0134749	Chemstores/McDonald	44.18
28-FEB-20	U0134883	Chemstores/Abbasi	19.45
02-MAR-20	U0134893	Chemstores/Abbasi	19.39
03-MAR-20	U0134905	Chemstores/Guho	47.82
04-MAR-20	U0134948	Chemstores/McDonald	31.77
05-MAR-20	I2123057	Qiagen Inc.	1216.35
05-MAR-20	U0134967	Chemstores/Abbasi	82.37
05-MAR-20	U0134980	Chemstores/Guho	-36.09
05-MAR-20	U0134982	Chemstores/Guho	75.44
09-MAR-20	U0134996	Chemstores/Abbissa	36.41
09-MAR-20	U0135008	Chemstores/Abbissa	16.03
13-MAR-20	U0135054	Chemstores/Abbissa	29.12
18-MAR-20	U0135104	Chemstores/Abbissa	9.73
25-MAR-20	U0135167	Chemstores/Abbissa	117.43
25-MAR-20	U0135175	Chemstores/Abbasi	143.66
29-MAY-20	U0135346	Chemstores/Abbisa	58.21
05-JUN-20	U0135394	Chemstores/Pokhrel	60.51
25-JUN-20	U0135503	Chemstores/Crites	2.00
E5747 Safety Supplies			
25-SEP-19	ZT574740	Supplies 09022019	21.18
E5910 Rent - Machinery & Equip			
28-AUG-19	I2091615	Culligan Water Conditioning	29.95
07-MAY-20	I2131585	Culligan Water Conditioning	29.95
E5940 Other Rentals and Leases			
20-AUG-19	I2090470	Boise State University	337.50
E5992 Promotion			
02-DEC-19	J1259868	Bkstr;TABLECLOTH CALS	188.00

			$ 65745.64

Subawards

ES001 Subaward 1 Expenses			
28-OCT-19	I2102349	Boise State University	27940.93
30-JAN-20	I2117336	Boise State University	25033.25
26-JUN-20	I2138244	Boise State University	33735.28
26-JUN-20	I2138245	Boise State University	31824.18
ES002 Subaward 2 Expenses			
01-MAY-20	I2130988	Idaho State University	35436.26
19-JUN-20	I2137457	Idaho State University	133198.43

			$ 287168.33

Small Equipment (<$5K)

E7830 <5K Computer Equipment Other			
16-JUL-19	I2084671	Ryu, Jae H.	1324.98
E7995 <5K Communication Equipment			
06-NOV-19	I2104173	Ryu, Jae H.	1196.74

			$ 2521.72

Capital Equipment (>=$5K)

E6850 >5K Medical/Surgery/Lab Equipment			
09-JUN-20	I2135871	Spectra Vista Corporation	18215.00
18-JUN-20	B1835155	Spectra Vista Corporation	0.00

			$ 18215.00

Tuition Remission and Training

E7140 Tuition and Fees - Grad Assistants

16-AUG-19	J1251999	G1GB for 171-55579	786.00
16-AUG-19	J1251999	SHI1 for 171-55579	951.00
16-AUG-19	J1251999	T1GB for 171-55579	4152.00
21-AUG-19	J1252645	G1GB for V00665494	786.00
21-AUG-19	J1252645	GP01 for V00665494	48.50
21-AUG-19	J1252645	SHI1 for V00665494	951.00
21-AUG-19	J1252645	T1GB for V00665494	4152.00
21-AUG-19	J1252645	VVSF for V00665494	100.00
22-AUG-19	J1252827	G1GD for 142-24168	786.00
22-AUG-19	J1252827	SHI1 for 142-24168	951.00
22-AUG-19	J1252827	T1GD for 142-24168	4152.00
03-SEP-19	J1253572	G1GA for 941-68901	596.00
03-SEP-19	J1253572	G1GB for 051-04535	786.00
03-SEP-19	J1253572	T1GB for 051-04535	4152.00
22-OCT-19	J1257016	AN01 for 051-04535	105.00
02-JAN-20	J1261084	G2GB for 171-55579	786.00
02-JAN-20	J1261084	SHI2 for 171-55579	951.00
02-JAN-20	J1261084	T2GB for 171-55579	4152.00
16-JAN-20	J1262236	G2GD for 142-24168	786.00
16-JAN-20	J1262236	SHI2 for 142-24168	951.00
16-JAN-20	J1262236	T2GD for 142-24168	4152.00
22-JAN-20	J1262441	G2GB for V00665494	786.00
22-JAN-20	J1262441	SHI2 for V00665494	951.00
22-JAN-20	J1262441	T2GB for V00665494	4152.00
22-JAN-20	J1262441	VVSF for V00665494	100.00
22-JAN-20	J1262488	G2GA for 151-29182	786.00
22-JAN-20	J1262488	G2GB for 051-04535	786.00
22-JAN-20	J1262488	G2HA for 041-97395	87.00
22-JAN-20	J1262488	T2GA for 151-29182	4152.00
22-JAN-20	J1262488	T2GA for 941-68901	596.00
22-JAN-20	J1262488	T2GB for 051-04535	4152.00
22-JAN-20	J1262488	T2HA for 041-97395	462.00
01-JUN-20	J1269697	G3HD for 171-55579	174.00
01-JUN-20	J1269697	MPX3 for 171-55579	70.00
01-JUN-20	J1269697	T3HD for 171-55579	924.00
02-JUN-20	J1269878	G3HA for 151-29182	87.00
02-JUN-20	J1269878	G3HA for 941-68901	87.00
02-JUN-20	J1269878	G3HB for 051-04535	87.00
02-JUN-20	J1269878	T3HA for 151-29182	462.00
02-JUN-20	J1269878	T3HA for 941-68901	462.00
02-JUN-20	J1269878	T3HB for 051-04535	462.00
17-JUN-20	J1271019	G3HB for V00665494	87.00
17-JUN-20	J1271019	T3HB for V00665494	462.00
24-JUN-20	J1271442	G3HB for 161-44626	87.00
24-JUN-20	J1271442	T3HB for 161-44626	462.00

			$ 56155.50

Total Expenses	$ 680812.59

Idaho State University

ESTIMATED FINAL INVOICE

For information regarding this invoice contact:
Aaron Tolman
208-282-3056

Renee Jensen-Hasfurther
Financial Contact
University of Idaho
875 Perimeter Drive, MS 3021
Moscow, ID 83844

Date Prepared: 06/12/2020
Contract: SG-3587-SB-877869
Purchase Order:
Invoice No.: RGEO2R-08 Revised
Reference invoice number on the payment

PERIOD COVERED: 12/01/2019 - 06/30/2020

SUBAWARD	BUDGET	**CURRENT EXPENSES**	CUMULATIVE EXPENSES	(Over)/Under BUDGET
Salary	$81,365.09	**$61,928.69**	$81,365.09	$0.00
Fringe Benefits	$18,858.82	**12,615.85**	$18,858.82	0.00
Material and Supplies	$10,500.00	**1,701.92**	$10,477.69	22.31
Equipment	$51,500.23	**51,500.23**	$51,500.23	0.00
Travel	$3,932.86	**2,951.74**	$3,932.86	0.00
Consultant Services	$2,500.00	**2,500.00**	$2,500.00	0.00
Totals	$168,657.00	**$133,198.43**	$168,634.69	$22.31

Cumulative Amount Received:	$35,436.26
Billed-Not Received*:	0.00
Current Expenses	$133,198.43
Credit Applied:	($231.54)
Total Due This Period	**$132,966.89**

PLEASE NOTE

The Total Now Due represents the current billing amount and any prior billings that have not yet been received as of the invoice date. If you have already sent payment for an invoice listed as billed-not received, please remit the CURRENT expense amount rather than the cumulative total. THANK YOU!

Lisa Wood

Lisa Wood, Director, Grants & Contracts Accounting
"I certify that the above bill is correct and just, that the amounts claimed represent fair charges against this subcontract."

Please make remittances payable to Idaho State University and remit to:
921 South 8th Avenue, Stop 8219
Pocatello, ID 83209-8219

BSU Account Analysis Report
From Period: 1-10
To Period: 12-20
Report Date: 6/26/20 10:57 AM

NATURAL_ACCOUNT2	NATURAL_ACCOUNT_DESC	PROJECT	NET_AMOUNT	ACCTNG_DATE	GL_BATCH_NAME	SUBLEDGER_JE_LINE_DESC
01 - Salary	Employees - Temporary	2000001188	3,200.00	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,200.00	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,200.00	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,200.00	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,200.00	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	1,600.00	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	1,600.00	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	2,355.60	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 1640510	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,111.20	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 1663033	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,111.20	11/29/2019	PPD_11/3/2019_11/16/2019 Payroll A 1686655	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,056.00	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,056.00	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 1728919	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,056.00	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
01 - Salary	Employees - Temporary	2000001188	3,056.00	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 177188	Journal Import Created
01 - Salary	Summer Salary	2000001188	5,541.50	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
01 - Salary	Summer Salary	2000001188	5,541.50	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	2/7/2020	PPD_1/12/2020_1/25/2020 Payroll A 1791738	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	2/21/2020	PPD_1/26/2020_2/8/2020 Payroll A 1813384 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	3/6/2020	PPD_2/9/2020_2/22/2020 Payroll A 1842597 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	3/20/2020	PPD_2/23/2020_3/7/2020 Payroll A 1865872 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	4/3/2020	PPD_3/8/2020_3/21/2020 Payroll A 1889401 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	4/17/2020	PPD_3/22/2020_4/4/2020 Payroll A 1912741 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	5/1/2020	PPD_4/5/2020_4/18/2020 Payroll A 1936587 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	5/15/2020	PPD_4/19/2020_5/2/2020 Payroll A 1957265 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	5/29/2020	PPD_5/3/2020_5/16/2020 Payroll A 1982147 N	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
01 - Salary	Students	2000001188	1,846.40	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
		Total Salary:	**$ 71,395.40**			
02 - Fringe	Group Insurance - Life	2000001188	25.23	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
02 - Fringe	Group Insurance - Life	2000001188	25.23	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
02 - Fringe	Group Insurance - Life	2000001188	25.23	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
02 - Fringe	Group Insurance - Life	2000001188	25.23	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 1640510	Journal Import Created
02 - Fringe	Group Insurance - Life	2000001188	25.23	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
02 - Fringe	Group Insurance - Life	2000001188	25.23	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
02 - Fringe	Group Insurance - Life	2000001188	35.49	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 1663033	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 1728919	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	970.84	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 177188	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	286.83	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
02 - Fringe	Group Insurance - Med & D	2000001188	286.83	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
02 - Fringe	Group Ins - Medical Grad	2000001188	1,967.00	2/21/2020	PPD_1/26/2020_2/8/2020 Payroll A 1813384 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	76.04	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	76.04	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	76.04	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	76.04	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	76.04	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	7.49	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	7.49	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	39.86	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 1640510	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	72.23	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 1663033	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	72.23	11/29/2019	PPD_11/3/2019_11/16/2019 Payroll A 1686655	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	69.87	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	69.87	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 1728919	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	69.86	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	69.87	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 177188	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	2/7/2020	PPD_1/12/2020_1/25/2020 Payroll A 1791738	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	2/21/2020	PPD_1/26/2020_2/8/2020 Payroll A 1813384 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	3/6/2020	PPD_2/9/2020_2/22/2020 Payroll A 1842597 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	3/20/2020	PPD_2/23/2020_3/7/2020 Payroll A 1865872 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	4/3/2020	PPD_3/8/2020_3/21/2020 Payroll A 1889401 N	Journal Import Created

02 - Fringe	Worker's Compensation	2000001188	8.64	4/17/2020	PPD_3/22/2020_4/4/2020 Payroll A 1912741 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	5/1/2020	PPD_4/5/2020_4/18/2020 Payroll A 1936587 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	5/15/2020	PPD_4/19/2020_5/2/2020 Payroll A 1957265 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	8.64	5/29/2020	PPD_5/3/2020_5/16/2020 Payroll A 1982147 N	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	34.57	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
02 - Fringe	Worker's Compensation	2000001188	35.93	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 164051(	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 166303	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	11/29/2019	PPD_11/3/2019_11/16/2019 Payroll A 168665	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 172891	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	173.44	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 177188	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	600.70	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
02 - Fringe	Employer Retirement Contr	2000001188	600.70	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 164051(	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 166303	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	11/29/2019	PPD_11/3/2019_11/16/2019 Payroll A 168665	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 172891	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
02 - Fringe	Retirement Sick Leave	2000001188	10.40	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 177188	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.16	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.16	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.16	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.16	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.16	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	2.08	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	2.08	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	3.07	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 164051(	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.04	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 166303	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	4.05	11/29/2019	PPD_11/3/2019_11/16/2019 Payroll A 168665	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	3.97	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	3.97	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 172891	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	3.97	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	3.98	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 177188	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	1.20	2/7/2020	PPD_1/12/2020_1/25/2020 Payroll A 1791738	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	1.20	3/6/2020	PPD_2/9/2020_2/22/2020 Payroll A 1842597 N	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	1.20	4/3/2020	PPD_3/8/2020_3/21/2020 Payroll A 1889401 N	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	1.20	4/17/2020	PPD_3/22/2020_4/4/2020 Payroll A 1912741 N	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	1.20	5/29/2020	PPD_5/3/2020_5/16/2020 Payroll A 1982147 N	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	9.48	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
02 - Fringe	Unemployment Insurance	2000001188	9.49	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	244.80	7/26/2019	PPD_6/30/2019_7/13/2019 Payroll A 1472339	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	244.80	8/9/2019	PPD_7/14/2019_7/27/2019 Payroll A 1490202	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	244.80	8/23/2019	PPD_7/28/2019_8/10/2019 Payroll A 1522239	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	244.80	9/6/2019	PPD_8/11/2019_8/24/2019 Payroll A 1547259	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	244.80	9/20/2019	PPD_8/25/2019_9/7/2019 Payroll A 1573798 N	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	122.40	10/4/2019	PPD_9/8/2019_9/21/2019 Payroll A 1597100 N	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	122.40	10/18/2019	PPD_9/22/2019_10/5/2019 Payroll A 1617565	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	180.21	11/1/2019	PPD_10/6/2019_10/19/2019 Payroll A 164051(	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	238.01	11/15/2019	PPD_10/20/2019_11/2/2019 Payroll A 166303	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	238.00	11/29/2019	PPD_11/3/2019_11/16/2019 Payroll A 168665	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	233.79	12/13/2019	PPD_11/17/2019_11/30/2019 Payroll A 171388	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	233.78	12/27/2019	PPD_12/1/2019_12/14/2019 Payroll A 172891	Journal Import Created

02 - Fringe	Social Security/Medicare	2000001188	233.78	1/10/2020	PPD_12/15/2019_12/28/2019 Payroll A 174973	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	233.78	1/24/2020	PPD_12/29/2019_1/11/2020 Payroll A 1771887	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	558.31	6/12/2020	PPD_5/17/2020_5/30/2020 Payroll A 2007658	Journal Import Created
02 - Fringe	Social Security/Medicare	2000001188	558.30	6/26/2020	PPD_5/31/2020_6/13/2020 Payroll A 2033051	Journal Import Created
		Total Fringe:	$ 18,559.54			
03 - Other Expense	Express Mail/Messenger	2000001188	29.06	8/30/2019	Payables A 1562916000006 1562930 Y	FEDEX 33191787~Shipping Waste water samples for research project~~TXN00486075 FEDEX 33191787~Shipping Waste water samples for research project~~TXN00486075
03 - Other Expense	Building Services	2000001188	1,339.55	3/31/2020	Payables A 1893303000001 1893308 Y	FM-243404 2/26/2020 RM 083-101 - ELECT: Please provide a quote to add a 220V outlet in the head house - Shay Gillette FM-243404 2/26/2020 RM 083-101 - ELECT: Pleas
03 - Other Expense	Medical & Laboratory Supp	2000001188	23.17	7/31/2019	Payables A 1505471000005 1505483 Y	TFS FISHERSCI ECOM HUS~algae testing supplies for project~~TXN00483147 TFS FISHERSCI ECOM HUS~algae testing supplies for project~~TXN00483147
03 - Other Expense	Medical & Laboratory Supp	2000001188	56.13	7/31/2019	Payables A 1505471000004 1505479 Y	TFS FISHERSCI ECOM HUS~algae testing supplies for project~~TXN00484009 TFS FISHERSCI ECOM HUS~algae testing supplies for project~~TXN00484009
03 - Other Expense	Medical & Laboratory Supp	2000001188	217.08	7/31/2019	Payables A 1505471000006 1505486 Y	VWR INTERNATIONAL INC~vials for algae TOC analysis~~TXN00480020 VWR INTERNATIONAL INC~vials for algae TOC analysis~~TXN00480020
03 - Other Expense	Medical & Laboratory Supp	2000001188	207.84	8/30/2019	Payables A 1562916000003 1562925 Y	FRED-MEYER #0613~water storage containers~~TXN00489551 FRED-MEYER #0613~water storage containers~~TXN00489551
03 - Other Expense	Medical & Laboratory Supp	2000001188	97.82	8/30/2019	Payables A 1562916000003 1562925 Y	THE HOME DEPOT 1806~secondary containment for water storage~~TXN00491220 THE HOME DEPOT 1806~secondary containment for water storage~~TXN00491220
03 - Other Expense	Medical & Laboratory Supp	2000001188	51.96	8/30/2019	Payables A 1562916000003 1562925 Y	FRED-MEYER #0449~water storage containers~~TXN00489591 FRED-MEYER #0449~water storage containers~~TXN00489591
03 - Other Expense	Medical & Laboratory Supp	2000001188	41.89	8/30/2019	Payables A 1562916000003 1562925 Y	THE HOME DEPOT #1806~materials for water sample collection~~TXN00489917 THE HOME DEPOT #1806~materials for water sample collection~~TXN00489917
03 - Other Expense	Medical & Laboratory Supp	2000001188	3,161.18	8/30/2019	Payables A 1562916000003 1562925 Y	HACH COMPANY~probes for production of effluent for algae experiments~~TXN00485209 HACH COMPANY~probes for production of effluent for algae experiments~~TXN
03 - Other Expense	Medical & Laboratory Supp	2000001188	75.92	8/30/2019	Payables A 1562916000003 1562925 Y	THE HOME DEPOT #1806~water storage containers~~TXN00491554 THE HOME DEPOT #1806~water storage containers~~TXN00491554
03 - Other Expense	Medical & Laboratory Supp	2000001188	190.44	9/1/2019	Payables A 1589162000001 1589163 Y	CORR009262 - HACH COMPANY~supplies for algae cultivation~~TXN00488820 CORR009262 - HACH COMPANY~supplies for algae cultivation~~TXN00488820
03 - Other Expense	Medical & Laboratory Supp	2000001188	23.94	9/1/2019	Payables A 1589162000001 1589163 Y	CORR009263 - OFFICESUPPLY.COM~supplies for algae cultivation~~TXN00487165 CORR009263 - OFFICESUPPLY.COM~supplies for algae cultivation~~TXN00487165
03 - Other Expense	Medical & Laboratory Supp	2000001188	51.96	9/30/2019	Payables A 1609056000002 1609061 Y	FRED-MEYER #0613~water storage containers for wastewater~~TXN00492762 FRED-MEYER #0613~water storage containers for wastewater~~TXN00492762
03 - Other Expense	Medical & Laboratory Supp	2000001188	-35.98	9/30/2019	Payables A 1609056000002 1609061 Y	DICKS SPORTING GOODS1202~return of unused water containers~~TXN00500063 DICKS SPORTING GOODS1202~return of unused water containers~~TXN00500063
03 - Other Expense	Medical & Laboratory Supp	2000001188	71.46	9/30/2019	Payables A 1609056000002 1609061 Y	VWR INTERNATIONAL INC~supplies for algae TOC analysis~~TXN00498288 VWR INTERNATIONAL INC~supplies for algae TOC analysis~~TXN00498288
03 - Other Expense	Medical & Laboratory Supp	2000001188	219.03	9/30/2019	Payables A 1609056000002 1609061 Y	TFS FISHERSCI ECOM HUS~algae cultivation supplies~~TXN00495199 TFS FISHERSCI ECOM HUS~algae cultivation supplies~~TXN00495199
03 - Other Expense	Medical & Laboratory Supp	2000001188	619.34	9/30/2019	Payables A 1609056000002 1609061 Y	TFS FISHERSCI ECOM HUS~supplies for NH4+ measurements~~TXN00493996 TFS FISHERSCI ECOM HUS~supplies for NH4+ measurements~~TXN00493996
03 - Other Expense	Medical & Laboratory Supp	2000001188	209.33	11/29/2019	Payables A 1712893000005 1712901 Y	TFS FISHERSCI ECOM HUS~ammonia measurement kits~~TXN00512742 TFS FISHERSCI ECOM HUS~ammonia measurement kits~~TXN00512742
03 - Other Expense	Medical & Laboratory Supp	2000001188	257.28	11/29/2019	Payables A 1712893000005 1712901 Y	HACH COMPANY~nutrient measurement chemicals~~TXN00516000 HACH COMPANY~nutrient measurement chemicals~~TXN00516000
03 - Other Expense	Medical & Laboratory Supp	2000001188	580.66	12/31/2019	Payables A 1755253000003 1755260 Y	TFS FISHERSCI ECOM HUS~filters for algae analyses~~TXN00518845 TFS FISHERSCI ECOM HUS~filters for algae analyses~~TXN00518845
03 - Other Expense	Medical & Laboratory Supp	2000001188	71.37	1/31/2020	Payables A 1802127000003 1802132 Y	TFS FISHERSCI ECOM HUS~algae cultivation testing matrials~~TXN00522955 TFS FISHERSCI ECOM HUS~algae cultivation testing matrials~~TXN00522955
03 - Other Expense	Medical & Laboratory Supp	2000001188	79.72	1/31/2020	Payables A 1802127000003 1802132 Y	TFS FISHERSCI ECOM HUS~algae cultivation testing matrials~~TXN00522941 TFS FISHERSCI ECOM HUS~algae cultivation testing matrials~~TXN00522941
03 - Other Expense	Medical & Laboratory Supp	2000001188	71.25	1/31/2020	Payables A 1802127000003 1802132 Y	TFS FISHERSCI ECOM HUS~algae cultivation testing matrials~~TXN00526671 TFS FISHERSCI ECOM HUS~algae cultivation testing matrials~~TXN00526671
03 - Other Expense	Medical & Laboratory Supp	2000001188	180.00	2/29/2020	Payables A 1855059000008 1855092 Y	BOISE COLD STORAGECOMPANY~storage of cultivation media for algae~~TXN00532605 BOISE COLD STORAGECOMPANY~storage of cultivation media for algae~~TXN0053
03 - Other Expense	Medical & Laboratory Supp	2000001188	962.66	2/29/2020	Payables A 1855059000008 1855092 Y	TFS FISHERSCI ECOM HUS~Algae cultivation and testing supplies~~TXN00537467 TFS FISHERSCI ECOM HUS~Algae cultivation and testing supplies~~TXN00537467
03 - Other Expense	Medical & Laboratory Supp	2000001188	313.23	2/29/2020	Payables A 1855059000008 1855092 Y	HACH COMPANY~Algae cultivation and testing supplies~~TXN00537564 HACH COMPANY~Algae cultivation and testing supplies~~TXN00537564
03 - Other Expense	Medical & Laboratory Supp	2000001188	39.27	2/29/2020	Payables A 1855059000009 1855094 Y	MARINE DEPOT~Algae cultivation and testing supplies~~TXN00534357 MARINE DEPOT~Algae cultivation and testing supplies~~TXN00534357
03 - Other Expense	Medical & Laboratory Supp	2000001188	49.15	2/29/2020	Payables A 1855059000009 1855094 Y	TFS FISHERSCI ECOM HUS~Algae cultivation and testing supplies~~TXN00537465 TFS FISHERSCI ECOM HUS~Algae cultivation and testing supplies~~TXN00537465
03 - Other Expense	Medical & Laboratory Supp	2000001188	438.28	3/31/2020	Payables A 1903946000006 1903960 Y	HACH COMPANY~materials for algae cultivation and analysis~~TXN00543625 HACH COMPANY~materials for algae cultivation and analysis~~TXN00543625
03 - Other Expense	Medical & Laboratory Supp	2000001188	56.13	3/31/2020	Payables A 1903946000006 1903960 Y	TFS FISHERSCI ECOM HUS~algae cultivation and testing supplies and storage~~TXN00537870 TFS FISHERSCI ECOM HUS~algae cultivation and testing supplies and sto
03 - Other Expense	Medical & Laboratory Supp	2000001188	501.23	3/31/2020	Payables A 1903946000005 1903959 Y	TFS FISHERSCI ECOM HUS~algae cultivation and testing supplies and storage~~TXN00538362 TFS FISHERSCI ECOM HUS~algae cultivation and testing supplies and storage~
03 - Other Expense	Medical & Laboratory Supp	2000001188	605.65	3/31/2020	Payables A 1903946000006 1903960 Y	TFS FISHERSCI ECOM HUS~materials for algae cultivation and analysis~~TXN00544079 TFS FISHERSCI ECOM HUS~materials for algae cultivation and analysis~~TXN0054407
03 - Other Expense	Medical & Laboratory Supp	2000001188	45.00	3/31/2020	Payables A 1903946000006 1903960 Y	BOISE COLD STORAGECOMPANY~materials for algae cultivation and analysis~~TXN00540021 BOISE COLD STORAGECOMPANY~materials for algae cultivation and analysis~
03 - Other Expense	Medical & Laboratory Supp	2000001188	1,081.15	5/29/2020	Payables A 2006128000002 2006131 Y	TFS FISHERSCI ECOM HUS~algae cultivation and testing supplies~~TXN00549163 TFS FISHERSCI ECOM HUS~algae cultivation and testing supplies~~TXN00549163
03 - Other Expense	Medical & Laboratory Supp	2000001188	90.60	5/29/2020	Payables A 2006128000002 2006131 Y	TFS FISHERSCI ECOM HUS~algae cultivation supplies~~TXN00549010 TFS FISHERSCI ECOM HUS~algae cultivation supplies~~TXN00549010
03 - Other Expense	Storage Space Rental	2000001188	55.00	9/30/2019	Payables A 1609056000001 1609060 2 Y	BOISE COLD STORAGECOMPANY~cold storage for H2O in Feris research~~TXN00494028 BOISE COLD STORAGECOMPANY~cold storage for H2O in Feris research~~TXN0049
03 - Other Expense	Storage Space Rental	2000001188	45.00	11/29/2019	Payables A 1712893000005 1712901 Y	BOISE COLD STORAGECOMPANY~frozen water storage~~TXN00512002 BOISE COLD STORAGECOMPANY~frozen water storage~~TXN00512002
03 - Other Expense	Storage Space Rental	2000001188	45.00	11/29/2019	Payables A 1712893000005 1712901 Y	BOISE COLD STORAGECOMPANY~frozen water storage~~TXN00512021 BOISE COLD STORAGECOMPANY~frozen water storage~~TXN00512021
03 - Other Expense	Academic Fees Pd By Dept/	2000001188	4,823.00	3/1/2020	Payables A 1871351000001 1871356 Y	CORR015336 - 114063379 Ayala,Edgardo Spring 2020 Graduate Assistant CORR015336 - 114063379 Ayala,Edgardo Spring 2020 Graduate Assistant
03 - Other Expense	Academic Fees Pd By Dept/	2000001188	4,823.00	3/1/2020	Payables A 1871351000001 1871356 Y	CORR015337 - 113077552 Torres,Alejandro Spring 2020 Graduate Assistant CORR015337 - 113077552 Torres,Alejandro Spring 2020 Graduate Assistant
		Total Other Expens	$ 21,864.75			
04 - Travel	Rental Vehicles-In State	2000001188	24.10	8/30/2019	Payables A 1562916000004 1562926 Y	CHEVRON 0095274~Rental fuel for E.Ayala to Moscow,ID to pick up research samples~TA#49273~TXN00490372 CHEVRON 0095274~Rental fuel for E.Ayala to Moscow,ID t
04 - Travel	Rental Vehicles-In State	2000001188	21.49	8/30/2019	Payables A 1562916000005 1562929 Y	CHEVRON 0095274~Rental fuel for E.Ayala to Moscow,ID to pick up research samples~TA#49273~TXN00490452 CHEVRON 0095274~Rental fuel for E.Ayala to Moscow,ID t
04 - Travel	Rental Vehicles-In State	2000001188	276.99	8/30/2019	Payables A 1562916000005 1562929 Y	ENTERPRISE RENT-A-CAR~Rental truck to pick up water for Feris lab~49273/49275~TXN00490757 ENTERPRISE RENT-A-CAR~Rental truck to pick up water for Feris lab~4927
04 - Travel	Rental Vehicles-In State	2000001188	46.96	8/30/2019	Payables A 1564130000001 1564144 Y	STINKER # 38~Rental fuel for E.Ayala to Moscow,ID to pick up research samples~TA#49273~TXN00490271 STINKER # 38~Rental fuel for E.Ayala to Moscow,ID to pick up res
04 - Travel	Rental Vehicles-In State	2000001188	32.30	8/30/2019	Payables A 1564130000001 1564144 Y	CHEVRON 0095274~Rental fuel for E.Ayala to Moscow,ID to pick up research samples~TA#49273~TXN00489867 CHEVRON 0095274~Rental fuel for E.Ayala to Moscow,ID t
04 - Travel	Commercial Airfare-Out Of	2000001188	442.10	7/31/2019	Payables A 1505471000005 1505483 Y	DELTA AIR 0067379000717~airfare in SLC to meet with Idaho and Utah dairymen~~TXN00480866 DELTA AIR 0067379000717~airfare in SLC to meet with Idaho and Utah
04 - Travel	Subsistence & Lodging-In	2000001188	93.10	9/1/2019	Payables A 1572382000001 1572384 Y	Per diem for two days in Moscow, ID retrieving water samples from Univ of ID Per diem for two days in Moscow, ID retrieving water samples from Univ of ID
04 - Travel	Subsistence & Lodging-In	2000001188	93.10	9/12/2019	Payables A 1583473000001 1583478 Y	Per diem reimbursement for Alex Torres in Moscow, ID in Aug to retrieve water samples Per diem reimbursement for Alex Torres in Moscow, ID in Aug to retrieve wa
04 - Travel	Subsistence & Lodging-Out	2000001188	149.18	7/31/2019	Payables A 1505471000005 1505483 Y	EXPEDIA 7451936748711~lodging in SLC to meet with Idaho and Utah dairymen~44643~TXN00480616 EXPEDIA 7451936748711~lodging in SLC to meet with Idaho and Uta
04 - Travel	Subsistence & Lodging-Out	2000001188	97.19	8/30/2019	Payables A 1564130000001 1564144 Y	MOTEL 6 MOSCOW ID~Lodging for Feris lab to pick up water for project~49273/49275~TXN00490119 MOTEL 6 MOSCOW ID~Lodging for Feris lab to pick up water for proje
		Total Travel:	$ 1,276.51			

BOISE STATE UNIVERSITY

IGEM # 19-002: Nucleic Acid Memory

July 1, 2019 – December 31, 2020 Annual Report

Will Hughes

Tim Andersen

Eric Hayden

Wan Kuang

Will Clay

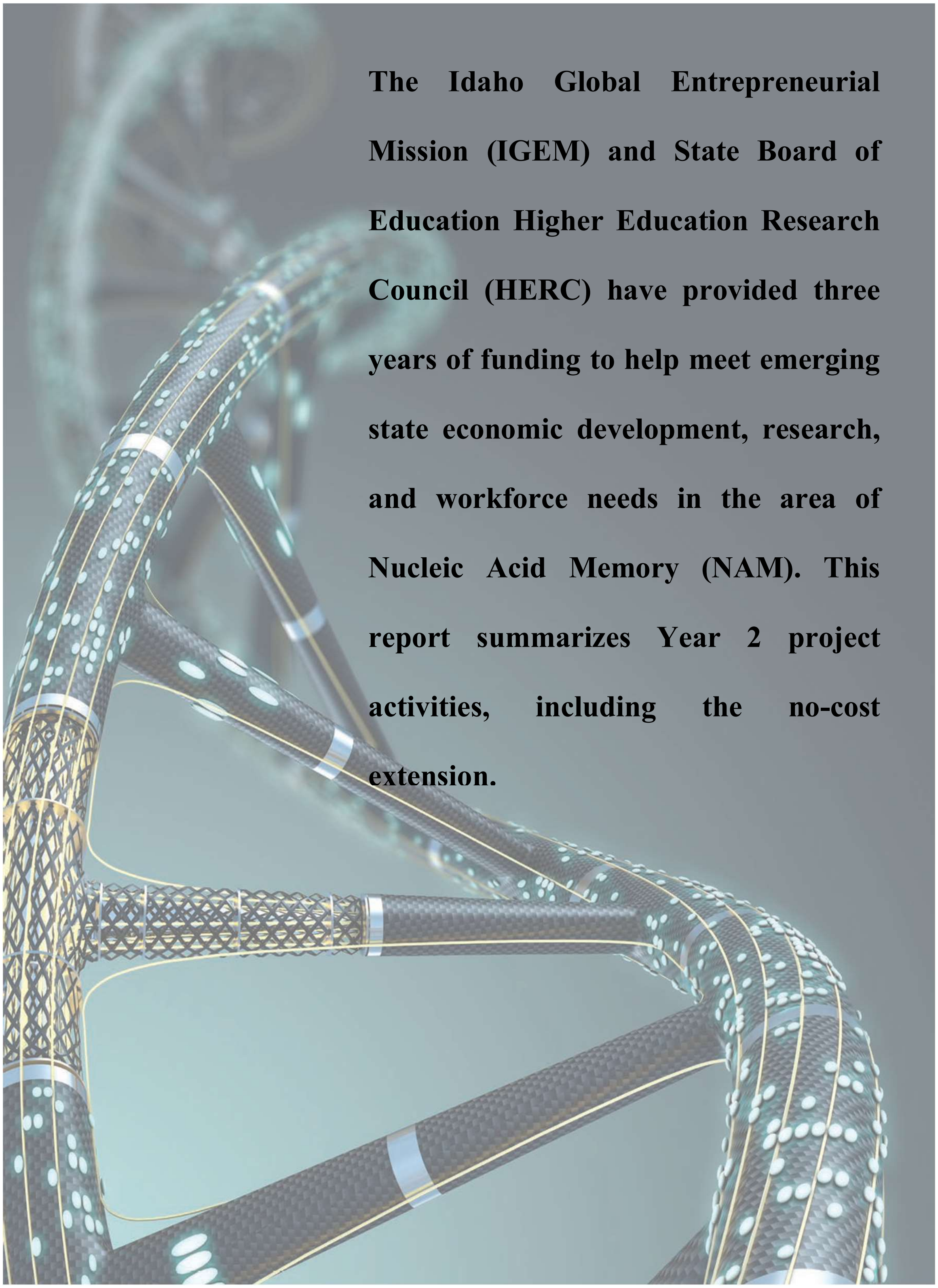
George Dickinson

Luca Piantanida

Mike Tobiason

Chad Watson

I. Project Summary



The Idaho Global Entrepreneurial Mission (IGEM) and State Board of Education Higher Education Research Council (HERC) have provided three years of funding to help meet emerging state economic development, research, and workforce needs in the area of Nucleic Acid Memory (NAM). This report summarizes Year 2 project activities, including the no-cost extension.

II. Project Overview

In 2016, the digital universe produced 16 ZB (1 ZB = 1 trillion GB) of data. In 2025 it will create 163 ZB. These data, once generated, cascade through the information lifecycle — from primary storage media in the form of hard disks and solid-state drives to archival media such as tape. While the semiconductor industry maximizes the density, stability, and energy efficiency of electronic and magnetic memory, both are fast approaching their physical and economic finish lines. As envisioned by the new Semiconductor Synthetic Biology Roadmap, DNA-based massive information storage is a fresh start for memory manufacturing in the United States. According to our study with Micron, Harvard, and the Semiconductor Research Corporation (SRC), DNA has a retention time that ranges from thousands to millions of years, 1 kg of DNA can store the projected digital universe in 2040, and DNA's energy of operation is 100 million times less than current electronic memory. As a result, nucleic acid memory has become a global conversation, a national investment, an industrial opportunity, and a local strength in Idaho.

Our vision is to pioneer a digital data storage paradigm in Idaho by designing, building, and testing accessible, editable, and non-volatile nucleic acid memory (NAM) technologies that are inspired by DNA circuits and made possible by our innovations in DNA nanotechnology. With support from IGEM-HERC, we are creating a Nucleic Acid Memory Institute to meet critical innovation, economic, and workforce development needs in Idaho. To expedite our vision of Idaho becoming a global leader in NAM, five tasks are being addressed over the life of the IGEM-HERC: **Task 1** – Create efficient algorithms for coding information into data strands. Error correction strategies will account for DNA insertions, deletions, and substitutions, as well as screen for biological sequences to ensure that the data has no genetic function. **Task 2** – Create a high-throughput, integrated analytical engine to design and select data strands using quantitative metrics based on an in-house, algorithm. **Task 3** – Create synthetic biological factories for manufacturing DNA scaffolds using rapid design-build-test cycles of genomes. Genome size and structure will be engineered. **Task 4** – Design and fabricate NAM storage platforms using the DNA scaffolds, and validate the functionality of genome scaffolds using atomic force microscopy. **Task 5** – Read arbitrary data files into NAM storage nodes using super-resolution microscopy. Realize sub-nanometer imaging resolution to enable high areal density data storage.

<u>This progress report spans July 1, 2019 to December 31, 2020. Listed below is a summary of our accomplishments during this time period. Because of COVID-19, our team continues to invest into computational work to offset the impact on our ability to perform experimental work.</u>

III. Summary of project accomplishments

The support provided by IGEM-HERC during year 1 of this project provided the infrastructure and team to create the first digital Nucleic Acid Memory (dNAM) proof-of-concept. Building on this foundation — which was described in the July 1, 2018 to June 30, 2019 Annual Report and reported in the July 1, 2019 to January 1, 2020 progress report — we conducted a series of experiments that validated dNAM as a platform for DNA-based information storage. This work led to a manuscript that was submitted to Nature on July 17, 2020. We were notified by the senior editor of Nature on October 26, 2020 that the reviewers did not recommend for publishing in Nature, but instead to consider addressing reviewer comments and submit to Nature Communications, which is an equally respected, widely-read, peer-reviewed journal within the scientific community. We are finalizing the manuscript for resubmission. We also submitted a proposal to the Semiconductor Synthetic Biology for Information Storage and Retrieval (SemiSynBio-II) program, which extends the dNAM platform supported by IGEM-HERC from two dimensions to three dimensions. Our novel approach spatially and temporally reads three-dimensional nucleic acid memory (3DNAM) with sub 5 nm lateral and 1 nm axial resolution. In brief, 3D NAM is a synergy between semiconductor technology and synthetic biology—integrating time-correlated super-resolution microscopy and DNA self-assembly to digitally read non-volatile and randomly accessible information in all three dimensions. With information densities above 10 Tbit/cm^2, read speeds over 56 Tbit/day, and the promise for scalable random access, 3DNAM has the potential to be a disruptive memory technology. While we were not selected for funding, in part because we have an active grant through the funding mechanism, the ideas generated and the proposal development process were a galvanizing experience for the team that has led us to explore new techniques and architectures for archival memory storage applications as part of our Year 3 IGEM-HERC deliverables.

The following report details the major work and outcomes supported by IGEM-HERC from July 1, 2019 to December 31, 2020, including updated content within the manuscript in support of the project tasks.

Task 1 – Create improved algorithms for coding information into data strands.

1.1 Encoding/decoding algorithms to create a working prototype of dNAM. dNAM relies on DNA-PAINT to detect individual DNA molecules and is routinely limited by incomplete strand incorporation, defective imager strands, fluorophore bleaching, and background fluorescence. To overcome these challenges, Prof Tim Andersen and graduate student Golam Mortuza created dNAM-specific information encoding and decoding algorithms that combine fountain codes with a custom, bi-level, parity-based, and orientation-invariant error detection scheme (**Fig. 1**). Fountain codes enable transmission of data over noisy channels. They work by dividing a data file into smaller units called droplets and then sending the droplets at random to a receiver. Droplets can be read in any order and still be decoded to recover the original file, so long as a sufficient number of droplets are sent to ensure that the entire file is received. The custom algorithm they developed encodes each droplet onto a single origami and adds additional bits of information for error correction to ensure that individual droplets will be recovered, in the presence of high noise, from individual origami. Together, the error correction and fountain codes increase the probability that the message is fully recovered while minimizing the number of DNA origami that must be observed. These encoding/decoding algorithms were used to create a working prototype of dNAM — encoding the short message '*Data is in our DNA!\n*', see *Task 5*, below.

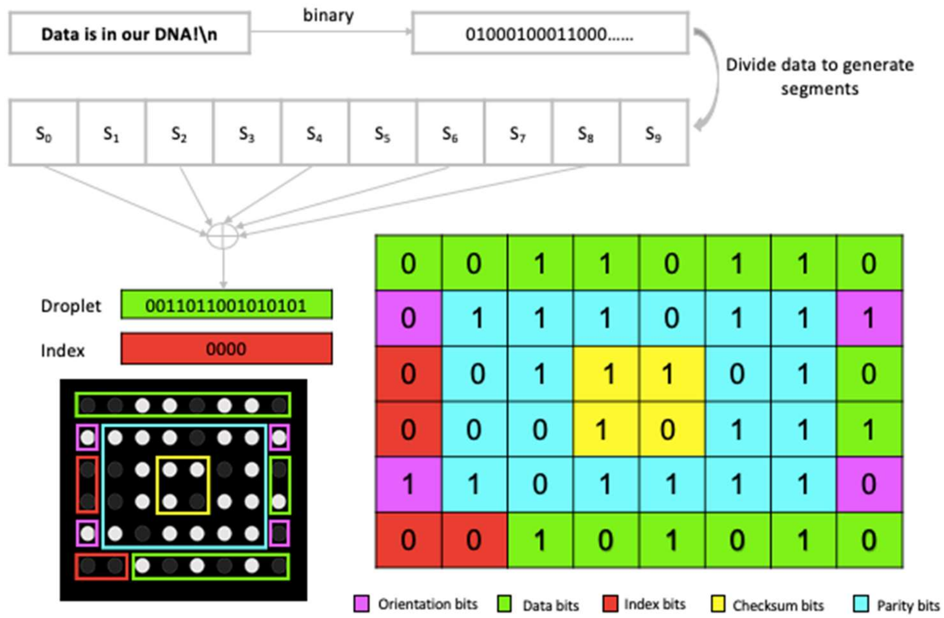


Figure 1. Example of Fountain Code implementation of dNAM digital encoding. The figure illustrates some of the main steps involved in encoding a digital message into dNAM. First a character string is divided into non-overlapping segments. These segments are combined in various patterns via an XOR operation to generate data droplets. Each droplet is assigned an index, error-correcting (checksum and parity) and orientation information and positioned within a grid to form the design used to synthesize a dNAM origami.

1.2 Size efficiency of the encoding scheme. Simulations were run to determine the size efficiency of the encoding scheme, as well as its ability to recover from errors. As shown in **Fig. 2A**, the number of origami required to encode a message of length *n* increases roughly at a linear rate up to *n* = 5000 bytes of data. Larger message sizes require more bits to be devoted to indexing, decreasing the number of available data bits per origami, creating a practical limit of 64 kilobytes of data for the prototype described in this work. This limit can be increased, however, by increasing the number of bits per origami. To determine the ability of the decoding and error correction algorithm to recover information in the presence of increasing error rates, *in silico* origami that encoded randomly generated data, were subjected to increasing bit error rates. The decoding algorithm robustly recovers the entire message for all tested message sizes when the average number of errors per origami is less than 7.4 (**Fig. 2B**). At 7.4 errors per origami, the message recovery rate droped to 97.5%, and as expected decreased rapidly with higher error rates (55%

recovery at 8.2 errors per origami, and 7.5% at 9 errors per origami). An important feature of our algorithm is that the origami recovery rate can be low (as low as 63%) and still recover the entire message 100% of the time.

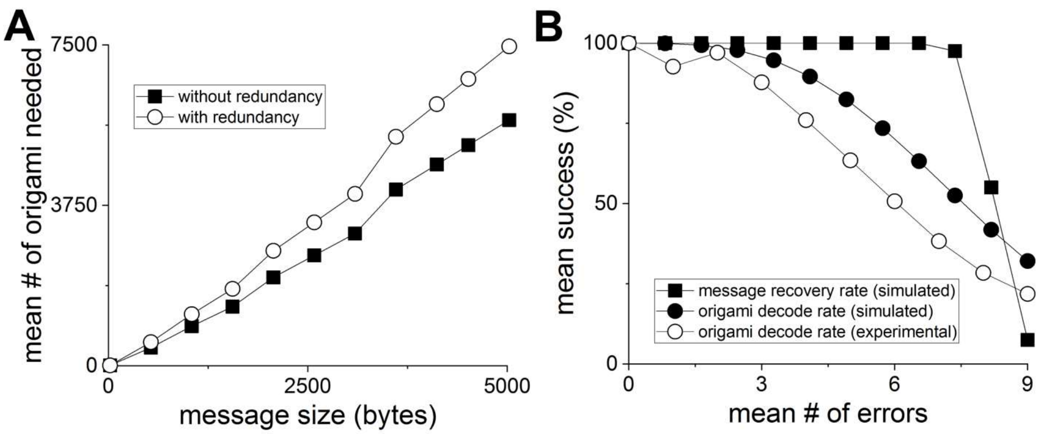


Figure 2. dNAM origami and message recovery rates in the presence of increasing errors. Simulations were performed to determine the theoretical success rates for correctly decoding individual dNAM origami and recovering encoded messages. The mean number of dNAM origami needed to successfully recover messages of increasing length with (open circles) or without (filled squares) redundant bits is plotted in (**A**). In (**B**) the mean success for recovering both individual origami (circles) and the entire message (squares) are plotted against the mean number of errors per origami (randomly generated for simulated data). Simulation recovery rates (filled symbols) are averages of all message sizes tested (160 to 12,800 bits). For experimental data (open circles) the mean success was estimated by comparing the decode algorithm's results with that of the template-matching algorithm. Two types of dNAM origami were simulated, with (open circles) and without (black squares) redundancy.

1.3 Number of origami needed to decode the 'Data is in our DNA!\n' message. As a further test of the efficiency of the encoding/decoding algorithm, we used a random sampling approach to determine the number of origami needed to decode the *'Data is in our DNA!\n'* message. We started with all the decoded binary output strings that were obtained from the single-field-of-view recordings and took random subsamples of 50-3000 binary strings. We passed each random subsample of strings through the decoding algorithm and determined the number of droplets that were recovered (**Fig. 3**). Based on the algorithmic settings used in the experiment, we found that only ~750 successfully decoded origami were needed to recover the message with near 100% probability. This number is largely driven by the presence of origami in our sample that were prone to high error rates and thus rarely decoded correctly.

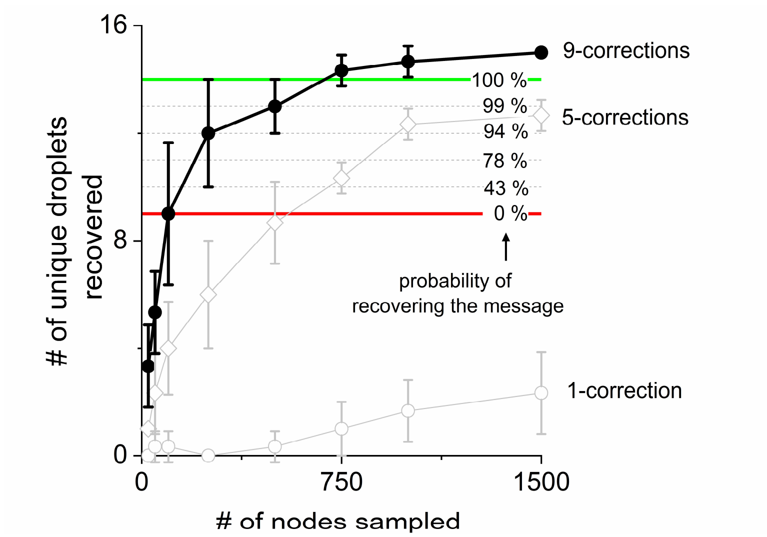


Figure 3. Number of dNAM origami required to recover the message. The mean number of unique dNAM origami matrices correctly decoded for randomly selected subsamples of decoded binary strings. The analysis was further broken out by the number of errors corrected for each origami, three examples are plotted (1, 5 and 9). Black filled circles depict the results for nine error corrections, which is the 'maximum allowable number of errors' parameter used in the decode algorithm for all other analysis reported here. The horizontal lines indicate the probability of recovering the message with different numbers of unique droplets. With fourteen or more droplets, the message should always be recovered (thick green line, and above indicates 100% chance of recovery) and with nine or fewer droplets the message will never be recovered (thick red line and below indicates 0% chance of recovery). Mean values for three experiments are shown. Error bars indicate ±SD.

Task 2 – Create a high-throughput, integrated analytical engine to design select data strands using quantitative metrics based on an in-house, algorithm.

This task was completed during the prior review. The sequence selection software called SeqEvo has been made publically available and Dr. Mike Tobiason, who created the software during his PhD, has returned to Boise State as a postdoctoral fellow uses the software to design and select DNA sequences for Tasks 3, 4, and 5. We have recently purchased high-performing computational resources in reduce the time and to increase the scale of the sequences that we can design/select.

Task 3 – Create a synthetic biological factory for manufacturing DNA scaffolds using a rapid design, build, and test cycle of genomes.

Microscopy results and modeling indicated that the outside edges of the origami tend to be poorly resolved and less stable than the inside of the origami. We hypothesized that enlarging the origami would allow the same amount of data to be stored while avoiding the outermost edge of the structure. However, this would require a larger, custom-designed ssDNA scaffold. Toward this goal, 10 novel scaffold sequences were designed that were ~11 kb in length, more than 50% larger than the common M13 scaffold. Having multiple designs will allow us to test our hypothesis that larger origami can improve our structures in general, ensuring that results are not based on individual sequences. A model of the large origami was built, and this was fed into a monte-carlo based computational algorithm that designs scaffold sequences compatible with the restraints of this design (**Fig. 4**). These sequences were computationally inserted into plasmids to design the

DNA sequences that must be synthesized. A database of ssDNA scaffolds and plasmids is under development. Gene synthesis and ssDNA production protocols are also in development. This effort was led by PhD candidate Sarah Kobernat, and several undergraduate VIP students were involved in the computational-based engineering effort and data management. Preliminary results were presented at the 26th International Conference on DNA Computing and Molecular Programming (DNA 26, September 14–17, 2020).

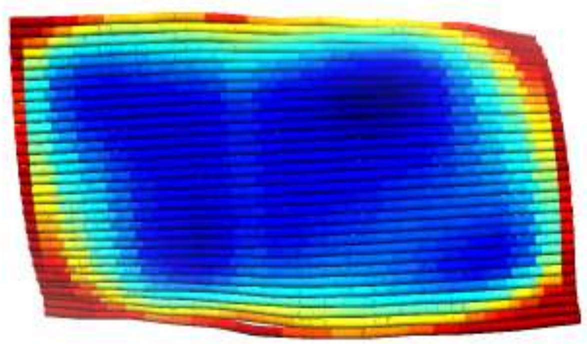


Figure 4. Origami edges are suboptimal for nanometer scale localizations. CanDo representation of an origami rectangle built from a 10.2kb custom DNA origami scaffold. Colors indicate the computed "flexibility" of the structure, where red is more flexible and blue is less flexible.

Task 4 – Design and fabricate NAM storage platforms using the DNA scaffolds, and validate the functionality of genome scaffolds using atomic force microscopy.

A workflow was developed for the design and fabrication of DNA origami storage nodes while developing the dNAM prototype. As described in *Task 1.1*, custom software was developed to encode digital data into patterns of data strands spread across multiple nodes. Additional software and excel spreadsheets were created to automate the selection of oligonucleotides, both for ordering and pipetting using an epMotion liquid handling system. Once origami were synthesized, quality control was carried out using DNA-PAINT SRM and atomic force microscopy. DNA-PAINT imaging indicated that, although the edges of origami were more sensitive to data strand insertion failures (**Fig. 5**), all of the data domains, in each of the origami designs, were detectable in each of three separate experiments (see *Task 5*).

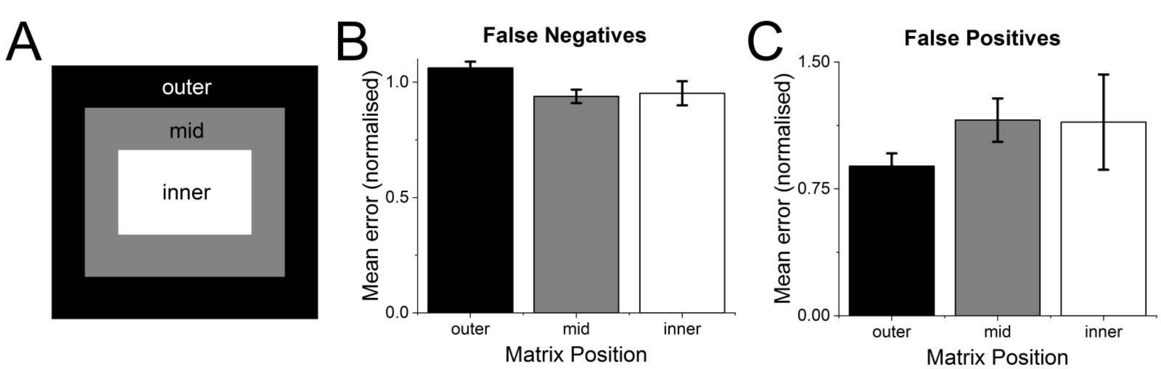


Figure 5. Outer edges and inner regions of dNAM origami are differentially error prone. The array positions of DNA origami (only considering structures with 15 or less errors, as identified by template matching) were classified as either 'outer', 'mid' or

‘inner’ depending on their position in the array (**A**). The mean error for each classification was calculated and normalized by dividing by the overall mean error for that zone. Plots of the mean normalized false negative (**B**) and false positive values (**C**) for each zone are shown. Mean values for three experiments are shown. Error bars indicate ±SD.

Each individual origami synthesis was visualized and validated by AFM. The AFM images further confirmed that the general shapes of all 15 origami designs were as expected with properly positioned data domains (**Fig. 6**). The results indicate that the extended staple strands do not substantially inhibit the synthesis of the 15 unique origami designs.

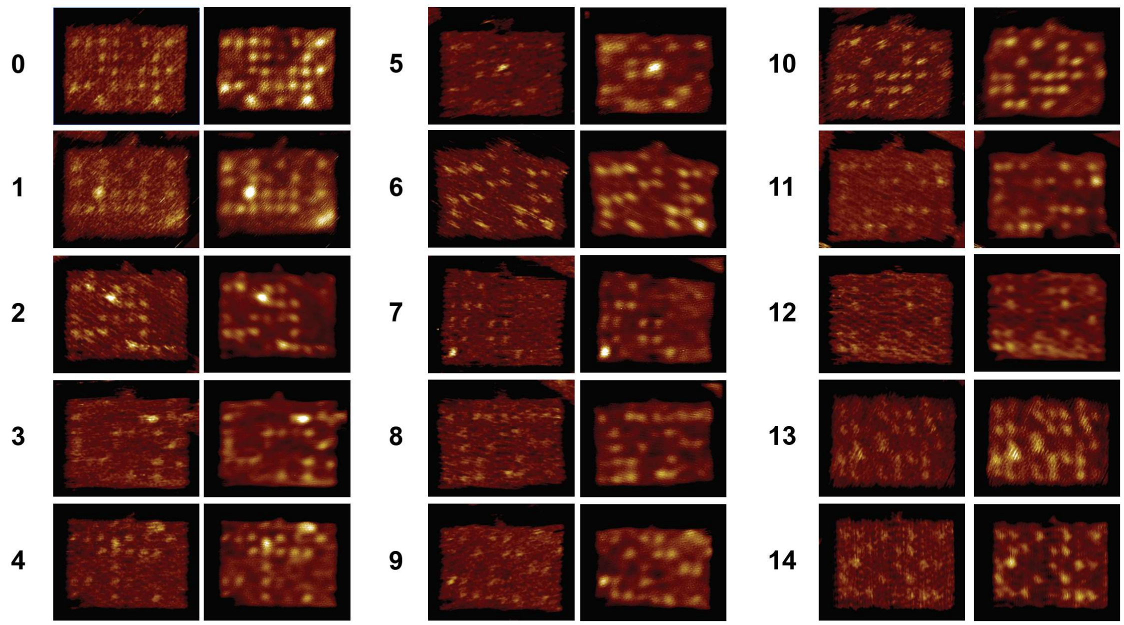


Figure 6. AFM images of dNAM origami. Representative AFM images of all 15 dNAM “Data is in our DNA!/n” origami, where most of dockings sites are visible. (An inverse FFT analysis with a band rejected filter has been applied to highlight the docking positions in right-hand panels). Every image is 90 x110 nm^2 and the color scale ranges over 250 pm.

Task 5 – Read arbitrary data files into NAM storage nodes using super-resolution microscopy.

5.1 Successful dNAM prototype. To test our dNAM concept, we encoded the message ‘*Data is in our DNA!\n*’ into 15 distinct DNA-origami nanostructures (**Fig. 7A**). Each origami was designed with a unique 6 x 8 data matrix that was generated by our encoding algorithm with data domains positioned ~10 nm apart. For encoding purposes, the message was converted to binary code (ASCII) and then segmented into 15 overlapping data droplets that were each 16 bits. Inspired in part by digital encoding formats like QR-codes, the 48 addressable sites on each origami were used to encode one of the 16-bit data droplets, as well as information used to ensure the recovery of each data droplet. Specifically, each origami was designed to contain a 4-bit binary index (0000 – 1110), twenty bits for parity checks, four bits for checksums, and four bits allocated as orientation markers (**Fig. 7B**). To fully recover the encoded message, we synthesized each origami separately, deposited an approximately equal mixture of all 15 designs (~20 femtomoles of total origami) onto a glass coverslip, and recorded 40,000 frames from a single field of view using DNA-PAINT (~4500 origami identified in 2,982 μm^2). Super-resolution images of the hybridized imager strands were reconstructed from signal blinks identified in the recording to map the positions of the data domains on each origami (**Fig. 7C**). Using a custom localization processing algorithm developed by Dr Will Clay, the signals were translated to a 6 x 8 grid and converted back to a 48-bit binary string—which was passed to the decoding algorithm for error correction, droplet recovery, and message reconstruction. The process enabled successful recovery of the dNAM encoded message from a single super-resolution recording.

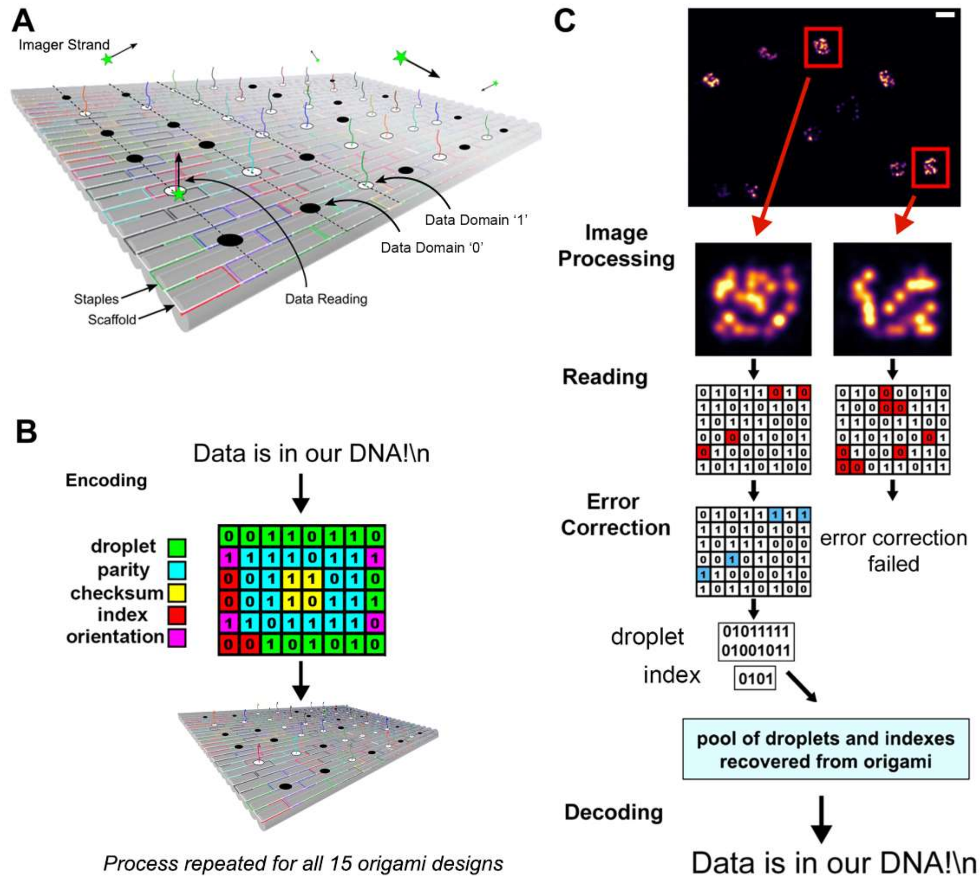


Figure 7. Binary dNAM overview. (**A**) Illustration of a binary dNAM origami, a DNA nanostructure with specific sequences used to localize data strands (a.k.a. information-bearing particles) to programmable sites within the DNA origami. Site-specific localization is enabled by extending/not-extending the structural staple strands of the origami to create physical representations of 1s/0s. The presence, absence, and identity of a data strand's docking sequence defines the state of each data strand, and is assessed by monitoring the binding of data imager strands via DNA-PAINT. (**B**) To enable reading of our test message, *'Data is in our DNA!\n'*, 15 dNAM origami were synthesized based on designs generated by the encoding algorithm (see Encoding in main text). For clarity, only one of the 15 designs is shown here. The colors of the matrix sites depicted in the design correspond with the roles of the site's bit values as follows: droplet (green), parity (blue), checksum (yellow), index (red), and orientation (magenta). (**C**) To 'read' the message, 4 μL of the DNA-origami mixture, containing 0.33 nM of each origami, was imaged using DNA-PAINT (top panel). The origami in the rendered image were identified and converted to an array of 1's and 0's corresponding to the pattern of localizations seen at each matrix location. The decoding algorithm performed error correction where possible, and successfully retrieved the entire message when sufficient data droplets and indexes were recovered. Scale bar, 100 nm.

As a quality control step, we evaluated all of the origami structures in order to confirm that the 15 different designs were successfully synthesized, with data domains in the intended addresses.

Automated image processing algorithms were developed to identify, orient and average multiple images of each origami from the DNA-PAINT recording of the mixture (**Fig. 8**).

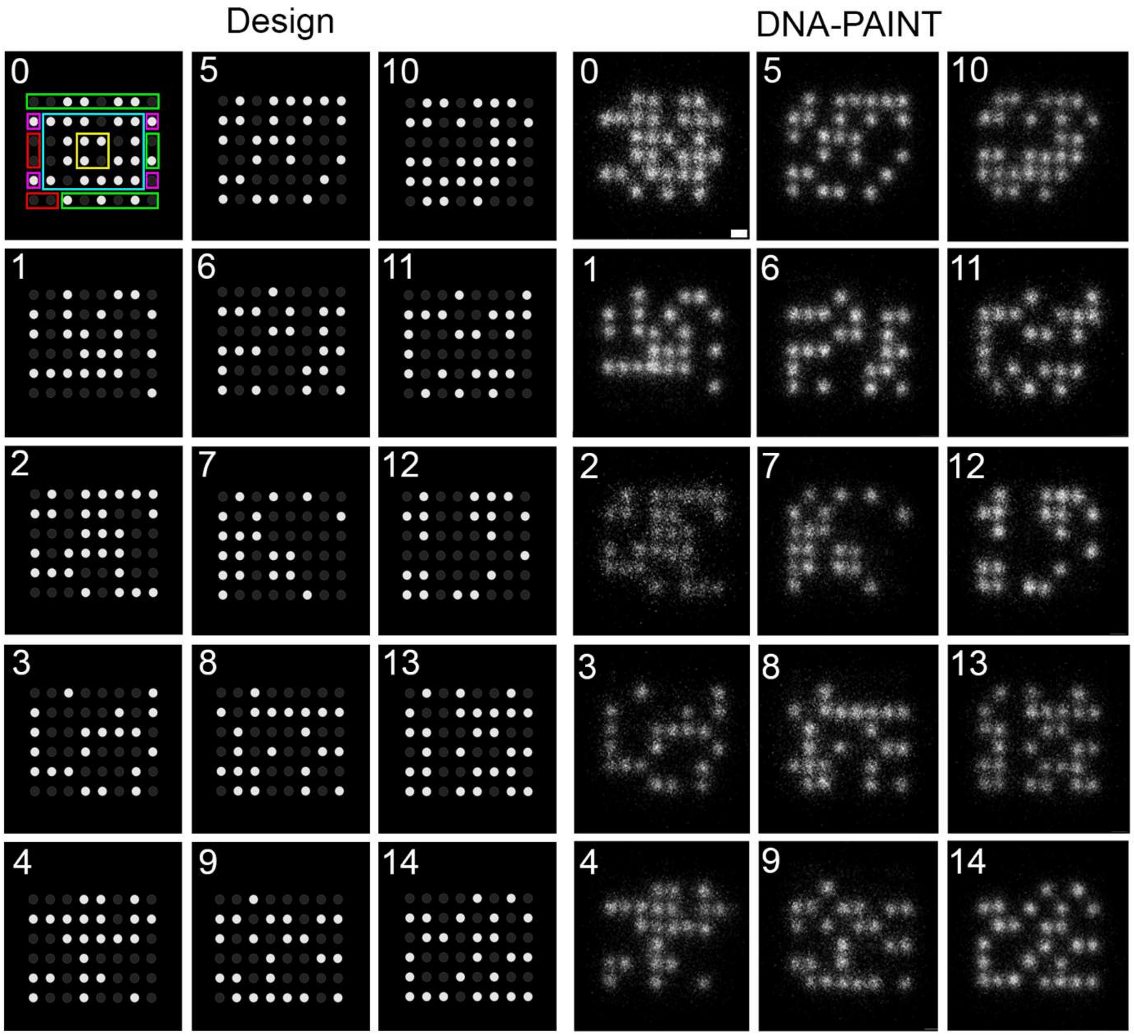


Figure 8. DNA-PAINT imaging of dNAM indicates all sites are recovered in a single read. dNAM origami from a DNA-PAINT recording were identified and classified by aligning and template matching them with the 15 design matrices (**Design**) in which all potential docking sites are shown, filled circles indicate sites encoded ‘0’ (dark grey) or ‘1’ (white). Colored boxes indicate the regions of the matrices used for the droplet (green), parity (blue), checksum (yellow), index (red), and orientation (magenta). For clarity, only the first design image includes the colored matrix sites. ‘Averaged’ images of 4560 randomly selected origami, grouped by index, are depicted right (**DNA-PAINT**). Scale bar, 10 nm.

Upon success, the mean number of each origami detected during a reocrding (**Fig. 9A**), the mean number of total errors including false positives and false negatives (**Fig. 9B**), the percentage of each origami successfully decoded (**Fig. 9C**), the percentage of each orgiami decoded versus the mean number of errors for each origami (**Fig. 9D**), and a comparison of the mean number of errors found in origami identified by template matching and the decode algorithm were calculated (**Fig. 9E**).

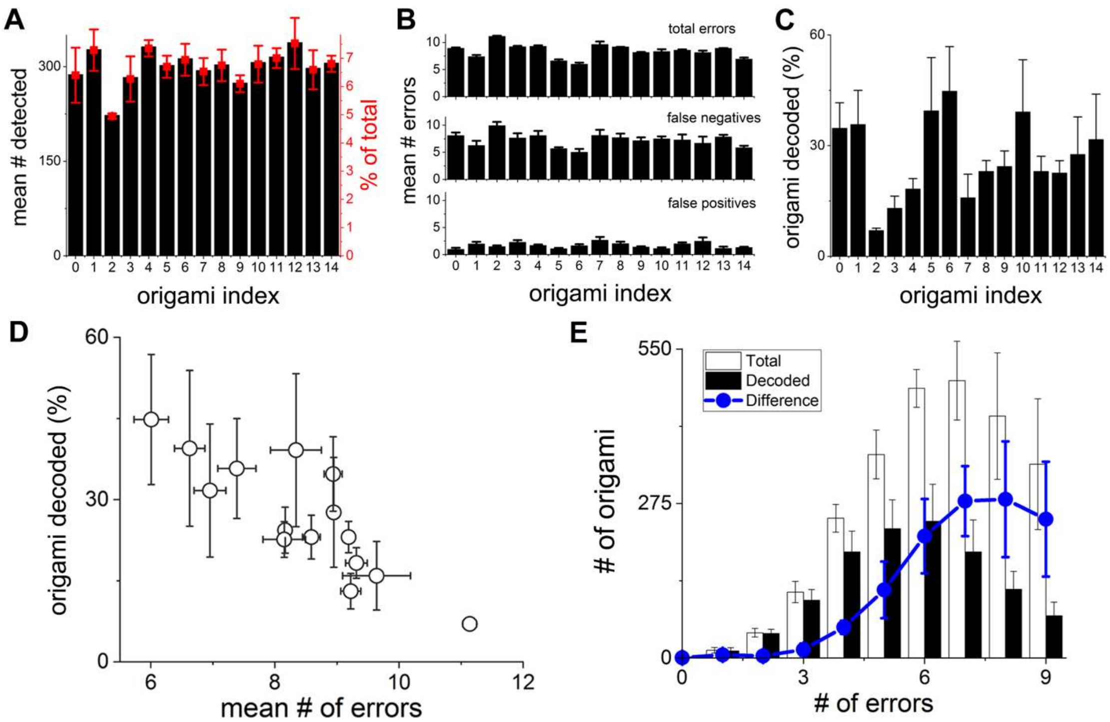


Figure 9. All 15 dNAM data strings were recovered from a single read. (**A**) plots the numbers of each index observed in a single recording, based on template matching. The mean counts are shown as black bars, percentage of total dNAM origami are shown in red. In (**B**) the mean number of total errors (top) for each structure is shown, based on template matching. The same errors are also shown after being grouped into false negatives (middle) and false positives (bottom). (**C**) depicts the percent of origami passed to the decode algorithm that had both their indexes and data strings correctly identified. In (**D**) the percentage of each origami decoded is plotted against the mean number of errors for each structure. (**E**) Histograms of the total mean numbers of errors found in origami identified by template matching (open bars) and the decode algorithm (black bars) are shown. The difference between the two is plotted in blue. Mean values for three experiments are depicted in all graphs, error bars indicate ±SD.

5.2 DNA-PAINT resolution. To evaluate the resolution of the DNA-PAINT experiments used in the dNAM proof-of-principle, FWHM values were derived by taking transect measurements centered on binding sites in rendered images (with 1-pixel blur applied) of either individual or 'averaged' dNAM origami (**Fig. 10**). In both cases at least ten binding sites were examined for each structure using with horizontally or vertically aligned positioned transects (**Fig. 10 A,B**). FWHM values of 6.6 nm ± 1.6 SD (single origami images, n = 124) and 7.2 nm ± 0.3 SD (averaged origami images, n = 47) were calculated from Gaussian fits to plots of the transect data (**Fig. 10 C,D**). This is important because the experimental resolution limits the information that can be read, not stored, in nucleic acid memory.

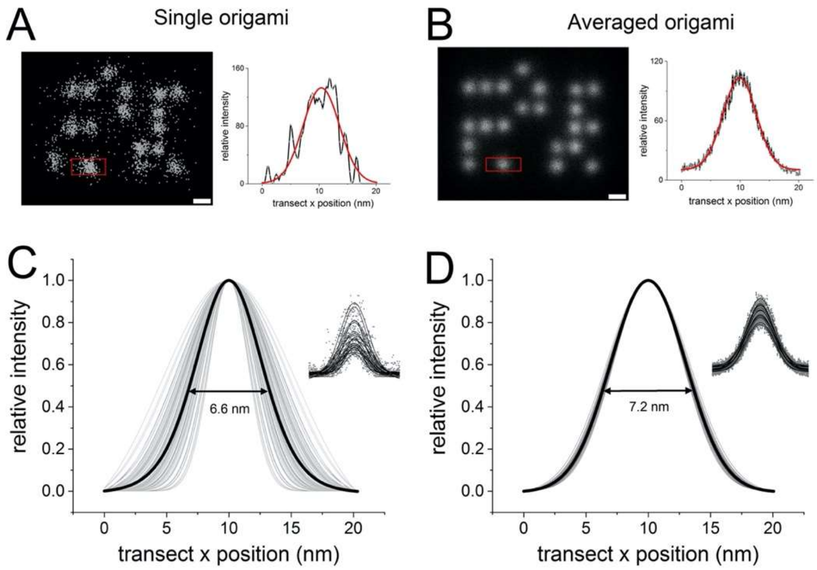


Figure 10. DNA-PAINT imaging demonstrates low nm resolution. FWHM values were derived by taking transect measurements centered on binding sites in rendered images of either individual (A) or 'averaged' dNAM origami (B). Transects were placed horizontally (as shown in red) on vertically for measurements. A plot from a single binding site is shown with a Gaussian fit to the data plotted in red. Gaussian fits for binding sites from each experiment are plotted in grey for both single (C) and 'averaged' (D) structures (after centering and normalization). The mean of the grey lines is shown in black. The inset plots are the representative results from a single experimental recording. The mean FWHM value for individual fits to each experiment was calculated and reported in the main text. Origami-6 was used in all cases, as it was the most consistently recovered structure. Scale bars, 10 nm.

5.3 – Sub-nanometer imaging resolution for SRM. Currently, we are capable of achieving a maximum resolution of ~5 nm using DNA-PAINT SRM. One route for further improvements in resolution is sample stabilization. To this end, Dr Will Clay has developed a method for real-time, active drift correction of a microscopy stage using tracking of multiple fiducial markers during acquisition. The system uses the same illumination optics, imaging optics, and sensor to detect molecular localizations and track the position of the markers so it is able to account for all potential sources of signal drift without any additional alignment or stabilization. The system uses a piezo nano-positioning stage to correct the sample drift between frames. The system is capable of stabilizing the position of the fiducial markers to less than 0.5 nm root mean square error when they are imaged alone and to 0.9 nm when they are imaged in the presence of many single molecule emitters. A visualization of this method is shown in **Figure 11**. The method identifies as many as 80 fixed markers on the sample and tracks their position using emitter localization in every frame in real time. The large number of trackers allows for averaging many positions, allowing for sub-nanometer measurement of drift even when the individual markers have poor signal to noise. **Figure 12** shows the results of a DNA-PAINT measurement taken on the same field of view of the same sample without (left) and with (right) our active drift correction system operating. Neither image has been corrected with post-processing drift correction. Without correction, the image is blurred significantly with long streaks, as is typical for uncorrected PAINT imaging. Post-processing analysis of this un-corrected image revealed over 1 micron of drift, indicating that the images would have drifted over 10 camera pixels during the course of the experiment. With active drift correction, the image was stable enough to resolve the emitting sites on the individual origami, spaced 20 nm apart, without any post processing. **Figure 13** shows the results of post-processing analysis on the actively corrected image to determine the amount of residual drift in each frame. The left panel shows the residual error in each of the 1000 frames collected, demonstrating little structure to the remaining drift and showing that the stage was stabilized to ±4 nm in over 99% of the frames and ±7 nm in every frame. Note that each frame is 300 ms long so 1000 frames spanned a 5-minute experiment. The right panel shows the same data collected as a histogram of the residual error. The RMS width of this distribution is 0.9 nm. The average number of localizations identified in each frame was roughly 2000, enough to form a DNA-PAINT image. Similar analysis of data taken on the same sample before the fluorophore-labeled DNA was introduced showed 0.5 nm RMS residual error, indicating that the systems performance is impacted by the presence of the DNA-PAINT blinks but not severely.

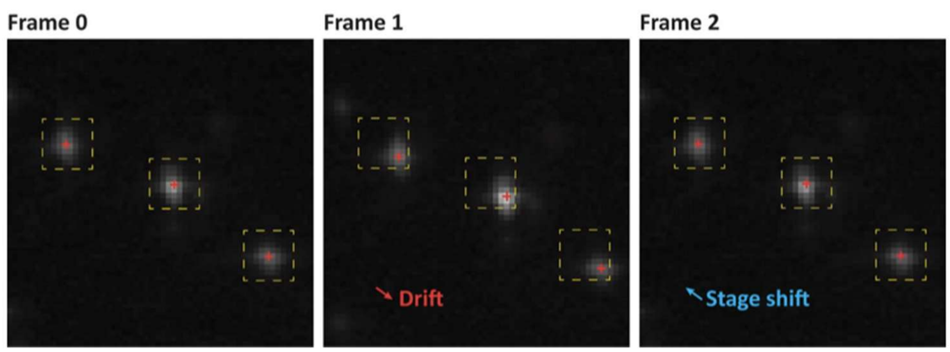


Figure 11. Schematic representation of the drift correction system. Yellow rectangles show regions of interest (ROIs) containing the signal from a fiducial tracking marker attached to the microscope slide. Red crosses show the fitted center position of the signal. In Frame 0, the markers are located in the center of the ROIs. In Frame 1, the positions have moved due to drift. In Frame 2, the stage has shifted to restore the markers to their original positions. The system applies these corrections after every frame with a minimum step size of 0.4 nm.

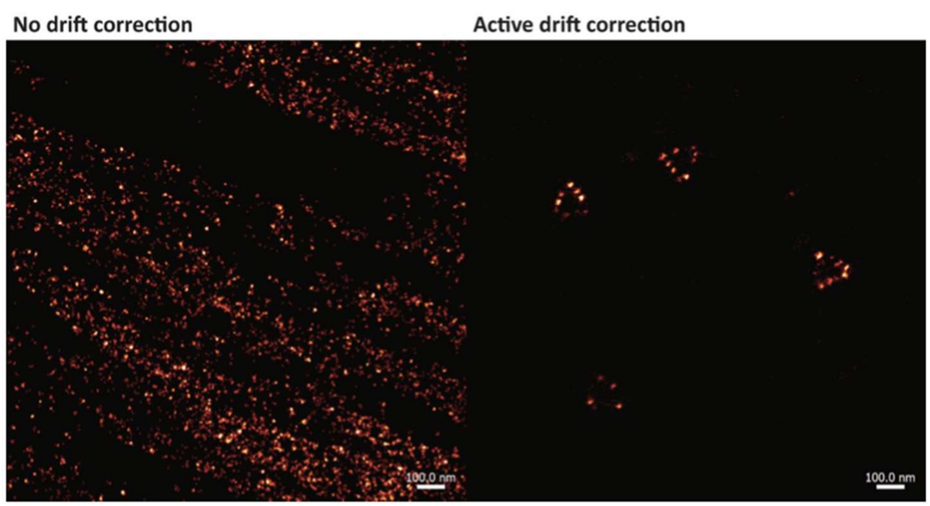


Figure 12. Super Resolution Microscopy Drift. Localization data collected from a super-resolution image of triangle shaped DNA origami, without any drift correction (left panel) and with active drift correction but no additional post processing (right panel). Resolved docking sites on the origami are spaced approximately 20 nm apart.

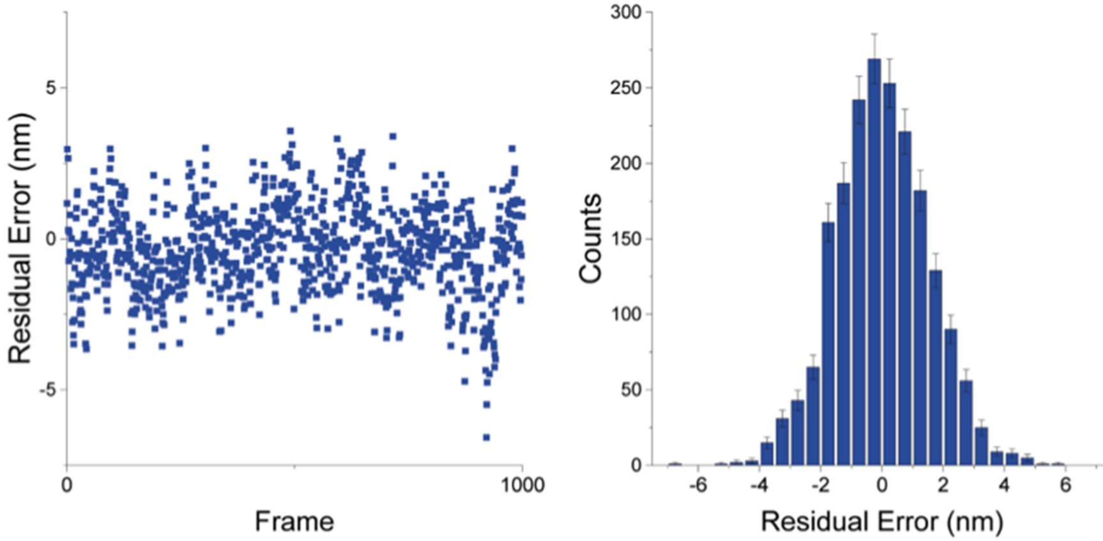


Figure 13 Error Analysis. Residual error in localization positions caused by uncorrected drift, based on post processing analysis of the image. Left panel shows the residual error in each of the 1000 frames of the experiment. Right panel shows same data in a histogram showing the occurrence of different amounts of error. The RMS width of the distribution is 0.9 nm.

IV. Demonstration of economic development and impact

Demonstration of Economic Development and Impact	**Year 1 Reporting Period 07/01/2018–06/30/2019**	**Current Reporting Period 07/01/2019–12/31/2020**
External Funding	$ 1,549,995	0
Number of External Grants	3	1 submitted, not recommended for funded
Private Sector Engagement	14 companies	2 companies, 1 VC group
University Engagement	11 universities	~20 universities
Federal Agency Engagement	5 agencies	4 (NSF, SRC, NRL, NIST, IARPA)
Industry Involvement	2 companies	2 companies (Micron, SRC)
Patents	0	1 Patent Application
Copyrights	0	0
Plant Variety Protection Certificates	0	0
Technology Licenses Signed	0	0
News Releases	3 articles	0
Start-up Businesses Started	0	1
Jobs Created outside of Boise State	0	6

External Funding

During this reporting period, we pursued the NSF SemiSynBio II proposal opportunity to grow dNAM from a 2D to a 3D technology. We were not awarded in part because of our active SemiSynBio I Award, as well as concerns that our next generation ideas were too ambitious. The benefit of applying is that our team is better positioned to resubmit the proposal next year and our team is clear minded on the preliminary results that we need to secure to achieve this goal. Target opportunities during the next award period include the NSF SemiSynBio III (if available), the NSF Partnerships for Innovation, and the NSF Planning Grants for Engineering Research Centers.

Engagement

With the backing of the NSF Office of Emerging Frontiers and Multidisciplinary Activities, Hughes hosted the 2019 Germination Meeting at Boise State University on August 15-16, 2019. The meeting focused on new approaches in cultivating risk-taking and impact-driven research culture. In response to this event, Hughes was encouraged by NSF to co-create an Institute for Transformative Scholarship at Boise State University to help researchers overcome the structural, cultural, personal, and financial barriers that prevent them from germinating and pursuing bolder ideas. As noted in the Year 1 Annual Report, the National Science Foundation (NSF) in collaboration with the Semiconductor Research Corporation (SRC) jointly awarded the research team $1,500,000 to address the scientific challenges facing NAM technologies. The funding mechanism was called *Semiconductor Synthetic Biology for Information Processing and Storage Technologies*. As part of this funding, the SRC holds an annual conference to showcase "*the quality and breadth of the SRC research portfolio, the excellence of SRC students and faculty, and the magnitude of the collaborative research investment made by industry through SRC*." Hughes and two PhD students (now graduated) on the NAM team, Chris Green and Mike Tobiason, attended the conference, which was held in Austin, Texas from September 8–10, 2019. "*The conference features student presentations and posters and gives SRC member companies multiple formal and informal occasions to network with SRC students. This is a great opportunity for students to meet with SRC member companies, including 7 of the top 10 semiconductor companies in the world. These networking occasions with SRC member companies give student opportunities to open the door to future full-time employment.*"

Hughes was also among a select group of scholars, industry stakeholders, and program managers to participate in a workshop on Nucleic Acid Nanotechnology. The workshop, held in Boston, Massachusetts in December 2019, was co-sponsored by the Materials Research Society and the prestigious Kavli Foundation. The goals of the workshop were to establish "priority research areas for next-generation applications of nucleic acid nanotechnology across diverse domains spanning computation, sensing, fabrication, therapeutics, and other areas." Through this process, Hughes reinforced relationships with Harvard University (George Church, William Shih), MIT (Mark Bathe), NIST (James Liddle), NRL (Igor Medintz), John's Hopkins (Rebecca Schulman), as well as established new relationships with the editors of Nature and Nature Materials. Based on ideas shared, George Church opened his lab to members of the NAM Institute at Boise State.

Business Development

Steven Burden, who successfully completed his PhD in Biomolecular Sciences, graduated

Classification	Number
Tenured or Tenure Track Faculty	4 (*2 full professors, 2 associate professors*)
Research Faculty	1 (*started a tenure-track faculty position*)
Project Manager	1 (*also focused on business development*)
Senior Lab Research Associate	1 (*manages the laboratory & supports team*)
Postdoctoral Fellows	3 (*performing at a research faculty level*)
Graduate Students	6 (*3 of the 6 graduated in December 2019*)
Undergraduate Students	10 (*5 female and 5 male*)

December 2019 as a member of the NAM Institute. Burden's dissertation topic was on the development of nucleic acid biosensors with allosteric fluorescence signals. For the NAM team, Burden played a lead role in our Vertically Integrated Project (VIP), where he trained undergraduate students to produce, purify, and ensure the quality control of single-stranded DNA scaffolds. Prior to graduating from Boise State, Burden co-founded a biotechnology startup (FACible BioDiagnostics — https://www.facible.com/). Based in Boise, Idaho, FACible BioDiagnostics is focused on developing rapid, low-cost, diagnostics. Burden began full time employment as the company's CEO on January 1, 2020. In addition, one of the co-founders, Clementine Gibard Bohachek, was a postdoctoral research scientist at Boise State University and was part of the NAM team during the spring of 2019, where she developed VIP training materials and trained VIP and NAM graduate students on practical laboratory approaches to synthetic biology. In all, FACible BioDiagnostics employs 6 people — three full time and three part time. The financial, scientific and professional support that Burden received during his PhD was critical for his ability to secure venture capital needed to start his company. The success of Burden highlights the entrepreneurial environment that is being cultivated by the NAM Institute and team. The team is actively reflecting on attempting to spin-off a second company related to the project.

V. Numbers of student, staff, and faculty participation

From a professional development perspective, the goal of the NAM Institute is to ensure the success of the people that make up the team, from students and postdoctoral research scientists to the faculty and staff that enable open innovation, ideation, and collaboration. And with any academic environment, matriculation to graduation is expected, supported, and applauded. Thus, we are happy to report that during this reporting period three PhD students on the NAM project successfully defended their PhD dissertation and graduated:

- **Steven Burden**, PhD in Biomolecular Sciences, Dissertation — *The Development of Nucleic Acid Biosensors with Allosteric Fluorescence Signals*
- **Chris Green**, PhD in Materials Science and Engineering, Dissertation — *Nanoscale Optical and Correlative Microscopies for Quantitative Characterization of DNA Nanostructures*.
- **Mike Tobiason**, PhD in Materials Science and Engineering, Dissertation — *Engineering Kinetically Uniform DNA Devices*
- **Golam Md Mortuza**, successfully completed their PhD proposal in Computer Science.

In addition, Reza Zadegan has started a tenure track faculty position at North Carolina A&T this past August. His professional development included but was not restricted to: grant writing support by Watson and Hughes; germination of research directions and intellectual risk management by Hughes; helping create his faculty package by Hughes, Andersen, and Hayden; mock interviews by Hughes; national and international networking opportunities by Hughes; technical training by Andersen, Hayden, Kuang, and Hughes; and professional training from Hughes and Watson. We also would like to acknowledge that one of the project principle investigators, Elton Graungnard, has transitioned from the team to focus his efforts on developing atomically-thin semiconducting materials for high performance, energy-efficient electronic devices.

New Hires

During this reporting period, two postdoctoral research scientists were hired: Luca Piantanida, who started on August 5, 2019 and Mike Tobiason, who started on November 16, 2020. Piantanida has a PhD in Nanotechnology from University of Trieste, where his dissertation was on developing DNA origami nanoactuators functionalized with gold nanoparticles for plasmon resonance tuning. Piantanida recently concluded a postdoctoral position at Durham University, UK under the supervision of Prof. Kislon Voïtchovsky, where he developed a novel atomic force microscopy approach for imaging biological interfaces in fluid. The no-cost extension provided by IGEM-HERC for Year 2 funding enabled the team to hire Mike Tobiason (he is being supported through Year 3 IGEM-HERC funding). Tobiason was a previous PhD student in the NAM Institute having earned his PhD on his work titled, "Engineering Kinetically Uniform DNA Devices." Tobiason's DNA biotechnology expertise along with his deep knowledge of NAM, he has been able to make an immediate impact to the project. In addition to the postdoctoral research scientists, we also hired a new Ph.D. student, Sarah Kobernat, in support of designing, producing, and optimizing large DNA origami scaffolds (Task 3). She is also supporting the Vertically Integrated Project through mentoring undergraduate students on scaffold design.

Vertically Integrated Project

The Vertically Integrated Project (VIP) model integrates teaching and learning into one framework in support of work-force development of students that can work at the interface of semiconductor manufacturing and synthetic biology. These students are engaging in research activities aimed toward the production, purification, and quality control of new single-stranded DNA origami scaffolds. The students range from sophomore to seniors and span four different majors: biology, chemistry, health sciences, and psychology. Specifically, the VIP students synthesized and purified several large DNA scaffolds. During the Fall 2019, the VIP students used *E. coli* cultures to express single stranded DNA ~8,000 and 10,000 bp in length. Currently, the bacteriophage M13mp18 is used to make the DNA scaffolds, but it limited to 7249 nucleotides. In addition to being longer than M13mp18, each of these scaffolds has a different sequence, potentially enabling orthogonal origami synthesis. In the Spring 2020, due to COVID restrictions, the VIP students transitioned from synthesis and characterization work in the laboratory to scaffold design and modelling work as described in *Task 3*.

VI. Description of Future Plans

Team Management – Integration and graduation

- Manage the financial risk of the anticipated higher education budget cuts in Idaho, in response to COVID-19, that have the potential to impact the NAM Institute.
- Target the next round of grant opportunities and start working towards their submission. Leverage the grant writing process as an opportunity for professional development of the postdoctoral fellows. These include the NSF Major Research Instrumentation Program, the NSF Partnerships for Innovation Program, potential SRC research development avenues, and the NSF SemiSynBio-III.
- Help the postdoctoral fellows identify the intellectual space they want to lead in the future; periodically meeting with them to establish their professional development plans.
- Seek collaborations with key internationally recognized research groups; with an eye for cross-training our laboratories.

Task 1 – Create improved algorithms for coding information into data strands.

- Use a convoluted encoder-decoder network to attempt to obtain a super-resolved image directly from the raw blinking events. While this technique has already been demonstrated on STORM (https://github.com/EliasNehme/Deep-STORM), when applied to our application space, it would be faster and could handle denser data better.
- Sharpening or deconvolving super-resolved images via a CNN trained on origami. There are multiple examples of successful applications of this technique to biological imaging

that may be more applicable to our system because of its rectilinear design (https://csbdeep.bioimagecomputing.com/tools/care/).

- Using object identification to automatically identify/classify origami in a super-resolved image to obtain binary strings to pass to our decoding algorithm. Our team has previously trained a YOLO-based CNN to identify buildings in aerial images (https://arxiv.org/abs/2004.10934), and it could be adapted for origami.

Task 2 – Create a high-throughput, integrated analytical engine to design select data strands using quantitative metrics based on an in-house, algorithm.

- The technical aspects of this task are complete. Next steps are to run SeqEvo on a high-performing cluster to decrease the time to run a job and increase the scale/complexity of the jobs that can be run.

Task 3 – Create a synthetic biological factory for manufacturing DNA scaffolds using a rapid design, build, and test cycle of genomes.

- With the successful development of software to optimize sequences, we will next set out to design and synthesize large scaffolds with sequences optimized for our specific origami designs. Several designs will be synthesized and compared. The super resolution microscopy advancements will aid in this comparison. This will require deeper integration from the research team.
- Develop quality control metrics for scaffolds. Each scaffold synthesis will need external quality control metrics to ensure batch to batch consistency in order to enable comparison.
- Determine the applicability of mass-spectrometry of DNA staple strands for defect analysis. We hypothesize that mass-spectrometry may provide information on several types of DNA damage that could lead to poor DNA-PAINT performance, such as depurination and deamination, that are not resolvable by other methods.

Task 4 – Design and fabricate NAM storage nodes using the DNA scaffolds.

- In addition to read and write using the dNAM platform, investigate editing.
- Explore the application of short Locked Nucleic Acid (LNA) and other DNA analogues in dNAM to increase the resolution of the super-resolution microscope during DNA-PAINT, as well as explore if 3DNAM (which is a derivative to seqNAM) is a viable system to increase information density in NAM.

Task 5 – Read arbitrary files into NAM storage nodes using super-resolution microscopy.

- Test methods to improve resolution on existing microscope, including reducing drift, improving drift correction, and increasing the signal-to-noise ratio.
- Use knowledge gained from optimizing existing microscope to design and test components for custom built super-resolution microscopy system while working toward a full prototype.
- Use simulation to better understand optimal imaging and sample design parameters to maximize data reading rate.

VII. Summary of Budget Expenditures

IGEM-HERC graciously allowed a no-cost extension of Year 2 funding through December 31, 2021. The below table summarizes expenditures associated with the project from July 1, 2019 to December 31, 2020. It also includes a budget adjustment made in response to the impact of COVID-19 on research operations. With the temporary closing of the research laboratories and the moratorium on travel, we projected $37,000 would be remaining at the end of our Year 2 no-cost extension (Dec. 31, 2020). We requested that $36,780.50 be re-budgeted into *Other Expenses* so the team can purchase DNA supplies in support of the research effort, which was approved by IGEM-HERC and $219.50 be placed in *Student Fees* to cover an overage. *Salary* and *Fringe* supported our graduate students, postdoctoral research scientists, an assistant research professor, a laboratory manager, and a project manager. *Other Expenses* were used to purchase modified and unmodified DNA oligos, supplies to process modified and unmodified DNA oligos into dNAM, super-resolution microscopy supplies, atomic force microscopy supplies, and computers. The oligos are used to assemble NAM blocks and to perform super-resolution microscopy studies. The atomic force microscopy supplies complement the super-resolution studies by confirming the design and structural stability of the dNAM. The computers were purchased in support of our algorithm development and newest postdoctoral research scientist. Major *Capital* purchases include an upgrade to our epMotion system, which enables us automate the mixing of solutions to synthesize DNA origami in both an accurate and efficient manner. The system was malfunctioning and was approaching its end-of-life. The upgrade ensures vendor support throughout the life of this project. Capital was used to purchase a server to improve our image processing efficiency. As part of analyzing dNAM, we compile over 60,000 high resolution images (~40 GB) per experiment. Post-processing of each series of experiments, and the 60,000+ images, are computationally intensive. When performed on a desktop computer, processing requires hours to days of processing time per experiment. The server is enabling more efficient image analysis. We also purchased an enclosure for the super-resolution microscopy system to enable low noise imaging, which will enhance image resolution.

Category	Original Year 2 Budget	Year 2 After Budget Adjustments	Expenditures	Encumbrances	Remaining Budget
Salary	$282,671.00	$276,201.00	$276,761.14	$307.20	$(867.34)
Fringe Benefits	$96,375.00	$83,138.88	$83,570.50	$63.20	$(494.82)
Other Expenses	$93,500.00	$130,500.00	$94,860.30	$35,000	$639.70
Travel	$15,000.00	$586.62	$586.62	--	--
Capital	$150,000.00	$146,900.00	$146,840.28	--	$59.72
Student Costs	$28,954.00	$29,173.50	$29,173.50	--	--
Total	$666,500.00	$666,500.00	$631,792.34	35,370.40	$(662.74)

VIII. Commercialization Revenue

Commercialization	Revenue
None.	$0

IX. Additional metrics established specific to individual project

Metrics	Number
External Funding	$ 1,549,995
Graduate Degrees Awarded	4 (3 PhD, 1 MS)
Dissertations Published	4 (3 PhD, 1 MS)
Invited Technical Presentations	15 (5 oral, 10 poster)
Software Tools Created	3
Peer-Reviewed Publications	1
Manuscripts in Preparation	4
Number of Graduate Students on the Project	2
Number of VIP Students Enrolled (grad and undergrad)	~10
Number of National and International Postdocs Hired	4
Number of Scientists that have become Tenure Track Faculty	1 (North Carolina A&T)
Number of PhD Students that have received Postdoc Fellowships	2 (NRC Fellowship)
Number of PhD Students that started a Company in Idaho	1 (6 employees)

Note: Listed above are specific, objective, measurable, and realistic performance metrics over the lifetime of the project. These metrics, many of which have been distributed throughout this report, are a reflection of project success and inform economic impact.

College of Science and Engineering

Department of Civil and Environmental Engineering

IGEM20-001

A Disaster Response Complex for Emergency Responders in Idaho

1st Year Annual Report

July 1, 2019 – August 31, 2020

August 31, 2020

Table of Contents

1.0 Basic Project Information

Funding Agency

Higher Education Research Council - Idaho Global Entrepreneurial Mission Program

Awarded Institution

Idaho State University, College of Science and Engineering, Department of Civil and Environmental Engineering

Grant Number

IGEM20-001

Project Title

A Disaster Response Complex for Emergency Responders in Idaho

Principal Investigator

Mustafa Mashal, Ph.D., P.E., Associate Professor

Co-Principal Investigator

Bruce Savage, Ph.D., P.E., Professor and Department Chair

Report Type

1st Year Annual Report: July 1, 2019 – August 31, 2020

2.0 Executive Summary

In the post 9/11 years, the national demand for training of emergency responders from the military and law enforcement branches has grown rapidly. There is a higher demand for emergency training of emergency responders than the current facilities can support. Recently, researchers at Idaho State University were awarded funding from the State of Idaho under HERC-IGEM grant. The focus of the project is the development of a Disaster Response Complex (DRC) for research, certification, and training of emergency responders in collaboration with the Directorate of National & Homeland Security at the Idaho National Laboratory (INL), and the Center for Advanced Energy Studies (CAES). The DRC has three pillars: 1) research, 2) curriculum and certification, and 3) training. All three pillars include the development of new indoor and outdoor complexes with training lanes/simulations to be used in both research, teaching, and training of emergency responders and the instrumentation of a collapsed structure. The training lanes will be used in combination with Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) surrogates/markers, the use of robots/small Unmanned Aerial Vehicle (sUAV), Virtual Reality (VR), Augmented Reality (AR), Geographic Information System (ArcGIS), Light Detection and Ranging (LiDAR), and Radio-Frequency Identification (RFID). The curriculum pillar includes offering courses in topics such as emergency response, gamma/chem spectroscopy, and safety culture. For the training pillar, the facility can be used to host events for clients such as the Department of Defense (DoD) CBRNE Response Enterprise (CRE) customers, military personnel, Idaho National Guard, and law enforcement agencies/fire departments from Idaho and the region. It is expected that the DRC will be a comprehensive facility that will incorporate natural (earthquakes, hurricanes, flooding) and man-made hazards in the training of emergency responders.

3.0 Summary of Project Accomplishments

This is the first annual report for the project. The first-year budget for the project was $525,100, which has been expended to the full amount. The formal project award letter from the Idaho State Board of Education (SBOE) was received on August 7, 2019. Given the COVID-19 situation and the lockdown, there were delays in the project. The project personnel would like to thank the Idaho State Board of Education for offering a no-cost two months extension for the first year of the project. This helped the personnel to accomplish more tasks for the project and use the first-year funding to the full benefit. Despite the pandemic and the lockdown in Idaho, the project personnel made substantial progress in the first year toward all three pillars of the DRC as described below. In addition, in line with ISU's branding, logos for the DRC were created. A website is also almost ready to be launched.

A. Research Pillar

Efforts in the research pillar were primarily focused on the use of robotics, AR, VR, Arc GIS, LiDAR, and RFID. Other research areas such as markers/surrogates for CBRNE training were also discussed with researchers from INL and ISU. Updates in each area of the research pillar are outlined as follows.

- Robotics: ISU researchers have discussed ideas with collaborators from Idaho National Laboratory (INL). INL has good capabilities, facilities and experts in robotics. Through the discussions, an ISU graduate student was identified and assigned to work with the INL group. The student has been focusing on the research aspect of the DRC and will be jointly supervised by senior researchers from ISU and INL. The graduate student (PhD level), collaborators from INL, academic advisor and supervisor from ISU have been identified. The student's paperwork was processed for access to labs and facilities at INL. The student will be working on adding capabilities to an existing INL's robot (e.g. enhancement for end of arm tooling and attachment of sensors/camera) to enhance its performance for disaster response. The student has also made the use of robotics in disaster response as the topic of his PhD dissertation at Idaho State University.
- AR/VR: ISU has partnered with INL researchers to develop a concept paper for the use of new technologies in disaster response and training. CAES provided $24,700 in funding for INL

researchers to develop the concept paper in collaboration with ISU researchers. Two ISU students have been working under the supervision of the INL researchers on this aspect of the project. The researchers from ISU and INL have been holding regular weekly meetings to discuss the elements and progress of the concept paper. The AR/VR is an emerging area of research interest to many public and private institutions, especially during a pandemic when travel is limited. The project personnel discussed the use of AR/VR for the training of emergency responders with the United States Northern Command, Defense Nuclear Weapons School, and other partners. There is a growing interest in this area and ISU/INL are actively looking for research and funding opportunities.

- <u>Arc GIS and LiDAR</u>: the outdoor collapsed structure is planned to be surveyed and shot by LiDAR during different construction stages. Results will be used for the AR/VR aspect of the project.
- <u>RFID</u>: a faculty with expertise in Electrical Engineering at ISU has been collaborating with the project personnel on the use of RFID in civil engineering applications. The internal seed grant was provided by the College of Science and Engineering at ISU to obtain preliminary results for the use of RFID and its accuracy. Although the seed grant is geared toward the application of RFID in the handling of precast concrete components, the results from the research will provide valuable insight if RFID can be used in the instrumentation of a collapsed structure or rubble pile. Based on the preliminary results, the researchers at ISU are interested to explore the application of RFID technology in disaster response.
- <u>CBRNE</u>: several meetings were held at the CAES between ISU and INL researchers. The meetings were focused on the development of chemical and biological markers. Collaborators from INL are well-established in the radiological and nuclear detection areas. Available opportunities for research in the development of markers/surrogates from agencies such as the Defense Threat Reduction Agency (DTRA) were discussed. This effort is continuing.
- Other technologies such as the use of sUAV have also been considered for applications in disaster response. INL has good capabilities in sUAV. In addition, the project personnel have discussed collaborating with the College of Technology at ISU, which has several sUAVs; some equipped with LiDAR.
- A journal paper titled "A Disaster Response Complex for Training of First Responders in Idaho" was prepared for submission to "Countering WMD Journal" which is published by the United States Army Nuclear and Countering WMD Agency.
- A graduate student attended the 9th Annual Energy Policy Research Conference in Boise, Idaho in September 2019. The student participated in the discussions and presented a poster from the project.
    - D. Garz, J. Cantrell, K. Hogarth, M. Mashal, and B. Savage (2019). A Disaster Response Complex for Training of First Responders in Idaho, 9th Annual Energy Policy Research Conference, Boise, ID, United States.
- The project PI (Dr. Mashal) attended the Winter Collaboration Meeting at CAES, January 23-24, 2020. The meeting was attended by many researchers from the Idaho National Laboratory, MIT, North Carolina State, and other universities.
    - Dr. Mashal had a presentation on "A Disaster Response Complex (DRC) for Training of Emergency Responders in Idaho".
    - Three students attended the meeting and presented a poster.
        - J. Cantrell, D. Garz, U.S. Medasetti. M. Mashal, and B. Savage (2020). "A Disaster Response Complex for Research, Curriculum, and Training of First Responders", CAES Winter Collaboration Meeting, Idaho Falls, ID, United States.

- An abstract from the DRC project was submitted for oral presentation at the 2020 American Society of Civil Engineers Southern Idaho Section "Civil Engineering Conference". The abstract was accepted for presentation, unfortunately, the conference was canceled due to the pandemic.
- An abstract from the DRC project was submitted for poster presentation at the 62nd Annual Meeting and Symposium of the Idaho Academy of Science and Engineering, April 11, 2020, Coeur d'Alene, Idaho. The conference was canceled due to the pandemic.
- The project personnel explored several grants from the Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), and the National Institute of Standards and Technology (NIST) for the DRC. A number of collaborators from ISU's Public Safety, Emergency Management, Emergency Services Department, and GIS Center were identified to pursue upcoming funding opportunity announcements in various topics under the DRC.
- CAES nominated the DRC as the CAES project for the Leadership in Nuclear energy Commission (LINE). The LINE Commission makes recommendations to the Governor on policies and actions of the State of Idaho to support and enhance the long-term viability and mission of the Idaho National Laboratory and other nuclear industries in Idaho. The Idaho LINE commission is looking to receive some recognition from the Governor for fostering research across the state.
- The project PI (Dr. Mashal) was nominated for the CAES Fellows Initiative, primarily for his work on the DRC project. The CAES Fellows initiative provides recognition and opportunities to university faculty, INL researchers, and staff who serve as leaders in the collaborative CAES community. The program incentivizes greater participation and collaboration by the community at large and serves as a vehicle to strengthen the CAES brand and identity. The CAES Fellows Initiative provides recognition, resources, and opportunities to a diverse cohort of academic faculty, INL researchers, and staff who are recognized and engaged leaders in the CAES community, active in a CAES focus area, and share the inter-institutional collaborative spirit that embodies CAES. In June 2020, CAES selected Dr. Mashal as one of six new CAES fellows. The six members of this diverse group — including a researcher with the U.S. Department of Energy's Idaho National Laboratory and faculty members from Boise State University, ISU and University of Wyoming — demonstrated extensive engagement in the CAES community, collaborating with partners at INL and the CAES universities in at least one of the focus areas outlined in the CAES strategy. Dr. Mashal was offered supplemental funding and opportunities by ISU toward the DRC project. These include:
    - ISU-CAES funds provided $16,000 to the project personnel toward setting up a small "Visualization Laboratory" in the Department of Civil and Environmental Engineering.
    - ISU-CAES funds provided Dr. Mashal with approximately $10,800 to engage ISU students in the DRC project and have them being co-supervised by the INL researchers.
    - ISU Research Office provided Dr. Mashal with $225,000 in funding toward materials and supplies, and building infrastructure. A part of this funding (approximately $30,000) was spent toward construction of the DRC outdoor training campus.
- Numerous meetings and tours of the DRC were held to discuss research collaboration with INL, CAES, ISU, law enforcement, office of emergency management, local fire departments, and private industry.

B. Curriculum and Certification Pillar

- On the curriculum side, the project personnel and INL researchers/instructors have been holding regular weekly meetings to develop a four-day long class in advanced gamma spectroscopy. A course description was prepared. The course content is geared toward the science officers from the military. The content of the course has been discussed with military officers from the United States Northern Command and the Defense Nuclear Weapons School.

- In partnership with Battelle Energy Alliance (BEA) and CAES, Idaho State University hosted the Laboratory Operations Supervisor Academy (LOSA) at no cost to 30 participating faculty, staff and students. LOSA is a prestigious training program developed by BEA, the operating contractor for INL and several other national labs for the Department of Energy. This half-day training discussed principles for the Safe Conduct of Research (SCoR) and utilized simulations and scenarios to demonstrate and build a lab safety culture. The Project PI (Dr. Mashal) and Project Manager (Jared Cantrell) offered this training at ISU. The LOSA Pilot training was sponsored by BEA for nearly $14,000. The project personnel have plans to expand LOSA for other faculty, staff, and students at ISU and make it a class under the DRC for the upcoming semesters.
- The project personnel have had discussions and tours of the outdoor DRC with potential instructors/partners to develop curriculum for emergency responders in the military, law enforcement, emergency management, and local fire departments. This is an on-going activity and with the projected completion of the training lanes in the outdoor DRC later in 2020, it is forecasted to gain more momentum. Given the current pandemic situation and travel restrictions, the project personnel are targeting participants from the local and regional level at this point. The project personnel have invited a couple of private industries to actively participate in the curriculum development for the DRC. The response from the private industry has been very positive so far. The project personnel are planning to reach out to potential instructors and form an "Advisory Committee" for the curriculum pillar of the DRC. The Advisory Committee will include experts from local fire departments, public institutions, law enforcement, state employees, and INL.

C. Training and Exercise Pillar

- This pillar includes the design and construction of an outdoor collapsed structure. The original footprint of the collapsed structure was 200 ft x 200 ft, the total area of the outdoor training and exercise facility was about 1-acre. The collapsed structure would house several training lanes such as subterranean, car-rescue, and shoring with possibilities for future expansion. Before starting construction, ISU held several meetings with potential users from the Idaho National Guard, Idaho National Laboratory, Idaho Office of Emergency Response, and local fire departments to gather their input/feedback for the outdoor facility and the training lanes. Based on the feedback of the potential users, the Idaho National Guard suggested enlarging the size of the overall facility to about 3-acres to accommodate Homeland Response Force (HRF) training sessions which typically can have between 500-800 responders training at once. The Civil Support Teams (CST) units are smaller (e.g. 22 responders) compared to HRF, but they hold more frequent training sessions (e.g. 12 times per year). The Idaho National Guard also indicated a desire for adding another training lane for high-angle rope rescue. It should be noted that the outdoor facility is planned to be utilized toward all three pillars of the DRC. The aforementioned stakeholders shared their needs for a training complex such as the DRC. They also provided ISU with information on the upcoming major training and exercise such as the Cascadia Rising 2022 in Idaho and the Wasatch Quake 2021 exercise in Utah. The contact at the Idaho National Guard, who is the Director of Joint Plans and Training, has shared the information about the ISU's DRC with the National Guard units in the states surrounding Idaho. He stated that the DRC at ISU "is a unique opportunity that, with some thought and input, the National Guard can leverage and fill a gap in available high-quality training sites in the western US without expending DoD funding".
- The project personnel worked with ISU's facilities to find a suitable location on the campus for the development of the outdoor facility. The unoccupied land behind the Idaho Accelerator Center (IAC) in Pocatello (Figure 1) was deemed suitable for the outdoor facility. The site had uneven

slopes with a pile of yard waste in the center. Soil composition is mostly silty sand with potential for erosion. A full engineering investigation of the site was carried out prior to breaking ground.

Figure 1. Location of the outdoor training facility for the DRC project

- In the first half of the year, the project personnel carried out the following tasks:
  - Surveyed the site (Figure 2).
  - Collected soil samples (Figure 3) from four test pits.
  - Performed lab tests on the soil samples to determine mechanical properties for cut and fill.
  - Developed cut and fill drawings and data (Figure 4).
  - Worked with ISU's Facilities to obtain the required work permits and identify the contractor (Starr Corp) for the earth work.
  - Developed the scope of work for Phase I of the construction that included obtaining DBS/erosion permits, obtaining estimates for construction, selecting the contractor, relocating all existing soil materials on site, moving, spraying, and compacting the existing bark and brush pile to help cover the exposed soil.
  - ISU Facilities subcontracted some design aspects such as "Erosion Control" to private firms and obtained all necessary permits for earth work from the City of Pocatello.
  - Held conversations and visited Teton Prestress Concrete in Idaho Falls (Figure 5), Oldcastle Infrastructure in Idaho Falls and Ogden, and Forterra Structural Precast in Salt Lake City (Figure 6) to obtain rubble and concrete sections for construction of the collapsed structure and the training lanes.
  - Visited several suppliers of heavy equipment in Montana and Utah to identify appropriate heavy equipment for purchase.

- Purchased heavy equipment that included a telehandler and backhoe (Figure 7). This equipment will be used to build basic training lanes, maintain the outdoor facility, and add new lanes based on the training scenarios and the client’s need.
- Despite the frozen ground, ground was broken on Monday, Dec 30, 2019 (Figures 8-9).

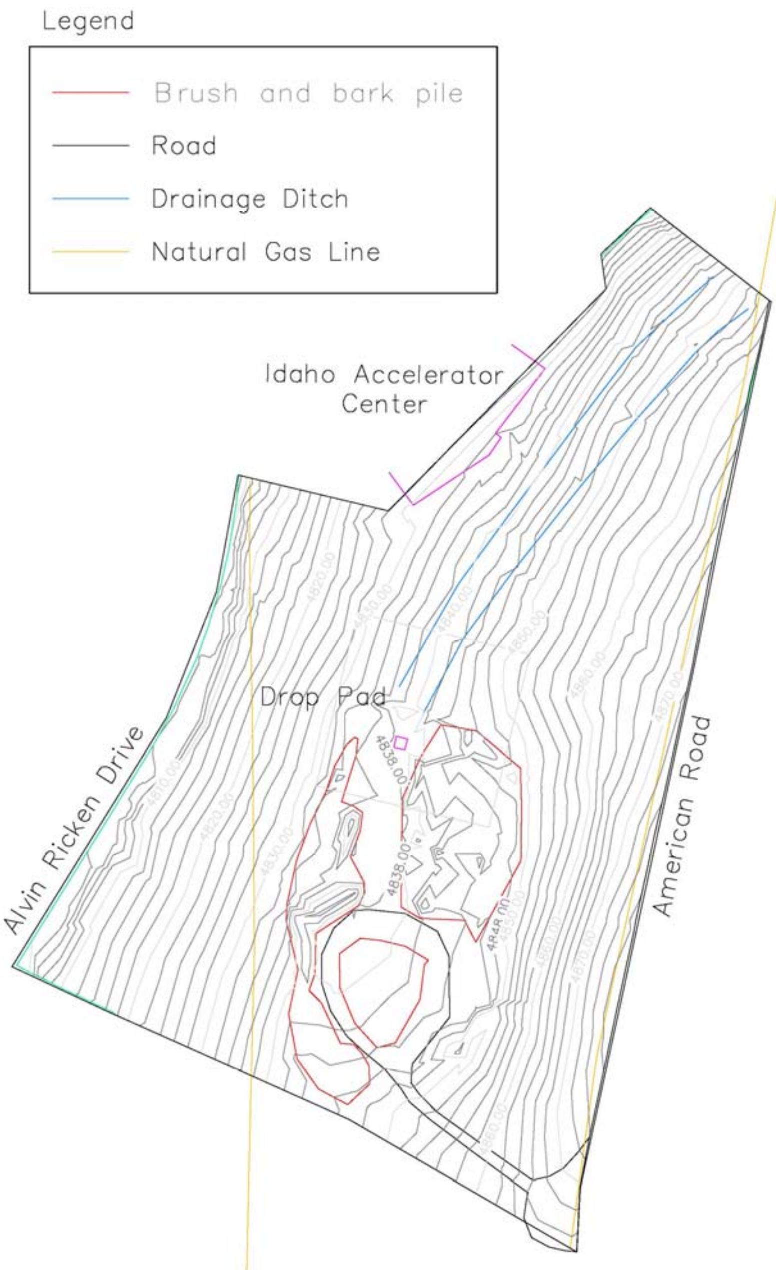


Figure 2. Surveying map of the outdoor training facility, surveyed in October 2019

Figure 3. Test pits for soil sampling

Figure 4. Cut and Fill plan of the outdoor training facility

Figure 5. Precast concrete waste pile at Teton Prestress Concrete in Idaho Falls

Figure 6. Precast concrete waste pile at Forterra Structural Precast Concrete in Salt Lake City

Figure 7. Heavy equipment for the maintenance of the outdoor training facility

Figure 8. Panoramic view of the outdoor training facility location before the start of ground preparation

Figure 9. Ground breaking on December 30, 2019

- In the second half of the year, despite the COVID 19 and lockdown restriction, the project personnel were able to work on the following tasks:
    - Completed construction of an approximately 2.5-acre compacted gravel base pad with eight inches of pit-run gravel topped with four inches of ¾ inch road mix. This created a year-round accessible area for training and exercises (Figure 10f).
    - Construction of a short gravel road to the facility and a perimeter fence with main entrance and pedestrian gates (Figures 10a-b).
    - Transported hundreds of tons of concrete sections from Idaho Falls and Ogden to the DRC site (Figures 10c-d). Prepared an inventory of all sections on-site for future use.
    - Purchased and transferred multiple conex boxes and various materials and supplies that will be used for outdoor and indoor training lanes (Figure 10e).
    - Carried out cost estimate, design, and drawings for the three basic lanes (Figure 11).
    - Completed construction of a complex subterranean lane (Figures 12-13).
    - Purchased a pick-up truck and 10-kip forklift for the DRC project.
    - Hosted visits and open houses during construction of the facility to gather more feedback from the potential users which included Public Safety, Emergency Management from ISU, Idaho State Police, Idaho Falls Fire Department, Pocatello Fire Department, Office of Emergency Management, Pocatello Police Department, INL, Department of Energy, Idaho National Guard, Idaho Civil Support Team, INL Oversight Program, and many others from public/private entities (Figure 14).
    - In addition to the outdoor training facility, the project personnel worked with ISU's Facilities to identify an appropriate indoor space for year-round training. After considering several options, the Armory Building (Figure 15) was selected. This selection was based on the feedback from INL, Idaho National Guard, and other clients. The Armory Building was an ideal place for smaller-scale training and offering special focused courses. The Armory Building was built in 1939 and originally housed the National Guard Armory. It was subsequently used by ISU for the Diesel Technology program. With the move of the Diesel Technology program in August 2020 to another location on campus, the Armory Building will be re-purposed to be used toward serving the National Guard units again. The building has a high-bay area as well as classrooms and vaults. ISU's Facilities worked diligently with relevant state entities to transfer this building to the DRC. The building is suitable for the expected activities without any major improvements. Together with the outdoor facility, the Armory building will provide substantial support for all three pillars of the DRC. The project personnel have prepared extensive designs and drawings for the

indoor facility, which will house a mock-up city block for indoor training scenarios (Figure 16).

(a) Perimeter fence under construction

(b) Gravel road to the entrance

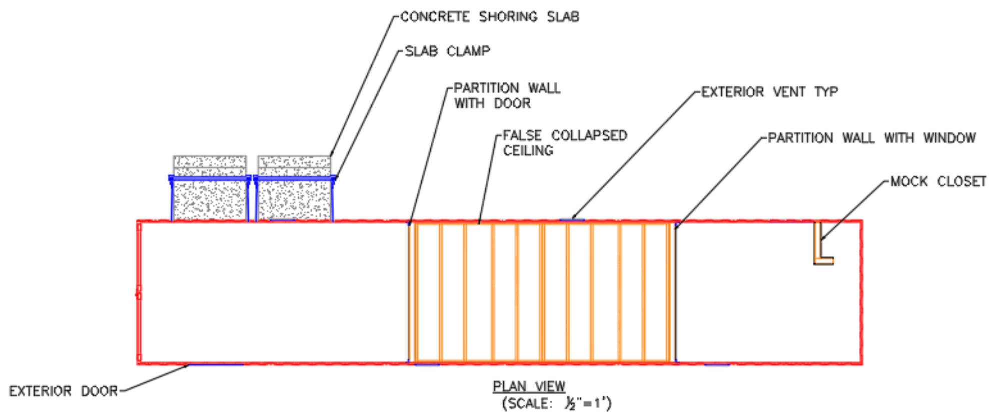
(c) Transfer of precast concrete sections

(d) Precast concrete sections for training lanes

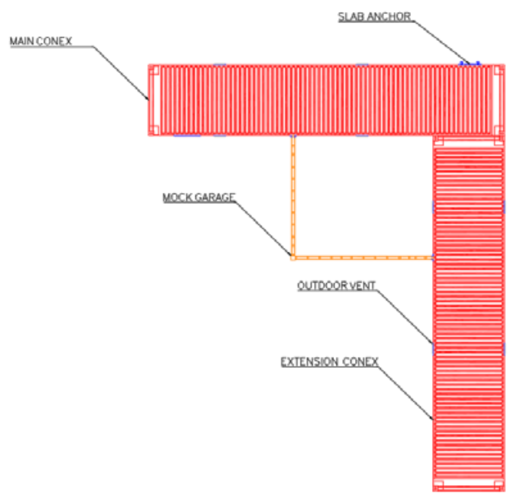
(e) Conex boxes and heavy equipment

(f) Gravel pad for staging area

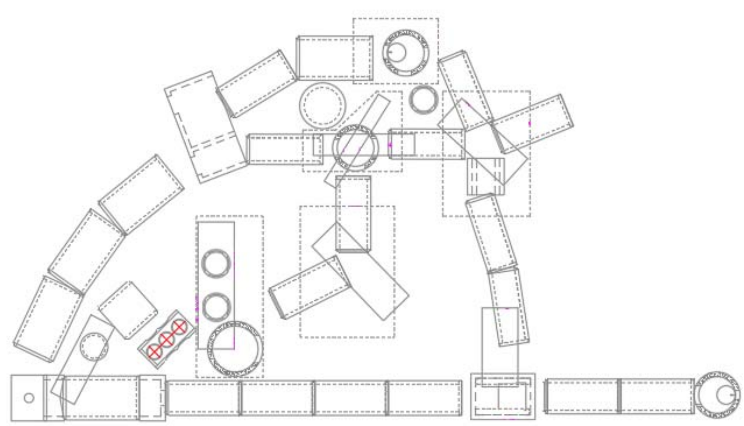
Figure 10. Construction photos from the outdoor DRC facility



(a) Main conex shoring lane details



(b) Mock garage details for the vehicle rescue lane



(c) Confined space rescue and subterranean lane layout

Figure 11. Details for the three basic lanes

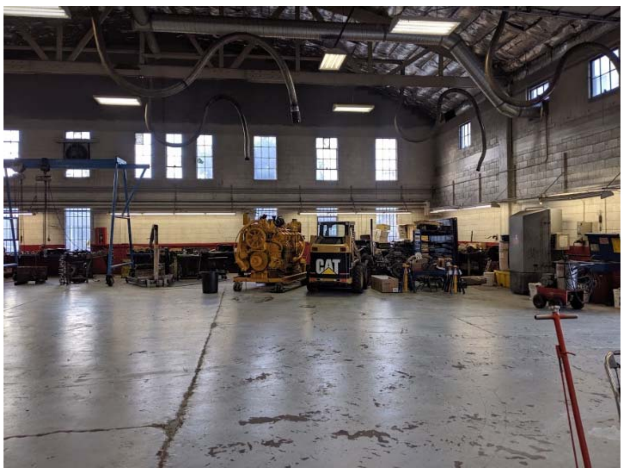
Figure 12. Photos from construction of subterranean lane

Figure 13. Completed subterranean lane

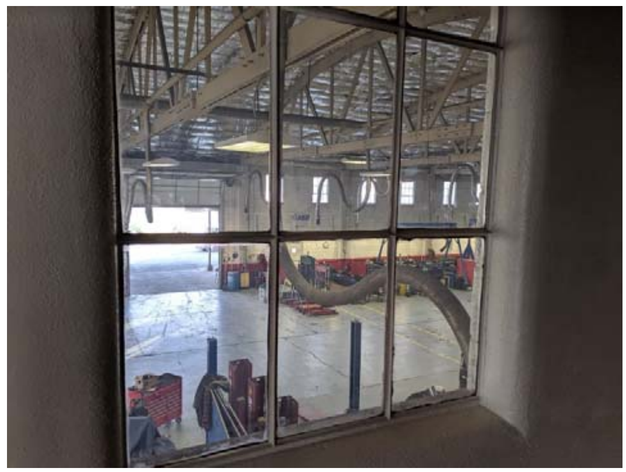
Figure 14. DRC Open House (August 2020)

(a) Front View

(b) Parking Lot on the West Side



(a) High Bay Area



(b) Lookout for High Bay area

(e) 360 view of the High Bay Area

Figure 15. Armory Building at ISU

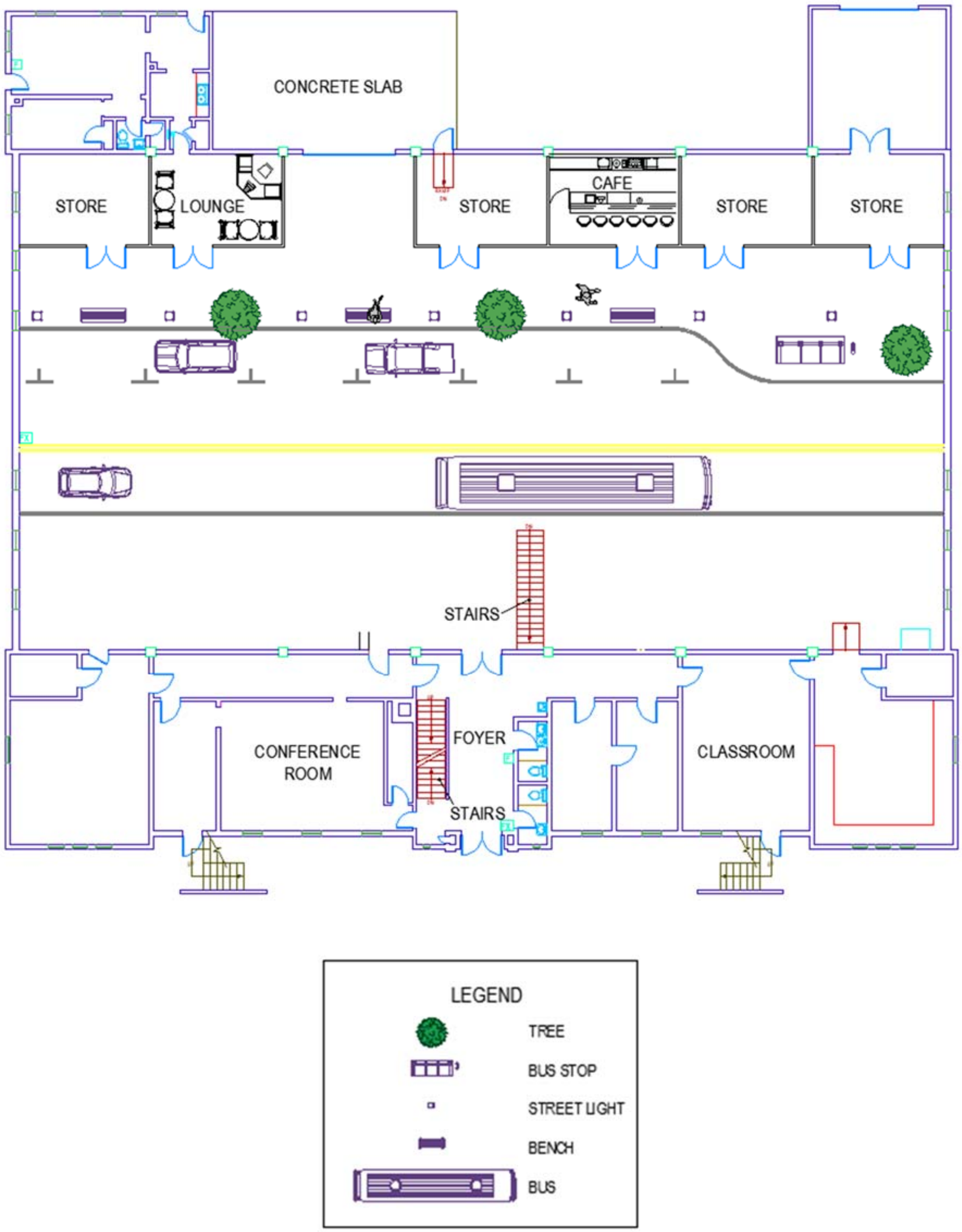


Figure 16. Indoor Facility: Mock City Street

- Besides the outdoor and indoor facilities, there are several other structures (e.g. Holt Arena and Stephens Performing Arts Center) owned by ISU which could be used to host training events. These structures offer state-of-the-art training in a realistic environment. The leadership at ISU is supportive of making the facilities available for the DRC project based on the schedule of the events.
- In 2020, multiple training events hosting more than 100 military and civilian responders were scheduled at ISU. Unfortunately, due to the lockdown, travel/gathering restrictions, spread of the virus, civil unrest and deployment of National Guard units in the locations where the participants were supposed to come to ISU, all these training events had to be canceled.

4.0 Plans for the Upcoming Reporting Period

Plans for each pillar of the DRC project are discussed below.

A. Research Pillar

- Continuing collaboration with ISU and INL researchers and exploring funding opportunities in different areas such as AR/VR, instrumentation, and new technologies for disaster response.
- Publishing more papers and highlighting DRC capabilities.

B. Curriculum and Certification Pillar

- Development of materials, identifying the instructors, and procuring the resources (e.g. advertisement, payment system etc.) for 1-2 short classes in partnership with private and public entities.
- Obtaining input from stakeholders on Federal Emergency Management Agency (FEMA) Certification requirements and processes. Reaching out to FEMA for potential partnerships.

C. Training and Exercise Pillar

- Completing construction of vehicle rescue, shoring lanes, and conex boxes.
- Starting construction of the city mock-up for the indoor training facility.
- Scheduling training events for potential partners and events, pending COVID-19 development.

5.0 Summary of Budget Expenditures

The project expenditure until August 31, 2020 is presented in Table 1. The allocated budget for the 1st year ($525,100) was spent for the full amount.

Table 1. Summary of Budget Expenditures

Salaries (faculty, graduate students, research engineer)	$172,154
Fringes (faculty, graduate students, research engineer)	$31,318
Travel	$1,552
Capital Expense	$122,117
Services and Supplies	$178,107
Tuition Remission (graduate student)	$19,852
Total Expenditure posted through August 31, 2020	**$ 525,100**

6.0 Partnerships and Impact

The project personnel have had discussions with the interested individuals and entities listed in Table 2 on this project on one or more pillars of the DRC project. The impact of the partnership has been creating opportunities for collaboration for everyone, especially for students and faculty at ISU.

A full-time Research Engineer/Lab Manager position was created for this project. The position was filled and the Research Engineer/Lab Manager started on November 4, 2019. The Research Engineer/Manager helps with all three pillars of the DRC project as well as co-supervising the students.

Table 2. Collaborators and Entities

No	Entity Name
1	Idaho National Laboratory • National and Homeland Security Directorate • Energy and Environment Science and Technology • Nuclear Science and Technology
2	The Center for Advanced Energy Studies
3	Department of Energy • Idaho Operations Office
4	Idaho Department of Environmental Quality • INL Oversight Program
5	Idaho Office of Emergency Management • Southeast Idaho • East Idaho • Boise Area
6	Idaho National Guard • Homeland Response Force • Civil Support Team
7	Idaho Falls Fire Department
8	Pocatello Fire Department
9	Pocatello Police Department
10	Idaho State Police
11	Qal-Tek Associates, LLC
12	Technical Resources Group, Inc.
13	Snake River Search, Inc.
14	Idaho State University • College of Technology • Kasiska Division of Health Sciences • Department of Mechanical Engineering • Department of Computer Science and Informatics • Health Physics • Physics • Department of Chemistry • Electrical Engineering • Environmental Monitoring Laboratory

- Department of Public Safety
- Emergency Management
- GIS Center

7.0 Faculty and Student Participation

Through August 31, 2020, the numbers of faculty, students, and other researchers who participated in one or more areas on the DRC project at ISU are listed in Table 3. Appendix 2 provides sample student activities for some of the students working on the project.

Table 3. Participating Researchers

Position	Numbers
Faculty	7 (including the PIs)
Graduate Students	6
Undergraduate Students	10
Researchers	6
Total	**29**

8.0 Metrics for Establishing Project Success and Economic Impact

Table 4 presents a summary of the metrics for establishing project success and economic impact for the first year of the project.

Table 4. Summary of the Criteria for Measuring Success for Year 1

Criteria	Pillars of the Disaster Response Complex		
	Research	Curriculum & Certification	Training & Exercise
Original Proposal	1. Detailed design/construction of the Phase I rubble pile. 2. Development of a website for the DRC and marketing using social media campaign. 3. Publication of two papers. 4. Hiring two graduate students who will work under joint supervision of ISU/INL.	1. Development of one class in emergency training in collaboration with INL/CAES. 2. Offering training courses to 50 students/first responders.	1. Training of 200 DoD CBRN Enterprise Elements (CRE) customers for radiological/nuclear response training. 2. Procurement of indoor space for CBRN and other training.
Actual Performance	1. Detail design and construction of the rubble pile was completed. 2. Logos were created, a website is almost ready to be launched. 3. Several posters were presented; a journal paper is ready for submission. 4. Two graduate students were hired to work on the DRC project under the	1. Course description and topics were developed for a class in gamma spectroscopy. The class was scheduled to be offered in December 2020. Given the pandemic situation and other approvals from the Department of Energy, the class content and schedule will be revised.	1. Multiple training events were scheduled at ISU under the DRC project in 2020. The number of emergency responders in these training events was projected to be more than 100. Unfortunately, the pandemic, lockdown, and travel/gathering restrictions did not allow for holding training events. This was beyond the control of the project personnel or ISU. The

	supervision of ISU/INL researchers. These students have made the DRC their topic for their PhD/MS dissertation/project. In addition, several other graduate students worked on the project as student employees and assistants.	2. A training for building safety culture (LOSA) was piloted to 30 students/faculty/staff at no-cost under a contract with BEA. LOSA is planned to become a curriculum that will be offered under the DRC at ISU.	project personnel are actively looking to schedule training events as the condition in Idaho and the national situation with COVID19 would allow. 2. An indoor facility was identified for the DRC. Preliminary design and drawings were completed for the indoor DRC.

9.0 Future Plans

The intent of the DRC was originally to be a self-sustaining entity by the end of the three years of funding. The pandemic and lockdown have put limitations on hosting training events in Pocatello. Several planned training events for 2020 had to be canceled. Given the uncertainty with the pandemic and how the situation for the rest of 2020 and 2021 will be, it is possible that DRC will need more than three years from the start of the project in August 2019 to become self-sustaining. Future improvements and renovations, adding new training lanes, maintenance of the facility and equipment, and salaries/fringes are intended to be funded through training, research, and certification revenue generated by both the indoor and outdoor facilities. Additionally, future grants and collaborators will be pursued to further develop the facilities for project continuation and expansion.

10.0 Expenditure Report

A detailed breakdown of the expenditure posted through August 31, 2020 is attached in Appendix 1.

11.0 Commercialization Revenue

The DRC aims to become self-sustaining through revenues collected from training, curriculum, and certification. Additionally, research funding from different opportunities and agencies are planned to be pursued to benefit the students, faculty, and other researchers.

Appendix 1: Summary of the Expenditures

Data_Description				Accounted Budget	Year-to-Date													Encumbrances	Total by ROWS
Fiscal_Month				Temporary Budget	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	August	Subtotal	YTD	
				Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
Index Only	Account			Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
AHRC48_APPR IGEM Response	Labor																	0.00	
Complex for Emeregency Responders		610_Salaries		263,800.00	0.00	0.00	(2,692.31)	(5,384.62)	(5,384.62)	(8,828.58)	(8,828.58)	(8,828.58)	(11,520.89)	(8,615.39)	(2,153.85)	(5,384.62)	(67,622.04)	0.00	196,177.96
		620_Irregular Help		0.00	0.00	(868.00)	(5,909.00)	(10,100.27)	(10,904.19)	(7,912.04)	(7,138.04)	(6,802.04)	(12,720.00)	(33,880.12)	(429.84)	(7,583.31)	(104,246.85)	0.00	(104,246.85)
		630_Fringe Benefits		0.00	0.00	(4.07)	(579.97)	(4,286.58)	(3,370.22)	(2,961.97)	(3,037.77)	(3,032.76)	(4,252.05)	(7,540.76)	(125.68)	(2,126.31)	(31,318.14)	0.00	(31,318.14)
	Direct Expenditures																	0.00	0.00
		700_Travel		0.00	(56.00)	(545.85)	(894.75)	0.00	0.00	0.00	(55.59)	0.00	0.00	0.00			(1,552.19)	0.00	(1,552.19)
		720_Services		112,200.00	0.00													0.00	112,200.00
			721_Employee Development Services	0.00	0.00	0.00	0.00	(272.69)	0.00	(26.63)	0.00	0.00	(26.63)	(53.26)			(379.21)	0.00	(379.21)
			722_General Services	0.00	0.00	(75.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			(75.00)	0.00	(75.00)
			724_Professional Services	0.00	0.00	(663.90)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(36.00)			(699.90)	0.00	(699.90)
			727_Administrative Services	0.00	0.00	0.00	0.00	0.00	0.00	(16.80)	0.00	0.00	0.00	(5,901.03)			(5,917.83)	0.00	(5,917.83)
			728_Computer/Tech Services													(88.88)	(88.88)		(88.88)
			729_Repair and Maintenance Services	0.00	0.00	0.00	0.00	(60.00)	0.00	0.00	0.00	0.00	0.00	0.00		(839.68)	(899.68)	0.00	(899.68)
			741_Rentals and Operating Leases	0.00	0.00	0.00	(135.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00			(135.00)	0.00	(135.00)
		730_Supplies		0.00	0.00													0.00	0.00
			733_Computer Supplies													(125.96)	(125.96)		(125.96)
			734_Repair and Maintenance Supplies	0.00	0.00	0.00	0.00	(3,035.63)	0.00	(53,631.84)	0.00	0.00	0.00	(105,075.82)	(560.95)		(162,304.24)	0.00	(162,304.24)
			736_Institutional/Specific Use	0.00	0.00	(211.59)	(118.34)	(199.00)	(87.82)	(8.50)	(184.05)	(59.47)	(3,496.58)	(2,381.39)	(537.94)	(196.84)	(7,481.52)	0.00	(7,481.52)
		800_Capital Expense		149,100.00	0.00													0.00	149,100.00
			820_Buildings and Improvements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(16,500.00)			(16,500.00)	0.00	(16,500.00)
			820C_> $5K Buildings and Improvements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00
			830_Computer Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(630.54)	0.00		(7,545.25)	(8,175.79)	0.00	(8,175.79)
			840_Motorized Equipment														0.00		0.00
			850_Specific Use Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(2,620.00)	(2,821.00)			(5,441.00)		(5,441.00)
			850C_> $5K Specific Use Equipment	0.00	0.00	0.00	(51,000.00)	(41,000.00)	0.00	0.00	0.00	0.00	0.00	0.00			(92,000.00)	0.00	(92,000.00)
		870_Educational and Training Assistance		0.00						0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00
			871_Educational and Training Assistance	0.00	0.00	(4,962.98)	0.00	0.00	(9,925.96)	0.00	0.00	0.00	0.00	0.00		(4,962.98)	(19,851.92)	0.00	(19,851.92)
	Subtotal																		0.00
Total by COLUMNS				525,100.00	(56.00)	(7,331.39)	(61,329.37)	(64,338.79)	(29,672.81)	(73,386.36)	(19,244.03)	(18,722.85)	(35,266.69)	(182,804.77)	(3,808.26)	(28,853.83)	(524,815.15)	0.00	284.85

Note: The remaining $284.85 will be spent by August 31, 2020. The Pay period was not run when this spreadsheet was generated on August 26, 2020.

Appendix 2: Sample Student Activities

Week No.	Dates	Graduate Student # 1	Graduate Student #2	Undergraduate Student #1	Graduate Student #3
Week 1	8/18/2019	Project Intro Meeting with Mashal (19th) Research DRC	Summarize and Review Literature Review		
Week 2	8/25/2019	Research DRC Completed Research Summary DRC Team Meeting (30th)	DRC Team Meeting (30th)	DRC Team Meeting (30th) Literature review on DRC plan Natural hazards in the USA to add with DRC plan Research on the key professional conferences to present DRC and journal papers	DRC Team Meeting (30th) Research DRC background information and other emergency training facilities in the U.S.
Week 3	9/1/2019	Start Preparing TOPO Survey Meet Darren to Discuss Survey (4th)	Continue Development of Concept Design	Prepare TOPO survey & map of the outdoor collapsed structure site Continue research on possible conferences to attend	Meeting with Darren Leavitt and Dan Garz to plan for topographical survey
Week 4	9/8/2019	First TOPO Survey of Project Location (11th) Second TOPO Survey of Project Location (13th) Draw Site TOPO Map DRC Team Meeting (13th)	Construction cost estimations DRC Team Meeting (13th)	DRC Team Meeting (13th)	DRC Team Meeting (13th) Field data collection of points for topographical map Create topographical map of DRC building site using Civil 3D
Week 5	9/15/2019	Study Civil 3D Begin Work on Site Plan	Develop Poster presentation for CAES Conference Redefine physical model	Literature review on the bleachers/stadium seating's Working on site plan	
Week 6	9/22/2019	Work on Site Plan MkII (24th)	Improve and add to physical model		
Week 7	9/29/2019	Attend CAES Energy Conference (29th-1st) Create Power Point for Meeting with INL	Finish Physical model improvments and additions	Reviewed skill sheets that are used by Idaho Technical Rescue Team provided by IOEM	
Week 8	10/6/2019	DRC Meeting with INL & Others (7th) Work on Site Plan	DRC Meeting with INL & Others (7th)	DRC Meeting with INL & Others (7th)	DRC Meeting with INL & Others (7th) Research possible training courses and seating options for training observation
Week 9	10/13/2019	Work on Site Plan Submit Plan Set MkVI to Jared (19th)		Review and go over possible training associated with Urban Search and Rescue Task Forces Research on overview of the facilities that were discussed in the meeting Went through the drawing of the Structural Collapsed Venue site of Idaho Army National Guard Camp	
Week 10	10/20/2019	DRC Meeting with Idaho National Guard (22nd) DRC Team Meeting Site Pad Design (23rd) TOPO Survey Piles on Project Site (24th) Update TOPO Map	DRC Meeting with Idaho National Guard (22nd)	DRC Meeting with Idaho National Guard (22nd)	DRC Meeting with Idaho National Guard (22nd)
Week 11	10/27/2019	Work on Site Plan Test Pit Excavation (30th) CAES Presentation (1st)	CAES Tour and Presentation	CAES Tour Working on site plan Test Pit Excavation	CAES Tour Geotechnical investigation by excavating test pits at DRC building site and collecting soil samples
Week 12	11/3/2019	Work on Site Plan Submit Plan Set 2019.11.8 to Jared			
Week 13	11/10/2019	Lab Testing of Test Pit Samples Scan & Upload Brochure		Lab Testing of Test Pit Samples	Performed Laboratory testing of soil samples to determine mechanical properties for proposed cut and fill
Week 14	11/17/2019	Prepare Points for Construction Staking (20th) Lab Testing of Test Pit Samples Construction Staking Survey (22nd)	Begin container drawings for fabrication		
Week 15	12/1/2019	Lab Testing of Test Pit Samples	Draft initial concepts for container lanes	Develop concept layout for indoor cityscape	
Week 16	12/8/2019				
Week 17	12/15/2019				
Week 18	12/22/2019				
Week 19	12/29/2019				
Week 20	1/5/2020				
Week 21	1/13/2020	Meet Dr. Mashal (13th) Meet Shankar (17th) Write Abstract (19th)	Develop overall outdoor facility layout Continue container drawings	Submit plans for cityscap for review	Develop subterraean lanes draft concept
Week 21	1/20/2020	Write Abstract (20th) Create DRC Poster for Presentation at CAES (21st) Poster Preperation for CAES Presentation (22nd) Visit Diesel Shop (22nd) Present Poster at CAES (23rd) Cost Estimate for City Block Mock Up (24th)			

Appendix 2: Sample Student Activities

Week No.	Dates	Graduate Student # 1	Graduate Student #2	Undergraduate Student #1	Graduate Student #3
Week 22	1/27/2020	Continue Cost Estimate	Finalize outdoor layout	Prepare detailed description of indoor facility	
		Draw Stud wall	Submit first drawings of containers for review		
		Submit Abstract & Bios for ASCE Conference (30th)			
Week 23	2/3/2020	Meet Chad Gross to Discuss Set Design (5th)			
		Continue Drawing City Block			
		Construct Geo Report Outline			
		Input Completed Labs from Fall into Excel			
		Prepare for Meeting with Mahar			
Week 24	2/10/2020	Meet Dr. Mahar (11th)	Review feedback for container drawings	Literature review of existing similar facilities	
		Prepare for Geo Lab			
		Lab Work (13th)			
		Strart Writing Geo Report (14th)			
Week 25	2/17/2020	Lab Work (17th)	Prepare poster for presentation	Assist with as built survey	Assist with as built survey
		As-Built Survey (18th)			
		Begin Drafting As-Built Survey (19th)			
		Look for Accelerator Building Geo Report			
		Continue Writing Geo Report			
		ASCE Presentation Planning (23rd)			
Week 26	2/24/2020	Draft As-Built Survey			
		Foundation Bearing Design (26th)			
		Foundation Bearing Design (27th)			
		Slope Stability Analysis (27th)			Continue outdoor design and drawing
		Geo Design Report (28th)	Visit Teton Prestress inf Idaho Falls for material selection		
Week 27	3/2/2020	DRC Meeting (2nd)			
		DRC Report Outline			
		DRC Geo Design Report			
		DRC Survey Report			
Week 28	3/9/2020	None (Sick)			
	3/13/2020	Campus Closed Due to Covid			
Week 29	3/16/2020	DRC Report Outline	Conex drawings	Prepare indoor cityscape drawing begin rework after review	Literature review of existing facilities
		Scan Meeting Notes			
		Write Meeting Outlines			
Week 30	3/30/2020	DRC Geo Deisgn Work (No Access to Geo Lab)			
		Investigate correlation of n-values and friction angles			
Week 31	4/6/2020	Discuss DRC With Dr. Mashal (7th)	Conex drawings continured submit for review		
Week 32	4/13/2020	Review Design of Wood Structure Notes & Begin Design			
		Zoom Meeting With Jared at Automotive Tech Facility (17th)			
Week 33	4/20/2020	Loading Calculations for DRC City Block			
		Beam Design for DRC City Block			
Week 34	4/27/2020	Bearing Wall Design for DRC City Block			
Week 35	5/4/2020	Earthquake Loading Calculation			
		Diaphragm Design for DRC City Block			
		Chord Design for DRC City Block			
Week 36	5/11/2020	Chord Design for DRC City Block			
		Collector Design for DRC City Block	Return to outdoor site for inventory		Inventory of outdoor site
		Shear Wall Design Calculation			Finalize outdoor layout
Week 37	5/18/2020	Shear Wall Design Calculation	Assist with receiving loads of materials from Idaho Falls and Ogden	Finalize indoor cityscape draft 1	Inventory of materials arriving on site
Week 38	5/25/2020		Begin drafting CWMD Journal Paper		
			CWMD Paper		
Week 39	6/1/2020			Assist with construction of outdoor lanes	Assist with construction of outdoor lanes
Week 40	6/8/2020			Assist with construction of outdoor lanes	Assist with construction of outdoor lanes
Week 41	6/15/2020			Assist with construction of outdoor lanes	Assist with construction of outdoor lanes
Week 42	6/22/2020			Assist with construction of outdoor lanes	Assist with construction of outdoor lanes
Week 43	6/29/2020		Submit first draft of Journal Paper		
			Submit conex drawings	Assist in preparing informational sheet for indoor facility	
Week 44	7/6/2020		Finalize conex drawings and estimate materials/costs		
Week 45	7/13/2020		Revise Jouranl paper	Rework indoor facility layout with INL suggestions and input	
Week 46	7/20/2020		Prepare white page for distribution		
Week 47	7/27/2020				
Week 48	8/3/2020		Submit for second draft of Journal Paper		
Week 49	8/10/2020	Return to project	Revise Jouranl paper		
		Update meeting			
Week 50	8/17/2020	Outdoor timber roof design	Revise Jouranl paper		
Week 51	8/24/2020	Indoor cityscape timber design	Submit for final review		
Week 52	8/31/2020				

ISBOE HERC-IGEM
Cellulosic 3D Printing of Modular Building Assemblies

FIRST YEAR REPORT
FISCAL PERIOD – SEPTEMBER 1, 2019 - JUNE 30, 2020

SUMMARY OF PROGRESS
July 13, 2020

Prepared for:
HERC-IGEM – Idaho State Board of Education
Mr. TJ Bliss

Authors:
Ken Baker, M. Arch – PI
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Dr. Damon Woods - Investigator

Report Number: 1 - December 31, 2019

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Prepared by:
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Ken Baker

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Contents

Acronyms and Abbreviations

3D printing	Three-dimensional printing
AM	Additive manufacturing
IDL	Integrated Design Lab
UI	University of Idaho

1. Introduction

The project objective is to identify the methodology, process, and materials necessary to three-dimensional cold print (3D print) building assemblies utilizing, to some maximum extent, wood products. Moving a significant portion of construction into a factory setting where labor and work is organized and executed more efficiently will have the following benefits: 1) increase the quality and energy efficiency of buildings; 2) lower overall construction costs; 3) provide appropriate compensation for a more skilled labor force and, 4) assist in mitigating the current construction skilled labor shortage challenge in Idaho.[i]

The outcome of this research is the development of a reliable and cost-effective process for printing panels (i.e., wall, floor, and roof assemblies) on a horizontal plane using a 3D printing process to produce a structural insulated panel. The proposal end goal is to build panels that are up to 10 feet wide by 16 to 20 feet in length that can be loaded onto a flatbed truck required to transfer it to the construction site for assembly.

Tasks for Year 1:

1) Research and identify the printing mix of wood/natural fibers, binders and adhesives;
2) Develop the technical description design for a 3D fibrous wood wall printing process, including prototype printer design specifications;
3) Develop the business case for private industry investment.

Summary for Year 1:

Significant discovery was made on each of the three tasks identified as Year 1 deliverables.

The team has successfully extruded a room temperature mixture of resins and wood that flows and cures well.

The team has experimented with spray and extrusion methods of printing and has developed the design for a printer that will produce a two foot by two foot by 6 to 10-inch thick assembly for thermal and eventual structural testing.

A business case has been developed and is ready for solicitation of private industry investment and information.

The Boise State University team has created a first draft analysis on constructability for the upcoming panels that provides a good overview of the site issues with modular construction such as moisture control.

Each of these discoveries are explained in more depth in Section 2 of this report.

2. Summary of Project Accomplishments for the reporting period just completed

Research and identify the printing mix of wood/natural fibers, binders and adhesives.

Prepared by: Armando McDonald, Ph.D

Year 1 reporting Dr. McDonald staffing: 1 M.S. student in Chemical Engineering. 1 woman. Salary expenditures and student tuition in the McDonald lab have focused on supporting the research efforts of one M.S. student. Capital and operational expenses are in line with ongoing and projected research activities on wood-resin curing research. Appropriated funds will be expended by the end of year 1.

Year 1 report overview

With the purchase of the DHR2 rheometer from TA instruments, curing behaviors of different adhesives including a faster curing phenol-resorcinol-formaldehyde (PRF), sodium silicate, and urea-formaldehyde resins were determined using temperature ramp (30 °C – 200 °C), frequency sweep (0.1 Hz – 10 Hz) and time sweep (90 s – 3600 s) modes. Rheology of wet wood/adhesive samples in different proportions (20 to 70% resin; 80 to 30% wood particles) were determined using the parallel plate geometry (2.5 mm Ø x 25 mm) and temperature ramp mode. Douglas-fir (mainly) wood particles of < 40 mesh were mixed with adhesives and cold pressed in a pellet die in Figure 1 at room temperature range, and promptly loaded between the rheometer plates to cure (Figure 1) at a constant axial force, frequency, strain and shear stress to obtain curing curves (viscosity versus temperature) as shown in Figure 2. The optimum parameters for wood/adhesive dynamic rheology characterization will be decided on after multiple trials and repeatable considerations.

In addition to using the DHR2 rheometer, a capillary rheometer setup (Figure 3) was employed to see how the wood particle/resin mixture flowed through different dies (1.4 mm Ø, 2.7 mm Ø, 4 mm Ø, and 4.89 mm Ø (Figure 3) under force. With an increase in fiber composition comes a higher pressure to extrude through the barrel and die.

Continuous dynamic and capillary rheology is ongoing to determine the best formulations and resins for 3D printing composite panels. Since these are time sensitive samples, several factors of mixing /loading time, temperature, frequency, and strain still play major roles in the reliable repeatability of sample characterization and results consistency.

Figure 1. (left) pellet press die (25 mm), (middle) pressed samples, (right) sample loaded onto rheometer

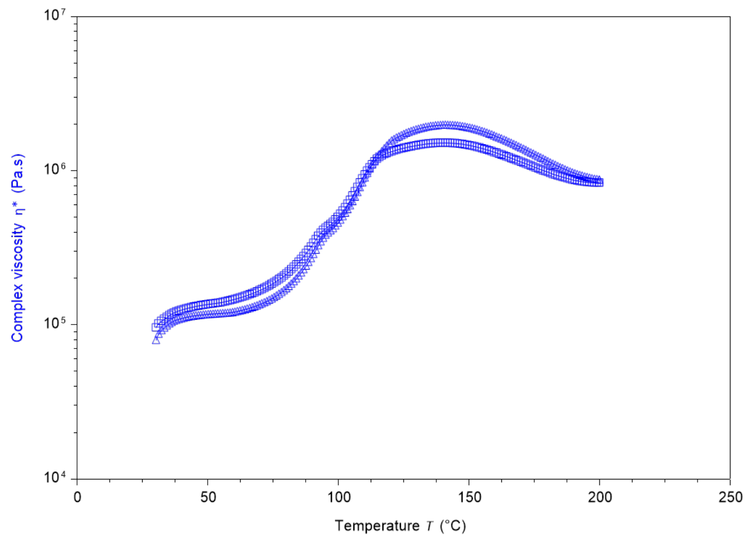


Figure 2. Curing curves of UF resin/wood particle (50/50 ratio) obtained on the DHR2 rheometer

Figure 3. (left) Capillary rheometer, (middle) dies used, and (right) extruded wood/resin mix through die

Develop the technical description design for a 3D fibrous wood wall printing process, including prototype printer design specifications.

Prepared by: Michael R. Maughan, Ph.D, PE

The University of Idaho (UI) Mechanical Engineering (ME) team has the responsibility of developing a 3D printing process and printer for depositing a wood waste composite mixture developed by other researchers in the UI College of Natural Resources (CNR). The goal is to make bespoke composite building panels. UI ME is also responsible for thermal modeling and optimization of the 3D printed composite building panels. The UI ME team has worked closely with CNR while they developed the composite mixture. The research approach is to identify good candidate techniques for wood deposition and to further develop and refine the techniques until the most effective technique emerges. Two techniques have been identified, extrusion and spray. Within extrusion there are two methods that show promise, extrusion via screw extrusion and direct extrusion with a plunger. Between January 2020 and June 2020, the following tasks have been accomplished. 1) Purchase a commercial screw extruder and modify to perform wood-composite mixture extrusion, 2) develop a 1.25” diameter format direct extrusion frame , 3) identify spray-deposition technique and begin developing appropriate experimental equipment, 4) begin development of modular 3D-printer frame, 5) identify and hire second graduate research assistant.

Screw extruder – Fig. 1 is a photograph of the commercial screw extruder purchased for wood-composite extrusion. The machine was originally developed for polymer filament extrusions but can be adapted for experiments on wood-composite mixtures. It features a heated extrusion barrel which will be used for curing of the polymer adhesive used in the wood composite. The machine has been modified to enlarge the extrusion nozzle diameter to more easily flow the viscous composite mixture.

Figure 1. SJ-35 screw extruder with modifications.

Direct extrusion frame – Based on initial experiments by CNR, direct extrusion shows some promise as s deposition technique. CNR has demonstrated 4mm diameter filament extrusion using a capillary rheometer and a load frame. The scale this technique up, UI ME has designed and fabricated a larger format rheometer barrel and frame. To implement this technique, the wood mixture is loaded into the barrel, then the plunger is inserted into the barrel. The load frame then applies load to the plunger, compressing and extruding the wood mixture out the nozzle at the bottom of the barrel. The direct extrusion frame positioned on the base of the load frame (outside of image) is shown in Fig. 2.

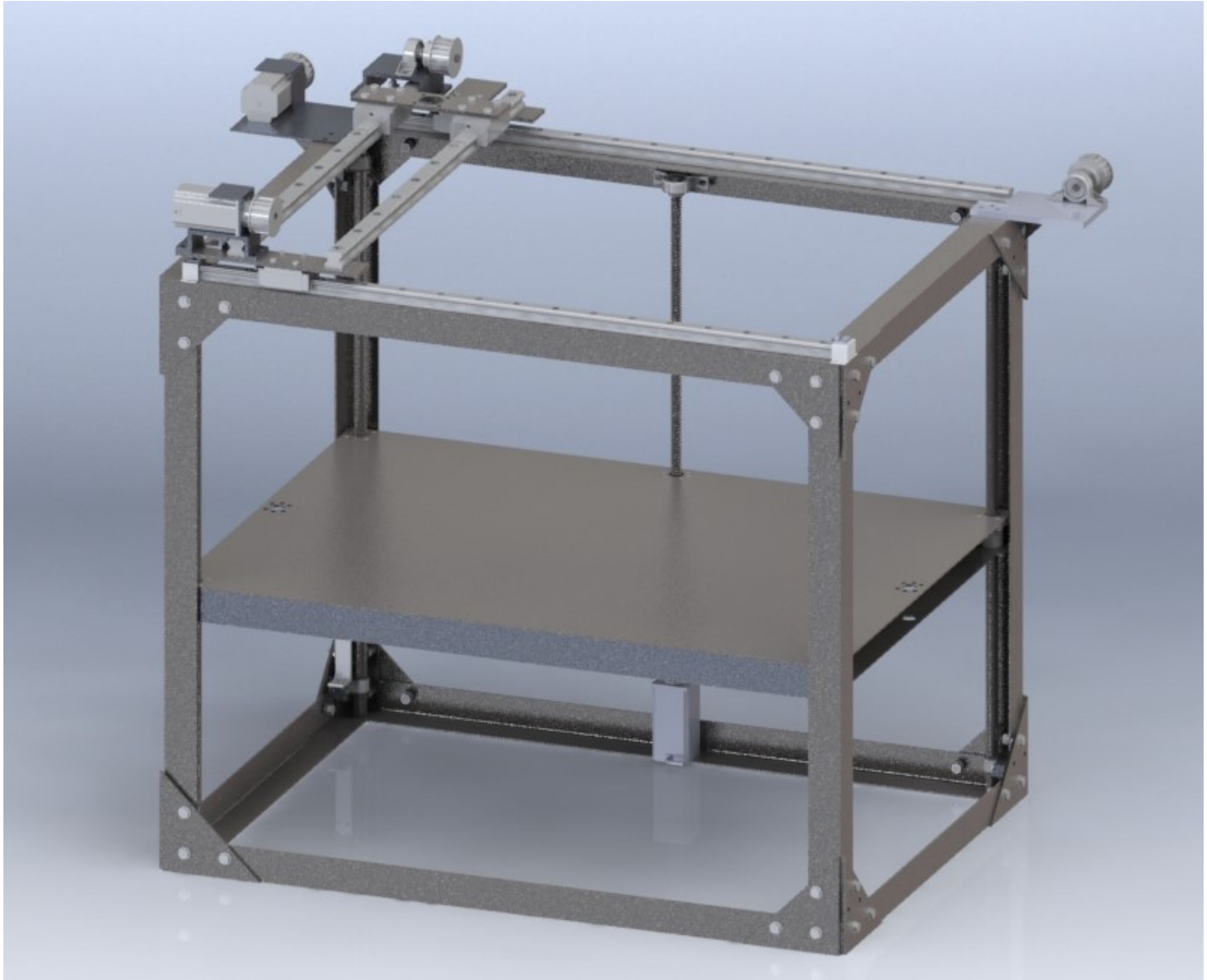
Spray-deposition technique – The spray deposition technique represents a major shift from traditional extrusion based additive manufacturing; however, considering the large format of the desired product, material spraying could be a viable technique to achieve high rates of manufacture. The UI team has procured a previously used wallboard texture sprayer. It required some repair, but the use of used equipment has been a benefit considering the reduced first-year budget. Experimentation is beginning with wood/water mixtures to assess appropriateness of this technique for production. The texture sprayer is shown in Fig. 3.

Figure 3. Commercial exterior texture sprayer

Modular 3D-printer frame – A student has been identified and hired to begin designing a 3D printer frame that can be adapted to either the extrusion technique or a spray technique. The printer system is being designed to accommodate an approximately 2 ft. x 2 ft. sample wall. The goal is to make it modular to accommodate changes as more is learned about the process.

Graduate research assistant – UI ME has been staffed with one graduate research assistant (GRA) during the first project year. GRA1 has focused on the deposition process and performance modeling of the material. The new GRA2 will further develop the printer frame.

The next page shows a rendering of the Year 1 printer design. This printer will be built in July of 2020 and used to print 2’ by 2’ wall assembly sections for analysis of thermal and structural properties.



Year 1 printer design

Develop the business case for private industry investment.

Prepared by: Ken Baker, M. Arch

The purpose of the business case is to clearly identify the value of a 3D printed panel when compared to current light commercial and residential construction wall framing practices. This value set will be used to solicit investment of private industry. Generally, a business case is defined as a subset or new opportunity that fits within the business plan that directs the activities of a company. To that end, the first inquiries for potential investors will be directed toward companies such as Katerra, a relatively new start up that has invested in manufacturing facilities for CLT (cross laminated timber). Our timeline for initial solicitation of investors is September, 2020.

The business case is attached as an addendum to this report. The business case has been developed in a presentation format because we believe that is how it can most easily be delivered and pertinent information presented. The document will be dynamic, changing as the actual printing mixture and manufacturing process is refined through continued research and application. Therefore, though not a draft, the business case is expected to change over the grant period.

There are seven areas of value that we determined make up the business case at this time:

1. Assembled embodied energy of key material
2. Mileage to place of manufacture
3. Labor cost
4. On site labor hours
5. Material cost
6. Assembly R value
7. Assembly carbon emissions

The seven areas of value have been assessed utilizing best practice and empirical data sources for the five most common construction methodologies used in light commercial and residential buildings (2 x 6 frame, SIPS, CLT, steel frame, CMU). Not yet common, our 3D panel printing method was assessed utilizing the same inquiry criteria so that valid comparisons could be made between methodologies in each construction (value) area. A scoring system was developed with the highest and lowest of each of the first seven value areas defining a scale from 1 to 5 within each of the seven value areas studied. The highest score (poorest result) for each of the seven value areas sets the top boundary of 5. The lowest, or best score of the seven value areas, is given a score of 1. All other construction methodology scores fall somewhere between the 1 and the 5 based on interpolative calculations. The scoring system allows for a simple visual comparison between, for example, total carbon emissions, labor cost and material costs, etc., between methodologies (value areas) – *See Table 1 next page.*

As presented in Table 1, the 3D printed panel has the overall lowest (highest value) score of the comparative methodologies and scored 1 (best) in all but R-value where the SIPS panel was highest value.

Criteria Rated	3D Print	SIPS (5-5/8")	Wood Frame (2x6)	Steel Frame (6" wide studs	CMU (Normal Weight 8"	CLT (30' span, 12" thick)
Assembly Embodied Energy of key material**	54.66	254.20	193.60	86.40	136.95	140.20
Mileage to place of manufacture	**5.00**	380.00	478.00	424.00	11.00	436.00
Labor Cost* ($/sq ft)	1.26	1.26	2.42	11.65	4.85	3.71
On Site Labor Hours*	0.02	0.02	0.03	0.22	0.10	0.47
Cost of Material* ($/sq ft)	3.09	4.41	3.09	10.65	4.16	13.48
Overall O&P cost for assembly*	4.16	7.20	4.16	29.00	12.65	5.90
Assembly R Value****	22.44	25.15	19	15.49	11.66	18.62
Assembly Carbon Emissions (kg CO2/kg**)	2.8	8.53	7.38	5.01	6.835	5.37
Assembly Embodied Energy of key material**	1.00	5.00	3.79	1.64	2.65	2.71
Mileage to place of manufacture	1.00	4.17	5.00	4.54	1.05	4.64
Labor Cost* ($/sq ft)	1.00	1.00	1.45	5.00	2.38	1.94
On Site Labor Hours*	1.00	1.00	1.06	2.76	1.70	5.00
Cost of Material* ($/sq ft)	1.00	1.51	1.00	3.91	1.41	5.00
Overall O&P cost for assembly*	1.00	1.49	1.00	5.00	2.37	1.28
Assembly R Value****	1.80	1.00	2.82	3.86	5.00	2.94
Assembly Carbon Emissions (kg CO2/kg**)	1.00	5.00	4.20	2.54	3.82	2.79
Total Overall Score	**8.80**	**20.17**	**20.32**	**29.26**	**20.38**	**26.31**

Table 1. Construction Methodology Value Score

To date, the analysis highly favors the 3D construction process over the other methodologies. It should be noted, however, that the 3D method is still under refinement and the value assessment could change as more exact discovery is made through research and testing. But, we believe the table values are very close to actual values as, for example, the 3D panels should have a very similar site labor cost for assembly as does the SIP system; R-value is a scientific process; and, carbon emissions for wood and wood waste is well documented. The area most questionable at this time is labor cost, specifically the comparison of a factory labor force to that of site labor. This is an area that will be refined as we work with manufacturers.

Table References

*Mewis, R. W. (2019). *Building construction costs with RSMeans data, 2020*. Rockland, MA: Gordian/RSMeans Data.

**Symons, K. (2011). Book review: Embodied Carbon: The Inventory of Carbon and Energy (ICE). A BSRIA Guide Embodied Carbon: The Inventory of Carbon and Energy (ICE). A BSRIA Guide Hammond Professor Geoff Jones Craig Lowrie Fiona Tse Peter. University of Bath with BSRIA, Bracknell, UK, 2011, ISBN 978 0 86022 703 8, £60, 136 pp. *Proceedings of the Institution of Civil Engineers - Energy*, *164*(4), 206–206. doi: 10.1680/ener.2011.164.4.206

***Density of Construction Materials in kg/m3 and lb/ft3. (2016, September 27). Retrieved from https://theconstructor.org/building/density-construction-materials/13531/

****Based on ASHRAE Fundamental calculations

*****Estimated utilizing similar industry methods

Constructability Analysis

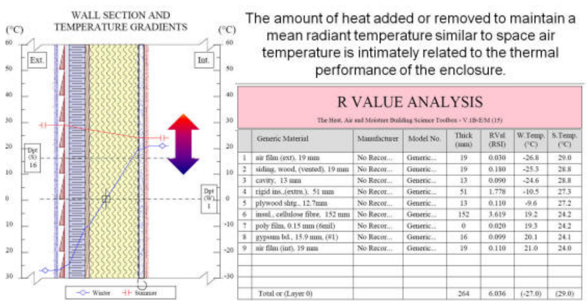
Prepared by: Casey Cline, Ph.D – Boise State University Construction Management

Constructability of the Cellulosic 3D printed panels

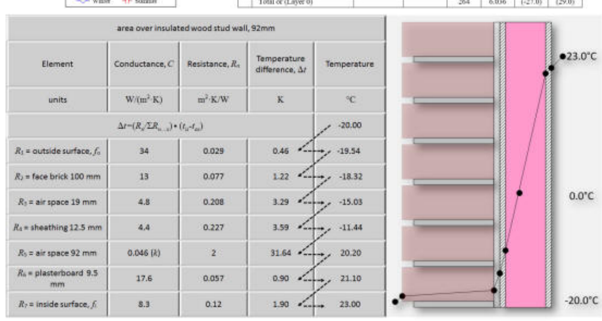
Panel construction

- Waterproof or water resistant or neither?
  - Affects transportation
  - Affects construction
  - Affects use in final structure - can it be used without finishes or must it be coated with something to provide water/weatherproofing
  - Because the panels will be made entirely out of wood, will they be dimensional stable or will they be susceptible to changes in dimensions due to moisture conditions?
- Type of edge construction?
  - Are they wood edged? Are they metal edged?
    - Affects shipping
    - Affects stacking
    - Affects connections
  - May affect fire - flame spread, smoke developed
- Size of final panels?
  - Should match up with other building materials, so recommend something in 16" increments. This is important for both structural reasons and for attaching finishes to final product.
  - What thickness will they be?
- Weight of panels?
- Finished surfaces of panels?
  - Can they be painted (will paint stick to them properly)?
  - Can they be stuccoed?
  - Do they have to be covered with another material? If so, how does that connect to panel?
  - What level of quality is the finish on each surface (inner and outer)?
  - What type of texture is the finish?
  - Can the finish be customized to the owner's request?
  - How durable are the finished surfaces? Can they withstand the abuse that will occur during transportation, assembly (from weather and equipment)?
  - Will final added finish be needed on one side or two sides?

- Maybe incorporate a hat track to facilitate attachment of gypsum wallboard on interior
- What level of consistency/quality will be produced in the 3D printing process? Will all of the panels be exactly the same (if desired)?
- How easy will it be to customize panels with cutouts, interior chases (maybe for electrical), openings for windows, doors, etc.?
- What about panel resistance to mold, rot from moisture, resistance to wind penetration?
- Flammability of panel
  - May require limited on-site delivery/stock without active fire protection onsite
- Panel joint connections vs finish of panels - what will be visible from joint connections and how does that affect aesthetics?
  - Must consider exterior panel joints and interior panel joints
  - They may not be the same depending on desired techniques of installation and use
- If panel is providing finished interior and exterior surfaces, how does it achieve a fire rating?
  - Could the binding agent enhance fire-resistance?
- Where does a moisture/vapor barrier fit into the panel design/installation? Without one correctly located, there may be damage within panel due to mold, mildew, rot.
  - Must analyze freeze point for panel
  -

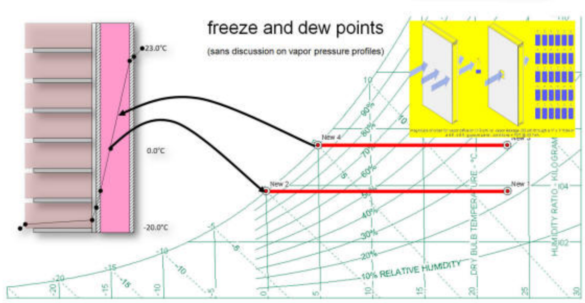


	Generic Material	Manufacturer	Model No.	Thick (mm)	RVal (RSI)	W.Temp. (°C)	S.Temp. (°C)
1	air film (ext), 19 mm	No Recor...	Generic...	19	0.030	-26.8	29.0
2	siding, wood, (vented), 19 mm	No Recor...	Generic...	19	0.180	-25.3	28.8
3	cavity, 13 mm	No Recor...	Generic...	13	0.090	-24.6	28.8
4	rigid ins.(extru.), 51 mm	No Recor...	Generic...	51	1.778	-10.5	27.3
5	plywood shtg., 12.7mm	No Recor...	Generic...	13	0.110	-9.6	27.2
6	insul., cellulose fibre, 152 mm	No Recor...	Generic...	152	3.619	19.2	24.2
7	poly film, 0.15 mm (6mil)	No Recor...	Generic...	0	0.020	19.3	24.2
8	gypsum bd., 15.9 mm, (#1)	No Recor...	Generic...	16	0.099	20.1	24.1
9	air film (int), 19 mm	No Recor...	Generic...	19	0.110	21.0	24.0
	Total or (Layer 0)			264	6.036	(-27.0)	(29.0)



area over insulated wood stud wall, 92mm

Element	Conductance, C	Resistance, R_s	Temperature difference, Δt	Temperature
units	W/(m²·K)	m²·K/W	K	°C
$\Delta t = (R_s/\Sigma R_{a...s}) \cdot (t_{is} - t_{os})$				-20.00
R_1 = outside surface, f_o	34	0.029	0.46	-19.54
R_2 = face brick 100 mm	13	0.077	1.22	-18.32
R_3 = air space 19 mm	4.8	0.208	3.29	-15.03
R_4 = sheathing 12.5 mm	4.4	0.227	3.59	-11.44
R_5 = air space 92 mm	0.046 (k)	2	31.64	20.20
R_6 = plasterboard 9.5 mm	17.6	0.057	0.90	21.10
R_7 = inside surface, f_i	8.3	0.12	1.90	23.00



- What is the level of air infiltration through panel?
  - Is it very low (similar to SIPs) or closer to traditional construction?

  - This will impact HVAC choices, particularly related to ventilation.
- What is the strength of the panel (need axial strength and bending strength, including splines, shear strength, deflection)?
- How much expansion/contraction will likely occur (what is coefficient of thermal expansion)?

Transportation logistics

- Long distance from manufacture to jobsite
  - Width of trucks allows 8'-6" maximum without special considerations
  - Height of stack on trucks 14"-0" maximum
  - What will long distance transport cost? Will weight or volume govern?
  - Should they be transported vertically (on edge) or horizontally (stacked)?
- Panels will need suitable edges to prevent damage when shipped
  - This may be part of panel design or something external to panel (ideally reusable if external)
- Unloading from trucks at jobsite
  - What do panels weight?
  - Need a Rough-terrain forklift for horizontal movement
  - Need Picking Eyes (two minimum) and crane for vertical unloading
  - Are panels Sturdy faced (durability) on both sides?
- How would deliveries occur?
  - Just in time delivery?
  - Stockpile size?
- Moving on job site to install

Constructability logistics

- How do the panels connect to each other?
  - Pretty much all SIPs panels are connected with some sort of spline located between the two outer layers
    - Generally, these splines are supposed to have adhesive applied on all sides of the joint, then nailed or screwed together. In practice, the adhesive appears to be challenging to put everywhere it is supposed to be and (based on limited data found) often gets partially or totally omitted, lowering the air tightness of the joint. On roof and floor panels, the screw/nail connections required for the spline also sometimes get omitted due to difficulties with access to install them, lowering the structural integrity of the connections.
  - Alternate ideas are weld plates, pin connections (like a hinge on a door)
    - These would need standardized locations (heights)
    - Might need engineer approval
    - What tolerances will be acceptable?

- How do they connect to the floor/foundation?
    - Will it be similar to SIPs with a bottom plate attached to the floor (similar to the splines) that is then attached to the panels?
    - Or maybe a centered V-Crest for centered V-Trough at footing or stem wall
    - Will it need a Sill Plate Gasket (Incorporated)?
    - Will it need a Connection plate?
        - Anchor Bolt or Expansion Anchor type?
        - Need Engineer Approval?
- How do they connect to the ceiling/roof?
    - How will they connect with trusses?
        - Weld Plate
        - Nail Plate
        - Pocket
        - Need Engineer Approval?
- What kind of sealant would be appropriate to use to seal joints at all connections?
- What bracing is needed temporarily to erect panels? Many claim no bracing is needed for SIPs assemblies, but that neglects wind and other horizontal forces that may occur.
- Safety requirements for erecting panels?
- Do they have to be moved with equipment or can they be moved erected with a couple of people?
- Panels should have a minimum of two picking eyes for vertical unloading
- Time for construction?
- What about electrical, plumbing, communications?
    - Will chases be located inside panel, or will utilities need to be external to panel?
    - If chases are possible inside panel, how easy will it be to cut openings for electrical boxes, etc.?
    - How does the transition from one panel to the next work?
    - Will the panels be suitable for conduit and flex cabling (engineer approval needed?)
- Windows/doors/other openings?
- How easy can the panel be modified size wise in the field?
- If there are voids within SIPs panels (due to construction modifications, connections, etc.), they are filled with expanding foam. How will this work with the 3D printed panels?
- Will the panels be dense enough to securely anchor connectors (nails/screws) firmly and prevent movement?
- How will expansion/contraction of panels be addressed?
- Interior final finishes needed for panels?
    - Gypsum wallboard
        - Connections
        - Expansion/contraction joints
    - Paint
    - FRP
- Exterior final finishes needed for panels?

- Paint
- EIFS
- Other cladding type

End user logistics

- Can you nail or screw into a panel easily to hang a picture?
- Can it be easily modified visually with paint/wallpaper/etc.?
- Fire ratings? Flame spread, smoke developed ratings?

3. Summary of Budget Expenditures

Salaries:	$32,551.94
Temp Help	$14,344.12
Fringe	$ 4,783.69
Travel	$ 1,403.79
Operating	$ 3,495.82
Small Equip	$ 1,495.68
Capital Equip	$64,854.63
BSU Sub	$17,088.36
Tuition	$19,011.15
TOTAL	**$159,029.18**

4. Demonstration of Economic Development/Impact

- Patents, copyrights
  - None at this time but our research indicates the cold-setting print media may be our first.
- Technology licenses signed
  - None at this time
- Private sector engagement

- We are working with Hexion, a wood adhesive manufacturer out of Oregon.
- During year two (July 1 2020 – June 30, 2021) we will implement systematic communications with potential investor companies such as Katerra. The initial goal is to inform and engage interest in our product and to solicit commitment to work with us.

- Jobs created
    - None at this time
- External funding
    - None at this time
- Other pertinent information

5. Numbers of Faculty and Student Participation

There are nine faculty participating in the grant, six from the U of I and three with BSU. There are two and one-half Research Associates working on the grant in year one. On July 1 of year two we will add two engineering grad students, one on the Moscow campus and one in Boise, for a total of four graduate students. The Boise State Construction Management program will contract with two undergraduate students to work on constructability issues during the school year.

6. Description of Future Plans for Project Continuation or Expansion

BSU

Casey Cline, Kirsten Davis, Ty Morrison

- Constructability
- Answers to Questions on list
- On site work with panels
    - Assembly
    - Connections
    - Which labor type (carpentry, welder, etc.)?

Chemical Team

Dr. Armando and Berlinda

- Resin System
- Resin Formulation (starting point and integration)
- Extrusion process of mixture
- Mixture contents
- Curing, depositing, extruding (characterize behavior)
- Compare to other resin systems

Mechanical Team

Dr. Mike, Evan, Conal, Robert

- Printer nominally built
- Extrusion process of mixture
- Trying in-situ depositions (screw extrucder)
- Deposition process, integrate flow model
    - Thermal conductivity model
- Material properties
- Sturctural testing?
- Dogbone samples
    - Tensile
    - Bending

Thermal Team

Dr. Tao, Dr. Ralph, Damon, Tais

- Try out Tempos meter unit
- Build test cell
- Experimental thermal testing (composition and energy code compliance)
    - Depend of samples and chemical team (coupons- 3” diameter, 1.25” thick min)
- Meet loads
- Decay with larger thermal affect- small coupons vs whole panel analysis
- 2’x2’ panels

IDL Team

Ken, Kelsey, Lyndsay

- Testing criteria for structural properties (tensile, bending, etc.)
- Code compliance
    - **Particleboard testing properties paper
- Business case
- Identify partners
- Constructability

- Marketability
- Manufacturability
- Manufacturing processes
- What industries are capable?
- Equipment and process
- Define our own manufacturing process

Four key outcomes are expected in year 2 of the three-year grant:

1. The print mix for cold setting print will be identified. There may be more than one mix as we see potential for both spray and extrusion processes.
2. The printer specifications and printer will be further defined as a product that could scale up for manufacturing large-scale panels.
3. Business/industry partners will be engaged and private investment will be solicited.
4. The thermal characteristics of printed panels will be assessed – see below.

Assessment and Thermal Characterization of Wall Panels

Faculty: L. Damon Woods, Ralph Budwig, and Tao Xing

Staff: William (Bob) Basham

Graduate Students: Tais Mitchell and Conal Thie

1. Assessment of existing wall panel technologies

We will work with the IDL faculty and students to catalog and compare a range of characteristics of existing wall panel technologies (density, cost, thermal conductance, structural properties…). The first step will be to conduct a literature review to develop a library of different panel configurations and performances. Then we will perform density and thermal analysis existing panels by both spreadsheet-based methods as well as program-based simulations. (Woods, Budwig, Watkins, and Mitchell)

2. Thermal characterization of 3D printed wall panels

We will design and implement testing methods for the thermal characteristics of the wall panels. This will include both laboratory testing and numerical modeling. In the lab, we will design a cubical test cell instrumented with multiple semiconductor surface and air temperature sensors. In addition, we will design and fabricate heat-flux sensors that may be place at specified locations on the test cell walls. The test cell will have four fixed walls fabricated of well-characterized materials. Then two opposite vertical walls will be changeable such that there is symmetry about the vertical mid-place of the test cell. We will calibrate the test cell and test procedure with changeable walls of well know thermal properties. Then the cell will be ready to test panels with unknown thermal properties. The numerical modeling effort will build a numerical model of the test cell and will be validated with walls of know thermal properties. After validation, it will change one or several wall panels to those of unknown thermal properties. One advantage of the numerical modeling is the ability to test panel configurations which have not yet been fabricated which can then guide future designs with respect to thermal performance. (All)

7. Commercialization Revenue

None to date.

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[i] Elliott, Blake; Wurtz, Everett; Swift, Nathan; and Manning, Dylan, "Construction Labor Shortage in Idaho: An Examination into the Causes and Consequences" (2017). *2017 Undergraduate Research and Scholarship Conference.*

Report for IF20-001

Summary

Accomplishment: In the last 6 months , the PO for SHG One laser system from Spectra Physics was successfully sent out from the university. There was a delay in purchasing due to legal and contractual obligations on both the company and university. The PO was sent out in the beginning of January. The entire budget of the incubation fund was used towards this purchase along with a cost match from the PI.

Plan forward:

In the next 6 month we plan to accomplish the following tasks

Task 1: Set up the laser system: The laser has a 3 month lead time. We plan to have the laser installed in the beginning of May.

Task 2: Set up the optical fabrication set up: We will set the fabrication set up for this system. We believe this will be done by Mid May

Task 3: Fabricate the sensors and testing: The fabrication of the sensors both, based on conventional Fiber Bragg Grating design and the designed Long Period Grating sensors will be fabricated on optical fibers and their performance will be characterized. We project the first sensor to be fabricated in the beginning of June and tested by mid June.

Summary of budget expenditure

Entire budget has been encumbered through the PO to Spectra physics

Number of faculty and student participation

Currently, Faculty participation: 1

Anticipated graduate student participation : 1

Patents, copyright received

None

Status of industry partnership

Fiberguide is currently waiting for the laser system. The PI and the company will leverage this instrument to submit a followup grant to NSF-COBRE.

DARWINS' DEMONS MOBILE: EXPANDING THE MARKET FOR EVOLUTIONARY PROCEDURAL CONTENT GENERATION.

FINAL REPORT:	Grant Number IF20-003
PRINCIPAL INVESTIGATOR:	Barrie Robison
REPORTING PERIOD:	July 1, 2019 – January 1, 2021

SUMMARY OF PROJECT ACCOMPLISHMENTS:

Hired lead artist and game developer (Landon Wright).

Hired development team:
Programmers: Lily Mason and Graeme Holliday
Music and Sound: Parker Piedmont
Interface and 2D Art: Aaron Yama
Marketing and Social Media: Savanna Estey

Developed "Darwin's Demons Moblie" into an advanced beta stage. The game is a space shooter that features evolving opponents that are procedurally generated. We can provide copies of the game for Android or Apple devices. A testing version of the game is also playable on Mac or PC desktop computers. The game features 5 ships, more than 50 pieces of upgradable equipment (weapons and defenses), 6 maps, and a soundtrack that evolves along with the enemy population.

Changed the name of the game to "Evolvy Bugs", which captures the more whimsical artistic style of the procedurally generated content.

Registered with Google Play store for sale.
Registered with Apple App store through the UI's account.

Integrated the in-game store page into the app.

Developed the microtransaction business model and are now incorporating it into the game's architecture. These features are the primary remaining content that needs to be developed before release. The delay in development of these features is directly related to the COVID pandemic.

Extensive evolutionary model tuning in collaboration with Kristen Martinet, a PHD student in the Bioinformatics and Computational Biology program. The evolutionary model for procedural content generation is functional and produces game results that are likely to increase replayability.

PLANS POST IGEM:

Complete final play testing.

Complete the integration of the microtransaction model into the Google Play and App store frameworks.

Develop store pages on Google Play and Apple App store.

Release the game on Google Play and App Store with a staggered release strategy. This will allow us to deal with post release bug fixes one platform at a time.

Begin and sustain an advertising and promotion campaign.

SUMMARY OF BUDGET EXPENDITURES:

All funds were expended. We received a no-cost extension because of the complications created by the COVID pandemic. The pandemic substantially disrupted our workflow and caused us to lose several of our student developers.

FACULTY AND STUDENT PARTICIPATION:

One staff (artist/game developer) and five students were directly supported by grant funds during the reporting period. In addition, one graduate student (Kristen Martinet) performed her doctoral rotation in the game studio and supported the development of the evolutionary model. The graduate student was not supported by the grant. Drs. Barrie Robison and Terry Soule were the primary faculty, but we collaborate with colleagues from Education (3), English (1), VTD (3), Music (1), and Business (1).

Total Student Participants: 6
Total Faculty Participants: 2
Total Staff Participants: 1

PATENTS, COPYRIGHTS, AND CERTIFICATES:

None, but we will file a disclosure with our office of Tech Transfer prior to commercial release.

LISCENSES AND START-UP BUSINESSES:

Should the game sales perform well, we will create an LLC.

INDUSTRY AND PRIVATE PARTNERSHIPS:

None (yet).

ADDITIONAL FUNDING AND BURN RATE:

We have applied for a $1.5 million grant from the National Institutes of Health with our colleagues from the College of Education. We were also part of a large NSF grant that was awarded to study tick borne disease (~$6 million). Approximately $250,000 over the next four years is allocated to the game studio to develop additional games. We are also working on additional proposals for future games that would be licensed to the LLC if formed.

ADDITIONAL INFORMATION:

We are happy to provide builds of the game upon request.

Cover Sheet

Ink Production Scale-Up

Semi-Annual Report

Reporting Period: Jul 1st, 2019 — Feb 1st, 2020

Technical Point of Contact

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Table of Contents

1. Summary of Project Accomplishments and Plans

1.1 Accomplishments for this report period

Although the HERC project started on July 1, 2019, the PI did not have access to the funds until September 13, 2019 when the account was set up by the Office of Sponsored Projects at Boise State. This report covers the activities performed since September 13, 2019 until February 1, 2020.

Milestone Achievements

- Hired undergraduate student, Ms. Jasmine Cox, to work on ink synthesis and printing.
- Hired Post-Doc Dr. Josh Eixenberger (15% effort) to work on ink volume scale-up.
- Ordered and received microviscometer to measure the viscosity of material inks being formulated in the Advanced Nanomaterials and Manufacturing Laboratory (ANML).
- Placed an order for a Tangential Flow System to help scale up ink production.
- Ink 1: Started working on ZnO (Zinc Oxide) inks since there is an immediate interest from NASA and Boeing in getting this ink from us. These inks will be the first to be commercialized from partner, INFlex Labs, LLC.
- Ink 2: Worked on formulating Nickel ink and testing its performance. Nickel ink will also be commercialized through the company. Oak Ridge National Lab is an immediate customer.

1.2 Plans for the next reporting period

During the next reporting period, we plan to

- Fine tune the inks and processing parameters so that we can demonstrate compatibility and printability with the printer suite we have at Boise State. This will help create a datasheet for the different inks being formulated, and help the company market the ink to potential customers.
- Demonstrate the synthesis of higher volumes of inks so that the ink manufacturing could be made commercially viable. The Tangential Flow System will be set up specifically for this purpose.
- Develop a business plan together with the company. We will approach potential customers with prototypes and samples. We have already identified a few customers, including NASA Ames, Boeing Corporation, and Oak Ridge National Lab.

2. Summary of Budget Expenditures for the Period Just Completed

<u>Expenditure from Boise State University: $50,696.53 to date</u>

During this reporting period, we spent $50,696.53 overall. Within this, two pieces of equipment were purchased – (1) a RheoSense Microviscometer to measure the viscosity of ink synthesized ($9,977.40) and (2) a Tangential Flow System to help scale up the ink volume ($21,150). The remainder was spent to cover the salaries and fringe of the undergraduate student and the postdoc. Expenses were also incurred for the printer use in the cleanroom and for ink characterization.

3. Number of Faculty and Student Participation Resulting from Funding

This project has had participation from one faculty member – Prof. Harish Subbaraman (PI), one undergraduate student, Ms. Jasmine Cox, and one post-doc, Dr. Josh Eixenberger. This project is providing hands-on ink synthesis and printing experience to the undergraduate student, and furthering the expertise of the post-doc who is skilled in the synthesis of nanoparticles and nanoparticle inks

4. Patents, copyrights, and plant variety protection certificates received or pending

While there is still great potential, as yet, there has been no idea or new technology reviewed on this project during this first time period that has led to any specific or particular new intellectual property.

5. Technology licenses signed and start-up businesses created

We have seen great interest from industry and national labs in trying to learn more about the project and procuring inks and associated processing information from us. Boise State and INFlex Labs are working on signing an agreement related to commercialization of the inks.

6. Status of private part/industry partnerships

PI Subbaraman received a NASA EPSCoR and NSF Nanomanufacturing awards. The incubation fund will enable setting up of state-of-the-art equipment for ink production scale-up. The EPSCoR grant will look into flexible electronic device development integration using a plasma jet printer for space applications. Currently, there are no ink vendors for the plasma jet tool, thus placing INFlex and Boise State in a very good position to work with the equipment manufacturer and promote our inks. The successful outcome from the current HERC project will lead to direct investment from interested companies and investors.

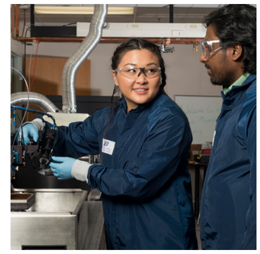
7. Additional Funding Received and Financial Burn Rate

As mentioned above, the PI has several other projects that utilize inks for developing flexible electronic devices and sensors. The work that will be performed in this project will be a natural extension of accomplishments in those projects. The PI is also constantly trying to secure extramural funding in this area, and we foresee efforts beyond the IF project going into further development of inks, sensors, and devices that can be used in the food storage, consumer electronics, space, and other markets.

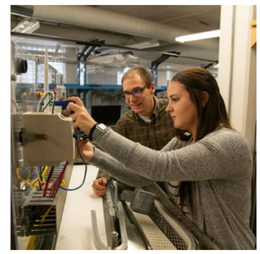
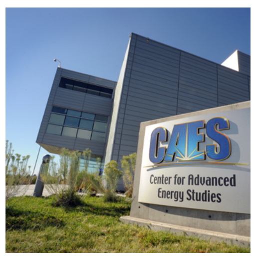
In terms of financial burn rate, we will be using the remainder of funds on ink production, ink characterization, and development of processing recipes on the commercial printing tools at Boise State.

2020 ANNUAL REPORT



BOISE STATE UNIVERSITY


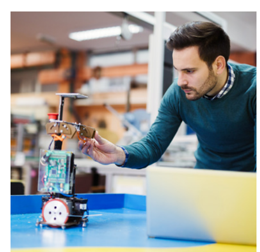
Idaho State University

INL
Idaho National Laboratory


University of Idaho

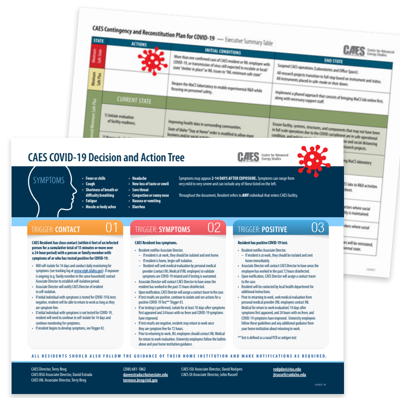



University of Wyoming


DIRECTOR'S LETTER

THE COVID-19 PANDEMIC MADE 2020 A TUMULTUOUS YEAR for everyone at CAES. The pandemic introduced significant uncertainty to the universities and Idaho National Laboratory (INL). Students and faculty were sent home from the universities when the pandemic hit, as were researchers at INL, and the CAES headquarters in Idaho Falls was shuttered for nearly a month. Restrictions were loosened over the summer, as researchers with approved projects were allowed to resume their work in the laboratories, but the majority of those who work in CAES have been telecommuting since March. At the end of the fiscal year, the CAES facility was still off-limits to visitors, tours remained canceled, and all seminars and most meetings were online only. The uncertainty wrought by the pandemic has not hindered CAES' ability to fulfill its mission and vision, however; in fact, 2020 was a banner year in terms of research wins and accomplishments for the CAES community as the implementation of the CAES Strategy continued to bear fruit. Among the highlights:

- In July, we broke ground on an INL-funded, $5 million project to install a new transmission electron microscope in one of the eight laboratories at CAES. This move will accelerate the innovative research into advanced materials that is critical to the U.S. maintaining its role as the world leader in nuclear innovation, particularly in the development of new reactors. It will significantly enhance INL collaboration with the universities, helping CAES fulfill its role of training the future energy workforce.
- CAES researchers from Boise State University, Idaho State University (ISU), and University of Idaho either led or collaborated on projects that were awarded nearly $5 million in funding from two DOE programs, the Nuclear Energy University Program and Nuclear Energy Enabling Technologies.
- A CAES researcher from ISU is leading a collaborative project with INL to build a disaster response complex on the ISU campus in Pocatello. The facility will train first responders from throughout the region and was made possible through a $1.1 million grant through the Idaho Global Entrepreneurial Mission.
- We named the inaugural cohort of CAES Fellows and are on the verge of launching a new workforce development program, the Joint Certificate in Nuclear Safeguards & Security.
- We wrapped up the third year of our flagship program, the CAES Summer Visiting Faculty Program, which drew 29 participants this year.
- Working groups were formed in all seven of the focus areas outlined in the CAES Strategy, with promising developments emerging from each.
- The first-ever CAES Annual Pitch Event (also known as Baby Shark Tank) attracted nearly three dozen registrants, with every CAES entity represented.
- We celebrated the 10th anniversary of the CAES headquarters facility in Idaho Falls with the Idaho governor proclaiming the first day of the fiscal year, Oct. 1, 2019, as CAES Day.



This is just a glimpse at what we accomplished in the 2020 fiscal year. We also saw several notable departures, including Director Noël Bakhtian and Chief Operations Officer Anita Gianotto, who left at the end of the year, and the announcement that University of Wyoming would exit the consortium in early 2021. More information on these developments can be found in this report.

CONTENTS

NEWS

CAES Day proclaimed in Idaho

Idaho Gov. Brad Little proclaimed Oct. 1, 2019, as CAES Day at CAES' 10th anniversary celebration on the same day. 2019 marked the anniversary of the opening for the CAES headquarters in Idaho Falls. The event in Boise was preceded by a celebration in Idaho Falls that drew more than 200 people, including CAES alumni from as far as Utah and Colorado. More than 100 people attended the invitation-only event in Boise, including Battelle Executive Vice President of Laboratory Operations Ron Townsend. The event featured presentations by:

- Gov. Brad Little
- Idaho National Laboratory Director Mark Peters
- Former Idaho Gov. C.L. "Butch" Otter
- Nuclear Energy Institute Vice President of Policy Development and Public Affairs John Kotek
- Boise State University President Marlene Tromp
- University of Idaho President Scott Green


Executive Department
State of Idaho

The Office of the Governor
Proclamation

State Capital
Boise

WHEREAS, the Center for Advanced Energy Studies (CAES) is a research, education, and innovation consortium bringing the Idaho National Laboratory (INL) together with the public research universities of Idaho and Wyoming, including Boise State University, Idaho State University, University of Idaho, and University of Wyoming; and

WHEREAS, CAES' vision is to create a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact; and

WHEREAS, CAES' mission is to inspire innovation and impact by leveraging collective capabilities to empower students, researchers, faculty, and industry to accelerate energy solutions; and

WHEREAS, CAES was conceived as a catalyst, activating world-class research assets at INL in combination with students and faculty at the universities to solve complex energy challenges while providing hands-on experience and mentorship that leads to valuable future career opportunities; and

WHEREAS, CAES is committed to conducting cutting-edge energy research, educating the next generation of scientists and engineers, and partnering with industry to advance competitiveness; and

WHEREAS, CAES focuses its efforts in the areas of nuclear energy, energy-water nexus, cybersecurity, advanced manufacturing, innovative energy systems, energy policy, and computing, data, and visualization; and

WHEREAS, CAES members have received more than $100 million in competitive grants and generated more than 1,700 publications, while inspiring the next generation by hosting more than 15,000 visitors; and

WHEREAS, CAES is a force multiplier created to spur collaboration for the greater good; and

WHEREAS, CAES over the last 10 years has served the State of Idaho and its residents with distinction;

NOW, THEREFORE, I, BRAD LITTLE, Governor of Idaho, do hereby proclaim October 1, 2019, to be

CENTER FOR ADVANCED ENERGY STUDIES
(CAES) DAY

in Idaho.

IN WITNESS WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Idaho at the Capitol in Boise on this 1st day of October, in the year of our Lord two thousand and nineteen and of the Independence of the United States of America the two hundred forty-fourth and of the Statehood of Idaho the one hundred thirtieth.

LAWERENCE DENNEY
SECRETARY OF STATE

BRAD LITTLE
GOVERNOR

COVID-19 impacts CAES operations

COVID-19 had a significant impact on operations at the CAES facility in fiscal year 2020. Access to the facility was restricted in mid-March, when only CAES residents and approved visitors were allowed inside the facility. All tours were canceled, and all CAES-sponsored travel has been on hold since then. INL employees at CAES began telecommuting on March 17, and university students, faculty and staff followed suit on March 18. After the Idaho governor issued a stay-home order in late March, the CAES facility was closed to everyone except key personnel. That status continued until mid-May, when the governor lifted his order, and access was restored on a case-by-case basis to researchers with an approved project plan. All others continued to telecommute. COVID-19-related policies were implemented, including a Decision and Action Tree to guide CAES residents who were exposed to the virus, developed symptoms or tested positive, and all who entered the facility were required to wear face coverings and practice social distancing, to conduct temperature self-checks upon entering the facility, and to work from home as much as possible to protect those whose work required laboratory access. At the close of the fiscal year, access remains restricted to those with a CAES badge – no visitors are allowed. Although researchers with an approved project plan have full access to the facility, all others must receive approval from their associate director for each visit. At the end of the fiscal year, access restrictions were expected to remain in place until spring 2021.

University of Wyoming announces 2021 departure from consortium

University of Wyoming (UW) notified CAES leadership in July that the university plans to withdraw from the CAES consortium in early 2021. Since joining the consortium in 2014, UW has broadened the potential impact and expanded the pool of students and faculty by 12,000-plus. UW has been a valued partner and, though it was a member for a relatively short time, the university, its faculty and its students made valuable contributions in several key areas, notably carbon management, energy storage and energy-water nexus. The UW School of Energy Resources, Energy Innovation Center, College of Engineering and Applied Science, and the leaders there – Katie Li-Oakey, Kipp Coddington, Amy Banic, Dean Roddick, Jon Brant, and Rob Godby, to name a few – all made significant contributions at CAES or were poised to do so. Though UW will no longer be a full-fledged member of the CAES consortium, CAES leadership is exploring options for the university's continued participation on a more limited basis.

Inaugural CAES Fellows cohort named

CAES ANNOUNCED THE FIRST COHORT OF CAES FELLOWS IN EARLY JUNE. Six Fellows were selected: an Idaho National Laboratory (INL) researcher and faculty members from Boise State University, Idaho State University, and University of Wyoming. The fellows have demonstrated extensive engagement in the CAES community and collaborated with partners at INL and the CAES universities in at least one of the focus areas outlined in the CAES Strategy. Each has exhibited impressive leadership: mentoring students, leading research projects and workshops, representing their organization at CAES events, and taking the initiative to create stronger bonds among the members of the CAES consortium. Fellows serve two-year appointments during which they are provided with resources and opportunities to drive further collaboration among the CAES entities. From its headquarters in Idaho Falls to spoke locations across Idaho and Wyoming, CAES leverages its collective expertise to inspire innovation and impact, empowering students, faculty, researchers, and industry to accelerate solutions to complex energy issues. The CAES Fellows initiative was launched in spring 2020 to advance this effort. Here are the 2020 CAES Fellows:

RON BORING
Idaho National Laboratory

A distinguished scientist and department manager for Human Factors and Reliability at INL, Ron Boring has been involved with CAES since its inception, when he led the Human Systems Simulation Laboratory. He has collaborated extensively with the CAES universities and participated in the 2020 CAES Summer Visiting Faculty Program. Boring's CAES collaboration dates to a Laboratory Directed Research and Development (LDRD) award he received jointly with University of Idaho that served as seed money for advanced human-machine interfaces for nuclear power plants. This effort led to an additional LDRD award and DOE funding. Boring joined INL in 2003 and has led research projects for the U.S. Nuclear Regulatory Commission, NASA, the U.S. Department of Energy, the Canadian Nuclear Safety Commission, the Department of Defense and the Norwegian Research Council.

MIKE BOROWCZAK
University of Wyoming

Mike Borowczak is the founding director of the Cybersecurity Education and Research Center at University of Wyoming (UW), where he has been an assistant professor of computer science since early 2018. Borowczak has championed several CAES endeavors at the university and has been involved in several efforts in the cybersecurity focus area at CAES. He has served as the UW lead for the pilot CAES Nuclear Safeguards & Security joint certificate initiative, is a member of the CAES Cybersecurity working group, and was recently granted a joint appointment with INL, an arrangement in which a researcher has formal ties to both INL and a university. Borowczak was a participant in the CAES Summer Visiting Faculty Program in 2020.

BRIAN JAQUES
Boise State University

Brian Jaques is an assistant professor in the Micron School of Materials Science and Engineering at Boise State University who has been involved with CAES since its opening in 2009, when he worked as a research engineer. He has collaborated on several CAES projects in the Nuclear Energy and Advanced Manufacturing focus areas and is currently the Boise State program manager for the In-Pile Instrumentation Program, an $8 million DOE-funded collaboration between INL and Boise State that calls for developing novel sensors for in-pile, in-situ measurements in a nuclear reactor core. Jaques, who recently received an INL joint appointment, is also collaborating on several pending proposals with CAES partners. A participant in the 2019 CAES Summer Visiting Faculty Program, Jaques currently serves as the CAES Nuclear Energy Focus Area lead at Boise State.

LAN LI

Boise State University

Lan Li is an associate professor in the Micron School of Materials Science and Engineering at Boise State who has been actively involved in CAES seminars, workshops, working groups, and proposal development. She led both sessions of the Remote Summer Boot Camp on Computing, Data and Visualization that were sponsored by CAES and INL's Collaborative Computing Center in summer 2020. Li is collaborating on two projects with CAES entities and has led the development of a computational materials science road map report to identify researchers with expertise in the field, equipment, computational power at the CAES institutions, research needs, and funding sources.

MUSTAFA MASHAL

Idaho State University

Mustafa Mashal is an associate professor in the Civil and Environmental Engineering Department at Idaho State University who has participated in several collaborative projects with INL and the CAES universities. This includes a project he leads that received a $1.1 million grant from the Idaho Global Entrepreneurial Mission initiative in 2019. CAES provided seed funding for the project, which calls for the construction of a Disaster Response Complex for research, certification and training first responders. Mashal was a participant in the CAES Summer Visiting Faculty Program in 2019 and is a current member of the Advanced Manufacturing and Energy Policy working groups. He also collaborated this year with the CAES Operations team to pilot a training program for Idaho State students that was modeled after Battelle's Laboratory Operations Safety Academy.

CLAIRE XIONG

Boise State University

Claire Xiong is an associate professor in the Micron School of Materials Science and Engineering at Boise State who has been a CAES collaborator since 2012, participating in several projects involving INL and the CAES universities. Her current projects with INL include a Laboratory Directed Research and Development project with the Energy Storage and Advanced Transportation group at INL, the In-Pile Instrumentation Program, and a project focused on nuclear materials for molten salt reactors. She is collaborating with researchers at the University of Idaho and University of Wyoming on a project aimed at the development of carbon electrode materials. She also has partnered with INL researchers Erik Dufek and Kevin Gering to write a book chapter on batteries and is the recipient of a National Science Foundation CAREER Award. Xiong has co-organized several CAES workshops and contributed to a CAES Nuclear Energy roundtable in 2020.

CAES unveils new fellowship, names inaugural Fellow

Dr. Veronika Vazhnik was named the inaugural Idaho Science and Technology Policy CAES Fellow. Closely aligned to the mission needs of CAES and INL, this fellowship is one of two offered through the newly launched Idaho Science and Technology Policy Fellowship program, a collaborative effort among University of Idaho, Boise State University and Idaho State University. The Fellows spend a year embedded in an Idaho state government agency, developing and implementing solutions that address challenges in areas such as energy, cybersecurity, water, public health, and economic development. The CAES Fellow will concentrate her efforts on one or more of the focus areas outlined in the CAES Strategy. The goal is to develop a network of leaders who understand government and policymaking and are prepared to use their knowledge and skills to create a better future, complementing CAES' vision of accelerating energy solutions and creating the next generation of energy leaders.

Vazhnik is a former graduate fellow at INL whose research has focused on bioenergy and landscape design decision-making. She earned her doctorate in biorenewable systems with a minor in operations research from Pennsylvania State University. She began her fellowship in August with the Idaho Office of Energy and Mineral Resources.

The Idaho Science and Technology Policy Fellowship program is led by U of I's McClure Center for Public Policy Research and is modeled on the American Association for the Advancement of Science, Science & Technology Policy Fellowship (AAAS STPF) Program, which brings scientists and engineers into a policy context where their technical knowledge and networks inform the federal government.

RESEARCHER, FACULTY, STAFF, AND STUDENT ACCOMPLISHMENTS

CAES associate director selected for INL post

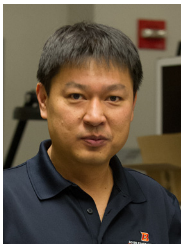
CAES Associate Director for Boise State David Estrada was named INL's Advanced Manufacturing deputy director for Academic Research in September. Estrada's new role calls for him to support and strengthen the Advanced Materials and Manufacturing for Extreme Environments initiative at INL and support multimission collaboration across the five INL directorates. He is charged with leading and cultivating the academic interactions and activities with the manufacturing initiative. This enables collaboration between industry and academia, and positions INL at the forefront of the U.S. Department of Energy's efforts to develop advanced reactor technology. It also strengthens the United States' position as the global leader in nuclear energy technology.

Collaboration has been a hallmark of Estrada's tenure as CAES associate director. Since assuming the role in 2019, he has amplified Boise State's relationship with CAES. He formalized the faculty and student-CAES community at the university by creating campus leads in each of the seven focus areas identified in the CAES Strategy. He championed the CAES Fellows initiative launched in FY20 and has helped lead Boise State students and

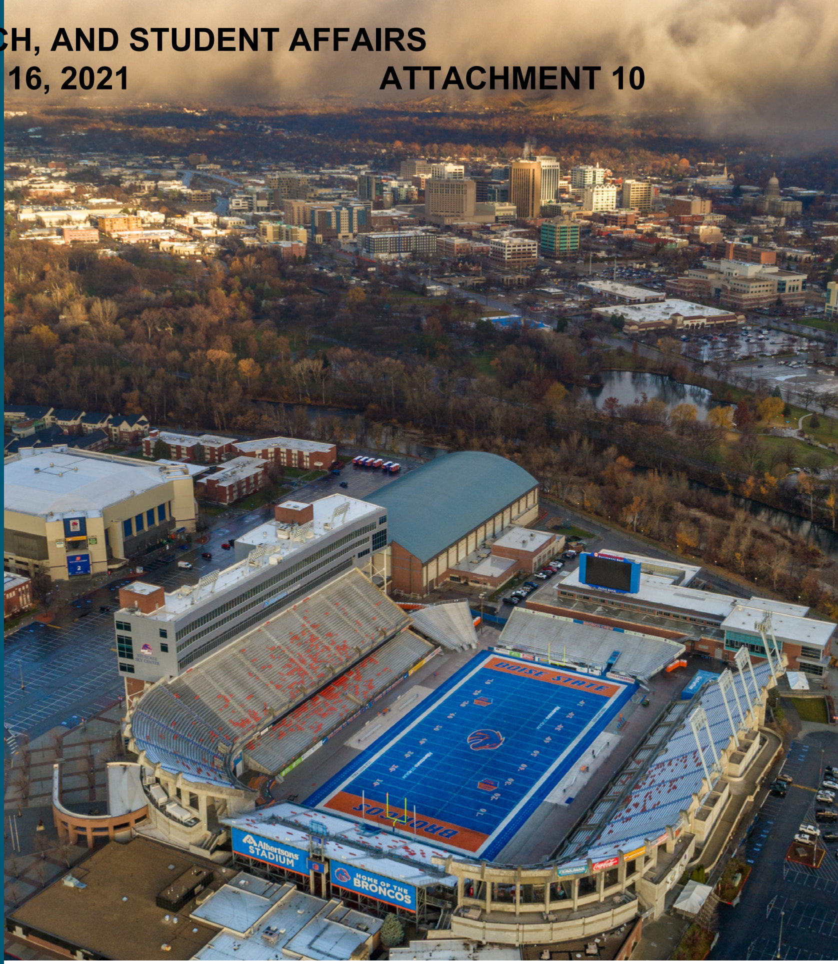
faculty in a litany of accomplishments, including the award of three Nuclear Science User Facilities (NSUF) Infrastructure Awards and two Nuclear Energy University Program Fellowships. Estrada's leadership has been instrumental in the ongoing development of an advanced manufacturing suite at CAES, which will soon feature a new transmission electron microscope funded by INL and a 3D metal printer made possible by an NSUF-funded, Boise State-led project on which he is a collaborator. An additional benefit of the joint appointment is to provide a national recruiting tool for CAES entities to leverage when seeking to hire top talent to the region and enhance the advanced manufacturing workforce pipeline.

Joint appointments offered to Boise State faculty members

Two Boise State University faculty members with CAES connections were offered joint appointments with Idaho National Laboratory in early 2020: Brian Jaques, a materials science and engineering assistant professor who was a cohort in the 2019 CAES Summer Visiting Faculty Program, and Sin Ming Loo, an electrical and computer engineering professor who collaborated with CAES to host a cybersecurity workshop in summer 2019. Jaques' research focuses on



nuclear materials and engineering materials for extreme environments. Loo's research focuses on cybersecurity and education.



Two Boise State faculty members with CAES connections receive NSF CAREER awards

Mike Hurley, an assistant professor in the Micron School of Materials Science and Engineering who took part in the CAES Summer Visiting Faculty Program in 2019, received a five-year, $500,000 award to further his research of corrosion. **Catherine Olschanowsky**, an assistant professor in the Department of Computer Science who serves as the Boise State campus lead in the CAES focus area of Computing, Data, and Visualization, received an award of more than $540,000 over five years for research aimed at boosting the efficiency of supercomputers.

Olschanowsky's research calls for collaboration with at-risk teenagers to develop an innovative infrastructure that decreases the execution time of scientific applications without the need for extensive changes to computer code. These changes would remove inefficiencies that occur during translation within supercomputers, optimizing performance.

The goal of Hurley's research on corrosion is to gain a better understanding of the complex interplay between materials and their environment, leading to the development of new methods to predict and assess corrosion, and guidelines for engineers to design new, more reliable materials. Hurley is also a collaborator on the In-Pile Instrumentation Program, a DOE-funded collaborative project between Boise State and INL.

CAREER awards are the National Science Foundation's most prestigious early career awards. They are distinct in that selected faculty must serve as academic role models in research and education and present integrated research and educational plans. While Olschanowsky plans to work with at-risk teens, Hurley will collaborate with K-12 schools and engineering professionals to increase public awareness of corrosion and corrosion control through activities that are being developed. Hurley's grant also will support a unique exchange partnership, expanding opportunities for Boise State students.

U of I professor notches research win

Haiyan Zhao, University of Idaho nuclear engineering assistant professor and CAES resident, received a $400,000 award from DOE's Nuclear Energy University Program for a project she leads in collaboration with researchers from the University of Utah and University of Nebraska. The project's objective is to improve fundamental understanding of the behavior of multicomponent fission products in eutectic chloride salts for pyroprocessing technology. A complete roundup of research wins for CAES affiliates begins on page 12.

Boise State participating in several new collaborative efforts with INL

CAES' focus on enabling collaboration among its member universities and INL has contributed to several recent collaborative efforts between Boise State and INL, including:

- Hoda Mehrpouyan, an assistant professor in computer science, is working with INL to develop a secure water testbed as part of her research related to the National Science Foundation's CAREER Award she received in April 2019. The $454,000, five-year CAREER award will allow Mehrpouyan to advance cybersecurity research aimed at protecting critical infrastructure such as water treatment plants.
- Professor Sin Ming Loo with Boise State's Electrical and Computer Engineering Department is working on a cyber culture project involving INL's Char Sample and Boise State's Anthropology Department.
- Professor Marion Scheepers' collaboration with INL's Robert Erbes led to the development of a Vertically Integrated Projects course at Boise State called Security of Portable Devices.
- Peter Risse, associate dean of Extended Studies; Assistant Professor Mehrpouyan; and Math Professor Liljana Babinkostova are participating in INL's Girls Go CyberStart program.
- Babinkostova also is working with INL Researcher Katya LeBlanc to develop a Computing Colloquium discussion that is expected to take place in spring 2021.
- In Spring 2020, Kathy Araújo, director of the Energy Policy Institute and associate professor of sustainable energy systems, innovation and policy, partnered with Kelly Wilson and Ryan Hruska of INL's Infrastructure Assurance and Analysis Group for a new course, 21st Century Opportunities and Challenges in Energy – Strategic Decision-making about Systems Change.

From White House fellowships to INL joint appointments and outstanding student awards, CAES-affiliated professors and students drew notice in FY20.

U of I professor completes White House fellowship

CAES resident Dakota Roberson, an assistant professor of electrical and computer engineering at the University of Idaho, recently completed a yearlong stint in the 2019-2020 Class of White House Fellows. The nonpartisan White House Fellows Program was created in 1964 by President Lyndon B. Johnson to provide professionals from diverse backgrounds an opportunity to engage in public service by serving in various roles in the federal government. Fellows participate in education programs that expand their knowledge of leadership, policymaking and contemporary issues. Roberson was placed at the Department of Defense for the yearlong fellowship. At CAES, he leads an interdisciplinary research team studying electrical grid stability and security, and he is an appointed nuclear engineering affiliate faculty at University of Idaho. Roberson has collaborated with numerous national laboratories, electric utilities, private stakeholders and universities to mitigate 21st century energy system threats. His engineering courses are structured to prepare students for careers in this area. Before joining the University of Idaho, he was with Sandia National Laboratories. In addition to his professorial duties, Roberson promotes science, technology, engineering and mathematics education through secondary school outreach and public speaking engagements to spark the curiosity of young scientists. He also volunteers as an advisor to regional energy infrastructure programs and a tech startup. Roberson was in the first cohort of the CAES Summer Visiting Faculty Program in 2018, and he was integral to launching CAES' monthly Codebreaker seminar series.

ISU dean sworn in as president of the American Nuclear Society

Mary Lou Dunzik-Gougar, CAES resident and associate dean of Science & Engineering at Idaho State University, was sworn in as president of the American Nuclear Society in June. Dunzik-Gougar is an associate professor of nuclear engineering and a senior reactor operator of ISU's Aerojet-General Nucleonics nuclear reactor. She also serves as co-lead of the Nuclear Energy working group at CAES. Dunzik-Gougar previously held a joint appointment with INL, where she led the Simulation Institute for Nuclear Enterprise Modeling and Analysis fuel cycle modeling project. She also worked at Argonne National Laboratory with various duties associated with pyroprocessing spent fuel.

CAES collaborator named ISU College of Science and Engineering's outstanding student

Kathryn Hogarth, a civil engineering student at Idaho State University and collaborator on a CAES-inspired project, received the ISU College of Science and Engineering's Outstanding Student Award in the spring. An undergraduate student with a 3.81 GPA, Hogarth is a member of a team led by ISU Associate Professor/CAES Fellow Mustafa Mashal that is working to build the Disaster Response Complex in Pocatello. CAES provided seed funding for the collaborative project, which includes INL researchers and received a $1.1 million grant from the Idaho Global Entrepreneurial Mission initiative in 2019. Hogarth was named ISU Student Employee of the Year in 2018-2019, served as president of the student chapter of the American Society of Civil Engineering for the 2019-2020 school year, is a member of ISU's University Honors Program, and is the goalkeeper for the ISU women's soccer team.

RESEARCH HIGHLIGHTS

The research pillar of the CAES Strategy was a focus in FY20, the second year of the plan's implementation. The results were a significant number of research wins and developments aimed at gathering momentum for impactful collaborative proposals, incentivizing new and existing one-on-one collaborations, and enabling more complex collaborations in the pursuit of research hubs. Among the goals in FY20 was to grow new capabilities in the CAES facility that would provide new value and draw faculty, students and researchers into the laboratories and offices. Efforts on this front included:

- Installing a 4.7-kilowatt research wind turbine outside of CAES headquarters that feeds generation data to DOE's Microgrids, Infrastructure Resilience and Advanced Controls Launchpad program and Wind for Schools. The turbine is virtually connected to a microgrid at INL's Energy Systems Laboratory. The installation of the 70-foot tall turbine in January made the front page of the Idaho Falls newspaper.
- In July, CAES hosted a virtual groundbreaking ceremony for a $5 million project to install a new Transmission Electron Microscope (TEM) in the CAES facility. The TEM is expected to be operational in early 2021 and represents the most technologically advanced TEM resource across the CAES complex (energy/spatial resolution, dynamic capture, broad electron range). This benefits the CAES universities, Nuclear Science User Facilities (NSUF), and several aspects of INL's mission and its Advanced Materials and Manufacturing for Extreme Environments initiative.
- The TEM will be a key feature in developing an Advanced Manufacturing Suite at CAES, complimented by the installation in FY21 of a 3D metal printer that will establish CAES' capability to additively manufacture metallic nuclear grade materials at CAES and within the NSUF network.
- Funding for the printer came via an NSUF award granted to Boise State University faculty member Mike Hurley for a project that sprung from Hurley's participation in the CAES Summer Visiting Faculty Program in 2019.
- CAES leadership and staff continue to prioritize and support the installation of a state-of-the-art NuScale power plant control room simulator, the result of a $285,000 Nuclear Energy University Program (NEUP) award in FY19 to a University of Idaho-led project, *Multi Universities SMR Simulators: NuScale*. Rich Christensen, UI's Nuclear

Engineering Department director, is the project's principal investigator.
- Outside the CAES facility, construction began in summer 2020 on the Disaster Response Complex, a collaborative project involving Idaho State University and INL. This will lead to a regional/national training center complex in Pocatello that mimics the features of a structure collapsed by an earthquake, hurricane or other natural disaster, for the research, certification, and training of first responders. ISU was awarded $1.1 million from the Idaho State Board of Education's Idaho Global Entrepreneurial Mission in summer 2019 to build the complex. Seed funding for the project came via a 2018 CAES program development award and a 2018 CAES Collaboration Fund award. The collaboration between INL and ISU provides expertise in chemical, biological, radiological, and nuclear research.

Collaboration funds recipients announced

CAES announced the 2020 recipients of $139,000 in CAES Collaboration Program Development Funds in May and nearly $116,000 in seed grants through the ISU-CAES Collaboration Fund. These initiatives are designed to help establish collaborative relationships between INL researchers and the CAES universities in research, education, and innovation, by directing funds to INL principal investigators and ISU project leads. After reviewing the submissions, CAES leadership determines which proposals are best suited to enhance collaborative relationships among the CAES entities in at least one of the seven focus areas outlined in the CAES Strategy. High priority was given to projects with a tie to future direct-funded work such as through a DOE solicitation. CAES congratulates the following teams:

CAES Collaboration Fund:

Advanced Manufacturing

- Rare Earth Elements, INL researchers Donna Baek and Mary Case, Energy & Environment Science & Technology (Caleb Hill, University of Wyoming)
- Atomic Layer Deposition, INL researchers Mary Case and Robert Fox, Energy & Environment Science & Technology (Elton Graugnard, Boise State)

Innovative Energy Systems

- Non-Thermal Plasma, INL researcher Hongquiang Hu, Energy & Environment Science & Technology (Haiyan Zhao & Sarah Xiao, U of I)

Computing, Data & Visualization

- Virtual Reality, INL researchers Rajiv Khadka & John Koudelka, Nuclear Science & Technology (Mustafa Mashal, ISU)

Nuclear Energy

- Molten Salt Nuclear Batteries, INL researcher Piyush Sabharwall, Nuclear Science & Technology (Rich Christensen, U of I, and Dan LaBrier, ISU)

Innovative Energy Systems

- Unique Carbon Materials, INL researcher Eric Dufek, Energy & Environment Science & Technology (Patrick Johnson, University of Wyoming)

ISU-CAES Collaboration Fund

Advanced Manufacturing

- Arch Culvert Bridges, ISU researchers Bruce Savage, James Mahar, Mustafa Mashal, Arya Ebrahimpour, Civil Engineering (Gabriel Ilevbare, Chris Wright and Richard Boardman, INL)
- Boron Nitride Films, ISU researcher Rene Rodriguez, Chemistry (Kris Campbell, Boise State; Mary Case and Robert Fox, INL)

Nuclear Energy

- Heat Exchanger Technology, ISU researcher Amir Ali, Nuclear Engineering (Piyush Sabharwall, INL)
- Ionic Liquid Synthesis, ISU researcher Kavita Sharma, Chemistry
- Molten Sodium Testing Program, ISU researcher Dan LaBrier, Nuclear Engineering (Colby Jensen, Bryce Kelly and Nic Woolstenhulme, INL)
- Reactor Transient Diagnostics, ISU researcher Leslie Kerby, Computer Sciences (Bob Borrelli, U of I)
- Wettability Measurements, ISU researchers Mary Lou Dunzik-Gougar, Amir Ali and Dan LaBrier, Nuclear Engineering (Yaqiao Wu, Boise State)

This is a simulation of the control room of a NuScale nuclear power plant, similar to the simulator that will be installed at CAES.

Working groups

Funds were awarded to working groups in the seven CAES Strategic Focus Areas – nuclear energy, advanced manufacturing, cybersecurity, energy-water nexus, innovative energy systems, energy policy, computing/data/visualization – with a priority on creating researcher-led initiatives. Working groups accomplished the following in FY20:

Six organizing workshops

- A workshop and roundtable held by the advanced manufacturing working group on Boise State University's campus in early March drew representatives from several outside organizations, including NASA, Oak Ridge National Laboratory, Air Force Research Laboratory, Boeing, Hewlett Packard, Fiberguide, Optomec and NIST.
- Nearly 200 people registered for a half-day, virtual workshop hosted by the CAES Energy Policy working group. The event featured a panel discussion on energy policy, jobs, industry conditions and economic challenges during the COVID-19 pandemic. The panel was among the highlights of a virtual workshop hosted by the CAES policy working group. The discussion featured John Kotek, Nuclear Energy Institute Policy Development and Public Affairs vice president; Marc Chupka, U.S. Energy Storage Association Research and Programs vice president; and Elise Hunter, Grid Alternatives Policy and Regulatory Affairs director.
- The cybersecurity working group held a workshop in late April, a daylong event that featured three breakout sessions and updates from each of the CAES entities on cyber-related initiatives.
- Technical workshops were held on topics including hydropower; energy storage; regional models of cyber cooperation; and carbon capture, utilization, and storage.

Three roundtables were held to shape future federal funding, convening small groups of thought leaders to write a white paper outlining a pitch to a federal partner for a national-level workshop hosted by CAES, to inform a future agency funding opportunity. White papers emerged from three working groups: cybersecurity, nuclear energy, and advanced manufacturing.

- Written by representatives from INL, University of Idaho, and Boise State University, the Cybersecurity working group's white paper, "Industry 4.0: Emerging Cybersecurity Threats & Challenges," calls for a workshop that would help foment novel ides and build new partnerships with diverse researchers across disciplinary fields. The two-day event will feature keynotes, panels and breakout sessions with an estimated 150 participants interested in developing cybersecurity solutions to threats that emerge with the development of new technology, particularly smart and connected manufacturing innovations.
- The Nuclear Energy working group's white paper, "Advanced Reactor Technology Initiatives: Bridging the Gap from Microsamples to Macrostructure," calls for revolutionizing the characterization and design processes of advanced reactor technology, potentially shortening the time to licensing for the next generation of nuclear power plants. Advanced reactor technology provides the nation with many strategic advantages and is needed for the U.S. to maintain its position as a global leader in nuclear energy. Based on this, the white paper, written by CAES Associate Director for University of Idaho John Russell, focused on the need to develop cost-competitive reactor technology to replace the nation's fleet of aging light water reactors.
- The Advanced Manufacturing working group was invited to submit a proposal for a NSF Future Manufacturing workshop based on its white paper, "Accelerating the Discovery and Qualification of Intelligent Materials and Methods for Extreme Environments." The paper calls for support for a national workshop to envision solutions to four interrelated future manufacturing challenges for the nuclear power sector. Since the development of new technology and a skilled workforce is critical to the success of future manufacturing in the region, the white paper states, the advice of experts would be invaluable for accelerating discovery and qualification of intelligent materials and methods in extreme environments.

Working groups established in the seven focus areas outlined in the CAES Strategy made significant progress in FY20 on efforts to enhance collaboration among the CAES entities.

The workshop would allow for the development of novel ideas and new partnerships with diverse researchers across disciplinary fields and at every career stage.

- White papers were also produced on these topics: bulk storage of hydrogen; a holistic approach to examining hydroelectric dam viability: economics, public health and environment; distributed pumped hydropower storage; and remote sustainability niches and microreactor potential in rural economic and agricultural development.
- The Cybersecurity working group produced a draft charter for the Cyber Resilience Innovation Council, which envisions Idaho as the nation's industrial cybersecurity resilience hub of expertise while developing a cooperative model and set of best practices that can be leveraged across the U.S. The council would promote the region's prosperity and resilience by creating pilot programs and partnerships designed to advance cybersecurity while building new partnership methods. It also would develop a talent pipeline for the cybersecurity field and support workforce development efforts by providing immersive learning environments and experience-based training programs.

Proposals/reports/white papers funded by CAES include:

Advanced manufacturing ($22k):

- Proposal by Indrajit Charit (U of I) and Brian Jacques (Boise State)
- White paper by Mustafa Mashal (ISU), Kunal Mondal (INL) and Michael McMurtrey (INL)

Cybersecurity ($22k)

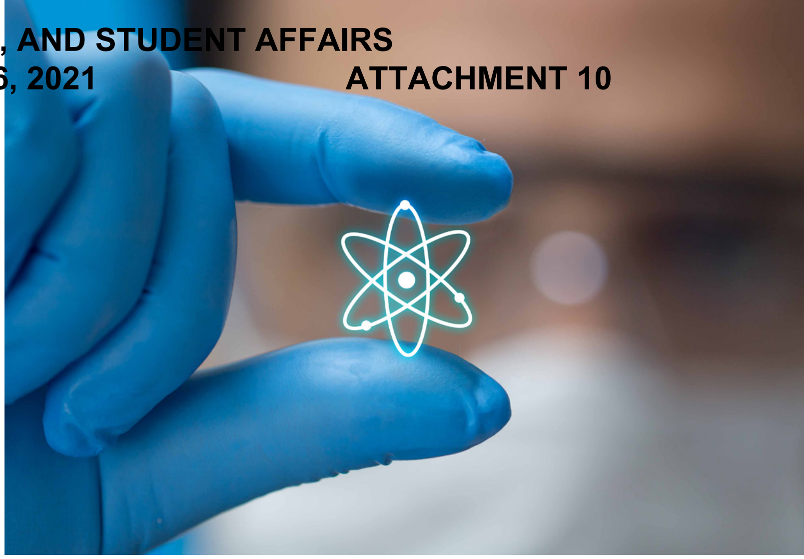
- Technical workshop report by Justin Wood (ISU) and Ron Fisher (INL)
- Proposal by Sean McBride (ISU), Rob Beason (INL) and Eleanor Taylor (INL)

Energy policy ($14k)

- White paper by Irene van Woerden (ISU), Bruce Savage (ISU), Mustafa Mashal (ISU), and Kathleen Araújo (Boise State)
- White paper by Steven Peterson (U of I), David Shropshire (INL), Geoffrey Black (Boise State), and Kathleen Araújo (Boise State)

Energy-water nexus ($7k)

- Technical workshop report by Karen Humes (U of I) and Bruce Savage (ISU)



Research wins

- Amir Ali, an assistant professor of nuclear engineering at Idaho State University, is leading a project in collaboration with fellow ISU faculty members Dan LaBrier, Chad Pope, and Jonathan Scott to upgrade the AGN-201M nuclear reactor at ISU. The project was one of 21 university-led projects awarded infrastructure grants through DOE's Nuclear Energy University Program (NEUP) to perform research reactor and infrastructure improvements. The reactor at ISU is essential to advancing the nuclear engineering science knowledge and serves as a fundamental tool in training reactor operators. This allows students to gain valuable experience before entering the nuclear workforce. Ali's project, which received a $59,262 award, calls for replacing the control rod drive mechanism on the half-century-old reactor with a newly developed alternative. The new design reduces complexity and probability of failure, and it improves the overall reliability and safety of the reactor.
- University of Idaho faculty member R.A. Borrelli, assistant professor of nuclear engineering, will help lead a $1 million Nuclear Energy Enabling Technologies-funded project in partnership with Brookhaven National Laboratory to build an adaptive control and monitoring platform for autonomous operation of advanced nuclear reactors. Researchers will develop an artificial intelligence-based platform that can support autonomous control of advanced reactors. The platform will use and integrate information from multiple sensors and support systems to issue appropriate commands to plant systems to keep the reactor within a safe operating envelope and avoid unnecessary shutdown. The work will include a cost-benefit analysis to evaluate the performance of the platform and the anticipated cost savings from its deployment.
- ISU Dean Mary Lou Dunzik-Gougar and ISU professor Dan LaBrier, CAES-affiliated faculty members, are collaborators along with INL researcher Wen Jiang on a project led by a researcher at University of Wisconsin that received an $800,000 NEUP award. The goal of the research is to gain a mechanistic understanding of and develop a predictive model for the tearing of the buffer layer in tristructural isotropic fuel particles.
- CAES Fellow Ron Boring of INL is a collaborator, along with INL researcher Vaibhav Yadav, on a University of Tennessee-led project that received an $800,000 NEUP award to develop a holistic artificial intelligence tool to increase the detection and mitigation of human factors errors in nuclear power plants.
- ISU research professor Richard Schultz and Don McEligot, an INL researcher and visiting professor with U of I, are collaborators on a project led by a researcher at City University of New York. The project aims to generate an experimental database for validating models used to analyze high-temperature gas reactors, to ensure passive cooling occurs when there is a loss of forced circulation or pressure. The project, which also includes industry partner Framatome, received $800,000 in NEUP funding.
- U of I chemical engineering professor Indrajit Charit received a three-year, $799,950 NEUP award, in partnership with University of Nevada, Reno, to make spent nuclear fuel short-term storage safer by better understanding how welds on stainless steel fuel canisters respond to compressive stress, surface texture modification and corrosion. Charit also is a collaborator on a project led by Boise State's Brian Jaques that won an award through the Idaho Global Entrepreneurial Mission last year.
- A team led by researchers from INL and U of I received a two-year, $1.5 million award through DOE's Energy Technology Commercialization Fund. The project, Development of a Prototype Control Room for an Advanced Reactor Vendor, is led by Ron Boring and Thomas Ulrich at INL; Roger Lew, a research assistant professor of virtual technology and design at U of I; and industry partner Kairos Power. It calls for the use of an INL-developed and copyrighted simulation tool, the Rancor Microworld. The tool would create a prototype of the control room for the Kairos Power reactor, a fluoride salt-cooled high-temperature small modular reactor designed to compete with natural gas for electricity generation. This is a critical step to ensure the proper design of control rooms for advanced reactor designs now under development.
- Boise State's Mike Hurley, in collaboration with INL researcher Donna Guillen, CAES Associate Director to Boise State David Estrada, and Boise State assistant professor Brian Jaques, led a project that received a NSUF award and will lead to the installation of a 3D metal printer at CAES for nuclear grade materials. The project emerged from the CAES Summer Visiting Faculty Program in 2019.

- Edoardo Serra received a grant for the project that emerged from his participation in the CAES Summer Visiting Faculty Program. Serra, an assistant professor in Boise State's Computer Science Department, was one of 18 visiting faculty in the visiting faculty program's first full year in 2019. He collaborated with INL researcher Shane Stailey from INL's National and Homeland Security Directorate on a project that covered two CAES focus areas: cybersecurity and computing, data, and visualization. The project calls for the creation of a framework for outreach activities to help teachers inspire students in grades 5-8 to pursue careers in cybersecurity. The outreach utilizes Lego Mindstorms in the field of cyber-physical system security and controls to spark interest. Lego Mindstorms kits allow students to build programmable robots using a brick computer that controls the system, plus sensors, motors, and Lego pieces. The project received a $25,000 grant through

a public-private partnership between Battelle Corporate Education Giving Funds and Idaho STEM Action Center.
- A project led by CAES Associate Director to Boise State assistant professor Brian Jaques and Boise State David Estrada received an award through the Idaho Global Entrepreneurial Mission grant program initiative. Jaques is the principal investigator on the project, Scalable Manufacturing of On-Chip Color Tunable Lasers, which calls for collaboration with industry partner Iris Light Technologies to design and develop materials for efficient and cost-effective lasing solutions. Boise State's role is to develop scalable processes to create nanomaterial inks from low-cost commodity materials in collaboration with the company's effort to commercialize a hybrid silicon nanomaterial laser produced with additive manufacturing printing of photonic inks.
- A project involving Boise State and INL, led by industry partner Applied Nanotech, was selected for a Phase I DOE award of $199,999 from the SBIR and STTR Programs Office within the DOE Office of Science. The project, Printed Sensor for Monitoring Reactor Health, calls for the development of innovative sensors to better monitor nuclear power plants, improving efficiency while reducing operations and maintenance costs. The project's first phase focuses on developing materials for printing multimodal sensors that can survive in extreme environments like those found at nuclear power plants. Manufactured with a 3D printer, the durable, low-cost sensors could be used for monitoring and controlling reactors and fuel cycle facilities. They can be directly printed onto fuel, cladding and structural components, and they would lead to efficiency gains and improved reliability in new and existing reactors. This creates cost savings. Other potential benefits include new materials and sensors for automotive, aerospace, renewable energy and manufacturing sensors and components for extreme environments.

Research wins (CAES affiliates)

- Dan Deng, assistant professor in Boise State's Department of Mechanical and Biomedical Engineering; Haarish Subbaraman, assistant professor in Boise State's Electrical and Computer Engineering Department; and CAES Associate Director for Boise State David Estrada were awarded $100,000 through the FlexTech Consortium for a project that calls for printing flexible piezoelectric sensors and energy harvesters.
- Subbaraman and Estrada also collaborated on a project awarded $200,000 through NextFlex, the Flexible Hybrid Electronics Manufacturing Institute in the Department of Defense's Manufacturing Technology Program, for a project involving an Advanced Flexible Hybrid Demonstrator for Unmanned Aerial Vehicle applications.
- University of Wyoming associate professor Jon Brant received a $1 million grant from DOE for a project to develop new membrane technology that could be used to treat produced water, or water that surfaces during hydraulic fracturing. Produced water is currently seen as a waste product in the natural gas industry, but Brant's project could change that by enabling the produced water to be reused in industrial applications. Brant's project, Resource Recovery and Environmental Protection in Wyoming's Greater Green River Basin Using Selective Nanostructured Membranes, got underway in early 2020. Some of the research is expected to be conducted in the CAES facility. Brant is co-lead of the CAES Energy-Water Nexus working group.
- Boise State's College of Engineering and Division of Extended Studies collaborated to secure a grant from the Idaho Workforce Development Council allowed them to create an online cyber-physical systems security certificate. The $833,958 grant covered costs related to starting up and developing the program, which launched in fall 2020.

EDUCATION HIGHLIGHTS

The education pillar was focused on the first-ever CAES joint certificate this year. CAES successfully completed the second year of a three-year plan to launch the pilot Nuclear Safeguards & Security joint certificate in fall 2021 by completing the course development, creating a road map, writing a business model, securing the support of university leadership, ensuring the participation of INL's Cybercore and Collaborative Computing Center, and beginning final administrative streamlining with university provosts and registrars.

CAES Summer Visiting Faculty Program completes third year

The CAES Summer Visiting Faculty Program completed its third year in August with 11 faculty members from CAES universities partnering with INL researchers to develop proposals in one of the CAES focus areas. The program is designed to create robust connections between the faculty members and INL researchers, creating long-term impact to the universities and INL; to bring in external funding to complete innovative and inspiring research, providing value to the institutions, INL, and the funding agency; and to facilitate student integration into joint research. Participants work together throughout the summer to produce a ready-to-submit CAES-branded proposal or, if a funding opportunity is not yet open, an extensive white paper.

CAES co-sponsors data science events

Sponsored by CAES and INL's Collaborative Computing Center, Remote Boot Camp: Computing, Data, and Visualization I and II drew more than 300 people. The virtual, collaborative symposiums drew representatives from every CAES entity and featured workshops on Software Carpentry and Computational Modeling and Data Science, and panel discussions. The goal was to advance CAES' efforts related to workforce development by sustaining continuing education among young researchers in order to maintain the skills and abilities needed for success in all aspects of advanced energy research and development.

CAES hosts panel discussion on journal writing

CAES hosted a panel discussion on journal writing in late February that sold out the day registration went live. The discussion featured panelists from CAES universities and INL and provided students, faculty, and early-career researchers with information to help them navigate the process of developing and submitting their work for publication. The Science of Science Writing: Effectively Communicating Through Journal Publications was held as part of the CAES Academy outlined in the CAES Strategy. CAES Academy serves as a construct for creating new joint educational offerings through the CAES universities and INL, to not only help build a future workforce with the skills and relationships needed for success but also to provide specialized training offerings for the current workforce. The goal of the panel discussion was to help CAES universities and INL maximize the quality and caliber of research in order to optimize its impact. The panelists provided attendees with the principles and effective tactics for developing and submitting a journal article that has high likelihood of being accepted. Topics ranged from ethics to references, available resources to traceability. Steve Hartenstein, chief science officer for INL's National and Homeland Security Science and Technology Directorate, served as moderator, and the panelists included Lyle Castle, ISU's vice provost for Academic Outreach and dean for Idaho Falls and a former editor for the Journal of Heterocyclic Chemistry, and David Petti, emeritus laboratory fellow at INL.

LOSA training held at ISU

Idaho State University collaborated with INL and CAES to offer six, four-hour sessions of the Laboratory Operations Supervisor Academy (LOSA), an innovative training program developed by Battelle Memorial Institute, the organization that operates INL and seven other national laboratories. LOSA utilizes simulations and scenarios, with participants assuming various roles, to build and maintain a safety culture at INL and other Battelle-operated national laboratories. The pilot program at ISU was led by Mustafa Mashal, associate professor and CAES Fellow, and Jared Cantrell, research engineer and lab manager in the Department of Civil and Environmental Engineering at ISU, and consisted of six LOSA sessions held over three days in late August. Despite uncertainties related to the pandemic, attendance was at capacity. The successful effort has led Mashal and Cantrell to work with CAES and ISU to make the training available to other interested CAES students, faculty and staff. The training is an example of CAES' ability to leverage one of its member's expertise for the benefit of other CAES entities. The goal is to expand this best-practice safety training to other CAES universities as CAES fulfills its vision of training the next generation of energy leaders. As an offering of the CAES Academy outlined in the CAES Strategy, LOSA training could one day allow CAESers to gain certification or a safety training designation on student transcripts.

U of I-Idaho Falls team wins CyberForce competition

The University of Idaho-Idaho Falls team took first place in DOE's CyberForce Competition at INL's Energy Innovation Laboratory in Idaho Falls. The local competition drew contestants from nine teams representing regional universities, including all of the CAES universities. There were several CAES connections among the competitors, including UI-Idaho Falls advisers Joe Leister, who formerly worked in the Applied Visualization Laboratory at CAES; Michael Haney, a U of I-INL joint appointee with an office in CAES; ISU's Sean McBride, an ISU-INL joint appointee; UW's Mike Borowczak, a CAES Fellow and frequent collaborator; and Boise State's Sin Ming Loo, who recently led a Cybercore/CAES cybersecurity workshop. The annual CyberForce competition is an interactive, scenario-based event in which teams engage in cybersecurity activities in collaboration with INL staff. The goal is to increase hands-on cyber education of the college students and professionals while boosting awareness of the critical infrastructure and cybersecurity nexus and developing a better understanding of cybersecurity in real-world scenarios.

The pandemic failed to impede the progress of several CAES initiatives in the education pillar in FY20.

STUDENTS IN THE LAB

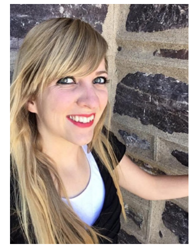
Boise State University students recognized

Boise State student Kiyo Fujimoto, an INL Graduate Fellow, received a national appointment with the Students, Post-Doctoral and Early Career Professionals Subcommittee of the President's Council of Advisors on Science and Technology.

Kaelee Novich, a Boise State student of Boise State Professor and CAES Fellow Brian Jaques who began her Ph.D. studies in fall 2020, received an internship through Washington Internships for Students of Engineering. Novich applied to the program under the mentorship of Jaques and CAES Director Noël Bakhtian. The prestigious internship program consists of outstanding third- or fourth-year engineering/computer science graduate programs chosen from a nationwide pool of applicants. Novich was president of Boise State's Speech and Debate Team, which went undefeated for two consecutive years. She completed an internship at INL in 2019.

Novich and fellow Boise State student Kati Wada were awarded fellowships through the Department of Energy-Office of Nuclear Energy's Integrated University Program in 2020. The two were among 34 students nationwide to receive one of the prestigious three-year fellowships, which provide $52,000 per year for graduate studies along with a $5,000 stipend to complete a summer fellowship at a DOE national laboratory or other approved research facility to strengthen the ties between students and DOE's energy research programs. Novich's fellowship has enabled her work with Jaques, the Boise State faculty lead on nuclear energy at CAES who's the principal investigator on the In-Pile Instrumentation Program at INL, a collaborative project between Boise State and INL. Wada's fellowship will enable her to continue to work with CAES associate director for Boise State David Estrada, an associate professor in the Micron School of Materials Science and Engineering. Her research focuses on modeling temperature and thermal conductivity for nuclear in-pile measurements and developing new instruments that will allow scientists to look into a nuclear reactor's core and observe never-before-measured phenomena.

U of I student receives NEUP fellowship



Kristen Geddes, a CAES resident and graduate student pursuing her Ph.D. at U of I, also received a fellowship through the NEUP program. Geddes serves as president of the American Nuclear Society's Student Section. Her research is on a molten salt nuclear battery, with a focus on closing the fuel cycle.

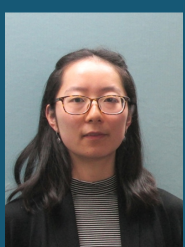
Intern prize winners from Boise State University and U of I

Two students from the CAES universities fared well at INL's 2020 Intern Poster Session, which featured more than 50 posters and eight technical presentations. Ember Sikorski from Boise State was named the winner of best technical presentation by a panel of technical reviewers, and University of Idaho student Graeme Holliday won for best poster in the business, communication, and support operations category.

Boise State University student lands 2020 Innovations in Nuclear Technology R&D Award

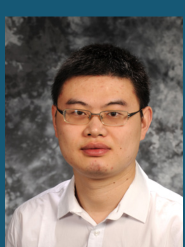
Boise State Ph.D. candidate in materials science and former INL intern Ember Sikorski won a 2020 Innovations in Nuclear Technology R&D Award in June. The award is through DOE's Office of Nuclear Technology Research and Development.

"I had a few ideas, but there are so many wildfires I thought this would be something that could save money and save lives," said Xingyue Yang , winner of the first-ever CAES Annual Pitch Event.



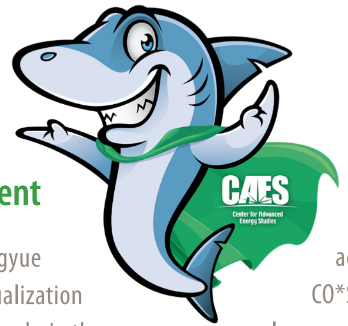
Xingyue Yang

Richard Skifton



Bo Zhang

CAES launches Baby Shark Tank event



CAES resident Xingyue Yang, an INL visualization researcher who works in the Applied Visualization Laboratory at CAES, won the inaugural CAES Annual Pitch Event (CAPE), also known as Baby Shark Tank. Yang's idea to use unmanned aerial vehicles to create enhanced visualization capabilities to train firefighting forces beat out nine other finalists in the competition, including several other CAESers.

INNOVATION HIGHLIGHTS

The CAPE/Baby Shark Tank combined elements of the three pillars of the CAES Strategy – research, education, and innovation. Everyone in the CAES community was eligible to participate – students and faculty at the universities and researchers at INL – and CAPE was open to all levels of ideas, from early-stage concepts to investment-ready research. Designed to help transfer the innovation and research that thrive at CAES from the laboratory to the commercial sector, the goal of this year's CAPE/Baby Shark Tank event was to teach the participants how to convince others – funding agencies, potential industry partners, or even investors – to take action in support of an idea. The competition began in August with 33 registrants, with each offered access to training via the CO*STAR and Rapid Idea Improvement Session (RIIS) methods. The field was narrowed to 18 in early September, and the finals featured 10 participants competing for cash prizes worth nearly $4,000. During the finals competition in late September, each finalist had five minutes to pitch their idea to a panel of judges: INL Deputy Laboratory Director for Science and Technology and Chief Research Officer Marianne Walck; ISU Acting Vice President for Research and Economic Development Donna Lybecker; INL Industry Engagement Director and Chief Commercial Officer Corey McDaniel; Nicolas Miller, executive director of the Venture College at Boise State University; and Nick Crabbs, co-chair of Boise Startup Week and a founding member of VYNYL. Yang won the $1,500 first-place prize for her idea to use drones equipped with thermal sensors and cameras to collect the data needed to create an enhanced visualization capability that would enable firefighters and fire managers to visualize real-time wildfire simulations in a 3D/immersive environment. The second-place winner, INL researcher Richard Skifton, won $1,000 for his idea: a sublime temperature sensor that measures temperature profiles by precisely locating specific temperatures of interest. INL researcher Bo Zhang was the third-place finisher, receiving $750 for his idea for a state-of-the-art electromagnetic shield that would allow for safer charging of electric vehicles. Skifton also won the People's Choice award, a $500 prize.

CAES ENERGY POLICY INSTITUTE

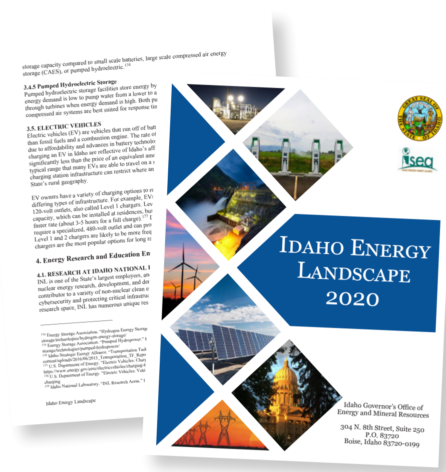
CAES Energy Policy Institute hosts 9th annual conference

The CAES Energy Policy Institute held its 9th annual Energy Policy Research Conference in October 2019. The theme of the three-day event was "Energy Decision-Making in Times of Disruptive Change." More than 150 people registered for the event, which included keynote speakers Carol Battershell, the former principal deputy director in the Department of Energy's Office of Policy; Mitch Colburn, resource planning and operations director for Idaho Power; Barbara Lockwood, vice president of regulation for Arizona Public Service Company; Boise State University President Marlene Tromp; and CAES Director Noël Bakhtian. EPI's annual conference examines the drivers and impacts of policy in energy-related systems, allowing attendees to explore issues and opportunities while fostering in-depth crosscutting exchanges of ideas. It brings together leading researchers, policymakers, industry practitioners, students and members of the private sector. Attendees included John Kotek, vice president of policy development and public affairs with the Nuclear Energy Institute; Zachary Tudor, associate laboratory director at INL; Desmarie Waterhouse, vice president of government relations and counsel for American Public Power Association; and Fouad Khan, associate editor for Nature Energy journal.

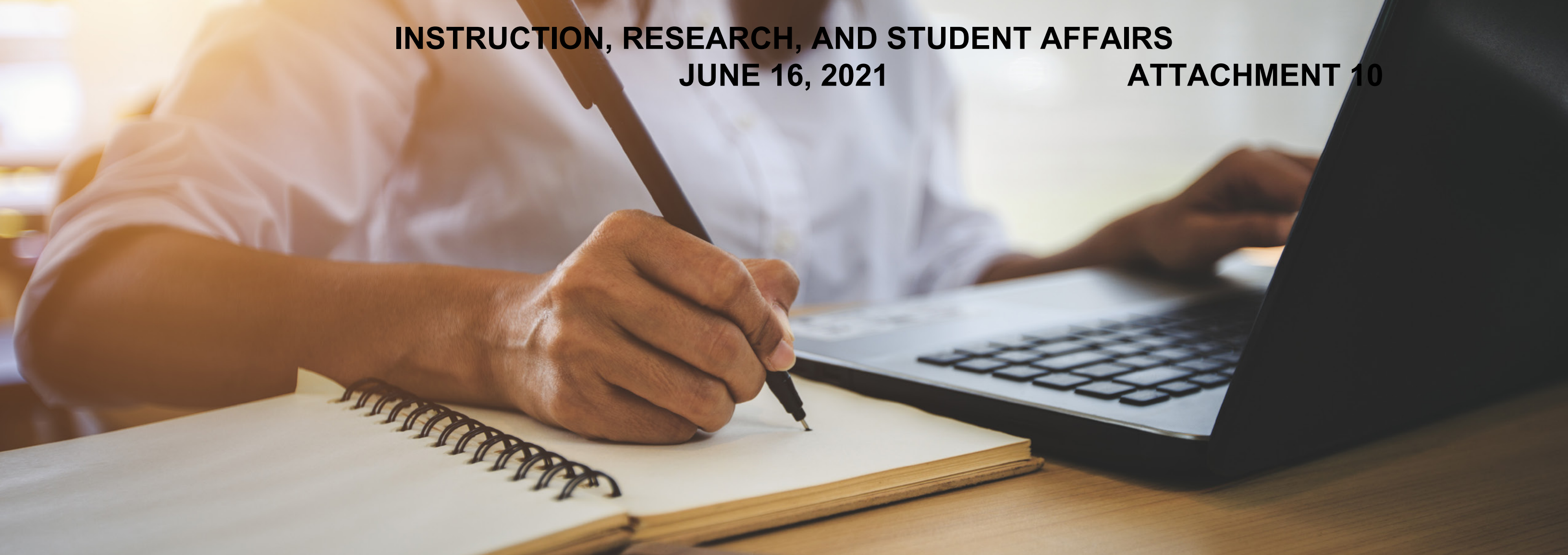
The 10th annual conference, now known as the Energy Policy Conference, was postponed due to the COVID-19 pandemic.

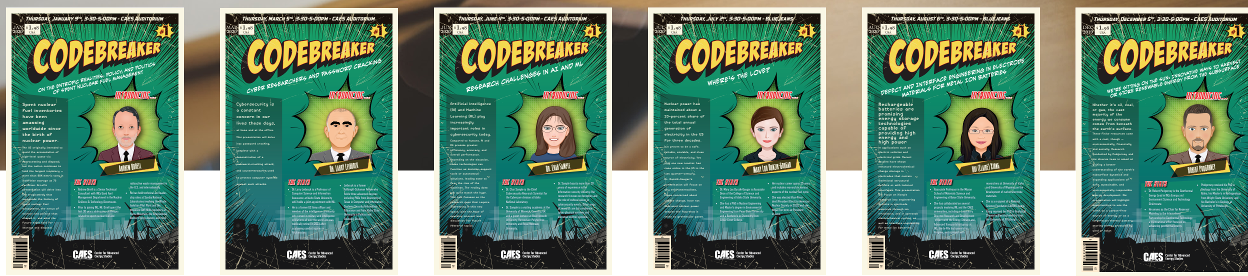
CAES, CAES Energy Policy Institute featured in publications

EPI's 9th annual Energy Policy Research Conference was the focus of a special issue of The Electricity Journal. The special edition features seven research articles focusing on a range of issues, including the nexus between energy policy and national security, energy storage systems, fuel supply chains in the Western Interconnect, and national policy approaches for addressing climate change. The conference was held in fall 2019 in Boise and drew attendees from throughout the world.



CAES and EPI were featured in Idaho Energy Landscape 2020, produced by the Governor's Office of Energy and Mineral Resources. CAES and EPI are featured in Idaho Energy Landscape 2020, a 65-page document produced by the Idaho Governor's Office of Energy and Mineral Resources. The document addresses all aspects of the state's energy sector, from consumption and prices to production, utilities and regulatory agencies.
EPI also is mentioned in Exploring Opportunities for Collaboration among U.S. University Energy Institutes, a 143-page document that provides an overview of the status of U.S. academic energy institutes and details opportunities and challenges surrounding the formation of a collaborative network of institutes.





MEETINGS, OPEN HOUSES, SEMINARS, AND SPEECHES

Codebreaker

CAES launched the Codebreaker seminar series in 2018 to provide a forum for students and researchers to address their work, communicate opportunities and challenges to a receptive audience, and to increase dialogue among CAES affiliates leading to further interdisciplinary collaborations and new groundbreaking research. Held on the first Thursday of each month, Codebreaker is an engaging presentation and Q&A forum that covers a range of topics in energy science, engineering, business and policy. The schedule in FY20 was disrupted by the pandemic, which forced the move to a virtual format. The presenters along with their affiliations and area of expertise are as follows:

Jason Barnes
U of I, Nuclear Energy

Mary Lou Dunzik-Gougar
ISU, Nuclear Energy

Duke Henningsen
INL/U of I, Human Performance Improvement initiative

Larry Leibrock
INL/ISU, Cybersecurity

Andrew Orrell
INL, Nuclear Energy

Rob Podgorney
INL, Energy-Water Nexus

Char Sample
INL, Cybersecurity

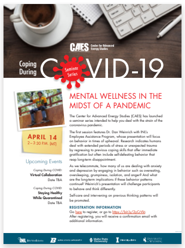
Andrew Slaughter
INL, Computing, Data, & Visualization

Claire Xiong
Boise State, Innovative Energy Systems

CAES-Cybercore Cybersecurity Talks

Before going on hiatus in the spring, this series was held monthly with the intent of furthering the collaborative objectives outlined in the CAES Strategy while bolstering Cybercore's mission of protecting critical infrastructure systems from an always-evolving threat landscape. Among the seminars in FY20 was a session in April that featured seven lightning presentations by University of Idaho professors and graduate students highlighting the capabilities of RADICL, a cybersecurity research lab developed and maintained by the Center for Secure and Dependable Systems for more than 15 years at U of I's main campus in Moscow and over the last few years at the Idaho Falls Center. Each presenter had 20 slides and 20 seconds to explain each slide.

Coping During COVID



CAES held a series of virtual seminars in FY20 to help students, researchers, and faculty contend with the pandemic.

The first seminar, Coping During COVID: Mental Wellness in the Midst of a Pandemic, featured a presentation by Dan Weinrich, counselor with the INL Employee Assistance Program, that addressed behavior in times of upheaval.

The second installment, Coping During COVID: Nutrition Wellness through Mindful Eating, featured a presentation by Natalie Christensen, Idaho State University sports dietitian, which focused on the ways in which nutrition is interwoven into every aspect of wellness and the ways that we can be mindful about our food choices and our relationships with food.

The third and final seminar, Coping During COVID: Keeping Physically Active During COVID-19, featured Leslee Blanch, a family and consumer science associate extension educator for the University of Idaho Bonneville County Extension. She discussed the importance of physical activity even in the midst of a pandemic.

Solve Climate by 2030

More than 150 people, from elementary school students to retirees, in Idaho and Wyoming, tuned in to an interactive, online event hosted by CAES that focused on ways to combat climate change locally. The CAES event was one of 52 seminars held in all 50 states through the Solve Climate by 2030 initiative. CAES represented Idaho and Wyoming at the event, which featured expert panelists from both states sharing climate change solutions. Among the panelists were Kipp Coddington, director of the Center for Energy Research and Policy Analysis at University of Wyoming, and INL's Shannon Bragg-Sitton. The panel discussion was followed by participants sharing their action ideas and voting live for the top three solutions. The goal was to come up with three ambitious but feasible actions that need to take place in Idaho and Wyoming to tackle climate change by 2030.

Collaborative Research Hubs

CAES hosted a panel discussion on winning collaborative research hubs in November 2019. The event filled the CAES auditorium and was streamed live by dozens, including groups at University of Wyoming and Boise State University. Moderated by Todd Combs, INL's associate lab director for Energy and Environment Science and Technology, the event featured several panelists who are currently directors or deputy directors of Energy Frontier Research Centers (EFRCs), or collaborative research hubs that receive DOE funding, including University of Wyoming Associate Professor Jon Brant, INL Laboratory Fellow Dave Hurley, and INL Directorate Fellow Simon Pimblott. Also serving as panelists were Andrew Schwartz, DOE's senior technical adviser for EFRCs, and John Russell, CAES associate director for University of Idaho. The panelists shared winning strategies for forming teams, creating proposals, and applying for collaborative research hubs such as EFRCs.

Events

CAES hosts legislative breakfast in Washington, D.C.

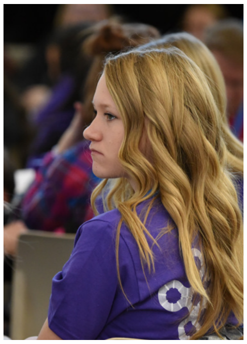
A CAES contingent visited Washington, D.C., in mid-February to host the Idaho Industries Breakfast, meet with DOE officials, and gather information related to the innovation pillar outlined in the CAES Strategy. The state's congressional delegation attended and spoke at the breakfast – senators Mike Crapo and James Risch and congressmen Mike Simpson and Russ Fulcher – along with dozens of Idaho industry representatives. CAES Director Noël Bakhtian updated attendees on CAES' efforts related to workforce development. Members of the CAES contingent, which included Bakhtian; Steering Committee members Harold Blackman from Boise State University and Scott Snyder from Idaho State University; CAES Associate Director for Idaho State University David Rodgers; CAES Associate Director for University of Idaho John Russell; and CAES Energy Policy Institute Director Kathleen Araújo, also met while in the nation's capital with staffers from the Idaho delegation and representatives from Nuclear Energy University Program, Johns Hopkins University's Technology Ventures, WeWork Labs, DOE's Office of Workforce Development for Teachers and Scientists, National Science Foundation's Established Program to Stimulate Competitive Research Section, Halcyon Incubator, and DOE's Clean Energy Education and Empowerment Initiative.

CAES hosts Winter collaboration event

Approximately 145 people registered for the annual Winter Collaboration Meeting at CAES in late January. Sponsored by CAES, INL, and National University Consortium, the event featured an update on INL's Laboratory Directed Research and Development Program, and breakout sessions on a range of topics, including Integrated Energy Systems, Nuclear Energy, Proposal Writing, Industry Engagement, and Advanced Manufacturing. The goal of the meeting was to help faculty and INL researchers establish collaborative networks and learn about opportunities for collaboration.

CAES, NUC host virtual collaboration event

CAES and the National University Consortium hosted a virtual collaboration event over three days in September 2020. The goal was to connect researchers interested in similar topics for the FY21 Consolidated Innovative Nuclear Research Funding Opportunity Announcement. Sessions included Microreactor Cost Reduction and End-User Application Integration, Improving Automation Use in Nuclear Power Plants, Cross-Cutting Research-Cybersecurity Research, and Understanding the Structure and Speciation of Molten Salt at the Atomic and Molecular Scale.



CAES hosts 13th annual My Amazing Future

Approximately 150 eighth-grade young women descended on CAES in February for My Amazing Future, an annual event geared toward boosting the participants' enthusiasm for the STEM subjects (science, technology, engineering and math). This marked the 13th year INL organized the event, which allows the students to interact with researchers, engineers and scientists and explore a range of topics, from DNA extraction from a strawberry to radioisotope thermoelectric generators to hands-on chemistry.

Open house

Recognizing that the CAES community (faculty, students, researchers) could benefit from additional touch points with the Executive Board, CAES began holding open houses to introduce new CAES initiatives and provide students, faculty, and researchers with initiative transparency and the opportunity to provide feedback to the CAES leadership team. In addition to the CAES director's biannual all-hands meetings and a special town hall meeting on the COVID-19 pandemic, CAES hosted these open houses this year:

- *CAES Fellows launch*
- *CAES Collaboration Fund 2020*
- *Baby Shark Tank launch*
- *IT greenfield feedback session*
- *Transmission electron microscope construction kickoff*
- *DOE student contests*
- *CAES initiatives*
  The Executive Board, with CAES staff, developed and finalized a series of foundational decisions and tools needed to build a successful collaborative consortium framework:
  - *CAES Definitions* – Formalizes when something is a CAES project, CAES equipment/facility, or a CAES affiliate (no formal definitions existed in the past, leading to many lost opportunities to brand, inability to calculate ROI, confusion, frustration, etc.)
  - *CAES Metrics* – Creates a framework for tracking successes in the CAES community
  - *CAES Menu* – A list of CAES offerings describing CAES initiatives in a single document, aka "How do you plug in to CAES?" for example
  - *Lab Space Designation Framework* – Outlines an inclusive, strategic process to designate facility labs with interdisciplinary "themes," focused around fostering collaborative, multi-institutional lab activities that provide value far beyond what INL or universities can provide individually, and to increase the ROI of the CAES facility resource
  - *Energy Frontiers Challenge* – Provides resources to CAES teams to develop hub-level proposals around three potential areas of collaboration: resilient critical material economy, accelerating energy transitions, and advanced manufacturing for extreme environments

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Applied Visualization Laboratory holds virtual meetings

Rajiv Khadka, an INL visualization researcher with the Applied Visualization Laboratory (AVL) at CAES, held a series of informative open house sessions each Wednesday in August, highlighting AVL's capabilities, demonstrating equipment, and discussing opportunities for collaboration. One of eight laboratories at CAES, AVL boasts several immersive environments for scientists and engineers to walk into their data, examine it and provide deep analysis in pursuit of their research. Khadka recently received his Ph.D. from the University of Wyoming.

Outside events

CAES director represents CAES at several events, moderates panel at LINE Commission

CAES Director Noël Bakhtian represented CAES at several events throughout the year:

- Bakhtian moderated a panel at the Leadership in Nuclear Energy (LINE) Commission meeting in Sun Valley in fall 2019. The panel discussion, Workforce and Higher Education, included Marianne Walck, deputy lab director and chief research officer at INL; Janet Nelson, at the time University of Idaho's vice president of research and economic development; Rachel Hayes-Harb, director of the Office of Undergraduate Research and Capstone Programs at University of Utah; and Rick Aman, president of College of Eastern Idaho.
- Bakhtian addressed the Idaho state Legislature's Federalism Subcommittee on Education about CAES initiatives during the 2020 legislative session, responding to a request for wins on federal-state partnership.
- Bakhtian took part in a virtual bilateral meeting that DOE hosted with Tunisian officials in July. The conference addressed policy priorities, technical potential, and possible collaborative opportunities between Tunisia and the United States. Bakhtian's presentation was on the Energy-Water Nexus.
- Bakhtian briefed the Idaho State Board of Education's Instruction, Research, and Student Affairs Committee on CAES' Nuclear Safeguards and Security joint certificate. Set to launch in fall 2021, the innovative CAES joint certificate being piloted is a 12-credit educational certificate that enables students to take a course at each of the CAES universities plus an optional capstone summer course at INL that will allow students to get hands-on work experience in nuclear safeguards and nonproliferation.
- Bakhtian and CAES Energy Policy Institute Director Kathy Araújo took part in the University Energy Institute Leaders 2020 Virtual Summit in mid-September 2020. The summit featured several breakout sessions focusing on maximizing policy impact, aligning strengths at universities to better address skills gaps in the energy industry and the future workforce, and maximining the impact of policy work through collaboration.
- Bakhtian participated in the Eighth Annual International Conference on Sustainable Development. The theme of the event was Cross-Cutting Solutions for the Decade of Action, and Bakhtian's presentation focused on CAES' collaborative efforts to develop the future energy workforce.

NEW FACES

CAES leadership changes

New director

Terry Brog took over as interim CAES director and chief operations officer in mid-October after former Director Noel Bakhtian accepted a position at Lawrence Berkeley National Laboratory and former COO Anita Gianotto accepted a position at INL.

Terry Brog, who will retain his position as senior technical adviser to Juan Alvarez, INL's Management & Operations deputy laboratory director, has previously served as research COO at Pacific Northwest National Laboratory and as interim laboratory director and COO at Princeton Plasma Physics Lab.

Bakhtian, who had been CAES director since spring 2017, was appointed the inaugural director of the Berkeley Lab Energy Storage Center. Gianotto, who joined CAES in 2018, is now chief operations officer for INL's Management System Transformation Initiative.

New VPR at ISU

Donna Lybecker assumed the role of acting vice president for Research and Economic Development (VPR) at Idaho State University in June, taking her place on the CAES Steering Committee

alongside the VPRs at the other CAES universities and INL Deputy Laboratory Director for Science and Technology and Chief Research Officer Marianne Walck. Lybecker had been Political Science Department chair at ISU and professor of International Relations, Environmental Politics, and Comparative Politics, and she previously served as the ISU science co-lead for the NSF EPSCoR Managing Idaho's Landscapes for Ecosystem Services (MILES) project grant. The MILES grant brings together faculty from the biophysical and social sciences, enabling research into the complexity of ecosystems and combining ecological research with public values, citizenship styles and power assessments. Lybecker is a member of the United States Environmental Protection Agency National Advisory Committee and an associate editor for the Social Science Journal and the International Journal for Sustainable Society. Her research interests include the politics of borders, environmental politics in the Western U.S. and Latin America, and the framing of political issues.

New VPR at U of I

Christopher Nomura joined the CAES Steering Committee on Oct. 1, when he became University of Idaho's vice president of research and economic development.

Nomura replaced Janet Nelson, who served in the position since 2016. Brad Ritts, U of I's associate vice president for research and a faculty member in the Department of Geological Sciences, had served since February as interim vice president of research and economic development.

Nomura earned his doctoral degree in biochemistry, microbiology and molecular biology at Pennsylvania State University and received his bachelor's degree in biology from University of California at Santa Cruz. An internationally recognized scientist and administrator, Nomura has more than 85 publications in top journals in his field and serves on several editorial boards. Prior to his arrival at U of I, Nomura was vice president for research and a biochemistry professor at State University of New York's (SUNY) College of Environmental Science and Forestry. At SUNY, Nomura also oversaw McIntire-Stennis funding, which is designed to expand forestry research and train future forestry scientists.

"Christopher Nomura has extensive experience fostering industry collaborations and working with both national and international research funding agencies," U of I President Scott Green said in a news release announcing Nomura's appointment. "His talent and energy will be valuable additions as the University of Idaho continues to grow our research enterprise in service to the state of Idaho."

Nomura, who has an extensive record of mentoring high school students, undergraduate and graduate students, postdocs and visiting scientists, has strong international connections to the RIKEN Institute (Japan), Hubei University (China) and Centro Nacional Patagonico (Argentina).

CAES facility staff changes

Rocklan McDowell joined CAES as research laboratory manager. McDowell previously worked in INL's Nuclear Science and Technology (NS&T) Directorate and replaces Jana Pfeiffer, Research Operations lead. She accepted a position as deputy operations lead with INL's NS&T Directorate.

Todd Christensen, with INL's facility operations and maintenance organization, recently came on as CAES facility liaison.

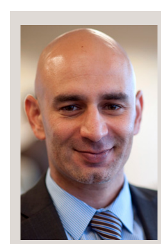
Aleah Lattin joined CAES as administrative assistant to former Chief Operations Officer Anita Gianotto. Lattin comes to CAES after more than five years at Jefferson School District #251 as the administrative assistant to the director of Student Services/Special Education Department.

Lab staffing changes

Amir Ali was named the lab lead for the Catalysis & Kinetics Laboratory in summer 2020. Ali has been a CAES resident since fall 2019, when he joined the Nuclear Engineering Department at Idaho State University as an assistant professor. His research focuses on experimental and computational analysis of the thermal-hydraulic problems of advanced reactors molten salt and liquid metals cooled reactors, and he leads a collaborative project that recently received an award from DOE's Nuclear Energy University Program. The roles and responsibilities of CAES lab leads include authorization for research to be conducted in the lab; collaboration with researchers to determine whether the lab can support the research and, if so, to ensure effective research and development occurs; establishment of environment, safety and health procedures and standards for their lab that complement CAES' procedures and standards; and ensuring that all laboratory work is performed in accordance with the Idaho State University safety manual.

The Microscopy and Characterization Suite added two new staffers in FY20, Sheng Cheng and Yu Lu. Cheng is senior research associate, instrument co-lead: Focused Ion Beam/Transmission Electron Microscope, and sample preparation lead in the Advanced Materials Laboratory. Cheng comes to CAES from NanoSteel. Lu is a senior research associate performing Focused Ion Beam/Transmission Electron Microscope/Atom Probe Tomography for MaCS. Lu comes to CAES after earning his Ph.D. from the University of Florida.

Michael Baskin was hired as CAES Innovation Ecosystem Advisor in summer 2020, charged with developing innovation and education portfolios. His background includes a focus on energy security with a particular focus on developing intellectual capital. He previously served as the first professor of energy studies at Marine Corps University, where he created energy security curriculum and innovation programs for students from multiple schools and colleges.



From 2013-2015, he served as a Fellow for the U.S. Department of Energy, where he catalyzed the Solar Ready Vets program, led a renewable energy sector hiring commitment of veterans for the First Lady's Joining Forces initiative, and was a liaison between the Office of Energy Efficiency and Renewable Energy and the U.S. Department of Defense.

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Araujo, K. "National Energy Transitions," Presentation, Community Library, in partnership with the Sun Valley Institute, Ketchum, ID, December 17, 2019.

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BY THE NUMBERS

29 *Operational items of concern in FY20, ranging from security issues to fire/oxygen sensor alarms that resulted in building evacuations to a phishing event*

119 *Radiological samples transferred in FY20 in the CAES facility*

252

INL employees participated in Employee Education programs at CAES universities

FROM CAES UNIVERSITIES

6 *Students received graduate fellowships at INL*

115 *Students interned at INL*

FROM CAES UNIVERSITIES

19 *Faculty members awarded INL joint appointments*

11 *Faculty members participated in the CAES Summer Visiting Faculty Program*

BY THE NUMBERS

0
INJURIES

$6.4
Million in FY20 Laboratory Directed Research and Development at INL

$1.3
Million Funding to CAES-affiliated faculty through DOE's Nuclear Energy University Program (primary award)

$2.4
Million Funding to CAES-affiliated faculty through DOE's Nuclear Energy University Program (partner award)

5
Project proposals in FY16

5
Project proposals in FY17

0
Project proposals in FY18

15
Project proposals in FY19

GA20-50561

SUBJECT

Open Educational Resources Report

REFERENCE

April 2018	Board received an update on an Open Educational Resources (OER) initiative.
June 2018	Board discussed system-wide access and affordability strategies including OER and requested an inventory and implementation timeline be provided at the October 2018 Board meeting.
August 2018	Board approved a line item request for OER funding.
December 2018	The Board was provided with a timeline and inventory update regarding OER and the total number of course sections delivered exclusively with OER throughout Idaho colleges and universities.
April 2019	The Board was provided with an inventory of common indexed courses for which funding will be focused for OER adoption.
August 2019	The Board approved the first reading of proposed new Board Policy III.U. Textbook and Instructional Material Affordability.
October 2019	The Board approved the second reading of proposed new Board Policy III.U. Textbook and Instructional Material Affordability.
February 2021	The Board temporarily waived the implementation deadline for Board Policy III.U. and requested an updated report on OER in public postsecondary education.
April 2021	The Board approved the first reading of proposed amendments to Board Policy III.U. Textbook and Instructional Material Affordability.

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.U. Textbook and Instructional Material Affordability

BACKGROUND/DISCUSSION

The Idaho State Board of Education has for many years prioritized efforts to improve educational access and affordability for students, while also supporting educators' freedom to pursue uniquely effective and innovative instructional practices in postsecondary classrooms. The Board has specifically promoted Open Educational Resources (OER) as a catalyst for lowering student costs, ensuring student access to course content, and empowering the scholarly agency of educators.

The version of Board Policy III.U. currently up for second-reading defines OER as "teaching, learning, and research materials that reside in the public domain or have been released under an intellectual property license, such as a Creative Commons license, that permits free use and repurposing by others." In other words, OER are available free-of-cost to students and enable new scholarly practices for faculty and students alike. Idaho's academic community has increasingly explored the use of OER over the past 15-20 years, and one of the more prominent statewide inquiry groups comprising faculty, staff, and students from multiple institutions recently commemorated its five-year anniversary via interinstitutional showcases of OER-related work and a proclamation from Governor Little recognizing Idaho's first, official Open Education Week.

The Board began learning about and promoting OER efforts in earnest in April 2018, when it received an update about existing efforts at the faculty level to increase access and affordability of instructional materials through emergent trends in open education. In December 2018, the Board received a statewide inventory of OER adoption in common-indexed general education matriculation (GEM) courses. This report narrowly focused on OER adoption across 43 courses and informed the expectations finalized in the version Policy III.U. that the Board adopted in October 2019.

Also relevant to the Board's promotion of OER is the budget line-item funded by the Idaho Legislature in 2019 (FY2020) for $50,000 to support faculty professional development around OER. This funding established multi-semester, statewide Faculty Fellowships in openness, pedagogy, advocacy, and leadership (OPAL). Over the last three semesters, 15 faculty have collaborated across institutions and disciplines in an effort to learn about open publishing, experiment with digital pedagogy, and assemble OER for use in Idaho's common-indexed GEM courses. The OER projects pursued by these fellows, like any OER project, are ongoing but also prominently curated and continuously improved with the Idaho Open Press—Idaho's premiere OER repository which is maintained by the Board Office. The Executive Director of the Board has authorized ongoing support for additional OPAL Fellowship cohorts under the Board Office systemwide budget.

The 2021 Legislature approved the Governor's budget recommendation for $1M to support the development of Zero Textbook Cost (ZTC) degrees at all four of Idaho's community colleges. ZTC degrees are two-year pathways that students can complete without the need to pay for textbooks or other instructional materials. OER and faculty professional development related to OER are critical components of effective ZTC degrees.

OER has become a scalable and sustainable means of increasing access and lowering costs for Idaho students, and the ZTC Degree and OPAL Fellowship initiatives are proving instrumental in building awareness among faculty about which open educational practices align with their everyday work as educators. Worth noting, however, is that many Idaho faculty have found ways to eliminate or dramatically reduce the cost of instructional materials without leveraging OER specifically, and these innovative practices have also inspired cross-institution collaborations between educators, students, and staff. As a result, Board Policy

III.U. has undergone a significant revision to recognize and support this broader context and is up for a second reading at this June 2021 Board Meeting.

Key revisions to policy III.U. emphasize that OER is but one means of effectively reaching Board goals for ensuring that every student has access to the instructional materials that they need to successfully navigate a course. In turn, the policy seeks to develop a more comprehensive understanding of existing faculty practices, the support resources available to those faculty at their institutions, and the aspirations of Idaho's academic technology in systematically supporting educational access and affordability.

In Spring 2021, the Board asked Board Staff to run a new inventory and report on the state of open, no-cost, and low-cost instructional materials used in Idaho postsecondary courses. Board Staff distributed a survey across two weeks in May and received responses from several hundred faculty from all eight public institutions. The results of this survey, as well as qualitative data from ongoing OER efforts being facilitated by the Board Office, have been synthesized into a report regarding instructional material access and affordability. Board Staff intend to use this data as a new descriptive baseline that may be revisited through an annual survey each spring.

IMPACT

Over the last academic year, open, free, and very low cost ($1–30) instructional materials were used by at least 471 faculty in at least 637 courses across Idaho's public postsecondary institutions. The decisions of these faculty positively influenced educational access and affordability for at least 25,096 students who paid an average of $9.59 or less for instructional materials while enrolled in these classes. Considering that 68 percent of these classes required free or open instructional materials, this estimate is conservative. Seventy-nine percent of the faculty who responded to the Spring 2021 survey have complete independence in choosing their instructional materials, and 12 percent are at least able to influence choices about the required materials in their courses. While 81 percent of respondents expressed familiarity with OER, just 40 percent indicated that they currently use OER to some degree in their classes. The qualitative data presented by faculty suggests that awareness of what constitutes OER continues to vary dramatically—a barrier that exists in Idaho and elsewhere. In direct relation to the 2019 inventory of OER use in common-indexed GEM courses, survey responses indicate that faculty have adopted OER in 12 more GEM courses, and fewer than six of the 43 GEM courses are not using OER in some capacity.

ATTACHMENTS

Attachment 1 – Open Educational Resources Report

STAFF COMMENTS AND RECOMMENDATIONS

This OER report establishes a new baseline for OER adoption and impact in Idaho. The hiring of Drs. Jonathan Lashley and TJ Bliss as the Associate Chief Academic Officer and Chief Academic Officer, respectively, has dramatically increased the momentum for open and accessible learning in Idaho postsecondary education. Drs. Lashley and Bliss are both internationally renowned experts in OER and open education and are deeply embedded in the grassroots open education community in Idaho. That said, the real work on this issue is being done by faculty and administrators at the postsecondary institutions, with appropriate support from the Board and Board Office staff.

BOARD ACTION

This item is for informational purposes only.

ATTACHMENT 1

Idaho State Board of Education

Open and Affordable Educational Resources in Idaho Public Postsecondary Education

Background

The Idaho State Board of Education has for many years prioritized efforts to improve educational access and affordability for students, while also supporting every educator's academic freedom to pursue uniquely effective and innovative instructional practices in postsecondary classrooms. The Board has specifically promoted Open Educational Resources (OER) as a catalyst for lowering student costs, ensuring student access to course content, and enhancing the scholarly agency of educators. Recent proposed revisions to Board Policy III.U. Textbook and Instructional Material Affordability, however, emphasize that OER is but one means of pursuing Board goals in ensuring that every student has access to the instructional materials that they need to successfully navigate their courses.

At the April 2021 regular Board meeting, Board members directed Board Staff to report on the state of open, no-cost, and low-cost instructional material use in public postsecondary education in Idaho. Board Staff distributed a survey in May 2021 and received responses from hundreds of faculty from across Idaho's eight public postsecondary institutions. The following report is provided as a new descriptive baseline relative to the revised expectations of proposed revisions to Board Policy III.U. that Board Staff plan to revisit through an annual survey each spring.

Methods

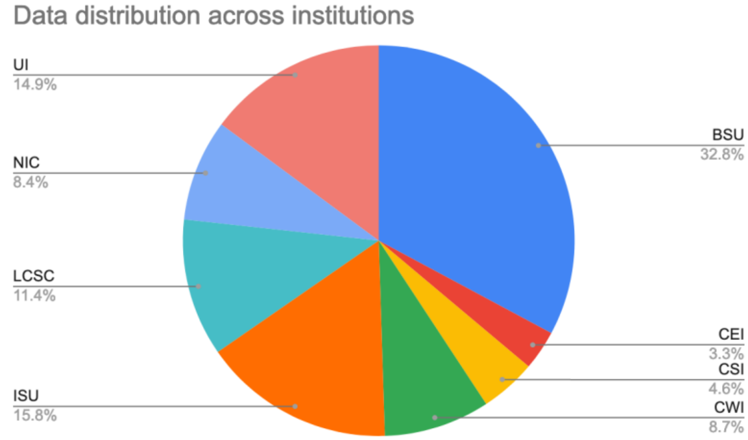
1. Board Staff collected data via a survey instrument between 5/10–5/25.
2. Provosts distributed the survey to faculty directly or conducted their own collection of similar data.
    - NIC and CSI collected data via their own methods.
3. Board staff collated and cleaned data where ethically possible, but some limitations exist.
    - Student enrollment in a class:
        - If ranges were provided an average was used.
        - In some cases, this information was not provided and was thus omitted from calculating the total number of students reached.
        - Total students reached was calculated only by the information provided by faculty (e.g., some faculty broke down enrollment by section and semester while others provided the cap or average for a course section).
        - If per semester numbers were listed, figures were multiplied by two.
        - The above decisions convey that estimated totals are conservative and worth comparing with institution records for a more accurate measurement in the future.
    - Course Level Distribution:
        - Courses that allow cross-level student enrollment were aggregated for course counts and disaggregated for evaluation of course level distribution.
    - Faculty participation in automatic billing programs should be confirmed with institutions.

ATTACHMENT 1

Results

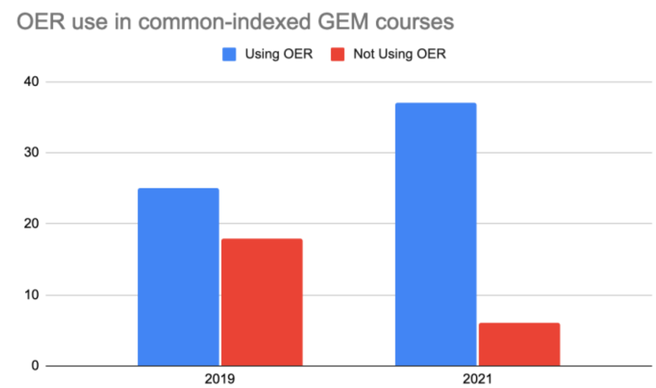
Scale

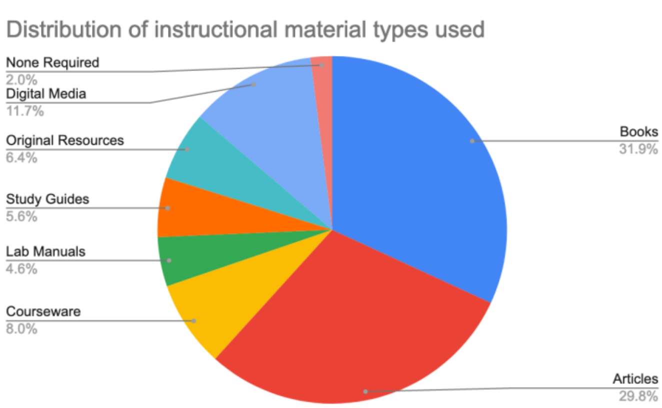
- **471 faculty** responded with information about **637 courses** that impose no or very low costs (under $30) for required instructional materials.
- These faculty represent **all eight** public postsecondary institutions.
- **68 percent** of faculty taught courses that exclusively used either open or free instructional materials.
- Reported courses using no- or very low-cost instructional materials enrolled an estimated **25,096 students** during the academic year.
- A conservative estimate of the average cost to these students is **less than $9.59 per course**
- **86 percent of reported no- and very-low cost courses** were taught at the undergraduate level while **14 percent** of courses were taught at the graduate level.



Current Practices

- Use of OER in common-indexed GEM courses has increased since 2019, and it is fair to estimate that **faculty in 37 of these 43** courses are currently using OER in some way in at least one of the eight institutions.
- Only **4 percent** of courses required print materials while **95 percent of courses** allowed students both print and digital access to instructional materials.



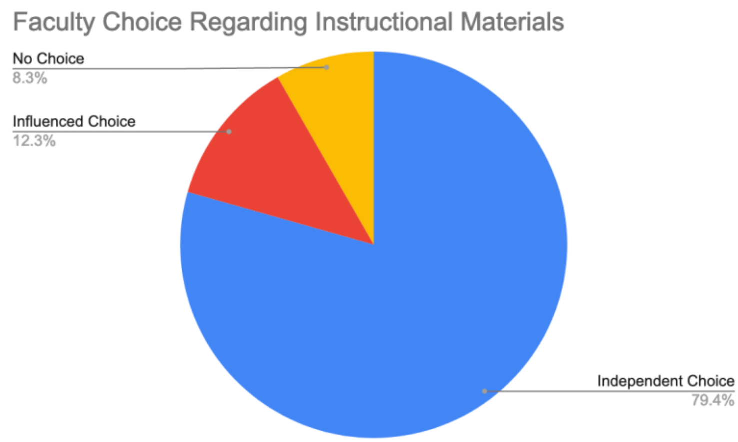


- **82 percent** of faculty expressed familiarity with OER but **only 40 percent** indicated that they are using OER in the courses they described.
- Books and Articles constitute **62 percent** of the instructional materials required in reported courses, and **more than 6 percent of materials** used were student- and faculty-authored original resources.
- Only **4 percent of faculty participated in automatic billing programs**, but 15 percent of faculty indicated that they did not know if they participated in such a program.

ATTACHMENT 1

Current Support/Resources

- OPAL Faculty Fellowships have sponsored new OER projects for **11 of the 43 common-indexed GEM courses** and the following have been identified as prospective high-need courses for the first round of OPAL fellowships: ANTH x101: Physical Anthropology, BIOL x227: Human Anatomy and Physiology I, CHEM x100: Concepts of Chemistry, CHEM x102: Essentials of Organic and Biochemistry, CHEM x111: General Chemistry I, and MATH x130: Finite Mathematics.
- **80 percent** of faculty made instructional material decisions independently, while stakeholder groups (students, other faculty, academic leaders, etc.) influenced the choices of **12 percent of faculty.**
- **8 percent of faculty had no choice** regarding the instructional materials that they used.
- **52 Percent of faculty** respondents indicated that they are interested in additional follow-up from the Board Office regarding reported instructional materials use.



Prospective Opportunities

- Board Staff will follow up with faculty who indicated interest in sharing more information about their use of no- and very low-cost instructional materials.
- Board Staff may further investigate and verify automatic billing program participation with institution bookstores and IT organizations.
- Board Staff may work with bookstores to further investigate the price of instructional materials in these courses relative to market rates.
- Board Staff may confirm course enrollments by reviewing reports from each IR organization.
- Board Staff may confirm the transferability of reported courses that are not common-indexed by working with Registrars and exploring records in the Course Transfer Website.
- Board Staff will explore the use of a more sophisticated survey tool for next year's data collection to streamline the cleaning and coding process.
- Accuracy of awareness about OER continues to be a pronounced barrier to faculty adoption of OER in Idaho public postsecondary education.
- Faculty continue to express ongoing uncertainty about the quality of OER, the sustainability of adopting and maintaining OER, how to navigate copyright, and whether the materials that they use may be considered open (in most cases, they could be).
- Multiple faculty indicated that leveraging library resources is a valuable and under-acknowledged means of promoting educational access at no new cost to students.
- Use of print-only resources is low but institutions may want to consider how they can facilitate print-on-demand services to ensure equitable access for all students.

SUBJECT

Board Policy III.G, Program Approval and Discontinuance and III.H. Program Review – First Reading

REFERENCE

February 14, 2019	The Board approved the first reading of proposed amendments to include review and approval procedures for applied baccalaureate degrees and microcertifications.
April 18, 2019	The Board approved the second reading of proposed amendments to Board Policy III.G.
August 29, 2019	The Board was presented with a first reading of proposed amendments to Board Policy III.G. Policy was referred back to Instruction, Research, and Student Affairs (IRSA) for additional discussion.
October 17, 2019	The Board approved the first reading of proposed amendments, which adds baccalaureate degree programs to the list of programs reviewed by the Board and changes requirements for new academic program proposals that consists of new state appropriations.
December 2019	The Board approved the second reading of proposed amendments to Board Policy III.G.
June 10, 2020	The Board approved a one year, partial waiver of the requirement for full proposals in Board Policy III.G.3.d and 4.d for modifications to academic programs, career technical programs and instructional and administrative units.

APPLICABLE STATUTES, RULE OR POLICY

Section 33-2107A, Idaho Code.
Idaho State Board of Education Governing Policies & Procedures, Section III.G.

BACKGROUND/DISCUSSION

Board Policy III.G. Postsecondary Program Approval and Discontinuance provides Idaho's public postsecondary institutions with procedures for the development, approval, and discontinuation of academic and career technical programs. Proposed amendments reorganize the structure of Board Policy III.G and streamline the proposal requirements for new, modification of, and discontinuation of academic and career technical programs into three main routes for review and/or approval. This includes a full proposal process, short proposal process, and notification letter process. Proposed amendments also aim to streamline the approval process for program changes reviewed and approved by the Board as well as changes the Board delegates to its Executive Director. The most notable change provides flexibility to the Executive Director to delegate authority to designees for the approval of academic and career technical program changes. Additional amendments include adding a section for the reduction and termination of career technical education(CTE) programs. Historically, discontinuation of CTE programs were subject to criteria and procedures in IDAPA 55.01.02. Rules Governing Postsecondary Program Reduction or Termination. This rule expired in June 2019 and was not renewed as part of the Governor's initiative to reduce the number of regulations in Administrative Code. Idaho Division of Career Technical Education (IDCTE) reviewed the language contained in the rule regarding the criteria for reduction and termination and notification to impacted employees. IDCTE determined to incorporate relevant language into Board Policy III.G as it aligns with criteria utilized in current practice. These criteria were shared with the Technical College Leadership Council on May 11, 2021, which resulted in recommendations to simplify the criteria for CTE program reduction or termination due to institutions deploying different methodologies to determine program health; and to change the timing of the notice provided to employees for the purposes of termination that would not conflict with institution human resource guidelines. Language was added to support these recommendations.

Other amendments include minor grammatical updates to existing definitions and the addition of new definitions for the Board's proposal forms (Full Proposal, Short Proposal, and Letter of Notification); adding additional language to clarify requirements for the review and/or approval of specific program changes; and removing sections on micro-certifications and CTE program inactivation. This will not remove the requirement for approval, but simply moves relevant procedural language to a guidance document or proposal form for such program options.

Staff reviewed other Board policies in Section III. Postsecondary Affairs and determined to transfer language that requires institutions to establish and maintain policies and procedures for evaluating programs and developing new programs in Board Policy III.H. Program Review into III.G. The addition of this provision in Board Policy III.G renders Board Policy III.H duplicative and unnecessary. Due to the reorganization of Board Policy III.G. and number of amendments the existing policy is being replaced in its entirety by the version provided in Attachment 1.

IMPACT

Approval of proposed amendments will create efficiencies and streamline review and approval requirements for staff at institutions and at the Office of the State Board of Education. These new efficiencies will enable institutions to notify accrediting bodies in a timelier manner and meet their respective catalog timelines. Board action will also repeal Board Policy III.H.

ATTACHMENTS

Attachment 1 – Board Policy III.G. Program Approval and Discontinuance – First Reading
Attachment 2 – Board Policy III.G. Program Approval and Discontinuance – Current Version
Attachment 3 – Board Policy III.H. Program Review – First Reading

STAFF COMMENTS AND RECOMMENDATIONS

Proposed amendments will create efficiencies and improve procedures related to the review and approval of postsecondary programs. As proposed amendments make it through the Board's review process, staff is recommending an extension through August 31, 2021 of the partial waiver of Board Policy III.G. approved in June 2020, to assist with the transition of new policy requirements and to continue to provide institutions with support and flexibility. Action on the waiver will occur in a separate IRSA agenda item at the June 2021 Regular Board meeting.

The Council on Academic Affairs and Programs reviewed these policy amendments on May 6, 2021. The Instruction, Research, and Student Affairs (IRSA) committee reviewed the proposed policy amendments on June 1, 2021. Staff recommends approval.

BOARD ACTION

I move to approve the first reading of proposed amendments to Board Policy III.G, Program Approval and Discontinuance, as submitted in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

AND

I move approve the first reading of Board Policy III.H. Program Review, repealing the policy in its entirety, as submitted in Attachment 3.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: G. Postsecondary Program Review Approval **August 2021**

This subsection shall apply to the University of Idaho, Idaho State University, Boise State University, Lewis-Clark State College, North Idaho College, College of Eastern Idaho, College of Southern Idaho, and College of Western Idaho.

1. Classifications and Definitions

   a. Academic Program shall mean a postsecondary educational program offered by an institution of higher education that leads to an academic or professional degree, certificate, or other recognized educational credential as defined in Board Policy Section III.E.

   b. Academic Program Components shall include options, minors, emphases, tracks, concentrations, specializations, and cognates as defined by each institution. For the purposes of this policy, a certificate is not an academic program component.

   c. Administrative Unit shall mean offices, centers, bureaus, or institutes that are responsible for carrying out administrative functions, research, or public service as their primary purpose, and are not responsible for academic or career technical programs.

   d. Career Technical Program shall mean a sequence or aggregation of competencies that are derived from industry-endorsed outcome standards and directly related to preparation for employment in occupations requiring a career technical certificate or degree as defined in Board Policy Section III.E. These programs must include competency-based applied learning that contributes to an individual's technical skills, academic knowledge, higher-order reasoning, and problem-solving skills.

   e. Career Technical Program Component shall mean instructional paths to fields of specialized employment, consisting of more than one specialized course.

   f. Financial Impact shall mean the total financial resources, regardless of funding source, needed to support personnel costs, operating expenditures, capital outlay, capital facilities construction or major renovation, and indirect costs that are incurred as a direct result of establishing, modifying, or discontinuing a new instructional program, instructional unit, or administrative unit. This includes the impact of moving resources from existing programs to proposed programs.

   g. Full Proposal shall mean a document submitted to the Board Office that contains details about substantive changes to academic or career technical education programming or administration that require review and approval by the full Board or the Executive Director or designee, as specified in this policy. The Full Proposal template is developed and maintained by the Executive Director or designee.

h. Instructional Unit shall mean departments, institutes, centers, divisions, schools, colleges, campuses, branch campuses, and research units (e.g. extension centers) that are responsible for academic programs or career technical programs.

i. Letter of Notification shall mean a letter from the institution to the Executive Director or designee, notifying the Board Office of changes to academic or career technical education programming or administration that do not require advanced approval by the Board or the Executive Director or designee, as specified in this policy.

j. Major shall mean a principal field of academic specialization that usually accounts for 25 to 50 percent of the total degree requirements. The concentration of coursework in a subject matter major serves to distinguish one program from others leading to the same or a similar degree.

k. Short Proposal shall mean a document submitted to the Board Office that contains details about non-substantive changes to academic or career technical education programming or administration that require review and approval by the Executive Director or designee, as specified in this policy. The Short Proposal template is developed and maintained by the Executive Director or designee.

2. Roles and Responsibilities

Program planning, review, and approval shall be a collaborative process which includes the Board, Board staff, the institutions, faculty, external advisory groups, regional and specialized accreditation bodies, and other stakeholders pursuant to Board Policy III.Z.

a. Each institution shall establish and maintain policies and procedures for evaluating existing programs and developing new program proposals. This evaluation process should be an integral component of the institution’s academic and career technical education planning and budgeting processes.

b. New program proposals and discontinuation requests shall be reviewed by the Council on Academic Affairs and Programs (CAAP). CAAP shall make recommendations to the Instruction, Research, and Student Affairs (IRSA) committee on instructional programmatic matters and related policy issues.

c. The Idaho Division of Career Technical Education shall review and make recommendations as appropriate to the IRSA Committee and/or the Board on instructional programmatic matters and policy issues related to their roles and responsibilities. The State Administrator is authorized to approve academic

ATTACHMENT 1

microcertifications developed by the institutions. in addition to career technical microcertifications.

d. The Professional Standards Commission shall review and make recommendations as appropriate to the Board on educator preparation programs for educator certification purposes. Educator preparation program approval for state certification purposes is governed by Administrative Code through a separate process. The processes for earning approval for certification should be conducted concurrently with the program approval process when practicable.

3. Academic Programming and Administration Proposal Submission and Approval

   a. Actions Requiring a Full Proposal

   Subsequent to institutional review and consistent with institutional policies, but prior to implementation, actions related to academic programs or units identified in this subsection require approval by the Board or the Executive Director or designee as indicated, and shall be submitted by the institution to the Executive Director or designee as a Full Proposal.

   i. The following actions require approval by the Board:

      1) Establishment of a new branch campus or change in location geographically apart from the main campus, regardless of financial impact. A location of an institution that is geographically apart and independent of the main campus is permanent in nature; offers at least 50% of the courses of an educational program leading to a degree, certificate, or other educational credential; has its own faculty and administrative organization; and has its own budgetary and hiring authority as defined by 34 CFR 600.2. Subsection 3.a.i.1 excluding the community colleges.

      2) Establishment of any new academic undergraduate or graduate program with a financial impact of $250,000 or more per fiscal year.

         a) All doctoral program proposals shall require an external peer review, regardless of financial impact. The external peer-review panel shall consist of at least two (2) members and will be selected by the Executive Director or designee and the requesting institution's Chief Academic Officer. Board staff shall notify the institution in writing whether it may proceed with the external peer-review process. External reviewers shall not be affiliated with a public Idaho institution. The review shall consist of a paper and on-site peer review, followed by the issuance of a report and recommendations by the panel. Each

ATTACHMENT 1

institution shall provide the panel with a template developed by the Executive Director or designee. The peer reviewer report and recommendations shall be a significant factor in the Board's evaluation of the program.

b) New educator preparation programs require concurrent submission of a Full Proposal to the Executive Director or designee and the Professional Standards Commission (PSC), regardless of financial impact. The PSC ensures programs meet the Idaho standards for educator certification. The Executive Director or designee ensures the program proposal is consistent with the program approval process and meets the standards approved by the Board and established by rule in Administrative Code. The PSC makes recommendations to the Board for approval of programs as vehicles for meeting the state certification requirements.

3) Establishment by a community college of any new applied baccalaureate program, pursuant to Section 33-2107A Idaho Code.
4) Establishment of any new program with academic program fees as defined in Board Policy Section V.R.
5) Adding program fees to existing programs requires full Board approval consistent with Board Policy Section V.R; however, such changes do not require submission of a Full Proposal.

ii. The following actions require approval by the Executive Director or designee:

1) Establishment of any new academic undergraduate or graduate program with a financial impact of less than $250,000 per fiscal year.
2) Discontinuation of an academic undergraduate or graduate program or instructional or administrative unit.
3) Establishment of any new instructional or administrative unit.
4) Establishment of any new academic undergraduate and graduate certificates consisting of more than 30 credits and with a financial impact of $250,000 or more per fiscal year.
5) Expansion of an existing program outside an institution's Designated Service Region as defined in Board Policy III.Z.
6) Conversion of a program option into a stand-alone program with a financial impact of $250,000 or more per fiscal year.
7) Consolidation of two or more undergraduate programs into one undergraduate program with a financial impact of $250,000 or more per fiscal year.
8) Consolidation of two or more graduate programs into one program.
9) Splitting of a graduate program into two or more programs.

ATTACHMENT 1

10) Addition of existing certificates or degrees to existing programs with a financial impact of $250,000 or more per fiscal year.

Each Full Proposal shall be reviewed by the Council on Academic and Affairs and Programs within 30 days of receipt. At the sole discretion of the Executive Director or designee, any Full Proposal may be referred to the full Board for review and approval. Requests requiring new state appropriations shall be submitted to the Board for review prior to or concurrently with submission of an institution's annual budget request.

b. Actions Requiring a Short Proposal

Subsequent to institutional review and consistent with institutional policies, but prior to implementation, the following actions related to academic programs or units require approval by the Executive Director or designee and shall be submitted by the institution to the Executive Director or designee as a Short Proposal:

i. Establishment of a new academic undergraduate or graduate certificate consisting of more than 30 credits with a financial impact of less than $250,000 per fiscal year.
ii. Addition of a certificate or degree to an existing program with a financial impact of less than $250,000 per fiscal year.
iii. Splitting of an undergraduate program into two or more undergraduate programs.
iv. Consolidation of two or more undergraduate programs into one undergraduate program with a financial impact of less than $250,000 per fiscal year.
v. Conversion of one program option into a stand-alone program with a financial impact of less than $250,000 per fiscal year.
vi. Conversion or transition of a degree type (e.g. Bachelor of Arts to Bachelor of Science).
vii. Conversion or transition of a certificate type (e.g. Technical Certificate of Completion to Basic Technical Certificate).
viii. Deviation from program credit definitions.
ix. Changes to program names or degree titles related to Statewide Program Responsibilities as defined in Policy III.Z (requires full board approval).
x. Establishment of new programs consisting of multiple certificates with similar coursework.
xi. Establishment of a dual degree from existing programs with a financial impact of less than $250,000 per fiscal year.

At the sole discretion of the Executive Director or designee, institutions may be required to submit a Full Proposal for any action identified in this subsection.

c. Actions Requiring a Letter of Notification

ATTACHMENT 1

Subsequent to institutional review and consistent with institutional policies, and within 30 days after implementation, institutions shall notify the Executive Director or designee of the following actions related to academic programs or units via a Letter of Notification:

i. Establishment of a new, modification to, or discontinuation of an academic program component.
ii. Establishment of a new academic undergraduate or graduate certificate consisting of fewer than thirty (30) credits.
iii. Program expansion within an institution's Service Region as defined in Board Policy III.Z.
iv. Establishment of a dual degree from existing undergraduate or graduate programs with a financial impact of less than $250,000 per fiscal year.
v. A change from clock hours to credit hours for an academic program.
vi. Addition of an online option to an existing academic program.
vii. Transition of an academic program with less than fifty percent (50%) of courses offered online exclusively to fifty percent (50%) or more of courses offered online exclusively.
viii. Transition of an academic program to an exclusively online format.
ix. Addition or removal of courses that represent a significant departure from existing academic program offerings or method of delivery.
x. A change in name or title of any academic program or instructional or administrative unit.
xi. A change of Classification of Instructional Program (CIP) code for any academic program.
xii. A credit change to an existing academic program.

At the sole discretion of the Executive Director or designee, institutions may be required to submit a Short Proposal or Full Proposal for any action identified in this subsection.

d. Minor changes to curriculum, descriptions of individual courses, or catalog listings do not require notification to or approval by the Board or the Executive Director or designee.

4. Career Technical Program Proposal Submission and Approval

a. Actions Requiring a Full Proposal

Subsequent to institutional review and consistent with institutional policies, but prior to implementation, requests for changes to career technical programs or units identified in this subsection require approval by the Administrator of the Idaho Division of Career Technical Education or designee (unless otherwise indicated)

ATTACHMENT 1

and shall be submitted by the institution to the Administrator or designee as a Full Proposal.

i. Establishment of a new career technical education program or certificate. New career technical programs or certificates with a financial impact of $250,000 or more per fiscal year require approval by the full Board.
ii. Discontinuation of career technical programs and components.
iii. Establishment of new career technical administrative or instructional units.
iv. Expansion of a career technical program outside an institution's Designated Service Region as defined in Board Policy III.Z.
v. Consolidation of two or more career technical programs into one career technical program with a financial impact of $250,000 or more per fiscal year.
vi. Conversion of one career technical program option into a stand-alone career technical program with a financial impact of $250,000 or more per fiscal year.
vii. Addition of career technical certificates or degrees to existing career technical programs with a financial impact of $250,000 or more per fiscal year.

For new or modified career technical programs or certificates, a Program Profile Attachment B is required. Each Full Proposal shall be reviewed by the Council on Academic and Affairs and Programs within 30 days of receipt. At the sole discretion of the Executive Director or designee, any Full Proposal may be referred to the Board for review and approval.

b. Actions Requiring a Short Proposal

Subsequent to institutional review and consistent with institutional policies, but prior to implementation, requests for changes in career technical programs or units identified in this subsection require approval by the Administrator or designee and shall be submitted by the institution to the Administrator or designee as a Short Proposal.

i. Splitting of a career technical program into two or more career technical programs.
ii. Consolidation of two or more career technical programs into one career technical program with a financial impact of less than $250,000 per fiscal year.
iii. Conversion of one career technical program option into a stand-alone career technical program with a financial impact of less than $250,000 per fiscal year.
iv. Addition of career technical certificates or degrees to existing career technical programs with a financial impact of less than $250,000 per fiscal year.
v. Inactivation of a career technical program. Inactivation allows program re-evaluation and assessment in response to rapid changes in industry for up to three years. If industry demand for the program does not resume within three years following approved inactivation, the program shall be discontinued pursuant to paragraph 8 of this policy.

ATTACHMENT 1

vi. Establishment of a new, modification to, or discontinuation of a microcertification, as defined in Board Policy III.E.
vii. Addition or removal of courses that represent a significant departure from existing career technical program offerings or method of delivery.
viii. Modification to existing career technical instructional or administrative units.
ix. Conversion or transition of one career technical program degree or certificate level to another degree or certificate level.
x. Deviation from program credit definitions.
xi. Minor changes to career technical courses.

For the addition or modification of career technical programs or certificates, a Program Profile Attachment B is required. At the sole discretion of the Administrator or designee, institutions may be required to submit a Full Proposal for any action identified in this subsection.

c. Actions Requiring a Letter of Notification

Subsequent to institutional review and consistent with institutional policies, and within 30 days after implementation, institutions shall notify the Administrator or designee of the following changes to career technical programs or units via a Letter of Notification:

i. Establishment of a new, modification to, or discontinuation of a career technical program component.
ii. Career technical program expansion within an institution's Designated Service Region as defined in Board policy III.Z.
iii. A change from clock hours to credit hours for a career technical program.
iv. Addition of an online option to an existing career technical program.
v. Transition of an academic program with less than fifty percent (50%) of courses offered online exclusively to fifty percent (50%) or more of courses offered online exclusively.
vi. Transition of a career technical program to an exclusively online format.
vii. A change in the name or title of any career technical program or instructional or administrative unit.
viii. A change of Classification of Instructional Program (CIP) code for any career technical program.
ix. A credit change to an existing career technical program.

At the sole discretion of the Administrator or designee, institutions may be required to submit a Short Proposal or Full Proposal for any action identified in this subsection.

d. Requests requiring new state appropriations shall be included in the annual budget request of the Idaho Division of Career Technical Education for Board approval.

ATTACHMENT 1

5. Sunset Clause for Academic and Career Technical Program Approval

   Academic and career technical programs approved by the Board or Executive Director or Division Administrator or designee must be implemented within five years. A program not implemented within five years from the approval date requires submission for approval of an updated proposal. Institutions shall notify the Executive Director or designee in writing when an approved program has not been officially implemented within the sunset timeframe. Institutions may request a change in the sunset timeframe indicated in the program proposal if a program's implementation is delayed.

6. Academic and Career Technical Program Proposal Denial Procedures

   a. The Executive Director or designee shall act on any Full Proposal or Short Proposal within thirty (30) days.

   b. If the Executive Director or designee denies a proposal, he/she shall provide specific reasons in writing to the institution. The institution shall have thirty (30) days in which to address the issue(s) for denial of the proposal. The Executive Director or designee shall have ten (10) working days after the receipt of the institution's response to re-consider the denial. If the Executive Director or designee denies the request after re-consideration, the institution may send its request and the supporting documents related to the denial to the Board for final reconsideration.

7. Program Discontinuance

   The primary considerations for program discontinuance are whether the program is an effective use of the institution's resources, no longer serves student or industry needs, or when programs no longer have sufficient students to warrant allocation of resources. This policy does not apply to programs that are discontinued as a result of financial exigency as defined in Board Policy Section II.N.

   a. Institutions shall develop policies, in accordance with the Northwest Commission on Colleges and Universities Accreditation Handbook, which requires institutions to make appropriate arrangements for enrolled students to complete affected programs in a timely manner with minimum interruptions.

   b. Any faculty or staff members whose employment the institution seeks to terminate due to the discontinuance of a program based upon Board Policy Section III.G. shall be entitled to the following procedures:

      i. Non-classified contract employees, including non-tenured faculty, may be dismissed or have their contracts terminated or non-renewed in accordance with Board and institutional policies.

ATTACHMENT 1

ii. State of Idaho classified employees shall be subject to layoff as provided in the rules of the Division of Human Resources. Classified employees of the University of Idaho shall be subject to layoff as provided in the policies of the University of Idaho.

iii. Tenured faculty will be notified in writing that the institution intends to dismiss them as a result of program discontinuance. This notice shall be given at least twelve (12) months prior to the effective date of termination.

iv. An employee who receives a notice of termination as a result of program discontinuance is entitled to use the internal grievance procedures of the institution. The sole basis to contest a dismissal following a program closure is in compliance with these policies.

8. Career Technical Program Reduction or Termination

For the reduction or termination of career technical programs, institutions shall adhere to criteria set forth by Idaho Division of Career Technical Education.

a. Conditions for Reduction or Termination

A program is subject to reduction or termination when one or more of the following conditions exist. Standards for the metrics listed below will be predetermined at the local level according to the institution's program health metrics for each category.

i. Inadequate Job Opportunities
ii. Inadequate Student Enrollment
iii. Inadequate Positive Placement
iv. Inadequate Completion Rate
v. Inadequate Finances

b. Notice to Employees

The institution must give notice in writing to employees who are affected by a program reduction or termination in accordance with Board and institutional policies.

9. Reporting

a. The Executive Director and Division Administrator or designee shall report semi-annually to the Board regarding all program proposals approved by the Executive Director or designee.

ATTACHMENT 1

b. All baccalaureate and graduate level programs approved by the Board require a report on the program's progress in accordance with a timeframe and template developed by the Executive Director or designee.

The Board is responsible for the establishment, maintenance, and general supervision of policies and procedures governing the academic and program affairs of the institutions. This subsection shall apply to the University of Idaho, Idaho State University, Boise State University, Lewis-Clark State College, North Idaho College, College of Eastern Idaho, College of Southern Idaho, and College of Western Idaho.

Program planning shall be a collaborative process which includes the Board, Board staff, the institutions, faculty, external advisory groups, regional and specialized accreditation bodies, and other stakeholders pursuant to Board Policy Section III.Z.

1. Classifications and Definitions

   a. Instructional Unit(s) shall mean departments, institutes, centers, divisions, schools, colleges, campuses, branch campuses, and research units (e.g. extension centers) that are responsible for academic programs or career technical programs.

   b. Administrative Unit(s) shall mean offices, centers, bureaus, or institutes that are responsible for carrying out administrative functions, research, or public service as their primary purpose, and are not responsible for academic or career technical programs.

   c. Academic Program(s) shall mean a systematic, usually sequential, grouping of courses forming a considerable part, or all, of the requirements (i.e., curricula) that provides the student with the knowledge and competencies required in a specialized field (i.e., major) for an academic certificate, an associate's, baccalaureate, master's, specialist, or doctoral degree as defined in Board Policy Section III.E.

   d. Major(s) shall mean a principal field of academic specialization that usually accounts for 25 to 50 percent of the total degree requirements. The concentration of coursework in a subject-matter major serves to distinguish one program from others leading to the same or a similar degree.

   e. Academic Program Components shall include options, minors, emphases, tracks, concentrations, specializations, and cognates as defined by each institution.

   f. Career Technical Program(s) shall mean a sequence or aggregation of competencies that are derived from industry-endorsed outcome standards and directly related to preparation for employment in occupations requiring career technical certificates, microcertifications, or an associate of applied science degree as defined in Board Policy Section III.E. These programs must include competency-based applied learning that contributes to an individual's technical skills, academic knowledge, higher-order reasoning, and problem-solving skills. A course or series of courses leading to a technical certificate of completion is not considered a program for approval purposes.

g. Career Technical Program Components including microcertifications shall mean instructional paths to fields of specialized employment, consisting of more than one specialized course, and may have a separate advisory committee.

h. Financial Impact shall mean the total financial resources, regardless of funding source, needed to support personnel costs, operating expenditures, capital outlay, capital facilities construction or major renovation, and indirect costs that are incurred as a direct result of the new instructional program or modification to an existing program. This includes instructional and administrative units.

2. Roles and Responsibilities

a. Institutions shall establish internal program review processes and procedures. Institutions shall follow their internal review processes and procedures pursuant to Board Policy Section III.H. prior to forwarding proposals to the Board.

b. Program proposals shall be reviewed by the Council on Academic Affairs and Programs (CAAP). CAAP shall make recommendations to the Instruction, Research, and Student Affairs (IRSA) committee on instructional programmatic matters and related policy issues.

c. The Idaho Division of Career Technical Education shall review and make recommendations as appropriate to the IRSA Committee and/or the Board on instructional programmatic matters and policy issues related to their roles and responsibilities. The State Administrator is authorized by the Board to approve academic and career technical microcertifications developed by institutions pursuant to the fiscal impact limits established in subsection 4.b in this policy.

d. The Professional Standards Commission shall review and make recommendations as appropriate to the Board on educator preparation programs.

3. Academic Program Proposal Submission and Approval Procedures

Subsequent to institutional review and consistent with institutional policies, all requests requiring Board or Executive Director approval will be submitted by the institution to Board staff as a proposal in accordance with a template developed by the Board's Chief Academic Officer. Each proposal shall be reviewed by CAAP within 30 days from receipt of said proposal.

a. Branch Campuses - The establishment of a new branch campus or change in location geographically apart from the main campus where the institution offers at least 50% of an education program shall require Board approval regardless of fiscal impact. This subsection of policy excludes community colleges.

b. Learning Outcomes - All postsecondary program approvals will include identifiable learning outcomes and competency measurements for graduates of their programs as defined in Board Policy III.X.

c. Academic Programs

i. All new, modification of, and/or discontinuation of academic program majors shall require completion of the program proposal prior to implementation. This includes certificates of 30 credits or more; associates, bachelors, masters, specialist, and doctoral degrees; instructional and administrative units. Proposals requiring new state appropriations shall be submitted to the Board for review prior to or concurrently with submission of an institution's annual budget request.

1) Any program leading to a master's, specialist, or doctoral degree must be approved by the Board prior to implementation. The Instruction, Research and Student Affairs Committee will be notified of baccalaureate degree proposals prior to implementation and may refer them to the Board for review and approval for those it determines appropriate.
2) Prior to implementation, an institution shall obtain Board approval of any new, modification of and/or discontinuation of academic or career technical programs, including instructional and administrative units with a financial impact of $250,000 or more per fiscal year.
3) Prior to implementation, an institution shall obtain Executive Director approval of the modification of and/or discontinuation of any academic program; new, modification of, and/or discontinuation of any career technical program; and instructional and administrative units with a financial impact of less than $250,000 per fiscal year.
3) Pursuant to Section 33-2107A Idaho Code, community colleges shall obtain Board approval of any new applied baccalaureate program regardless of fiscal impact.
4) Prior to implementation, an institution shall obtain Board approval of any modification and/or discontinuation of all graduate programs leading to a master's, specialist, or doctoral degree regardless of fiscal impact.
5) The Executive Director may refer any proposal to the Board or subcommittee of the Board for review and action.

ii. Modifications to existing programs shall include, but not limed to, the following:

1) Expanding an existing program outside a designated service region.
2) Converting one program option into a stand-alone program.
3) Consolidating an existing program to create one or more new programs.
4) Adding a degree program not already approved by the Board.

5) Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
6) Transitioning of existing programs to an online format.
7) Changes from clock hours to credit hours or vice-versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.

ii. Microcertification requests requiring approval will be submitted by the institution to the Division of Career Technical Education (Division) through an approval process in accordance with a template developed by the Division staff. Each request shall be reviewed within 30 days from receipt of request. Academic microcertifications shall be reviewed by Division and Board staff.

1) Prior to implementation, an institution shall obtain State Administrator approval of any new, modification, or discontinuation of a microcertification as defined in Board Policy III.E.
2) Within a microcertification, specific information shall be contained where the microcredential was earned, the detailed criteria required to earn it, the name of the student and the program to ensure the microcredential is specific to the individual who earns it.

iv. All doctoral program proposals shall require an external peer review. The external peer-review panel shall consist of at least two (2) members and will be selected by the Board's Chief Academic Officer and the requesting institution's Provost. Board staff will notify the institution in writing whether it may proceed with the external peer-review process. External reviewers shall not be affiliated with a public Idaho institution. The review shall consist of a paper and on-site peer review, followed by the issuance of a report and recommendations by the panel. Each institution shall provide the panel with a template developed by the Board's Chief Academic Officer. The peer reviewer's report and recommendations will be a significant factor of the Board's evaluation of the program.

v. New educator preparation programs require concurrent submission of the program proposal to the Board office and the Professional Standards Commission (PSC) prior to implementation. The PSC ensures programs meet the Idaho standards for certification. The Board office ensures the program proposal is consistent with the program approval process and meets the standards approved by the Board and established in rule. The PSC makes recommendations to the Board for approval of programs as vehicles for meeting the state certification requirements.

d. Academic Program Components, Program Changes, and Procedures

New, modification, and/or discontinuation of academic program components, and academic undergraduate and graduate certificates of less than thirty (30) credits may require a proposal. For academic program components or certificates requiring a proposal, subsection 3.c.i. of this policy applies.

i. New, modification, and/or discontinuation of academic program components; academic undergraduate and graduate certificates of less than thirty (30) credits and credit changes to existing programs require a formal letter notifying the Office of the State Board of Education prior to implementation of such changes. New academic certificates that require the creation of any new course(s) or resources must provide information in the letter of notification explaining how personnel and fiscal resources will be allocated or reallocated to support the delivery of the new course(s). All letters of notification for new academic certificates must provide the certificate’s cost to students, and evidence of the certificate’s value to students and workforce needs.
ii. Program name or title changes to degrees, departments, divisions, colleges, or centers; or changes to Classification of Instructional Programs (CIP) codes require a formal letter notifying the Office of the State Board of Education prior to implementation of such changes. Name changes for non-functional purposes are approved pursuant to Board Policy I.K. Naming/Memorializing Building and Facilities.
iii. If the change is judged to be consistent with academic program components and program changes as provided in this section, Board staff will notify the institution in writing that they may proceed with said changes. If the change is determined to be inconsistent with academic program components or the CIP code change represents a significant departure from existing offerings, Board staff will notify the institution in writing and they will be required to complete a program proposal.
iv. Changes to program names or degree titles related to Statewide Program Responsibilities as provided in Board Policy III.Z., must be requested in writing and submitted to Board staff for review and approval by the Board.
v. Minor curriculum changes in a program; descriptions of individual courses; and other routine catalog changes do not require notification or approval.

4. Career Technical Program Proposal Submission and Approval Procedures

All career technical program requests requiring Board or Executive Director approval will be submitted by the institution to the Division of Career Technical Education as a proposal in accordance with a template developed by Board staff. Each proposal shall be reviewed within 30 days from receipt of said proposal. Requests requiring new state appropriations shall be included in the annual budget request of the State Division of Career Technical Education for Board approval.

a. Learning Outcomes
All postsecondary program approvals will include identifiable learning outcomes and competency measurements for graduates of their programs as defined in Board Policy Section III.X.

b. Career Technical Programs and Components

i. All new, modification, and/or discontinuation of career technical programs and components, shall require completion of the program proposal prior to implementation. This includes instructional and administrative units. Career technical program proposals shall be forwarded to the State Administrator of the Division of Career Technical Education for review and recommendation. The State Administrator shall forward the request to CAAP for its review and recommendation. Once CAAP and/or State Administrator recommends approval, the proposal shall be forwarded, along with recommendations, to the Board for action.

1) Prior to implementation, an institution shall obtain Board approval of any new, modification, and/or discontinuation of career technical programs and components with a financial impact of $250,000 or more per fiscal year.
2) Prior to implementation, an institution shall obtain Executive Director approval of any new, modification, and/or discontinuation of career technical programs and components with a financial impact of less than $250,000 per fiscal year.
3) The Executive Director may refer any proposal to the Board for review and action.

ii. Modifications to existing programs shall include, but not be limited to, the following:
1) Expanding an existing program outside a designated service region.
2) Converting one program option into a stand-alone program.
3) Consolidating an existing program to create one or more new programs.
4) Adding a certificate or degree program not already approved by the Board.
5) Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
6) Transitioning of existing programs to an online format.
7) Changes from clock hours to credit hours or vice-versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.

iii. Microcertification requests requiring approval will be submitted by the institution to the Division of Career Technical Education through an approval process in accordance with a template developed by Division of Career Technical Education staff. Each request shall be reviewed within 30 days from receipt of request.

3) Prior to implementation, an institution shall obtain State Administrator approval of any new, modification , or discontinuation of a microcertification as defined in Board Policy III.E regardless of fiscal impact.
4) Within a microcertification, specific information shall be contained where the microcredential was earned, the detailed criteria required to earn it, the name of the student and the program to ensure the microcredential is specific to the individual who earns it.

c. Career Technical Program Notification Procedures

Program changes to existing career technical programs may require a proposal. For career technical programs requiring a proposal, subsection 4.b.i. of this policy applies.

i. Program name or title changes to degrees, departments, divisions, colleges, or centers; changes to CIP Codes; or credit changes to existing programs require a formal letter notifying the State Administrator prior to implementation of such changes.

ii. If the change is judged to be consistent with program changes as provided in this section, the State Administrator will notify the institution in writing that they may proceed with said changes. If the change is determined to be inconsistent with definition of program components, the State Administrator will notify the institution in writing and they will be required to complete the program proposal.

iii. Minor changes to courses within a current program (e.g., course number, title, description, addition, deletion, and/or credit hours) must be submitted to the State Division of Career Technical Education.

d. Career Technical Program Inactivation

i. The purpose of a career technical program inactivation is to respond to rapid changes in industry demand, allowing time for program assessment and inactivation. If industry demand for the program does not resume within three years following the inactivation, the program shall be discontinued pursuant to IDAPA 55.01.02.

ii. Program inactivation requires a formal letter notifying the State Administrator requesting inactivation. The letter will include:

1) Description and rationale for the modification
2) Implementation date
3) Arrangement for enrolled students to complete the program in a timely manner
4) Impact of accreditation, if any
5) Impact to current employees of the program
6) Impact on current budget

iii. The State Administrator will make a recommendation in writing to the Board office. The Board office will send notification to the institution.

iv. Program re-activation requires a formal letter notifying the State Administrator requesting re-activation.

5. Sunset Clause for Program Approval

Academic and career technical education programs approved by the Board or Executive Director must be implemented within five years. A program not implemented within five years from the approval date requires submission for approval of an updated proposal. Institutions shall notify the Board office in writing when an approved program has not been officially implemented. Institutions may request a change in the sunset timeframe indicated in the program proposal if a program’s implementation is delayed for any reason.

6. Academic and Career Technical Program Proposal Denial Procedures

a. The Executive Director shall act on any request within thirty (30) days.

b. If the Executive Director denies the proposal he/she shall provide specific reasons in writing. The institution shall have thirty (30) days in which to address the issue(s) for denial of the proposal. The Executive Director has ten (10) working days after the receipt of the institution's response to re-consider the denial. If the Executive Director denies the request after re-consideration, the institution may send its request and the supporting documents related to the denial to the Board for final reconsideration.

7. Program Discontinuance

The primary considerations for instructional program discontinuance are whether the instructional program is an effective use of the institution’s resources, no longer serves student or industry needs, or when programs no longer have sufficient students to warrant its allocation. This policy does not apply to instructional programs that are discontinued as a result of financial exigency as defined in Board Policy Section II.N.

For career technical program discontinuance, institutions shall adhere to criteria and procedures as provided in IDAPA 55.01.02.

a. Students - Institutions shall develop policies, in accordance with the Northwest Commission on Colleges and Universities Accreditation Handbook, which requires institutions to make appropriate arrangements for enrolled students to complete affected programs in a timely manner with minimum interruptions.

b. Employees - Any faculty or staff members whose employment the institution seeks to terminate due to the discontinuance of a program based upon Board Policy Section III.G. shall be entitled to the following procedures:

   i. Non-classified contract employees, including non-tenured faculty, may be dismissed or have their contracts terminated or non-renewed in accordance with Board and institutional policies.

   ii. State of Idaho classified employees shall be subject to layoff as provided in the rules of the Division of Human Resources. Classified employees of the University of Idaho shall be subject to layoff as provided in the policies of the University of Idaho.

   iii. Tenured faculty will be notified in writing that the institution intends to dismiss them as a result of program discontinuance. This notice shall be given at least twelve (12) months prior to the effective date of termination.

   iv. An employee who receives a notice of termination as a result of program discontinuance is entitled to use the internal grievance procedures of the institution. The sole basis to contest a dismissal following a program closure is in compliance with these policies.

8. Reporting

   a. The Office of the State Board of Education shall report biannually to the State Board of Education all program approvals and discontinuations approved by the Executive Director.

   b. All baccalaureate and graduate level programs approved by the State Board of Education require a report on the program's progress in accordance with a timeframe and template developed by the Board's Chief Academic Officer.

ATTACHMENT 3

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: H. Program Review ~~August 2007~~August 2021

~~1. Coverage~~

~~Academic and career technical programs, administrative units, research centers/institutes, and public service components at University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho, and North Idaho College are included in this subsection.~~

~~2. Program Review~~

~~Program review is the method by which the Board and the institutions evaluate proposed and existing postsecondary programs. The goals of program review are: (a) maintenance and enhancement of the quality of instruction, research, and public service efforts, (b) assurance of the postsecondary education system's responsiveness to changing societal and state needs, (c) promotion of effective and efficient management of the state's resources, and (d) assist the institutions in defining how effective their programs are.~~

~~In the context of program review for and by the Board, a program is a curriculum or course of study in a discipline specialty that leads to a certificate or degree. It is often but not always the same as a "major." Administrative units of research and public service are those that are: (a) essential to student training, (b) an integral part of an academic/ career technical program, (c) related to institutional role and mission, or (d) serve the consumer/state interests.~~

~~3. Purposes~~

~~Categories of academic and career technical programs reviewed at the institutional and state levels as directed by the Board include:~~

~~a. State-Level Review~~

~~1) New, expanded, and cooperative programs. (*See also* "Instructional Program Approval," Section III, Subsection G.)~~

~~2) Programs proposed for consolidation, relocation, or discontinuance.~~

~~3) Administrative units of research and public service.~~

ATTACHMENT 3

~~4) Existing programs by audit procedures and special topic reviews.~~

~~5) Distance learning/technology program delivery.~~

~~The Board will establish procedures and criteria for each audit and special topics review, which are germane to each audit and special topics review.~~

~~b. Institutional Review~~

~~The institutional reviews include all categories identified above for state-level review with the exception that the review of existing programs and administrative units of research and public service is carried out as part of the systematic evaluation of all programs within a period of time established by the Board.~~

~~4. Institutional Policies and Procedures~~

~~Each institution will establish and maintain policies and procedures, following the guidelines of the Board and subject to Board approval, for evaluating existing programs and new program proposals, as well as programs proposed for (a) expansion, (b) delivery at an off-campus site by various distance learning methods or in cooperation with another institution, a business, or an industry; (c) consolidation, (d) relocation, or (e) discontinuance. The evaluation process should be an integral component of the institution's academic and vocational education planning and budgeting processes.~~

~~5. Statewide Policies and Procedures~~

~~State-level review of new and existing programs will be integrated with the state-level academic and career technical planning and budgetary processes and where possible in concert with accreditation self-study and on site review by the accrediting body.~~

~~6. Official Vehicle for the Approval of Teacher Education Programs~~

~~The official vehicle for the approval of teacher education programs will be the National Council for Accreditation of Teacher Education (NCATE) approved Idaho Standards for the Initial Certification of Professional School Personnel. The Teacher Certification Office will provide each institution with any revisions to the Idaho Standards for the Initial Certification of Professional School Personnel. Teacher education programs must ensure their pre-service teachers meet the components~~

ATTACHMENT 3

~~(knowledge, disposition, and performance) of the Core Teacher Education Standards and the standards of the level and/or content area(s) in which they plan to be endorsed. *(Effective Sept. 1, 2001.*~~*)*

SUBJECT

Board Policy III.G. - Partial Waiver Extension

REFERENCE

February 14, 2019	The Board approved the first reading of proposed amendments to include review and approval procedures for applied baccalaureate degrees and microcertifications.
April 18, 2019	The Board approved the second reading of proposed amendments to Board Policy III.G.
August 29, 2019	The Board was presented with a first reading of proposed amendments to Board Policy III.G. Policy was referred back to Instruction, Research, and Student Affairs (IRSA) for additional discussion.
October 17, 2019	The Board approved the first reading of proposed amendments, which adds baccalaureate degree programs to the list of programs reviewed by the Board and changes requirements for new academic program proposals that consists of new state appropriations.
December 2019	The Board approved the second reading of proposed amendments to Board Policy III.G.
June 10, 2020	The Board approved a partial waiver of the requirement for full proposals in Board Policy III.G.3.d and 4.d for modifications to academic programs, career technical programs and instructional and administrative units.

APPLICABLE POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.G Postsecondary Program Approval and Discontinuance

BACKGROUND/DISCUSSION

Board Policy III.G., Postsecondary Program Approval and Discontinuance, provides Idaho's public institutions with procedures for the development, approval, and discontinuation of academic and career technical programs, including instructional and administrative units.

Currently, Board policy requires completion of a proposal form and approval of modifications to existing academic programs, career technical programs, and instructional and administrative units. These include, but are not limited to, the following program modifications:

- Expansion of an existing program outside a designated service region
- Converting one program option into a stand-alone program
- Consolidating an existing program to create one or more new programs
- Adding a degree or certificate program not already approved by the Board

- Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
- Transitioning existing programs to an online format.
- Changes from clock hours to credit hours or vice versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.
- Modification of existing programs as provided above resulting from Program Prioritization.
- Reorganizing, merging, and bifurcating existing instructional and administrative units, including moving programs and resources.

A partial waiver of Board Policy III.G was approved in June last year to provide institutions flexibility with implementing these types of modifications due to pandemic and Program Prioritization processes occurring on some campuses. This waiver also provided opportunities for staff to work with the Council on Academic Affairs and Programs and the Instruction, Research and Student Affairs Committee to conduct a complete audit of Board Policy III.G and identify potential amendments to the policy to improve efficiency in the Board's oversight efforts.

A first reading of proposed amendments to Board Policy III.G is being presented to the Board under a separate agenda item at the June 2021 Board meeting. While these amendments go through the Board's review process, Board approval is requested to extend the waiver of the proposal requirement in Policy III.G.3.d and 4.d for modifications to academic programs, career technical programs, and instructional and administrative units through August 31, 2021. The exception to this waiver will be the expansion of existing program offerings outside an institution's designated service region, as defined in Board Policy III.Z. Those types of modifications will continue to require a full program proposal and will be subject to the review and approval process per III.G.

In place of full proposals for the other types of modifications, institutions will continue to supply a letter of request for approval by the Board's executive director, provided that the fiscal impact is below $250,000 per fiscal year consistent with policy. The executive director will retain the right to request full proposals for modifications as he deems necessary. New programs, discontinuation of programs, and inactivation of programs will continue to require a program proposal or letter of request, as per policy, and will follow the regular process.

IMPACT

Approval of the waiver will provide institutions with continued support in implementing modifications and will provide staff with time to roll out the new policy requirements, forms, and procedures prior to the beginning of fall 2021.

STAFF COMMENTS AND RECOMMENDATIONS

Implementing this temporary waiver will provide ongoing support and flexibility to institutions with implementing programmatic or structural modifications while amendments to Board Policy III.G go through the Board's review and approval process. Additionally, the waiver will provide staff with the necessary time to implement the new policy requirements, establish new proposal forms, and procedures prior to the beginning of fall 2021.

The proposed extension of the waiver was shared with the Council on Academic Affairs and Programs on May 6, 2021 and with the Instruction, Research, and Student Affairs Committee on June 1, 2021.

Board staff recommends approval.

BOARD ACTION

I move to extend the waiver of the requirement for a full proposal in Board Policy III.G.3.d and 4.d for modifications to academic programs, career technical programs, and instructional and administrative units until August 31, 2021. In lieu of a full program proposal requirement, institutions will use the letter of notification process during this time period.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

Idaho State Board of Education

GOVERNING POLICIES AND PROCEDURES

SECTION: III. POSTSECONDARY AFFAIRS **December 2019**

SUBSECTION: G. Postsecondary Program Approval and Discontinuance

The Board is responsible for the establishment, maintenance, and general supervision of policies and procedures governing the academic and program affairs of the institutions. This subsection shall apply to the University of Idaho, Idaho State University, Boise State University, Lewis-Clark State College, North Idaho College, College of Eastern Idaho, College of Southern Idaho, and College of Western Idaho.

Program planning shall be a collaborative process which includes the Board, Board staff, the institutions, faculty, external advisory groups, regional and specialized accreditation bodies, and other stakeholders pursuant to Board Policy Section III.Z.

1. Classifications and Definitions

   a. Instructional Unit(s) shall mean departments, institutes, centers, divisions, schools, colleges, campuses, branch campuses, and research units (e.g. extension centers) that are responsible for academic programs or career technical programs.

   b. Administrative Unit(s) shall mean offices, centers, bureaus, or institutes that are responsible for carrying out administrative functions, research, or public service as their primary purpose, and are not responsible for academic or career technical programs.

   c. Academic Program(s) shall mean a systematic, usually sequential, grouping of courses forming a considerable part, or all, of the requirements (i.e., curricula) that provides the student with the knowledge and competencies required in a specialized field (i.e., major) for an academic certificate, an associate's, baccalaureate, master's, specialist, or doctoral degree as defined in Board Policy Section III.E.

   d. Major(s) shall mean a principal field of academic specialization that usually accounts for 25 to 50 percent of the total degree requirements. The concentration of coursework in a subject-matter major serves to distinguish one program from others leading to the same or a similar degree.

   e. Academic Program Components shall include options, minors, emphases, tracks, concentrations, specializations, and cognates as defined by each institution.

   f. Career Technical Program(s) shall mean a sequence or aggregation of competencies that are derived from industry-endorsed outcome standards and directly related to preparation for employment in occupations requiring career technical certificates, microcertifications, or an associate of applied science degree as defined in Board Policy Section III.E. These programs must include competency-based applied learning that contributes to an individual's technical skills, academic knowledge, higher-order reasoning, and problem-solving skills. A course or series of courses leading to a technical certificate of completion is not considered a program for approval purposes.

g. Career Technical Program Components including microcertifications shall mean instructional paths to fields of specialized employment, consisting of more than one specialized course, and may have a separate advisory committee.

h. Financial Impact shall mean the total financial resources, regardless of funding source, needed to support personnel costs, operating expenditures, capital outlay, capital facilities construction or major renovation, and indirect costs that are incurred as a direct result of the new instructional program or modification to an existing program. This includes instructional and administrative units.

2. Roles and Responsibilities

   a. Institutions shall establish internal program review processes and procedures. Institutions shall follow their internal review processes and procedures pursuant to Board Policy Section III.H. prior to forwarding proposals to the Board.

   b. Program proposals shall be reviewed by the Council on Academic Affairs and Programs (CAAP). CAAP shall make recommendations to the Instruction, Research, and Student Affairs (IRSA) committee on instructional programmatic matters and related policy issues.

   c. The Idaho Division of Career Technical Education shall review and make recommendations as appropriate to the IRSA Committee and/or the Board on instructional programmatic matters and policy issues related to their roles and responsibilities. The State Administrator is authorized by the Board to approve academic and career technical microcertifications developed by institutions pursuant to the fiscal impact limits established in subsection 4.b in this policy.

   d. The Professional Standards Commission shall review and make recommendations as appropriate to the Board on educator preparation programs.

3. Academic Program Proposal Submission and Approval Procedures

   Subsequent to institutional review and consistent with institutional policies, all requests requiring Board or Executive Director approval will be submitted by the institution to Board staff as a proposal in accordance with a template developed by the Board's Chief Academic Officer. Each proposal shall be reviewed by CAAP within 30 days from receipt of said proposal.

   a. Branch Campuses - The establishment of a new branch campus or change in location geographically apart from the main campus where the institution offers at least 50% of an education program shall require Board approval regardless of fiscal impact. This subsection of policy excludes community colleges.

b. Learning Outcomes - All postsecondary program approvals will include identifiable learning outcomes and competency measurements for graduates of their programs as defined in Board Policy III.X.

c. Academic Programs

i. All new, modification of, and/or discontinuation of academic program majors shall require completion of the program proposal prior to implementation. This includes certificates of 30 credits or more; associates, bachelors, masters, specialist, and doctoral degrees; instructional and administrative units. Proposals requiring new state appropriations shall be submitted to the Board for review prior to or concurrently with submission of an institution's annual budget request.

1) Any program leading to a master's, specialist, or doctoral degree must be approved by the Board prior to implementation. The Instruction, Research and Student Affairs Committee will be notified of baccalaureate degree proposals prior to implementation and may refer them to the Board for review and approval for those it determines appropriate.
2) Prior to implementation, an institution shall obtain Board approval of any new, modification of and/or discontinuation of academic or career technical programs, including instructional and administrative units with a financial impact of $250,000 or more per fiscal year.
3) Prior to implementation, an institution shall obtain Executive Director approval of the modification of and/or discontinuation of any academic program; new, modification of, and/or discontinuation of any career technical program; and instructional and administrative units with a financial impact of less than $250,000 per fiscal year.
3) Pursuant to Section 33-2107A Idaho Code, community colleges shall obtain Board approval of any new applied baccalaureate program regardless of fiscal impact.
4) Prior to implementation, an institution shall obtain Board approval of any modification and/or discontinuation of all graduate programs leading to a master's, specialist, or doctoral degree regardless of fiscal impact.
5) The Executive Director may refer any proposal to the Board or subcommittee of the Board for review and action.

ii. Modifications to existing programs shall include, but not limed to, the following:

1) Expanding an existing program outside a designated service region.
2) Converting one program option into a stand-alone program.
3) Consolidating an existing program to create one or more new programs.
4) Adding a degree program not already approved by the Board.

5) Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
6) Transitioning of existing programs to an online format.
7) Changes from clock hours to credit hours or vice-versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.

ii. Microcertification requests requiring approval will be submitted by the institution to the Division of Career Technical Education (Division) through an approval process in accordance with a template developed by the Division staff. Each request shall be reviewed within 30 days from receipt of request. Academic microcertifications shall be reviewed by Division and Board staff.

1) Prior to implementation, an institution shall obtain State Administrator approval of any new, modification, or discontinuation of a microcertification as defined in Board Policy III.E.
2) Within a microcertification, specific information shall be contained where the microcredential was earned, the detailed criteria required to earn it, the name of the student and the program to ensure the microcredential is specific to the individual who earns it.

iv. All doctoral program proposals shall require an external peer review. The external peer-review panel shall consist of at least two (2) members and will be selected by the Board's Chief Academic Officer and the requesting institution’s Provost. Board staff will notify the institution in writing whether it may proceed with the external peer-review process. External reviewers shall not be affiliated with a public Idaho institution. The review shall consist of a paper and on-site peer review, followed by the issuance of a report and recommendations by the panel. Each institution shall provide the panel with a template developed by the Board’s Chief Academic Officer. The peer reviewer's report and recommendations will be a significant factor of the Board’s evaluation of the program.

v. New educator preparation programs require concurrent submission of the program proposal to the Board office and the Professional Standards Commission (PSC) prior to implementation. The PSC ensures programs meet the Idaho standards for certification. The Board office ensures the program proposal is consistent with the program approval process and meets the standards approved by the Board and established in rule. The PSC makes recommendations to the Board for approval of programs as vehicles for meeting the state certification requirements.

d. Academic Program Components, Program Changes, and Procedures

New, modification, and/or discontinuation of academic program components, and academic undergraduate and graduate certificates of less than thirty (30) credits may require a proposal. For academic program components or certificates requiring a proposal, subsection 3.c.i. of this policy applies.

i. New, modification, and/or discontinuation of academic program components; academic undergraduate and graduate certificates of less than thirty (30) credits and credit changes to existing programs require a formal letter notifying the Office of the State Board of Education prior to implementation of such changes. New academic certificates that require the creation of any new course(s) or resources must provide information in the letter of notification explaining how personnel and fiscal resources will be allocated or reallocated to support the delivery of the new course(s). All letters of notification for new academic certificates must provide the certificate’s cost to students, and evidence of the certificate’s value to students and workforce needs.
ii. Program name or title changes to degrees, departments, divisions, colleges, or centers; or changes to Classification of Instructional Programs (CIP) codes require a formal letter notifying the Office of the State Board of Education prior to implementation of such changes. Name changes for non-functional purposes are approved pursuant to Board Policy I.K. Naming/Memorializing Building and Facilities.
iii. If the change is judged to be consistent with academic program components and program changes as provided in this section, Board staff will notify the institution in writing that they may proceed with said changes. If the change is determined to be inconsistent with academic program components or the CIP code change represents a significant departure from existing offerings, Board staff will notify the institution in writing and they will be required to complete a program proposal.
iv. Changes to program names or degree titles related to Statewide Program Responsibilities as provided in Board Policy III.Z., must be requested in writing and submitted to Board staff for review and approval by the Board.
v. Minor curriculum changes in a program; descriptions of individual courses; and other routine catalog changes do not require notification or approval.

4. Career Technical Program Proposal Submission and Approval Procedures

All career technical program requests requiring Board or Executive Director approval will be submitted by the institution to the Division of Career Technical Education as a proposal in accordance with a template developed by Board staff. Each proposal shall be reviewed within 30 days from receipt of said proposal. Requests requiring new state appropriations shall be included in the annual budget request of the State Division of Career Technical Education for Board approval.

a. Learning Outcomes
All postsecondary program approvals will include identifiable learning outcomes and competency measurements for graduates of their programs as defined in Board Policy Section III.X.

b. Career Technical Programs and Components

i. All new, modification, and/or discontinuation of career technical programs and components, shall require completion of the program proposal prior to implementation. This includes instructional and administrative units. Career technical program proposals shall be forwarded to the State Administrator of the Division of Career Technical Education for review and recommendation. The State Administrator shall forward the request to CAAP for its review and recommendation. Once CAAP and/or State Administrator recommends approval, the proposal shall be forwarded, along with recommendations, to the Board for action.

1) Prior to implementation, an institution shall obtain Board approval of any new, modification, and/or discontinuation of career technical programs and components with a financial impact of $250,000 or more per fiscal year.
2) Prior to implementation, an institution shall obtain Executive Director approval of any new, modification, and/or discontinuation of career technical programs and components with a financial impact of less than $250,000 per fiscal year.
3) The Executive Director may refer any proposal to the Board for review and action.

ii. Modifications to existing programs shall include, but not be limited to, the following:
1) Expanding an existing program outside a designated service region.
2) Converting one program option into a stand-alone program.
3) Consolidating an existing program to create one or more new programs.
4) Adding a certificate or degree program not already approved by the Board.
5) Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
6) Transitioning of existing programs to an online format.
7) Changes from clock hours to credit hours or vice-versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.

iii. Microcertification requests requiring approval will be submitted by the institution to the Division of Career Technical Education through an approval process in accordance with a template developed by Division of Career Technical Education staff. Each request shall be reviewed within 30 days from receipt of request.

3) Prior to implementation, an institution shall obtain State Administrator approval of any new, modification , or discontinuation of a microcertification as defined in Board Policy III.E regardless of fiscal impact.
4) Within a microcertification, specific information shall be contained where the microcredential was earned, the detailed criteria required to earn it, the name of the student and the program to ensure the microcredential is specific to the individual who earns it.

c. Career Technical Program Notification Procedures

Program changes to existing career technical programs may require a proposal. For career technical programs requiring a proposal, subsection 4.b.i. of this policy applies.

i. Program name or title changes to degrees, departments, divisions, colleges, or centers; changes to CIP Codes; or credit changes to existing programs require a formal letter notifying the State Administrator prior to implementation of such changes.

ii. If the change is judged to be consistent with program changes as provided in this section, the State Administrator will notify the institution in writing that they may proceed with said changes. If the change is determined to be inconsistent with definition of program components, the State Administrator will notify the institution in writing and they will be required to complete the program proposal.

iii. Minor changes to courses within a current program (e.g., course number, title, description, addition, deletion, and/or credit hours) must be submitted to the State Division of Career Technical Education.

d. Career Technical Program Inactivation

i. The purpose of a career technical program inactivation is to respond to rapid changes in industry demand, allowing time for program assessment and inactivation. If industry demand for the program does not resume within three years following the inactivation, the program shall be discontinued pursuant to IDAPA 55.01.02.

ii. Program inactivation requires a formal letter notifying the State Administrator requesting inactivation. The letter will include:

1) Description and rationale for the modification
2) Implementation date
3) Arrangement for enrolled students to complete the program in a timely manner
4) Impact of accreditation, if any
5) Impact to current employees of the program
6) Impact on current budget

iii. The State Administrator will make a recommendation in writing to the Board office. The Board office will send notification to the institution.

iv. Program re-activation requires a formal letter notifying the State Administrator requesting re-activation.

5. Sunset Clause for Program Approval

Academic and career technical education programs approved by the Board or Executive Director must be implemented within five years. A program not implemented within five years from the approval date requires submission for approval of an updated proposal. Institutions shall notify the Board office in writing when an approved program has not been officially implemented. Institutions may request a change in the sunset timeframe indicated in the program proposal if a program’s implementation is delayed for any reason.

6. Academic and Career Technical Program Proposal Denial Procedures

a. The Executive Director shall act on any request within thirty (30) days.

b. If the Executive Director denies the proposal he/she shall provide specific reasons in writing. The institution shall have thirty (30) days in which to address the issue(s) for denial of the proposal. The Executive Director has ten (10) working days after the receipt of the institution's response to re-consider the denial. If the Executive Director denies the request after re-consideration, the institution may send its request and the supporting documents related to the denial to the Board for final reconsideration.

7. Program Discontinuance

The primary considerations for instructional program discontinuance are whether the instructional program is an effective use of the institution’s resources, no longer serves student or industry needs, or when programs no longer have sufficient students to warrant its allocation. This policy does not apply to instructional programs that are discontinued as a result of financial exigency as defined in Board Policy Section II.N.

For career technical program discontinuance, institutions shall adhere to criteria and procedures as provided in IDAPA 55.01.02.

a. Students - Institutions shall develop policies, in accordance with the Northwest Commission on Colleges and Universities Accreditation Handbook, which requires institutions to make appropriate arrangements for enrolled students to complete affected programs in a timely manner with minimum interruptions.

b. Employees - Any faculty or staff members whose employment the institution seeks to terminate due to the discontinuance of a program based upon Board Policy Section III.G. shall be entitled to the following procedures:

   i. Non-classified contract employees, including non-tenured faculty, may be dismissed or have their contracts terminated or non-renewed in accordance with Board and institutional policies.

   ii. State of Idaho classified employees shall be subject to layoff as provided in the rules of the Division of Human Resources. Classified employees of the University of Idaho shall be subject to layoff as provided in the policies of the University of Idaho.

   iii. Tenured faculty will be notified in writing that the institution intends to dismiss them as a result of program discontinuance. This notice shall be given at least twelve (12) months prior to the effective date of termination.

   iv. An employee who receives a notice of termination as a result of program discontinuance is entitled to use the internal grievance procedures of the institution. The sole basis to contest a dismissal following a program closure is in compliance with these policies.

8. Reporting

   a. The Office of the State Board of Education shall report biannually to the State Board of Education all program approvals and discontinuations approved by the Executive Director.

   b. All baccalaureate and graduate level programs approved by the State Board of Education require a report on the program's progress in accordance with a timeframe and template developed by the Board's Chief Academic Officer.

SUBJECT

Board Policy III.Q. – Admissions Standards and Board Policy III.O. – Course Placement – Second Reading

REFERENCE

June 2007	Board approved the first reading of amendments to Board Policy III.Q.
August 2007	Board approved the second reading of amendments to Board Policy III.Q.
December 2013	Board approved the first reading of amendments to Board Policy III.Q.
February 2014	Board approved the second reading of amendments to Board Policy III.Q.
April 2017	Board approved the first reading of amendments to Board Policy III.Q.
June 2017	Board approved the second reading of amendments to Board Policy III.Q.
June 2020	Board approved a temporary waiver of the College Entrance Exam minimum admission requirement in response to the COVID-19 pandemic.
April 2021	Board approved the first reading of amendments to Board Policy III.Q.

APPLICABLE STATUTES, RULE OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.Q, Admissions Standards

BACKGROUND / DISCUSSION

At the April 2021 Regular Board meeting, the Board discussed the shift in the college entrance exam landscape over the past year. There were significant alterations to college admissions requirements nationwide during this period, with many institutions adopting either “test blind” or “test optional” policies.

The national movement away from college entrance exam scores in 2020 was primarily due to the limited or nonexistent capacity at testing sites in many high school students’ local areas due to the COVID-19 pandemic. For some institutions, such decisions were also hastened by a growing body of research suggesting scores on these exams predict family income and ethnicity as well or better than success in first-year college coursework.

In response to the COVID-19 pandemic, in June 2020, the Board approved a temporary waiver of Board Policy III.Q.4.a. (college entrance exam score as an Idaho public postsecondary minimum admissions requirement) for students seeking admission for the 2020-2021 academic year. This waiver will expire in June 2021.

IMPACT

Approval of the policy amendments will remove college entrance exam scores as an Idaho public postsecondary minimum admissions requirement for academic and career technical programs, incorporate relevant policy from Board Policy III.O into Board Policy III.Q, and repeal Board Policy III.O.

ATTACHMENTS

Attachment 1 – Board Policy III.Q. Admissions Standards – Second Reading
Attachment 2 – Board Policy III.O. Course Placement – Second Reading

STAFF COMMENTS AND RECOMMENDATIONS

No changes were made between the first and second readings of these policies. Board staff recommends approval.

BOARD ACTION

I move to approve the second reading of proposed amendments to Board Policy III.Q. Admission Standards as presented in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

AND

I move approve the second reading of Board Policy III.O. Course Placement, repealing the policy in its entirety as presented in Attachment 2.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: Q. Admission Standards **June ~~2017~~2021**

~~1. Coverage~~

~~The University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho and North Idaho College are included in this subsection. The College of Eastern Idaho, College of Southern Idaho, College of Western Idaho and North Idaho College are exempted from certain provisions of this admission policy whenwhere established in by their local boards of trustees.~~

~~2. Purposes~~

~~The purposes of the admission policies are toThis policy is intended to accomplish the following goals:~~

~~a. Promote institutional policies which meet or exceed minimum statewide standards for admission to higher education institutions;~~

~~b. Inform students of the academic and technical degree expectations of postsecondary level work;~~

~~c. Improve the quality of academic and technical degree preparation for postsecondary programs;~~

~~d. Enhance student access to academic and technical degree programs; and~~

~~e. Admit to postsecondary education institutions those students for whom there is a reasonable likelihood of success.~~

~~3~~1. Institution Policies

~~The college and universities~~Each postsecondary institution must establish institutional policies which meet or exceed the following minimum academic and career technical admission standards. Additional and more rigorous requirements also may be established by the ~~college and universities~~ institutions for admission to specific programs, departments, schools, or colleges ~~within the institutions~~. Consistent with institutional policies, admission decisions may be appealed by applicants to the institutional admissions committee.

~~4~~2. Academic ~~College and University~~Postsecondary Institution Program ~~Regular~~ Admission

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: Q. Admission Standards **June ~~2017~~2021**

a. Academic Program Regular Admission

Students attending an Idaho public school, or Idaho private school that has entered a Direct Admission participation agreement with the Board, may be notified of their admission to an Idaho public college or university through the State Board's Direct Admission Program. Admission awarded through the program is contingent ~~upon~~ on the verified level of achievement in high school curriculum ~~and performance on a college entrance exam,~~ and successful completion of ~~state~~Idaho high school graduation requirements.

An applicant who is not admitted under the Board's Direct Admission Program must ~~complete each of the minimum requirements listed below. International students and those seeking postsecondary career technical studies are exempt.~~

~~a. Submit scores received on the American College Test (ACT) or Scholastic Aptitude Test (SAT) and/or other standardized diagnostic tests as determined by the institution. These scores will be required of applicants graduating from high school in 1989 or later. Exceptions include applicants who have reached the age of 21. These applicants are subject to each institution's testing requirements; and~~

~~b. G~~graduate from a~~n~~ ~~accredited~~ high school accredited by a body recognized by the Board and complete the Admission Standards Core ~~c~~Courses ~~below~~ with a minimum 2.00 cumulative grade point average. Applicants who graduated from high school prior to 1989 will be subject to the admission standards at the time of their high school graduation. Each institution may develop a separate policy for the admissions and placement of ~~I~~international students~~ and those seeking postsecondary career technical education studies are exempt.~~.

Admission Standards Core Courses

Subject Area	Minimum Requirement	Select from These Subject Areas
Secondary Language Arts and Communication	8 credits	Composition, Literature, and Oral Communication

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: Q. Admission Standards **June ~~2017~~2021**

Mathematics	6 credits	A minimum of six (6) credits. ~~,~~ Secondary Mathematics includes Integrated Mathematics, Applied Mathematics, Business Mathematics, Algebra, Geometry, Trigonometry, Fundamentals of Calculus, Probability and Statistics, Discrete Mathematics, and courses in Mathematical Problem Solving and Quantitative Reasoning.~~including Applied Math I or Algebra I; Geometry or Applied Math II or III; and Algebra II~~. A total of 8 credits are strongly recommended. Four (4) of the required mathematics credits must be taken after 9th grade. Courses not identified by traditional titles, (i.e., Algebra I or Geometry), may be used as long as they contain all of the critical components of higher math functions~~)~~ prescribed by the State Mathematics ~~Achievement~~ Content Standards. Institutions may recognize other Mathematics courses as meeting this requirement if those courses are taken in compliance with the Idaho state minimum graduation requirements. ~~Other courses may include Probability, Discrete Math, Analytic Geometry, Calculus, Statistics, and Trigonometry. Four (4) of the required mathematics credits must be taken in the 10th, 11th, and 12th grade.~~
Social Studies	5 credits	American Government (state and local), Geography, U.S. History, and World History. Other courses may be selected from Economics, ~~(~~including Consumer Economics, if it~~s~~ aligns to the state content standards~~)~~, Psychology, and Sociology.
Science	6 credits	Secondary sciences include instruction in Applied Sciences, Earth and Space Sciences, Physical Sciences, and Life Sciences. ~~Anatomy, Biology, Chemistry, Earth Science, and Geology. Physiology, Physics, Physical Science, Zoology.~~ A maximum of two (2) credits may be derived from career technical science courses when courses are aligned to state career technical content standards, and/or Applied Biology, and/or Applied Chemistry. (Maximum of two (2) credits). Institutions may recognize other Science courses as meeting this requirement if those courses are taken in compliance with the Idaho state minimum graduation requirements. Must have laboratory science experience in at least two (2) credits. A laboratory science course is defined as one in which at least one (1) class period per week is devoted to providing students with the opportunity to manipulate equipment, materials, or specimens;

ATTACHMENT 1

		to develop skills in observation and analysis; and to discover, demonstrate, illustrate, or test scientific principles or concepts.
Arts and Humanities (including world languages)	2 credits	Humanities courses include instruction in Visual Arts, Music, Theatre, Dance, or World Language aligned to the Idaho content standards for those subjects. Other courses such as Literature, History, Philosophy, Architecture, or Comparative World Religions may satisfy the humanities standards if the course is aligned to the Interdisciplinary Humanities Content Standards.~~Literature, History, Philosophy, Fine Arts (if the course is aligned to the state arts and humanities content standards), and inter-disciplinary humanities (related study of two or more of the traditional humanities disciplines)~~. History courses beyond those required for state high school graduation may be counted toward this category. World Language is strongly recommended. The Native American Languages may meet the world language credit requirement
Other College Preparation	3 credits	Speech or Debate ~~(~~[no more than one (1) credit~~)~~]. Debate must be taught by a certified teacher. Studio/Performing Arts (art, dance, drama, and music). Foreign Language (beyond any foreign language credit applied in the Humanities/Foreign Language category). Secondary Career Technical ~~Education classes~~courses (no more than two (2) credits) in Agricultural Science and Technology; Business Technology Education; Computer Science Technology; Engineering; Family and Consumer Sciences; Marketing Technology Education; Technology Education~~Agricultural science and technology, business and office education, health occupations education, family and consumer sciences education, occupational family and consumer sciences education, technology education, marketing education, trade, industrial, and technical education~~, and individualized occupational training.

If ~~the high school~~ the student graduated from a high school that does not offer a required course, applicants may contact the institutional admission officer for clarification of provisional admission procedures.

High school credit counted in one (1) category (e.g., Humanities/World Languages) may not also count in another category.

~~5~~b. Academic ~~College and University~~ Provisional Admission

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: Q. Admission Standards **June ~~2017~~2021**

i. A degree-seeking applicant who does not qualify for admission based on subsection 4.~~b~~a. above, but who satisfies one (1) of the criteria below, may seek provisional admission by petitioning the institutional admissions~~ director~~ officer ~~.~~:

1) ~~i.~~ Graduated from a~~n~~ ~~accredited~~ secondary school accredited by a body recognized by the Board but has not completed the Admission Standards Core courses set forth above;

~~ii.~~2) Did not graduate from a~~n~~ ~~accredited~~ secondary school accredited by a body recognized by the Board, including home schooled students, and has acceptable performance on either the General Educational Development (GED) ~~T~~test or another standardized diagnostic test~~s~~ ~~such~~ accepted by the institution~~s.~~;

~~iii.~~3) Deserves ~~special~~ consideration by the institution because of special status~~,~~ (e.g., disadvantaged or minority students, delayed entry students, returning veterans, or gifted and talented students wishing to enter college early).

A student seeking provisional admission to any public postsecondary institution must take at least ~~two~~one (~~2~~1) ~~testing~~ assessment indicator~~s~~ that will allow the institution to assess competency and placement.~~, one (1) of which must be the ACT or SAT. ACT or SAT scores must be submitted prior to enrollment.~~

ii~~b~~. If provisionally admitted, a student will enroll with provisional standing and is subject to the institutional grade retention. A provisionally admitted student may change to regular admission status upon satisfactory completion of fourteen (14) baccalaureate level credits, twelve (12) of which must be general education courses. Regular admission status must be attained within three (3) registration periods or the student will be dismissed, subject to institutional committee appeal procedures.

~~6. Advanced Opportunities~~

~~Secondary students who wish to participate in the Advanced Opportunities program outlined in Board Policy Section III.Y. Advanced opportunities, must follow the procedures outlined in Board Policy III.Y Advanced Opportunities.~~

~~7~~c.~~.~~ Academic Transfer Admission

ATTACHMENT 1

i~~a~~. A degree-seeking student who, after graduating from high school or earning a GED, has earned at least fourteen (14) or more semester hours of transferable academic college level credit from a regionally accredited college or university with a minimum cumulative GPA of 2.00 may be admitted.

ii~~b~~. A student not meeting the requirement in subsection ~~7~~6.a. may petition the institutional admissions ~~director~~officer to be admitted. If admitted, the student must enroll on probation status, meet all conditions imposed by the institutional admissions committee, and complete the first semester with a minimum 2.00 GPA, or may be dismissed.

d~~8~~. Academic Program Placement

Placement assessment indicating potential for success may be required for some academic programs. Placement requirements vary according to the program. Each institution shall establish academic program placement policies and publish these policies in an accessible manner on the institution's website.

3~~8~~. Career Technical ~~Education~~ Program Admissions

a. Admission Standards

Regular or Provisional admission standards apply to individuals who seek a technical certificate or Associate of Applied Science (A.A.S.) degree through a career technical program. The admission standards and placement criteria do not apply to workforce development or short-term training programs. Career technical programs employ program admission processes in addition to institutional program admission.

~~Placement Tests~~

~~Placement test scores indicating potential for success are generally required for enrollment in a career technical program of choice. Placement score requirements vary according to the prograc. Idaho Technical College System~~

~~The career technical education programs are offered at the following locations:~~

~~Region I Coeur d'Alene, North Idaho College~~
~~Region II Lewiston, Lewis-Clark State College~~

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: Q. Admission Standards **June ~~2017~~2021**

~~Region III Nampa, College of Western Idaho~~
~~Region IV Twin Falls, College of Southern Idaho~~
~~Region V Pocatello, Idaho State University~~
~~Region VI Idaho Falls, College of Eastern Idaho~~

~~d.~~b. Student Advising

i. Clarify the importance of career planning and preparation: high school students should be actively engaged in career planning prior to entering the 9th grade. Career planning assures that students have sufficient information about self and work requirements to adequately design an education program to reach their career goals.

ii. Emphasize that career technical courses in high school, including career technical advanced opportunities and work-based learning connected to school-based learning, are beneficial to students seeking continued education in career technical programs at the postsecondary level.

iii. Clarify the kind of educational preparation necessary to successfully enter and complete postsecondary studies. Mathematics and science are essential for successful performance in many career technical programs. Programs of a technical nature generally require greater preparation in applied mathematics and laboratory sciences.

iv. Clarify that career technical programs of one or two years in length may require additional time if applicants lack sufficient educational preparation.

~~e~~c. Career Technical Program Regular Admission

Students desiring Regular Admission to any of Idaho's technical colleges must meet the following standards. Students planning to enroll in programs of a technical nature are also strongly encouraged to complete the recommended courses. Admission to a specific career technical program is based on the capacity of the program and specific academic and/or physical requirements established by the technical college/program.

i. Standards for students who graduated from high school in 1997 or earlier

ATTACHMENT 1

1) High School diploma with a minimum 2.0 GPA[1] from a high school accredited by a body recognized by the Board; and

2) Placement examination[2] ~~(ACT, SAT or other diagnostic/placement tests~~ as determined by the institution. Scores may also be used to determine placement eligibility for specific career technical programs~~.)~~; and

3) Satisfactory completion of high school coursework that includes at least the following:

   a) Mathematics -- 4 credits (6 credits recommended) from challenging math sequences of increasing rigor selected from courses such as Algebra I, Geometry, Applied Math I, II, and III, Algebra II, Trigonometry, Discrete Math, Statistics, and other higher level math courses. Two (2) mathematics credits must be taken in the 11th or 12th grade. Less rigorous mathematics courses taken in grades 10-12 after 1998, such as pre-algebra, review mathematics, and remedial mathematics, shall not be counted.

   b) Science -- 4 credits (6 credits recommended, with 4 credits in laboratory science) including at least 2 credits of laboratory science from challenging science courses including applied biology/chemistry, principles of technology (applied physics), anatomy, biology, earth science, geology, physiology, physical science, zoology, physics, chemistry, and agricultural science and technology courses (500 level and above).

   c) Secondary Language Arts and Communication -- 8 credits. Applied English in the Workplace may be counted for English credit.

   d) Other -- Career technical courses, including postsecondary credits earned pursuant to Board Policy III.Y. Advanced Opportunities and organized work-based learning experiences connected to the school-

[1]An institution may substitute a composite index placement exam score and high school GPA for the GPA admission requirement.

[2]~~If accommodations are required to take the placement exam(s) because of a disability, please contact the College to which you are interested in applying.~~

ATTACHMENT 1

based curriculum, are strongly recommended. High School Work Release time not connected to the school-based curriculum will not be considered.

ii. Standards for Others Seeking Regular Career Technical Program Admission

Individuals who graduated from high school, received their GED prior to 1997, or who are at least 21 years old and who desire Regular Admission to the technical colleges must have a:

1) High School diploma with a minimum 2.0 GPA from a high school accredited by a body recognized by the Board; or

2) General Educational Development (GED) certificate[3]; and

3) ~~ACT, SAT or other d~~Diagnostic/placement tests as determined by the institution~~s~~. Scores may also be used to determine admission eligibility for specific career technical programs.

~~9~~.d. Career Technical Program Provisional Admission

Students who do not meet all requirements for ~~r~~Regular ~~a~~Admission may apply to a technical program under provisional admission. Provisionally admitted students who are conditionally admitted must ~~successfully~~ complete appropriate remedial, general and/or technical education coursework related to the career technical program for which ~~r~~Regular ~~a~~Admission status is desired, and to demonstrate competence with respect to that program through methods and procedures established by the technical college. Students desiring Provisional Admission must ~~have a~~ meet the following standards:

i. High School diploma or GED certificate~~3~~; and
ii. ~~ACT, SAT or other~~ diagnostic/placement tests as determined by the institution~~s~~. Scores may also be used to determine placement eligibility for specific career technical programs.~~)~~

[3]~~Certain i~~Institutions may ~~allow individuals who do not have a high school diploma or GED to be admitted if they~~ applicant ~~can demonstrate the necessary ability to succeed in a~~ career ~~technical program through appropriate tests or experiences~~ as ~~determined by the institution.~~

ATTACHMENT 1

iii. Institutions may allow individuals who do not have a high school diploma or GED to be admitted if the applicant can demonstrate the necessary ability to succeed in a career technical program through appropriate tests or experiences as determined by the institution.

~~10~~e. Career Technical Program Placement Criteria~~: Procedures for placement into specific career technical programs~~

Placement test scores indicating potential for success are generally required for enrollment in a career technical program of choice. Placement score requirements vary according to the program.

Each institution shall establish career technical program placement policies and publish these policies in an accessible manner on the institution's website.

Specific career technical programs may require different levels of academic competency and admission requirements. Students must also be familiar with the demands of a particular occupation and how that occupation matches individual career interests and goals. Therefore, before students can enroll in a specific program, the following placement requirements must be satisfied:

i. ~~a.~~ Specific program requirements (including placement exam scores) established by the technical program. A student who does not meet the established requirements for the program of choice will have the opportunity to participate in remedial education to improve their skills; and

ii. Formal procedures and definitions for program admission employed by the technical college. Program admission requirements and procedures ~~are~~shall be clearly defined and published for each program.

ATTACHMENT 2

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: O. Course Placement ~~October 2016~~June 2021

~~1. Coverage~~

~~University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho, and North Idaho College are included in this subsection, herein referenced as "institution."~~

~~2. Academic College and University Course Placement~~

~~a. Each institution shall submit their academic course placement policies to the Office of the State Board of Education for publication in a single online location.~~

~~b.~~a. ~~Any amendments made to an institution's academic course placement policy must immediately be submitted to the Office of the State Board of Education for updating the published policy.~~

SUBJECT

Board Policy III.U. Instructional Material Access and Affordability – Second Reading

REFERENCE

April 2018	Board received an update on an Open Educational Resources (OER) initiative.
June 2018	Board discussed system-wide access and affordability strategies including OER and requested an inventory and implementation timeline be provided at the October 2018 Board meeting.
August 2018	Board approved a line item request for OER funding.
December 2018	The Board was provided with a timeline and inventory update regarding OER and the total number of course sections delivered exclusively with OER throughout Idaho colleges and universities.
April 2019	The Board was provided with an inventory of common indexed courses for which funding will be focused for OER adoption.
August 2019	The Board approved the first reading of proposed new Board Policy III.U. Textbook and Instructional Material Affordability.
October 2019	The Board approved the second reading of proposed new Board Policy III.U. Textbook and Instructional Material Affordability.
February 2021	The Board temporarily waived the implementation deadline for Board Policy III.U.
April 2021	The Board approved the first reading of proposed amendments to Board Policy III.U. Textbook and Instructional Material Affordability.

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.U.

BACKGROUND/DISCUSSION

In response to concerns about Board Policy III.U. from faculty and administrators in Idaho's public higher education institutions, the Board Office established a Working Group comprising faculty and academic leaders from all eight public institutions to amend the policy. This Working Group met several times to develop a new version of the policy that more precisely defines the scope, relevance, and expectations for improving instructional material access and affordability while also addressing the concerns raised by the academic community mentioned above.

IMPACT

Approval of the new version of the policy will provide Idaho colleges and universities with guidance for ensuring that all students have reliable low- or no-cost access to instructional materials. The new version of the policy also sets expectations for goal-oriented, institution-supported, and measurable access and affordability initiatives at our institutions.

ATTACHMENTS

Attachment 1 – Board Policy III.U. Instructional Material Access and Affordability – Second Reading

STAFF COMMENTS AND RECOMMENDATIONS

There were no changes between the first and second readings of this policy. Board staff recommends approval.

BOARD ACTION

I move to approve the second reading of Board Policy III.U. Instructional Material Access and Affordability, as submitted in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: U. Instructional Material Access and Affordability **June 2021**

1. Definitions

   a. "Automatic charge" is an additional course fee automatically charged to a student by an institution or entity authorized by the institution for the purpose of providing access to instructional materials. Special course fees as defined in Board policy V.R. are not considered automatic charges for instructional materials

   b. "Course marking" is the act of assigning specific attributes (e.g., letters, numbers, graphic symbols, colors, etc.) to course sections that help students quickly identify important information and make informed decisions at time of registration.

   c. "Instructional materials" are print or digital media used to support access to knowledge. Books, articles, lab manuals, study guides, software, subscriptions, modules, multimedia, assessments, assignments, courseware, and full courses are common examples of instructional materials.

   d. "Cost" is the consistent total list price for the faculty-preferred format of all required instructional materials in a single course or course section for one term and shall be qualified as follows:

      i. "Zero cost" means a total list price of $0.
      ii. "Very low cost" means a total list price of $1-$30.
      iii. "Low cost" means a total list price of $31-$50.
      iv. "Mid cost" means a total list price of $51-$100.
      v. "High cost" means a total list price of more than $100.

   e. "Open Education Resources (OER)" are teaching, learning, and research materials that reside in the public domain or have been released under an intellectual property license, such as a Creative Commons license, that permits free use and repurposing by others.

2. Institution Plans for Instructional Material Access and Affordability

   a. Each institution shall develop and implement a plan to increase access and affordability of instructional materials for all students.

   Plans shall include the following elements:

ATTACHMENT 1

i. Resources and support to help faculty ensure all instructional materials are relevant and accessible for all students, especially students who require learning accommodations or additional modes of delivery (e.g. a print version of a digital textbook, internet access, etc.).
ii. Policies and/or strategies that minimize the cost of instructional materials for students while maintaining the quality of education, the academic freedom and responsibility of faculty and students, and the recognition that the average cost of instructional materials is higher in certain disciplines, and some disciplines require higher cost materials which are used over multiple terms or throughout an entire program.
iii. Professional development opportunities for faculty and staff related to the discovery, adoption, and use of OER and other affordable instructional materials.
iv. Strategies to support faculty adoption, adaption, and/or use of OER and other affordable instructional materials.
v. Programs, incentive structures, or other strategies to encourage and support faculty to publicly share OER developed for their own courses.
vi. Course marking processes at the time of course schedule releases that indicate the cost of instructional materials in course sections that are reliably zero cost or very low cost, as defined in this policy.
vii. Course marking processes at the time of course schedule releases that indicate course sections that reliably require the purchase of, including an automatic charge for, any access codes for instructional materials.
viii. Strategies with measurable goals for improving and using readily available and relevant OER or other very low cost instructional materials in common-indexed courses (as articulated in Board Policy III.N.6.b.), including dual credit courses.

b. Plans may include the following elements:

i. Course marking that indicates the cost of instructional materials in course sections at time of registration that are low cost, mid cost, and/or high cost, as defined in this policy.
ii. Strategies with measurable goals for improving and using readily available and relevant OER or other affordable instructional materials in non-common-indexed courses.
iii. Policies or procedures that encourage faculty to be intentional in selection and use of instructional materials, including ongoing review and reconsideration of required materials.
iv. Inclusion of efforts to increase access and affordability of instructional materials as part of tenure and promotion processes.
v. Other elements as determined by the institution.

ATTACHMENT 1

c. Institutions shall submit their initial plans to the Board Office for review and feedback by June 1, 2022. Institutions shall regularly review and update their plans as needed.

d. Institutions shall submit to the Board Office a report on the implementation and outcomes of their plans annually. The format and requirements of this annual report shall be determined by the Executive Director or designee.

UNIVERSITY OF IDAHO

SUBJECT

Master of Science in Cybersecurity

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.G.

BACKGROUND/DISCUSSION

University of Idaho (U of I) proposes to create a new Master of Science (M.S.) in Cybersecurity to be offered in Moscow, Coeur d'Alene, and Idaho Falls. U of I has offered a variety of cybersecurity courses as technical electives through the Department of Computer Science since 1991. This degree will be focused on advanced cybersecurity concepts, building on the content of the existing undergraduate cybersecurity degree. Currently, undergraduate degrees in cybersecurity are not common. The proposed M.S. in Cybersecurity includes a 'leveling' course to support students who have a related but non-cybersecurity degree.

In 1999 the University of Idaho was designated a National Center of Academic Excellence (CAE) in Information Assurance Education by the National Security Agency (at the time, Information Assurance was the U.S. Government term for Cybersecurity). U of I was one of the first seven universities in the nation to receive this designation, and the institution has maintained it every renewal cycle.

The M.S. in Cybersecurity meets CAE certification standards that require precise course content and a dedicated degree path forward for Cybersecurity students. We expect it to also receive accreditation through Accreditation Board for Engineering and Technology (ABET), the Engineering accreditation organization. It also complies with standards adopted by the U.S. Government's National Institute of Standards and Technology Cybersecurity Workforce Framework – a catalog of job duties along with knowledge, skills and abilities for those jobs, for a wide range of cybersecurity careers.

IMPACT

The proposed M.S. in Cybersecurity degree program contributes to the statewide cybersecurity initiative by offering a second graduate program with a different focus than the recently approved M.S. Cybersecurity program at BSU. The two programs are only duplicative in name, not in content or learning outcomes. The U of I program is research based, focuses on computer science and software engineering, and provides the groundwork for postgraduate, research-focused studies in cybersecurity. This program will lead to new knowledge about this industry and positions Idaho to be a focal point for cybersecurity advancement. It supports the collaboration between Idaho's higher education institutions to meet the growing workforce demand for cybersecurity expertise and related fields. The U of I is committed to growing the cybersecurity partnership with the Idaho National

Laboratory and developing a variety of degree offerings to meet a variety of cybersecurity workforce demands. Data from EMSI predicts a 30.4% increase in jobs (510 jobs) in Idaho through 2029 and a 27.8% increase nationally. In our 16-county region, job growth is expected to increase 26.0% (134 jobs) through 2029.

U of I anticipates adding a cybersecurity seminar course, which will be covered by existing resources and faculty. The university provides that many of the courses required for the program are currently being taught as computer science (CS) courses. U of I will convert those to become cybersecurity (CYB) courses or cross-list them as CS/CYB courses. Existing faculty will shift some of their teaching duties from existing CS courses to the equivalent CS/CYB courses. U of I does not anticipate significant changes to the courses available to CS students. Students will be assessed lab fees to support client computers, used by students in the lab courses. The exact fee will be dependent upon estimated enrollment and will be amortized over three years. U of I anticipates the cost per student per year will range from $75 - $150 per credit over the next three fiscal years. Financial impact ranges from $6,654 - $14,154 over a four-year period for operating expenditures and equipment.

ATTACHMENTS

Attachment 1 – M.S. Cybersecurity Program Proposal
Attachment 2 – U of I Cybersecurity Degree Programs

BOARD STAFF COMMENTS AND RECOMMENDATIONS

University of Idaho anticipates eight enrollments initially and projects that the program will reach 20 students by the fifth year, graduating approximately 6-10 students per year once the program is up and running. If the program does not reach sustained enrollments of 12 full-time students, the university will sunset the program.

U of I's request to offer an M.S. in Cybersecurity is consistent with their Service Region Program Responsibilities and their current institution plan for Delivery of Academic Programs in Regions I, II, and IV. In accordance with Board Policy III.Z., no institution has the statewide program responsibility specifically for cybersecurity programs.

The following represents related programs processed or approved by the Board or Executive Director consistent with Board Policy III.G since Fall 2020:

Instit.	Title	Degree/Certificate	Implementation Date
BSU	Cyber-Physical Systems Security for All	Undergraduate Certificate	8/3/2020
BSU	Cyber Operations	Undergraduate Certificate	8/3/2020
BSU	Cybersecurity	Graduate Certificate	8/3/2020
BSU	Institute for Pervasive Cybersecurity	N/A	12/21/2020
BSU	Cyber Operations and Resilience	Master of Science	8/2/2021
BSU	Cyber Operations and Resilience	Bachelor of Science	8/2/2021
BSU	Cybersecurity	Master of Science	8/2/2021

Instit.	Title	Degree/Certificate	Implementation Date
CSI	Introduction to Cybersecurity	Basic Technical Certificate	8/10/2020
ISU	Cyber-Physical Systems Engineering Technology	Bachelor of Applied Science	8/10/2020
ISU	Computer Science Cybersecurity	Undergraduate Certificate	8/10/2021
ISU	Secure Cyber Operations	Graduate Certificate	8/10/2021
UI	Cybersecurity	Bachelor of Science	8/16/2021

The proposed M.S. in Cybersecurity differs from Boise State University's recently approved Master's level program in Cybersecurity in that the U of I's program will be a research based program consisting of a thesis and a non-thesis option. The program will build from the university's existing Bachelor of Science in Cybersecurity, which was approved in April 2020, and will be offered in Moscow, Coeur d'Alene, and Idaho Falls. Boise State University's M.S. in Cybersecurity is an interdisciplinary program consisting of three specific emphases in Computer Science, Cryptanalysis and Signals Analysis, and Management and will be offered in Boise.

Based on the proposal submitted, the proposed program was designed to be in compliance with criteria, knowledge, and skills as provided in the Center of Academic Excellence in Cyber-Defense (CAE-CD) denomination by the U.S. National Security Agency and the U.S. Department of Homeland Security. As provided in the program proposal, Idaho has two denomination institutions: University of Idaho and Idaho State University. Based on this denomination status, the university provides there are no programs similar to the proposed degree with significant coverage of Cybersecurity knowledge and skills as provided in the CAE-CD criteria.

Other programs include: University of Idaho - M.S. in Computer Science and Graduate Certificate in Secure and Dependable Computing Systems; Boise State University - M.S. in Computer Science, Ph.D. in Computing with an emphasis in Cybersecurity, and Graduate Certificate in Computer Science. Additionally, Boise State will offer an M.S. in Cyber Operations and Resilience, M.S. in Cybersecurity, and a Certificate in Cryptography and Cryptanalysis, beginning fall 2021.

U of I indicates that Idaho State University, as a CAE-CD denomination institution, offers degrees with significant cybersecurity content, knowledge, and skills in either Bachelor of Science or Associate of Applied Science degrees. ISU currently offers an M.S. in Computer Science with Data Analysis and Science emphases, and an Associate of Applied Science and an Intermediate Technical Certificate in Industrial Cybersecurity Engineering Technology.

The proposal completed the program review process and was presented to the Council on Academic Affairs and Programs on April 1, 2021; and to the Instruction, Research, and Student Affairs on June 1, 2021. Staff recommends approval and notes that this new program at UI could be a meaningful contribution to ongoing statewide cybersecurity efforts.

BOARD ACTION

I move to approve the request by University of Idaho to create a Master of Science in Cybersecurity, as presented in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

Institutional Tracking No. ____________

Idaho State Board of Education

Proposal for **Undergraduate/Graduate Degree** Program

Date of Proposal Submission:	February 2020
Institution Submitting Proposal:	University of Idaho
Name of College, School, or Division:	College of Engineering
Name of Department(s) or Area(s):	Computer Science

Program Identification for Proposed New or Modified Program:

Program Title:	Cybersecurity					
Degree:	MS	Degree Designation		Undergraduate	X	Graduate
Indicate if Online Program:						
CIP code (consult IR /Registrar):	**11.1003 Computer and Info. Systems Security/Information Assurance.**					
Proposed Starting Date:	Summer 2021					
Geographical Delivery:	Location(s)	Moscow, CdA, Idaho Falls	Region(s)	I, II, IV		
Indicate (X) if the program is/has:		Self-Support		Professional Fee		Online Program Fee
Indicate (X) if the program is:	X	Regional Responsibility		Statewide Responsibility		

Indicate whether this request is either of the following:

	New Graduate Certificate (30 credits or more)		Expansion of Existing Program
	New Undergraduate Certificate (30+ cr.)		Consolidation of Existing Program
X	New Graduate Program		New Off-Campus Instructional Program
	New Undergraduate Program		Other

Revised 10/27/17
Page 1

Approval Signatures:

John Crepeau	9 March 2020		
College Dean (Institution)	Date	Vice President for Research	Date
	4-5-2021		5-3-21
Graduate Dean or other official	Date	Academic Affairs Program Manager, OSBE	Date
			5/3/21
FVP/Chief Fiscal Officer (Institution)	Date	Chief Academic Officer, OSBE	Date
Torrey Lawrence		Todd J. Kilburn	5/3/21
Provost/VP for Instruction (Institution)	Date	Chief Financial Officer, OSBE	Date
President	Date	SBOE/Executive Director Approval	Date

Revised 10/27/17
Page 2

Before completing this form, refer to Board Policy Section III.G., Postsecondary Program Approval and Discontinuance. This proposal form must be completed for the creation of each new program. All questions must be answered.

Rationale for Creation or Modification of the Program

1. **Describe the request and give an overview of the changes that will result.** *Will this program be related or tied to other programs on campus? Identify any existing program that this program will replace.*

   Since 1991, the Department of Computer Science has offered a variety of Cyber Security courses as technical electives in our undergraduate degree program. In 1999 the University of Idaho was designated a National Center of Academic Excellence (CAE) in Information Assurance Education by the National Security Agency (at the time, Information Assurance was the US Government term for Cybersecurity). We were one of the first seven universities in the nation to receive this designation, and we have maintained it every renewal cycle.

   In the past few years, the CAE certification process has become more prescriptive, requiring more precise course content and a dedicated degree path forward for Cybersecurity students. ABET (the Engineering accreditation board) now accredits cybersecurity degree programs. Also, the US Government has adopted the NIST Cybersecurity Workforce Framework – a catalog of job duties along with knowledge, skills and abilities for those jobs, for a wide range of cybersecurity careers.

   This growth of standardized program content, along with the tremendous growth in job opportunities for our graduates, has led to the conclusion that we need to establish dedicated degree paths in cybersecurity. This degree will be focused on advanced cybersecurity concepts, building on the content of an undergraduate cybersecurity degree. Because currently undergraduate degrees in cybersecurity are rare, we are including a 'leveling' course in the program for students with a related, but non-cybersecurity degree.

2. **Need for the Program**. *Describe the student, regional, and statewide needs that will be addressed by this proposal and address the ways in which the proposed program will meet those needs.*

   a) **Workforce need:** *Provide verification of state workforce needs that will be met by this program. Include State and National Department of Labor research on employment potential. Using the chart below, indicate the total projected annual job openings (including growth and replacement demands in your regional area, the state, and nation. Job openings should represent positions which require graduation from a program such as the one proposed. Data should be derived from a source that can be validated and must be no more than two years old.*

      List the job titles for which this degree is relevant.

      The following are US Department of Labor (DOL) Occupation Titles requiring cybersecurity skills:

      1. *Information Security Analysts* – This is the DOL Job title for the following specialized cybersecurity work roles:
         a. System Security Analyst
         b. Cyber Defense Analyst
         c. Cyber Defense Infrastructure Support Specialist

d. Vulnerability Assessment Analyst
e. Cyber Defense Forensics Analyst

2. *Network Operations Specialist*
3. *Software Developer*
4. *System Administrator*
5. *Technical Support Specialist*

	State DOL data	Federal DOL data	Other data source: (describe)
Local (Service Area)			EMSI Study (see below).
State		520 in 2016 + 150 by 2026	http://www.projectionscentral.com/Projections/LongTerm
Nation		100,000 in 2016 +28,500 by 2026	

Provide (as appropriate) additional narrative as to the workforce needs that will be met by the proposed program.

Our Emsi analysis predicts a 30.4% increase in jobs (510 jobs) in Idaho through 2029 and a 27.8% increase nationally. In our 16-county region, job growth is expected to increase 26.0% (134 jobs) through 2029.

b) **Student need.** What is the most likely source of students who will be expected to enroll (full-time, part-time, outreach, etc.). Document student demand by providing information you have about student interest in the proposed program from inside and outside the institution. If a survey was used, please attach a copy of the survey instrument with a summary of results as **Appendix A.**

We have had regular enrollments in our cybersecurity courses over the past several years, from current computer science students at both the undergraduate and master's level. Most have indicated an interest in focusing their studies in cybersecurity but are not able to due to the demands of the current computer science undergraduate degree program.

Table 1: Past enrollments in the CS courses that have cybersecurity as the focus (undergraduate/ graduate). The graduate level courses will become part of the core of the new cybersecurity program.

Course	AY 16-17	AY 17-18	AY 18-19	Fall 2019
CS 336 (Intro course)	19	24	14	24
CS 439/539 (Applied Security)	10/4	9/10		2/3
CS 437/537 (Computer Forensics)	1/21		5/32	
CS 438 Network Security		5/10	8/16	
Security Special Topics			0/11	/11

In addition to internal demand, we expect to see increases in new student enrollment due to the strong growth of cybersecurity jobs in the region, state, and nationally.

c) **Economic Need**: *Describe how the proposed program will act to stimulate the state* *economy by advancing the field, providing research results, etc.*

Studies have shown that there is a major unmet need for cybersecurity professionals. These professionals help businesses protect their assets from cyber criminals. Untrained individuals spend more time and effort, and therefore more corporate resources, developing less than ideal solutions. A trained cybersecurity professional will be able to get the work done with less effort and fewer resources. Furthermore, our economy and critical infrastructures are today very dependent on digital and computer-based systems. Adequately protecting such systems is of paramount and essential importance, and a likely a prerequisite, for a healthy economy in the State of Idaho and the Nation.

d) **Societal Need**: *Describe additional societal benefits and cultural benefits of the program.*

There is a great need for cybersecurity expertise across all businesses and government sectors. Whether it be in the area of e-commerce, web applications, mobile apps, business, military, health, agriculture, critical infrastructures, or processing big data, there is a need to protect information systems and individual privacy, and to ensure the integrity of our systems. A look at the news every week brings about reports of cybersecurity breaches and loss of private information, financial loss, or the potential for disruption of critical infrastructure.

Cybersecurity experts agree that many of these problems could be fixed if a wider portion of the workforce was aware of best-practice cybersecurity technologies and processes. At the same time, these experts agree that we need to constantly improve these technologies and processes given the advances made by cyber criminals and the constant deployment of new connected technologies which introduce new attack surfaces and vulnerabilities.

e) **If Associate's degree, transferability**:

3. **Similar Programs.** *Identify similar programs offered within Idaho and in the region by other in-state or bordering state colleges/universities.*

The proposed *Masters of Science in Cybersecurity* degree was designed from the ground-up to be exceedingly compliant with the criteria, knowledge, and skills detailed in the Center of Academic Excellence in Cyber-Defense (CAE-CD) denomination by the U.S. National Security Agency and the U.S. Department of Homeland Security.

Source: (https://www.iad.gov/NIETP/documents/Requirements/CAE_CDE_criteria.pdf)

Under the Center of Academic Excellence in Cyber-Defense criteria, institutions offering compliant cybersecurity-focused 2-year degrees are denominated as CAE-2Y, and institutions offering compliant Bachelor-level or Graduate-level cybersecurity-focused degrees are denominated CAE-CD (these can be minors, certifications, or emphasis options within a degree). The table below shows the number of CAE-CD and CAE-2Y denominated institutions in Idaho and its neighboring states of Montana, Nevada, Oregon, Utah, and Washington. The state of Wyoming appears to have no CAE-CD nor CAE-2Y denominated educational institutions.

Source: https://www.iad.gov/NIETP/reports/cae_designated_institutions.cfm (2019-09-09)

Count of Education Institutions with CAE Designation Per State

State	CAE-2Y	CAE-CD	CAE-R	Total
Idaho	1	2		3
Montana	2			2
Nevada	1	1		2
Oregon	2			2
Utah		2		2
Washington	5	2	1	8
Total	**11**	**7**	**1**	**19**

Idaho Public Institutions: Four-year and Graduate:

There are currently two Center of Academic Excellence in Cyber-Defense (CAE-CD) denominated institutions in Idaho: The *University of Idaho* and *Idaho State University*. Source: https://www.iad.gov/NIETP/reports/cae_designated_institutions.cfm

The following table lists programs that we believe to be similar and are being offered by public colleges or universities in Idaho. In this case our definition of similar is that the program is:

a) Offered by an institution also denominated as a Center of Academic Excellence in Cyber-Defense (CAE-CD) and
b) The degree is a Bachelor of Science degree with significant coverage of Cybersecurity knowledge and skills.

Under such definition, and to the best of our knowledge, there are no programs, significantly similar to the degree being proposed that are currently offered at other public educational institutions in Idaho.

Similar Programs offered by Idaho public institutions (list the proposed program as well)		
Institution Name	**Degree name and Level**	**Program Name and brief description if warranted**
University of Idaho	**Graduate Certificate in Secure and Dependable Computing Systems**	**This is part of the MS in CS program.**

University of Idaho:

Related degrees and certificates offered by the University of Idaho are listed below.

- Graduate Academic Certificate in Secure and Dependable Systems.
- Sources: https://www.uidaho.edu/degree-finder/a-z-index
  https://www.uidaho.edu/academics/dee/programs-courses/certificates

The University of Idaho also offers a *Bachelor of Science in Computer Science* degree and a recently approved *Undergraduate Certificate in Cybersecurity*. Students that complete the B.S. in Computer Science degree plus the UG Certificate in Cybersecurity have gained a set of knowledge and skills satisfactorily compliant with the CAE-CD knowledge and skills criteria. Based on such degree and emphasis area, the University of Idaho is currently denominated a CAE-CD until 2021. It is important to note that such denomination was evaluated under the previous and less comprehensive knowledge and skills CAE-CD criteria. Other related degrees at the University of Idaho are graduate level degrees and certificates. A proposal for a

B.S. in Cybersecurity is currently under review by the SBOE.

Boise State University:
To the best of our knowledge the degrees and certificates listed below may offer coverage of Cybersecurity-related knowledge and skills within some of the required and elective courses and with varying degrees of coverage.

- Master of Science in Computer Science.
- Doctor of Philosophy in Computing, Cybersecurity emphasis
- Graduate Certificate in Computer Science.
- Sources: https://majors.boisestate.edu/computer-science
  https://majors.boisestate.edu/information-technology-management
  https://coen.boisestate.edu/cs/undergraduates/minor-cybersecurity

Beginning Fall 2021, Boise State University will offer an MS in Cyber Operations & Resilience; MS in Cybersecurity and a Certificate in Cryptography and Cryptanalysis.

Idaho State University:

The degrees offered by ISU that we believe may include significant Cybersecurity knowledge and skills are listed below. Idaho State University is a Center of Academic Excellence in Cyber-Defense (CAE-CD) denominated institution. Given this information, it appears that the degrees offered at ISU that include significant coverage of Cybersecurity content, knowledge, and skills appear to be either Bachelor of Business Administration or Associate of Applied Science degrees, neither of which is a graduate program.

- Master of Science in Computer Science: Data Analysis Emphasis.
- Master of Science in Computer Science: Science Emphasis.
- Intermediate Technical Certificate on Industrial Cybersecurity Engineering Technology.
- Sources: http://coursecat.isu.edu/undergraduate/programs/
  http://coursecat.isu.edu/graduate/programs/
  https://www.isu.edu/cyberphysicalsecurity/

Idaho Public Institutions: Two-year:

The degree proposed in this form is a Master of Science degree. Hence, we are not considering 2-year Associate programs as significantly similar to the degree proposed in this form even if such degrees may appear to have partial knowledge and skills overlap.

Similar Programs offered by other Idaho institutions and by institutions in nearby states		
Institution Name	**Degree name and Level**	**Program Name and brief description if warranted**
University of Washington, Bothell (Bothell, Washington).	M.S. in Cybersecurity Engineering.	M.S. in Cybersecurity Engineering: (https://www.uwb.edu/cybersecurity)

4. **Justification for Duplication with another institution listed above.** (if applicable). *If the*

Revised 10/27/17
Page 7

proposed program is similar to another program offered by an Idaho public institution, provide a rationale as to why any resulting duplication is a net benefit to the state and its citizens. Describe why it is not feasible for existing programs at other institutions to fulfill the need for the proposed program. There is no similar Master of Science in Cybersecurity program in Idaho. The proposed program will have a specific designation and will be aligned with criteria provided in the CAE-CD. The focus will be on advanced cybersecurity concepts, building on content of the undergraduate cybersecurity degree. Boise State will begin offering an MS in Cybersecurity in Fall 2021. This program will consist of three specific emphases and focus on: Computer Science, Cryptanalysis, and Signals, Analysis and Management.

5. **Describe how this request supports the institution's vision and/or strategic plan.**

The University Vision: "The University of Idaho will expand the institution's intellectual and economic impact and make higher education relevant and accessible to qualified students of all backgrounds."

Our strategic plan focuses on an *Engaged Learning Community* supported by *Scholarly and Creative Activity with National and International Impact*.

Cybersecurity has becoming an increasingly important part of day-to-day life, government, and business. It is no longer just the province of the government and banking but touches more and more aspects of our lives.

Our past research and teaching activities have had national and international impact but have primarily focused on technical aspects of cybersecurity. Branching out our core cybersecurity expertise from a subset of computer science to a full, independent degree program will enable us to expand our students' understanding of cybersecurity not only from the technical point of view, but also include societal and business aspects of cyber security. These include issues such as privacy, ethical hacking, and business continuity planning. The full breadth of this education will provide our students with a richer education and make them better able to serve their communities as the needs of cybersecurity continue to grow and expand.

6. **Assurance of Quality.** *Describe how the institution will ensure the quality of the program. Describe the institutional process of program review. Where appropriate, describe applicable specialized accreditation and explain why you do or do not plan to seek accreditation.*

The Department of Computer Science and the College of Engineering will conduct annual internal assessment of the program, reviewing attainment of student outcomes for each course as well as program outcomes. We will use the process we use for continual assessment and improvement as recommended by national accreditation organizations.

The University of Idaho plans to continue certification as a Center of Academic Excellence in Information Assurance Education (in the area of Cyber Defense) through the NSA/DHS sponsored CAE program.

7. **In accordance with Board Policy III.G., an external peer review is required for any new doctoral program.** Attach the peer review report as **Appendix B**.

Not applicable.

8. **Teacher Education/Certification Programs** All Educator Preparation programs that lead to certification require review and recommendation from the Professional Standards Commission (PSC) and approval from the Board.

Will this program lead to certification?

Yes_____ No___X__

If yes, on what date was the Program Approval for Certification Request submitted to the Professional Standards Commission?

9. Three-Year Plan: Is the proposed program on your institution's approved 3-year plan? Indicate below.

Yes __X__ No _____

Proposed programs submitted to SBOE that are not on the five-year plan must respond to the following questions and meet at least one criterion listed below.

a. **Describe why the proposed program is not on the institution's five year plan.** When did consideration of and planning for the new program begin?

Not applicable.

b. **Describe the immediacy of need for the program**. What would be lost were the institution to delay the proposal for implementation of the new program until it fits within the five-year planning cycle? What would be gained by an early consideration?

Not applicable.

Criteria. As appropriate, discuss the following:

i. How important is the program in meeting your institution's regional or statewide program responsibilities? Describe whether the proposed program is in response to a specific industry need or workforce opportunity.
ii. Explain if the proposed program is reliant on external funding (grants, donations) with a deadline for acceptance of funding.
iii. Is there a contractual obligation or partnership opportunity to justify the program?
iv. Is the program request or program change in response to accreditation requirements or recommendations?
v. Is the program request or program change in response to recent changes to teacher certification/endorsement requirements?

Curriculum, Intended Learning Outcomes, and Assessment Plan

10. Curriculum for the proposed program and its delivery.

a. **Summary of requirements.** Provide a summary of program requirements using the following table.

Credit hours in required courses offered by the department (s) offering the program.	30
Credit hours in required courses offered by other departments:	0
Credit hours in institutional general education curriculum	0
Credit hours in free electives	0
Total credit hours required for degree program:	30

b. **Curriculum**. *Provide the curriculum for the program, including a listing of course titles* *and credits in each.*

Masters in Cybersecurity

Required MS courses (thesis or non-thesis):
- 3 credits of CYB 501 -- Cybersecurity Seminar - 1 credit. Taken three times. This seminar will cover issues related to modern cybersecurity. Research papers, ethical hacking, etc. This will be distinct from the CS graduate seminar.
- CYB507/CS507 -- Research Methods - 3 credits. Currently exists as CS507.
- CYB536 -- Advanced Information Assurance - 3 credits. Currently exists as CS536.
- CYB540 -- Network Security - 3 credits. Currently exists as CS536.
- CYB520 – Digital Forensics – 3 credits. CYB520 - Computer and Network Forensics - 3 credits. Currently exists as CS547.
- Subtotal course credits: 15.

Plus
Non-Thesis Track:
- CYB 599 -- Non-Thesis MS Cyber Research: 5 credits.
- Electives as agreed with Advisor: 10 credits.
- Total: 30 credits. (15 credits or required courses + 15 credits of electives and project).

Thesis Track:
- CYB 500 - Thesis - 6 to 9 credits.
- Electives as agreed with Advisor: 6 to 9 credits.
- Total: 30 credits. (15 credits or required courses + 15 credits of electives and thesis)

c. **Additional requirements.** *Describe additional requirements such as comprehensive examination, senior thesis or other capstone experience, practicum, or internship, some of which may carry credit hours included in the list above.*

Non-thesis students must complete a project. Thesis students must complete and defend a thesis.

11. Program Intended Learning Outcomes and Connection to Curriculum.

a. **Intended Learning Outcomes.** *List the Intended Learning Outcomes for the proposed program, using learner-centered statements that indicate what will students know, be able to do, and value or appreciate as a result of completing the program.*

Graduates of the program will have an ability to:

1. Ability to clearly present, in oral form, research results and the broader implications of that research for both the field of cybersecurity and for society.
2. Ability to clearly present, in written form, research results and the broader implications of that research for both the field of cybersecurity and for society.
3. Ability to do original research in cybersecuirty and to appropriately and accurately analyze the results.
4. An in-depth knowledge of cybersecurity and the ability to apply that knowledge, integrating and building upon the foundation provided by a relevant undergraduate degree.
5. Demonstrate an understanding of the broader implications of research for cybersecurity and for society.

12. **Assessment plans**
We will use a combination of the same general assessment processes currently used by the Computer Science Department for its BS, MS, and PhD degrees in Computer Science. In particular we will use the graduate rubrics (included below) used as part of the MS and PhD degrees, and the coursework assessment template from the BS degree. The BS in CS degree has been accredited since 1993, first by the CS Accreditation Board (CSAB) and then by ABET, which replaced CSAB.

   a. **Assessment Process.** *Describe the assessment process that will be used to evaluate how well students are achieving the intended learning outcomes of the program.*

There are three main methods by which student outcomes are assessed, divided into direct and indirect measures:

1. Student Work from: CYB536 Advanced Information, CYB540 Network Security, and CYB520 Computer and Network Forensics. Direct measure of knowledge of content material and skills.
2. Student Work from: CYB501 Cybersecurity Seminar. Direct measure of knowledge of the societal impact of cybersecurity and professional ethics.
3. Rubrics completed by each students' major professor and committee members at the time of their project presentation or thesis defense.

Each of these measures are described in more detail below. Faculty review and discussion of these measures is a critical part of the overall assessment process and faculty input is included in the analysis of the measures. Faculty review takes place during department meetings in the spring semester and during the department retreat every fall.

Student Work
Faculty select representative material from the courses, potentially including assignments, projects, quizzes, exams, presentations, etc., with which to assess the student outcomes. The table given below shows the standard evaluation template used for assessments based on course materials.

Committee Rubrics
The rubric completed by the student's major professor, and committee for thesis students, consists of the following table:

Category	Exceeds Requirements (4)	Meets Requirements (3)	Partially Meets Requirements (2)	Does Not Meet Requirements (1)
U of I Outcome: Learn and Integrate				
Students work shows an in-depth knowledge of the degree subject matter.				
U of I Outcome: Think and Create				
Student has demonstrated the ability to do original research and to appropriately and accurately analyze the results.				
U of I Outcome: Communicate				
Written Communication: has produced a clear, meaningful document.				
Oral Communication: has produced a clear, meaningful presentation and responded well to questions.				
U of I Outcome: Clarify purpose and perspective; Citizenship				
Student has demonstrated an understanding of the broader implications of that research for both the field and society.				

b. **Closing the loop.** *How will you ensure that the assessment findings will be used to improve the program?*

As noted above, the measures of student obtainment of the outcomes are discussed during faculty meetings in the spring as the data become available – direct measure of student performance in class is normally measured in the fall classes. In addition, the entire curriculum is reviewed both in the spring as part of the meeting with the department's Industrial Advisory Board and in the fall as part of the department's annual retreat.

c. **Measures used.** *What direct and indirect measures will be used to assess student learning?*

These are discussed under **a. Assessment Process** above.

d. **Timing and frequency**. *When will assessment activities occur and at what frequency?*

Assessments based on students' performance in courses are typically conducted during the fall semester so that they can be reviewed in the spring. The graduate defense rubric is completed at the time of the students' thesis defense or project presentation.

Enrollments and Graduates

13. **Existing similar programs at Idaho Public Institutions.** Using the chart below, provide enrollments and numbers of graduates for similar existing programs at your institution and other Idaho public institutions.

No Idaho Public Institution currently offers a MS in Cybersecurity.

Existing Similar Programs: Historical enrollments and graduate numbers								
Institution and Program Name	**Fall Headcount Enrollment in Program**				**Number of Graduates From Program (Summer, Fall, Spring)**			
	FY_16_	FY_17_	FY_18_	FY_19_ (most recent)	FY_16 _	FY_17_	FY_18 _	FY_19_ (most recent)
BSU	0	0	0	0	0	0	0	0
ISU	0	0	0	0	0	0	0	0
UI	0	0	0	0	0	0	0	0
LCSC	0	0	0	0	0	0	0	0

Revised 10/27/17
Page 12

14. **Projections for proposed program:** Using the chart below, provide projected enrollments and number of graduates for the proposed program:

Proposed Program: Projected Enrollments and Graduates First Five Years											
Program Name: MS in Cybersecurity											
Projected Fall Term Headcount Enrollment in Program						**Projected Annual Number of Graduates From Program**					
FY 21 (first year)	FY 22	FY 23	FY 24	FY 25	FY 26	FY 21 (first year)	FY 22	FY 23	FY 24	FY 25	FY 26
8	12	16	18	20	20	-	-	6	8	10	10

15. **Describe the methodology for determining enrollment and graduation projections.** Refer to information provided in Question #2 "Need" above. What is the capacity for the program? Describe your recruitment efforts? How did you determine the projected numbers above?

Maximum capacity is determined by the size of the secure, computer equipped classrooms. These hold 20 students. Currently we only anticipate offering one section of each course, which limits us to no more than 20 students. We also anticipate that some of the CYB courses will be taken by graduate students (MS and PhD) in the computer science program.

The numbers in the table are based on current demand for courses in cybersecurity within computer science. We expect a fair number of students in the first year due to pent-up demand followed by a lower, but steady, stream of incoming students.

16. **Minimum Enrollments and Graduates.**

   a. Have you determined minimums that the program will need to meet in order to be continued? What are those minimums, what is the logical basis for those minimums?

   To maintain a viable program, we need to provide a regular offering of cybersecurity courses. Some of these courses can be taken by students in other majors.

   If we have least 16 students in the program, we will have roughly 8 cybersecurity majors in each class. We anticipate a number of CS graduate students to also participate in these courses, bring the numbers up to 10-12 per course, which is a reasonable size for a graduate level course.

   b. What is the sunset clause by which the program will be considered for discontinuance if the projections or expectations outlined in the program proposal are not met?

   We anticipate that the program will undergo an CAE accreditation review in Fall 2025. If the program is unable to become accredited at that time, we will need to evaluate our shortcomings, and if the program is not sustainable, begin the process of terminating the program. Similarly, if we can't reach sustained enrollments of at least 12 full time MS students we will need to sunset the program. In either case students can transition to the CS degree with minimal difficulty.

University of Idaho

Master of Science in Cybersecurity - Addendum

3. **Program Prioritization**

   Is the proposed new program a result of program prioritization?

   Yes_____ No X___

   If yes, how does the proposed program fit within the recommended actions of the most recent program prioritization findings.

4. **Credit for Prior Learning**
   Indicate from the various cross walks where credit for prior learning will be available. If no PLA has been identified for this program, enter 'Not Applicable'.

   The cybersecurity degree is designed to be accredited under the Center for Academic Excellence (CAE) criteria. The CAE has strict requirements that students have documented instruction on specific knowledge units (KUs). At this point we don't see a guaranteed way to successfully document that a given PLA meets a required knowledge unit. We feel that the value of a CAE accredited program to our graduates is critical enough that we don't want to jeopardize receiving CAE accreditation.

5. **Affordability Opportunities**
   Describe any program-specific steps taken to maximize affordability, such as: textbook options (e.g., Open Educational Resources), online delivery methods, reduced fees, compressed course scheduling, etc. This question applies to certificates, undergraduate, graduate programs alike.

   The program will be available at the Moscow, Coeur d'Alene, and Idaho Falls campuses so students have more options to participate in the program.

   Some courses will be available remotely using Zoom. Some courses are likely to be available semi-synchronous with recorded lectures, but synchronous assignments and exams. We are working with other Idaho institutions to make some courses available at other institutions via video conferencing. At this time it is un-likely that any courses will be available fully asynchronously and self-paced.

   We do consider the cost to students in choosing educational materials and where possible select materials that minimize student and institutional costs.

Resources Required for Implementation – fiscal impact and budget

17. Physical Resources.

a. **Existing resources**. Describe equipment, space, laboratory instruments, computer(s), or other physical equipment presently available to support the successful implementation of the program.

The full program will be offered in Moscow, Coeur d'Alene (CdA) and Idaho Falls (IF).

RADICL Lab, this is a specially designed, secure computing lab used to teach advanced cybersecurity courses that include attack and defense. In Moscow this lab is in JEB6. In Idaho Falls this lab is in CHE104. In Coeur d'Alene this lab is in iDen104.

General Computing Lab, this is a standard computing lab designed to teach programming and defense-oriented cybersecurity. In Moscow this lab is in JEB321. In IF this lab is in CHE204. In CdA this lab is currently in HC240B.

If this program is eventually to be offered in Coeur d'Alene and Idaho Falls via live video conferencing, video capable classrooms are critical. In Moscow there are two available video classrooms EP202 and EP204, both of which hold 35 students. The CS Department currently gets priority scheduling for EP204. In Coeur d'Alene two video classrooms are available in the Harbor Center. In Idaho Falls video classrooms are available in the CHE building.

b. **Impact of new program**. What will be the impact on existing programs of increased use of physical resources by the proposed program? How will the increased use be accommodated?

There will be increased use of the RADICL lab at all three campuses. Currently there is sufficient available timeslots and room in these labs to manage the increased use on the Moscow and Idaho Falls campuses.

c. **Needed resources.** List equipment, space, laboratory instruments, etc., that must be obtained to support the proposed program. Enter the costs of those physical resources into the budget sheet.

No additional resources are needed.

18. Library resources

a. **Existing resources and impact of new program**. Evaluate library resources, including personnel and space. Are they adequate for the operation of the present program? Will there be an impact on existing programs of increased library usage caused by the proposed program? For off-campus programs, clearly indicate how the library resources are to be provided.

Library resources are sufficient.

b. **Needed resources**. What new library resources will be required to ensure successful implementation of the program? Enter the costs of those library resources into the budget sheet.

None.

19. Personnel resources

a. **Needed resources.** Give an overview of the personnel resources that will be needed to implement the program. How many additional sections of existing courses will be needed? Referring to the list of new courses to be created, what instructional capacity will be needed to offer the necessary number of sections?

Resources for additional Sections:

None

Resources for new Courses:

A review of the program curriculum shows that many of the courses are currently being taught as CS courses (they will become Cybersecurity CYB courses or cross-listed CS/CYB courses). The primary course addition will be the Cybersecurity seminar, which we have the resources to offer with existing faculty. It may partially replace existing, non-course, lab research meetings that focus on reading and reviewing research papers.

b. **Existing resources**. Describe the existing instructional, support, and administrative resources that can be brought to bear to support the successful implementation of the program.

This program will be offered as an additional degree option within the Department of Computer Science. Hence all of the existing support, administrative staff, office space, etc. that is currently available within CS will be available to this program.

Impact on existing programs. What will be the impact on existing programs of increased use of existing personnel resources by the proposed program? How will quality and productivity of existing programs be maintained?

We will create a separate curriculum/petitions committee from the Cyber Security faculty to oversee the program. This will minimize the impact on existing personnel and the existing Computer Science degrees.

Additionally, CYB students will lead to an increase in size in some current CS courses that will become the cross listed CS/CYB courses. We have instructional capability to accommodate the additional students.

Existing faculty will shift some of their teaching duties from existing CS courses to the equivalent CS/CYB courses. This will not create a significant change in the courses available to CS students.

c. **Needed resources.** List the new personnel that must be hired to support the proposed program. Enter the costs of those personnel resources into the budget sheet.

Personnel:

None.

20. Revenue Sources

a) **Reallocation of funds:** If funding is to come from the reallocation of existing state appropriated funds, please indicate the sources of the reallocation. What impact will the reallocation of funds in support of the program have on other programs?

No existing funds will be reallocated.

b) **New appropriation**. If an above Maintenance of Current Operations (MCO) appropriation is required to fund the program, indicate when the institution plans to include the program in the legislative budget request.

c) **Non-ongoing sources**:

i. If the funding is to come from one-time sources such as a donation, indicate the sources of other funding. What are the institution's plans for sustaining the program when that funding ends?

ii. Describe the federal grant, other grant(s), special fee arrangements, or contract(s) that will be valid to fund the program. What does the institution propose to do with the program upon termination of those funds?

d) **Student Fees**:

i. If the proposed program is intended to levy any institutional local fees, explain how doing so meets the requirements of Board Policy V.R., 3.b.

There will be student lab fees to support the client computers, used by the students in the lab courses to connect to the secure servers. These fees will be used only for resources used in class. The exact amount of the fee will be dependent upon estimated enrollment and will be amortized over 3 years – the standard replacement cycle for the computers.

ii. Provide estimated cost to students and total revenue for self-support programs and for professional fees and other fees anticipated to be requested under Board Policy V.R., if applicable.

21. Using the budget template provided by the Office of the State Board of Education, provide the following information:

- Indicate all resources needed including the planned FTE enrollment, projected revenues, and estimated expenditures for the first **four** fiscal years of the program.
- Include reallocation of existing personnel and resources and anticipated or requested new resources.
- Second and third year estimates should be in constant dollars.
- Amounts should reconcile subsequent pages where budget explanations are provided.
- If the program is contract related, explain the fiscal sources and the year-to-year commitment from the contracting agency(ies) or party(ies).
- Provide an explanation of the fiscal impact of any proposed discontinuance to include impacts to faculty (i.e., salary savings, re-assignments).

Program Resource Requirements.

- Indicate all resources needed including the planned FTE enrollment, projected revenues, and estimated expenditures for the first **four** fisca
- Include reallocation of existing personnel and resources and anticipated or requested new resources.
- Second and third year estimates should be in constant dollars.
- Amounts should reconcile subsequent pages where budget explanations are provided.
- If the program is contract related, explain the fiscal sources and the year-to-year commitment from the contracting agency(ies) or party(ies)
- Provide an explanation of the fiscal impact of any proposed discontinuance to include impacts to faculty (i.e., salary savings, re-assignment

I. PLANNED STUDENT ENROLLMENT

	FY 21		FY 22		FY 23	
	FTE	Headcount	FTE	Headcount	FTE	Headcount
A. New enrollments	4	4	12	12	16	16
B. Shifting enrollments	4	4	0	0	0	0
Total Enrollment	**8**	**8**	**12**	**12**	**16**	**16**

II. REVENUE

	FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time
1. New Appropriated Funding Request	-	-	-	-	-	-
2. Institution Funds	-	-	-	-	-	-
3. Federal	-	-	-	-	-	-
4. New Tuition Revenues from Increased Enrollments	54,893	N/A	166,602	N/A	225,342	N/A
5. Student Fees	600	N/A	1,800	N/A	2,400	N/A
6. Other (i.e., Gifts)	-	-	-	-	-	-
Total Revenue	55,493	-	168,402	-	227,742	-

Ongoing is defined as ongoing operating budget for the program which will become part of the base.
One-time is defined as one-time funding in a fiscal year and not part of the base.

III. EXPENDITURES

	FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time
A. Personnel Costs						
1. FTE	0	N/A	0	N/A	0	N/A
2. Faculty	$ -	$ -	$ -	$ -	$ -	$ -
3. Adjunct Faculty	$ -	$ -	$ -	$ -	$ -	$ -
4. Graduate/Undergrad Assistants	$ -	N/A	$ -	$ -	$ -	$ -
5. Research Personnel	N/A	N/A	N/A	N/A	N/A	N/A
6. Directors/Administrators		N/A		N/A		N/A
7. Administrative Support Personnel	$ -	$ -	$ -	$ -	$ -	$ -
8. Fringe Benefits	$ -	N/A	$ -	N/A	$ -	N/A
9. Other:	$ -	N/A	$ -	N/A	$ -	N/A
Total Personnel and Costs	$ -	$ -	$ -	$ -	$ -	$ -

	FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time
B. Operating Expenditures						
1. Travel	$ -	$ -	$ -	$ -	$ -	$ -
2. Professional Services	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Services	$ -	$ -	$ -	$ -	$ -	$ -

	FY 21 On-going	FY 21 One-time	FY 22 On-going	FY 22 One-time	FY 23 On-going	FY 23 One-time
4. Communications	$ 500	$ 2,000	$ 500	$ -	$ 500	$ -
5. Materials and Supplies	$ 7,150	$ -	$ 7,150	$ -	$ 7,150	$ -
6. Rentals	$ -	$ -	$ -	$ -	$ -	$ -
7. Materials & Goods for Manufacture & Resale	$ -	$ -	$ -	$ -	$ -	$ -
8. Miscellaneous	$ -	$ -	$ -	$ -	$ -	$ -
Total Operating Expenditures	$ 7,650	$ 2,000	$ 7,650	$ -	$ 7,650	$ -

	FY 21		FY 22		FY 23	
	On-going	One-time	On-going	One-time	On-going	One-time
C. Capital Outlay						
1. Library Resources	$ -	$ -	$ -	$ -	$ -	$ -
2. Equipment	$40,000.00	$0.00	$40,000.00	$0.00	$40,000.00	$0.00
Total Capital Outlay	$40,000	$0	$40,000	$0	$40,000	$0

	FY 21		FY 22		FY 23	
D. Capital Facilities Construction or Major Renovation						
E. Other Costs						
Utilites						
Maintenance & Repairs						
Other						
Total Other Costs	$0	$0	$0	$0	$0	$0

TOTAL EXPENDITURES:	$47,650	$2,000	$47,650	$0	$47,650	$0
Net Income (Deficit)	$7,843	-$2,000	$120,752	$0	$180,092	$0

Budget Notes (specify row and add explanation where needed; e.g., "I.A.,B. FTE is calculated using…"):

I.A.B.	
Row 84	Communication expenses are for advertising the program - these will come from CS funds: F&A returns, EO, etc.
Row 107	Renewing client machines in the computer labs, covered by lab fees. Initially the bulk of the lab fees will come from CS (non-CYE
Row 105	This is grant funded
Row 78	No travel funds for recruiting are included because the chair and members of the program already travel around the state extensi advertising.

l years of the program

Start FY
. 21
ts).

FY 24	
FTE	Headcount
18	18
0	0
18	**18**

FY 24	
On-going	One-time
-	-
-	-
-	-
254,712	N/A
2,700	N/A
-	-
257,412	-

FY 24	
On-going	One-time
0	N/A
$ -	$ -
$ -	$ -
$ -	$ -
N/A	N/A
	N/A
$ -	$ -
$ -	N/A
$ -	N/A
$ -	$ -

FY 24	
On-going	One-time
$ -	$ -
$ -	$ -
$ -	$ -

$ 500	$ -	
$ 7,150	$ -	
$ -	$ -	
$ -	$ -	
$ -	$ -	
$ 7,650	$ -	

FY 24		
On-going	One-time	
$ -	$ -	
$40,000.00	$0.00	Grant funded
$40,000	$0	

FY 24	
$0	$0

$47,650	$0	
$209,762	$0	

3) students using the labs.

ively, these trips will incorporate

U OF I: CYBERSECURITY PROGRAMS

Doctoral Degree:	**Ph.D. in Cybersecurity (planned Fall 2022)**
Related Degrees:	Ph.D. in Computer Science
	Ph.D. in Electrical Engineering

Master's Degree:	**M.S. in Cybersecurity (planned Fall 2021)**
Graduate Certificates:	**Graduate Certificate in Secure and Dependable Computing Systems**
	Graduate Certificate Power Systems Protection and Relaying
	Graduate Certificate Critical Infrastructure Resilience
Related Degrees:	M.S. in Computer Science or Technology Management
	MS. or M. Eng. in Computer Engineering or Electrical Engineering

Undergraduate Degree:	**B.S. in Cybersecurity**
Undergraduate Certificate:	**Undergraduate Certificate in Cybersecurity**
Related Degrees and Minors:	B.S. in Computer Science or Computer Engineering
	B.S. in Electrical Engineering or Industrial Technology
	Minor in Computer Science
	Minor in Electrical Engineering