SUBJECT

Board Policy III.B. Academic Freedom and Responsibility and Board Policy III.P. Students – Second Reading

REFERENCE

October 2020	The Board approved a first reading of amendments to Board Policy III.P. that brought the policy into compliance with new Title IX Regulations.
December 2020	The Board approved a second reading of amendments to Board Policy III.P.
December 2021	The Board approved a first reading of amendments to Board Policies III.B and III.P.

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.B., III.P., and III.U.

BACKGROUND/DISCUSSION

Board Policy III.B. Academic Freedom and Responsibility was created as part of the process in the late 1900s when postsecondary personnel policies were moved from Administrative Code to the Board's Governing Policies and Procedures. At that time, it was common for the Board to consider the Board Policy Manual as a whole rather than individual policy changes. Due to the way the minutes to the Board meetings were structured at that time it is not possible to determine the exact date Board Policy III.B was first codified, other than it was prior to 2000. Only technical changes that did not require Board approval have been made to the policy since that time, with the most recent change occurring in 2002.

In the summer of 2021, a workgroup of interested faculty and administrators from all eight public postsecondary institutions in Idaho developed a proposed major revision of Board Policy III.B., which included moving and expanding on some language in Board Policy III.P. Students.

IMPACT

The proposed amendments will bring Board policy III.B. into alignment with current nationally accepted standards of academic freedom and academic responsibility, The amendments clearly define key terms, delineate the academic freedoms and academic responsibilities of students, faculty, and institutions alike, and outline the general limitations of these freedoms and responsibilities.

An additional, incidental revision to Board Policy III.P is also proposed, removing language about vaccine categories that are no longer utilized by the Centers for Disease Control and Prevention. This change will prevent confusion about vaccine related information in Board policy.

ATTACHMENTS

Attachment 1– Board Policy III.B. Academic Freedom and Responsibility – Second Reading
Attachment 2 – Board Policy III.P. Students – Second Reading

BOARD STAFF COMMENTS AND RECOMMENDATIONS

Between the first and second readings, one proposed revision has been made to Policy III.B. at the suggestion of Board Member Hill. This revision re-orders the sentences of paragraph 3.b.iii. for the sake of clarity and coherence. No public comment has been received regarding this policy between the readings and no other additional revisions are proposed.

BOARD ACTION

I move to approve the second reading of proposed amendments to Board Policy III.B. Academic Freedom and Responsibility, as submitted in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

AND

I move to approve the second reading of proposed amendments to Board Policy III.P. Students, as submitted 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: B. Academic Freedom and Academic Responsibility ~~April 2002~~February 2022

~~In adopting the following policy statement concerning academic freedom and responsibility, the State Board of Education and Board of Regents of the University of Idaho affirms its belief that academic freedom should not be abridged or abused.~~

~~Institutions of higher education are operated for the common good and not to further the interests of individual faculty members or the institution as a whole. Academic freedom is essential to protect the rights of the faculty member in teaching and the student in learning. Freedom in research and teaching is fundamental to the advancement of truth. Academic freedom carries with it responsibilities as well as rights.~~

~~1. Teaching~~

~~The faculty member is entitled to freedom in the classroom in discussing the subject material but should not introduce matters not germane to the subject.~~

~~2. Research~~

~~The faculty member is entitled to freedom in research and the publication of the results. However, research for pecuniary return, when that research is a part of the faculty member's assigned duties or when the research involves use of institutional facilities or resources not usually available to the general public may be undertaken only with prior written approval by the chief executive officer or his or her designee.~~

~~3. Responsibilities~~

1. Definitions

   a. Academic Freedom is a long-standing philosophical, legal, and constitutional principle of freedom of speech that advances the right of postsecondary students, faculty, and institutions to pursue educational opportunities that seek, examine, apply, discuss, and build knowledge, theories, values, concepts, or ideas without fear of censorship, retaliation, or threat to institutional status.

   b. Academic Responsibility is the commitment by students, faculty, and institutions to strive to protect the academic freedom of others by appreciating their special position in the community, performing academic obligations with intellectual honesty, promoting the free exchange of ideas, and showing respect toward those with whom they both agree and disagree.

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c. Faculty are employed to forward the academic mission of a college or university through teaching, research, service, and other scholarly contributions. Students may assume similar employment with institutions as graduate teaching or research assistants. Further, postdoctoral researchers may assume similar employment with institutions. In addition to the foregoing definition, faculty are employees of the institution pursuant to Board Policy II.G.

d. Student means any person duly admitted and enrolled at an institution under governance of the Board as defined in Board Policy III.P.

2. Students

This policy recognizes the academic freedom and academic responsibility to individuals with the status of student.

a. Academic Freedom of Students

In addition to constitutionally protected freedoms of speech, assembly, and religion, students have the right to engage in free inquiry, intellectual debate, and freedom of scholarship both on and off campus. Students shall not be subject to retaliation, or censorship in response to their beliefs, opinions, research, publications, creative activity, and participation in institutional governance. Students are subject to the responsibilities outlined in paragraph 2.b. of this policy. This academic freedom includes but is not limited to:

i. Instructional Environments

1) Students have the right to express personal opinions about concepts and theories presented in their courses and to disagree with opinions expressed by faculty and fellow students, even as they continue to be responsible for the assigned course content.
2) Students are entitled to fair and even treatment in all aspects of student-faculty relationships.
3) Students may not be directed or otherwise compelled to personally affirm, adopt or adhere to any particular political, religious or philosophical tenet or ideology.
4) Students shall not be evaluated on the basis of their adherence to any particular political, religious, or philosophical tenet or ideology.

ii. Research, Publication, and Creative Activity

1) Students may pursue research topics of their choosing, pursuant to institutional research standards.
2) Students have the right to publish and present their research as well as engage in the production and exhibition of creative works.

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3) Students are entitled to attribution for discoveries and original research conducted.

iii. Participation in Institutional Governance

1) Students have the right to participate in institutional governance through appropriate institutional processes.
2) Students have the right to express opinions and provide feedback concerning institutional governance and administration without fear of censorship or retaliation.
3) In matters of disciplinary action, students have the right to due process and to be held accountable using academic standards and institutional procedures.

iv. Community and Campus Involvement

1) Students have the right of free expression on and off campus.
2) Students have the right to organize student associations and to request official recognition or status from their institution for such associations.
3) Students have the right to be free from requirements to make personal or political choices against their beliefs or values.

b. Academic Responsibility of Students

Academic freedom carries certain responsibilities which broadly include contributions to the academic community, acknowledgement of the validity of a diverse range of perspectives, commitment to learning relevant information, and good stewardship of the academic community. Students assume, at minimum, the following responsibilities in relation to academic freedom:

i. By enrolling in a public postsecondary institution, students agree to adhere to the institutions' student codes of conduct and to respect the rights of others, including the right to express differing opinions. Students also agree to acknowledge that faculty may expose students to a broad range of diverse perspectives, and to foster and defend intellectual honesty, freedom of inquiry and instruction, and free expression on and off campus. Expression of dissent and attempts to produce change shall not be carried out in ways which injure individuals, damage institutional facilities, disrupt classes, or interfere with institutional activities. Students who seek to call attention to grievances must do so in accordance with institutional policies and procedures, and in ways that do not significantly impede the academic functions of the institution.

ii. Students have a responsibility to engage in scholarship, learn material that is relevant to course outcomes, and adhere to course syllabi, institutional student codes of conduct, and other institutional policies related to research and publication.

iii. Students are responsible for the academic integrity of their coursework, including, but not limited to, producing original works for assignments, completing assessments, and activities using their own knowledge and experience.

iv. Students are responsible for conducting and reporting research in an ethical manner. The design, conduct, and presentation of research may exist beyond the contexts of a specific course. However, students are subject to an institution's expectations for scholarly inquiry and academic integrity.

v. Students shall not threaten the rights or the safety of others while exercising academic freedom. Students will frequently participate in pluralistic learning environments, but shall not be required to make personal or political choices against their beliefs or values.

3. Faculty

This policy recognizes the academic freedom and academic responsibility to individuals with the status of faculty.

a. Academic Freedom of Faculty

In addition to constitutionally protected freedoms of speech, assembly, and religion, faculty have the right to engage in free inquiry, intellectual debate, and freedom of scholarship both on and off campus. Faculty shall not be subject to retaliation or censorship in response to their research, publications, creative activity, pedagogy, participation in institutional governance, and all other official aspects of their job description. When speaking or writing as a citizen, ~~the~~ each faculty member should be free from institutional censorship or discipline. Faculty are subject to the responsibilities outlined in paragraph 3.b. of this policy. This academic freedom includes but is not limited to:

i. Pedagogy and Curriculum Development

1) Faculty have the right to determine course content, including the use of relevant materials, subject to institutional curriculum development processes and policies.
2) Faculty have the right to determine the instructional methodologies used to engage learners in the course content and evaluate student performance.

ii. Research, Publication, and Creative Activity

1) Faculty may pursue research topics of their choosing, pursuant to institutional research standards.
2) Faculty have the right to publish and present their research as well as engage in the production and exhibition of creative works, within the requirements of Board Policy V.M. related to intellectual property.
3) Faculty are entitled to attribution for discoveries and original research.

iii. Participation in Institutional Governance

1) Faculty have the right to participate in institutional governance.
2) Faculty have the right to express opinions and provide feedback concerning institutional governance and administration without fear of censorship or retaliation.
3) In matters of promotion, tenure, and disciplinary action, faculty have the right to due process and to be judged by their peers using established academic standards and institutional procedures.
4) Faculty have the right to participate in institutional processes that determine who may teach, what may be taught, how it shall be taught, and what methods will be used for student admission.

b. Academic Responsibility of Faculty

Academic freedom carries with it certain responsibilities which broadly include maintaining competence in scholarship, exposing students to a diverse range of perspectives, ensuring that students are taught relevant information, and being good stewards of the academic community. Faculty assume, at minimum, the following responsibilities in relation to academic freedom:

i. Each faculty member of the institution is a citizen, a member of a learned profession, and a representative of the institution. Membership in the academic community imposes on ~~administrators,~~ faculty ~~members, other institutional employees, and students~~ an obligation to respect the ~~dignity~~rights of others, ~~to acknowledge the~~including the right ~~of others~~ to express differing opinions, and to foster and defend intellectual honesty, freedom of inquiry and instruction, and free expression on and off ~~the~~ campus ~~of an institution~~. Expression of dissent and attempts to produce change shall not be carried out in ways which injure individuals, damage institutional facilities, disrupt classes, or interfere with institutional activities. Faculty who seek to call attention to grievances must do so in accordance with institutional policies and procedures, and in ways that do not significantly impede the academic functions of the institution. ~~However, a~~As a member of the academic community and a representative of the institution, ~~the~~each faculty member should at all times be ~~accurate~~intellectually honest, exercise appropriate restraint, ~~show respect for the opinions of others~~, and make every effort to indicate that he or she is not an official spokesperson

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for the institution. Furthermore, each faculty member must refrain from using institutional resources to further his or her interests or activities which are not a part of the assigned responsibilities to the institution.

ii. Faculty members are expected to maintain professional competence in their field(s) of specialization, congruent with their teaching, service, and scholarly expectations.

iii. ~~Faculty may expose students to an intellectual diversity of scholarly and creative views related to the faculty member's discipline and/or specific field of study.~~ ~~It is the responsibility of the f~~Faculty ~~members~~ are responsible ~~to~~ for presenting the ~~subject matter~~ content in their courses in a way that is consistent with the collective goals of the institution, college, and department or program. When presenting content, faculty may expose students to an intellectual diversity of scholarly and creative views related to the faculty member's discipline and/or specific field of study.

iv. Faculty shall meet their workload requirements established in their employment agreements. This may include the expectation that the faculty member conducts class, meets with and mentors students, provides clear learning outcomes, and/or participates in group deliberations to develop instructional programs.

v. Faculty are responsible for participating in institutional processes to establish goals for student learning, to design and implement general programs of education and specialized study that intentionally cultivate intended learning, and to assess students' achievement.

vi. Faculty shall not threaten the rights or the safety of students, other faculty, and administrators, while exercising academic freedom. Faculty may not refuse to enroll or teach a student because of the student's beliefs, interpretations, or applications of knowledge. Faculty have the responsibility to facilitate pluralistic learning and work environments, but shall not require others to make personal or political choices against their beliefs or values.

4. Institutions

This policy confers academic freedom and academic responsibility to institutions.

a. Academic Freedom of Institutions

Institutional rights to academic freedom are in concert with the academic freedom of students and faculty. A college or university has the autonomy to create and maintain an atmosphere which is most conducive to a diverse range of scholarship. Institutions have the right to develop processes that determine who may teach, what may be taught, how it shall be taught, and what methods will be used for student admission, pursuant to Board Policy III.Q.

Institutions perform functions, such as the selection of faculty and admission of students, that are intertwined with the exercise of academic freedom. The academic freedom of an institution is necessary to protect and support the academic freedom of those who comprise an institutional community.

b. Academic Responsibility of Institutions

Academic freedom carries with it certain responsibilities which broadly include the educational functions of an institution, the ethical administration of academic affairs, and the protection of student and faculty academic freedom. Institutions assume, at minimum, the following responsibilities in relation to academic freedom:

i. Institutions have a responsibility to set, maintain, and enforce policies that protect the academic freedom and promote the academic responsibility of faculty and students.

ii. Institutions shall adopt appropriate procedures for transparently evaluating the members and activities of the academic community that are consistent with and respectful of the ideals of academic freedom.

iii. Institutions shall also dedicate adequate resources, space, and programming toward the advancement of academic freedom among its greater community.

iv. Institutions have a responsibility to create and deliver academic programs and shall develop appropriate policies and processes to aid content and curriculum delivery that are consistent with the ideals of academic freedom.

v. Institutions must create admissions and selection policies, procedures, and practices for students that are in harmony with the academic mission of the institution and that are consistent with the ideals of academic freedom.

vi. Institutions have the responsibility to facilitate pluralistic learning environments, but shall not require others to make personal or political choices against their beliefs or values.

5. Limitations

The following limitations exist to the academic freedom and academic responsibility of students, faculty, and institutions:

a. Academic freedom does not permit members of an institutional community to harass, threaten, or intimidate others.

b. Student academic freedom does not grant students the right to refuse to complete assigned coursework without consequence.

c. Academic freedom does not protect faculty members from colleague or student challenges to, or disagreement with, their instructional methods.

d. Academic freedom does not protect faculty or students from institutional or non-institutional penalties for violating the law.

e. Academic freedom does not confer the right to faculty or students to violate institutional policies; though academic freedom does confer the right of faculty and students to criticize such policies.

f. Academic freedom does not protect faculty or students from disciplinary action consistent with established institutional policies.

g. Academic freedom does not protect faculty or students from sanctions or dismissal for professional misconduct or poor performance consistent with established institutional policies.

h. Academic freedom does not protect faculty or students from investigations into allegations of or discipline for scientific misconduct or other violations of institutional policy.

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Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: P. STUDENTS ~~December 2020~~February 2022

The following policies and procedures are applicable to or for any person designated as a student at an institution under governance of the Board. A "student" means any person duly admitted and regularly enrolled at an institution under governance of the Board as an undergraduate, graduate, or professional student, on a full-time or part-time basis, or who is admitted as a non-matriculated student on or off an institutional campus.

1. Nondiscrimination

It is the policy of the Board that institutions under its governance must provide equal educational opportunities, services, and benefits to students without regard to race, color, religion, sex, national origin, age, handicap, or veterans status, including disabled veterans and veterans of the Vietnam era in accordance with:

a. Title VI of the Civil Rights Act of 1964, as amended, 42 U.S.C. 2000d *et seq*., which prohibits discrimination on the basis of race, color, or national origin in programs and activities receiving federal financial assistance.

b. Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. 794, which prohibits discrimination on the basis of handicap in programs and activities receiving federal financial assistance.

c. Title IX of the Education Amendments of 1972, as amended, 20 U.S.C. 1681 *et seq*., which prohibits discrimination on the basis of sex in education programs and activities receiving federal financial assistance.

d. The Age Discrimination Act of 1975, as amended, 42 U.S.C. 6101 *et seq*., which prohibits discrimination on the basis of age in programs or activities receiving federal financial assistance.

e. Chapter 59, Title 67, Idaho Code, and other applicable state and federal laws.

2. Sexual Harassment

a. Each institution must establish and maintain a positive learning environment for students that is fair, humane, and responsible. Sexual discrimination, including sexual harassment, is inimical to any institution.

b. Sexual harassment violates state and federal laws and the Governing Policies and Procedures of the Board. "Sexual harassment" is defined by the regulations implementing Title IX at 34 C.F.R. § 106.30 (a).

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c. Each institution must develop and make public procedures providing for the prompt response, in a manner that is not deliberately indifferent, to allegations of sexual harassment in the institution's education programs or activities of which the institution has actual knowledge. Each institution's policies and procedures must comply with the regulations in 34 C.F.R. Part 106.

~~3. Academic Freedom and Responsibility~~

~~Institutions of postsecondary education are conducted for the common good and not to further the interests of either the individual student or the institution as a whole. Academic freedom is fundamental for the protection of the rights of students in learning and carries with it responsibilities as well as rights.~~

~~Membership in an academic community imposes on students an obligation to respect the dignity of others, to acknowledge the right of others to express differing opinions, and to foster and defend intellectual honesty, freedom of inquiry and instruction, and free expression on and off the campus of an institution. Expression of dissent and attempts to produce change may not be carried out in ways which injure individuals, damage institutional facilities, disrupt classes, or interfere with institutional activities. Speakers on the campuses must not only be protected from violence but must also be given an opportunity to be heard. Those who seek to call attention to grievances must do so in ways that do not significantly impede the functioning of the institution.~~

~~Students are entitled to an atmosphere conducive to learning and to fair and even treatment in all aspects of student-teacher relationships. Teaching faculty may not refuse to enroll or teach a student because of the student's beliefs or the possible uses to which the student may put the knowledge gained from the course. Students must not be forced by the authority inherent in the instructional role to make personal or political choices.~~

~~4~~3. Catalog and Representational Statements

Each institution will publish its official catalogue and admissions, academic, and other policies and procedures which affect students. (*See also* "Roles and Missions," Section III, Subsection I-2.)

Each institutional catalogue must include the following statement:

> Catalogues, bulletins, and course or fee schedules shall not be considered as binding contracts between [institution] and students. The [institution] reserves the right at any time, without advance notice, to: (a) withdraw or cancel classes, courses, and programs; (b) change fee schedules; (c) change the academic calendar; (d) change admission and registration requirements; (e) change the regulations and requirements governing instruction in and graduation from the institution and its various divisions; and (f) change any other regulations affecting students. Changes shall go into force whenever the proper authorities so determine and shall apply not only to prospective students but also to those who are matriculated at the time in [institution]. When economic and other conditions permit, the [institution] tries to provide advance

notice of such changes. In particular, when an instructional program is to be withdrawn, the [institution] will make every reasonable effort to ensure that students who are within two (2) years of completing graduation requirements, and who are making normal progress toward completion of those requirements, will have the opportunity to complete the program which is to be withdrawn.

No employee, agent, or representative of an institution may make representations to, or enter into any agreement with, or act toward any student or person in a manner which is not in conformity with Board Governing Policies and Procedures or the approved policies and procedures of the institution.

~~5~~4. Student Records

The collection, retention, use, and dissemination of student records is subject to the requirements of the Family Educational Rights and Privacy Act of 1974, as amended, and implementing regulations. Each institution will establish policies and procedures for maintenance of student records consistent with the act and implementing regulations and will establish and make public an appeals procedure which allows a student to contest or protest the content of any item contained in his or her institutional records.

~~6~~5. Full-Time Students

a. Undergraduate Student

For fee and tuition purposes, a “full-time” undergraduate student means any undergraduate student carrying twelve (12) or more credits (or equivalent in audit and zero-credit registrations).

i. Student Body Officers and Appointees

For fee and tuition purposes, the president, vice president, and senators of the associated student body government are considered full-time students when carrying at least the following credit loads: (a) president, three (3) credits and (b) vice president and senators, six (6) credits.

ii. Editors

Editors of student published newspapers are recognized as full-time students when carrying a three credit load, and associate editors are recognized as full-time students when carrying a six credit load.

b. Graduate Student

For fee and tuition purposes, a “full-time” graduate student means any graduate student carrying nine (9) or more credits, or any graduate student on a full appointment as an instructional or graduate assistant, regardless of the number of credits for which such instructional or graduate assistant is registered.

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~~7~~6. Student Governance

The students at each institution may establish a student government constitution for their own duly constituted organization, which must be consistent with Board Governing Policies and Procedures. Each student constitution must be reviewed and approved by the Chief Executive Officer. Any amendments to the student constitution must also be reviewed and approved by the Chief Executive Officer.

~~8~~7. Student Financial Aid

Each institution will establish policies and procedures necessary for the administration of student financial aid.

a. Transfer of Delinquent National Direct Student Loans. (*See* Section V, Subsection P)

b. Student Financial Aid Fraud

   Each institution under governance of the Board should, as a matter of policy, initiate charges against individuals who fraudulently obtain or misrepresent themselves with respect to student financial aid.

~~9~~8. Fees and Tuition

a. Establishment
   Policies and procedures for establishment of fees, tuition, and other charges are found in Section V, Subsection R, of the Governing Policies and Procedures.

b. Refund of Fees
   Each institution will develop and publish a schedule for refund of fees in the event a student withdraws in accordance with regulations governing withdrawal.

~~10~~9. Student Employees

a. Restrictions

   No student employee may be assigned to duties which are for the benefit of personal and private gain, require partisan or nonpartisan political activities, or involve the construction, operation, or maintenance of any part of any facility which is used for sectarian instruction or religious worship. No supervisor may solicit or permit to be solicited from any student any fees, dues, compensation, commission, or gift or gratuity of any kind as a condition of or prerequisite for the student's employment.

b. Policies and Procedures

   Each institution will develop its own policies and procedures regarding student employment, including use of student employment as a part of financial assistance available to the student. Such policies and procedures must ensure that equal employment opportunity is offered without discrimination and that wage administration is conducted in a uniform manner. Such policies also must include a statement of benefits available to student employees, if appropriate.

c. Graduate Assistants

Each institution is delegated the authority to appoint within the limitations of available resources graduate assistants in a number consistent with the mission of the institution. Graduate assistantships are established to supplement a graduate student's course of study, with employment appropriate to the student's academic pursuits.

Each institution will establish its own procedures for appointment of graduate assistants which will include (a) qualifications, (b) clear and detailed responsibilities in writing, and (c) maximum number of hours expected and wages for meeting those requirements.

Matriculation, activity, and facility fees for graduate assistants will be paid either by the student or by the department or academic unit on behalf of the student. Graduate students will be covered by appropriate insurance in accordance with institutional procedures for work-related illness or injury.

d. Hourly or Contractual Employment

Each institution may employ students on an hourly or contractual basis in accordance with the needs of the various departments or units, available funds, and rules of the Division of Human Resources (or the University of Idaho classified employee system) or federal guidelines when work-study funds are used.

~~11~~10. Student Conduct, Rights, and Responsibilities

Each institution will establish and publish a statement of student rights and a code of student conduct. The code of conduct must include procedures by which a student charged with violating the code receives reasonable notice of the charge and is given an opportunity to be heard and present testimony in his or her defense, and an opportunity to appeal any disciplinary action. Such statements of rights and codes of conduct, and any subsequent amendments, are subject to review and approval of the chief executive officer.

Sections 33-3715 and 33-3716, Idaho Code, establish criminal penalties for conduct declared to be unlawful.

~~12~~11. Student Services

Each institution will develop and publish a listing of services available to students, eligibility for such services, and costs or conditions, if any, of obtaining such services.

~~13~~12. Student Organizations

Each student government association is responsible, subject to the approval of the institution's chief executive officer, for establishing or terminating student organizations supported through allocation of revenues available to the association. Expenditures by or on behalf of such student organizations are subject to rules, policies, and procedures of the institution and the Board.

~~14~~13. Student Publications and Broadcasts

Student publications and broadcasts are independent of the State Board of Education and the institutional administration. The institutional administration and the State Board of Education assume no responsibility for the content of any student publication or broadcast. The publishers or managers of the student publications or broadcasts are solely liable for the content.

~~15~~14. Student Health Insurance

Students are responsible for making arrangements for coverage of their medical needs while enrolled in a post-secondary institution on a part- or full-time basis. Accidents, injuries, illnesses, and other medical needs of students (with limited exceptions in the case of student employees of an institution who experience workplace injuries within the course and scope of their employment) typically are not covered by the institution's insurance policies. The types and levels of medical/clinical support services available to students varies among the institutions and among the local communities within which institutions conduct operations.

a. Health Insurance Coverage Offered through the Institution

Each institution, at the discretion of its chief executive officer, may provide the opportunity for students to purchase health insurance through an institution-offered plan. Institutions are authorized to provide student health insurance plans through consortium arrangements, when this option serves the interests of students and administration. Institutions which elect to enter contractual arrangements to offer student health insurance plans (either singly or through consortium arrangements) should comply with applicable Board and State Division of Purchasing policies. Institutions which elect to offer health insurance plans to their students are authorized, at the chief executive officer's discretion, to make student participation in such plans either optional or mandatory.

b. Mandatory Student Health Insurance

Each institution, at the discretion of its chief executive officer, may require all or specified groups (for example, international students, intercollegiate athletes, health professions students engaged in clinical activities, student teachers, etc.) to carry health insurance that meets coverage types and levels specified by the institution. Administration and enforcement of any such health insurance requirements, and procedures for dealing with any exceptions thereto, lie within the authority of the institution presidents or their designees.

c. Other Medical Support Services and Fees

Institutions are authorized to support or supplement students' medical needs through services provided by college/university clinics, health centers, cooperative arrangements with community/regional health care providers, etc. In cases where such services are provided, institutions are authorized to establish optional or mandatory fees to cover the delivery cost of such services.

d. Financial aid considerations

Any medical insurance or health services-related fees which are mandated by an institution as a condition of participation in any institutional program are considered a bona fide component of the institution's cost of college and are a legitimate expenditure category for student financial aid.

~~16~~15. Student Vaccine Informational Materials

Each institution shall provide current information on vaccine-preventable disease to each student at the time of admission or enrollment for classes. The information shall include, at a minimum:

a. symptoms, risks, especially as the risks relate to circumstances of group living arrangements for vaccine-preventable diseases that are known to occur in adolescents and adults;

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b. current recommendations by the United States Centers for Disease Control and Prevention on ~~Category A and B~~ vaccines;

c. information regarding where the vaccinations can be received; and

d. the benefits and risks of vaccinations, and specific information for those persons at higher risk for the disease.

~~17~~16. Students Called to Active Military Duty

The Board strongly supports the men and women serving in the National Guard and in reserve components of the U.S. Armed Forces. The Board encourages its institutions to work with students who are called away to active military duty during the course of an academic term and provide solutions to best meet the student's current and future academic needs. The activated student, with the instructor's consent, may elect to have an instructor continue to work with them on an individual basis. Additionally, institutions are required to provide at least the following:

a. The activated student may elect to completely withdraw. The standard withdrawal deadlines and limitations will not be applied. At the discretion of the institution, the student will receive a "W" on his or her transcript, or no indication of enrollment in the course(s).

b. One hundred percent (100%) of the paid tuition and/or fees for the current term will be refunded, as well as a pro-rated refund for paid student housing fees, meal-plans, or any other additional fees. Provided, however, that if a student received financial aid, the institution will process that portion of the refund in accordance with each financial aid program.

~~18~~17. Student Complaints/Grievances.

a. The State Board of Education and Board of Regents of the University of Idaho, as the governing body of the state's postsecondary educational institutions, has established the following procedure for review of institution decisions regarding student complaints/grievances:

   i. The Board designates its Executive Director as the Board's representative for reviewing student complaints/grievances, and authorizes the Executive Director, after such review, to issue the decision of the Board based on such review. The Executive Director may, in his/her discretion, refer any matter to the Board for final action/decision.

   ii. A current or former student at a postsecondary educational institution under the governance of the Board may request that the Executive Director review any final institutional decision relating to a student's attendance at the institution, except as set for under paragraph iii. The student must have exhausted the complaint/grievance resolution procedures that have been established at the institution level. The Executive Director will not review complaints/grievances that have not been reported to the institution, or processed in accordance with the institution's complaint/grievance resolution procedures.

iii. Matters involving a violation of an institution's code of student conduct will only be reviewed if the basis for the request is that the institution substantially failed to follow its procedures resulting in a failure to give the student reasonable notice of the violation and opportunity to be heard, or to present testimony. Sanctions imposed by the institution will remain in effect during the pendency of the review.

iv. A request for review must be submitted in writing to the Board office to the attention of the Chief Academic Officer, and must contain a clear and concise statement of the reason(s) for Board review. Such request must be received in the Board office no later than thirty (30) calendar days after the student receives the institution's final decision on such matter. The student has the burden of establishing that the final decision made by the institution on the grievance/complaint was made in error. A request for review must include a copy of the original grievance and all proposed resolutions and recommended decisions issued by the institution, as well as all other documentation necessary to demonstrate that the student has strictly followed the complaint/grievance resolution procedures of the institution. The institution may be asked to provide information to the Board office related to the student complaint/grievance.

v. The Chief Academic Officer will review the materials submitted by all parties and make a determination of recommended action, which will be forwarded to the Executive Director for a full determination. A review of a student complaint/grievance will occur as expeditiously as possible.

vi. The Board office may request that the student and/or institution provide additional information in connection with such review. In such event, the student and/or institution must provide such additional information promptly.

vii. The Board's Executive Director will issue a written decision as to whether the institution's decision with regard to the student's complaint/grievance was proper or was made in error. The Executive Director may uphold the institution's decision, overturn the institution's decision, or the Executive Director may remand the matter back to the institution with instructions for additional review. Unless referred by the Executive Director to the Board for final action/decision, the decision of the Executive Director is final.

b. The Board staff members do not act as negotiators, mediators, or advocates concerning student complaints or grievances.

SUBJECT

Board Policy III.G. Postsecondary Program Review and Approval – Second 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, which 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 consist 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.
June 16, 2021	The Board approved an extension of the 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.
June 16, 2021	The Board approved the first reading of proposed amendments to Board Policy III.G, which reorganizes and streamlines proposal requirements and provides flexibility to the Executive Director to delegate authority to designees for the approval of academic and career technical program changes.
August 26, 2021	The Board approved the second reading of proposed amendments to Board Policy III.G.
December 15, 2021	The Board approved the first reading of proposed amendments to Board Policy III.G.

APPLICABLE STATUTE, RULE OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.G.
Section 33-2107A, 33-2202, and 33-2205, Idaho Code.

BACKGROUND/DISCUSSION

In August 2021, the Board approved a major revision to Board Policy III.G. Postsecondary Program Approval and Discontinuance. This revision restructured the policy to include three levels of review, based on the nature of requested programmatic changes: full proposal, short proposal, and letter of notification. After the second reading was approved, Board staff identified an unintended conflict in the policy that cannot be handled as a minor technical correction.

IMPACT

Amendments will correct the erroneous conflict and duplicative language in the policy. Amendments will also provide institutions with the necessary procedures for discontinuing certificates and will align roles for program approval for the State Administrator and Executive Director in compliance with Idaho code.

ATTACHMENTS

Attachment 1 – Board Policy III.G. Postsecondary Program Review and Approval – Second Reading

BOARD 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 proposed amendments to Board Policy III.G, Postsecondary Program Review and Approval, 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: G. Postsecondary Program Review and Approval ~~August 2021~~February 2022

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 of the Board 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 of the Idaho Division of Career Technical Education is authorized to approve academic 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 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 does not apply to~~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 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

ATTACHMENT 1

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 or discontinuation of any existing 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.
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 as a Short Proposal:

i. Establishment of a new or discontinuation of any existing 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.
xii. Modification to existing academic instructional or administrative units

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

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 or discontinuation of any existing 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.~~iv. A change from clock hours to credit hours for an academic program.
~~vi.~~v. Addition of an online option to an existing academic program.
~~vii.~~vi. 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.~~vii. Transition of an academic program to an exclusively online format.
~~ix.~~viii. Addition or removal of courses that represent a significant departure from existing academic program offerings or method of delivery.
~~x.~~ix. A change in name or title of any academic program or instructional or administrative unit.
~~xi.~~x. A change of Classification of Instructional Program (CIP) code for any academic program.
~~xii.~~xi. 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 State Administrator ~~and~~ or the Executive Director or designee and shall be submitted by the institution 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 State Administrator or 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 State Administrator ~~and~~ or Executive Director or designee and shall be submitted by the institution 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 7 of this policy.
vi. Addition or removal of courses that represent a significant departure from existing career technical program offerings or method of delivery.
vii. Modification to existing career technical instructional or administrative units.
viii. Conversion or transition of one career technical program degree or certificate level to another degree or certificate level.
ix. Transition of a career technical program to an exclusively online format.
x. Addition of an online option to an existing career technical program.
xi. Transition of a career technical program with less than fifty percent (50%) of courses offered online exclusively to fifty percent (50%) or more of courses offered online exclusively.
~~xii.~~

For the addition or modification of career technical programs or certificates, a Program Profile Attachment B is required. Upon the recommendation of the State

Administrator ~~and~~ or at the 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

Subsequent to institutional review and consistent with institutional policies, and within 30 days after implementation, institutions shall notify the State Administrator ~~and~~ or the Executive Director 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.~~
~~v.~~iv. A change in the name or title of any career technical program or instructional or administrative unit.
~~vi.~~v. A change of Classification of Instructional Program (CIP) code for any career technical program.
~~vii.~~vi. A credit change to an existing career technical program.
~~viii.~~vii. Minor changes to career technical courses. Requires a program profile Attachment B and letter.

Upon the recommendation of the State Administrator ~~and~~ or at the 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. Requests to establish, modify, or discontinue a microcertification, as defined in Board Policy III.E, require approval by the State Administrator ~~and~~ or shall be submitted by the institution in accordance with a template developed by the Division of Career Technical Education.

e. Requests requiring new state appropriations shall be included in the annual budget request of the Idaho Division of Career Technical Education for Board approval.

5. Sunset Clause for Academic and Career Technical Program Approval

Academic and career technical 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 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.

      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 or designee shall report semi-annually to the Board regarding all program proposals approved by the Executive Director or designee.

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.

SUBJECT

Semi-Annual Report of Approved Program Requests

REFERENCE

August 2020	Board received the semi-annual report
February 2021	Board received the semi-annual report
August 2021	Board received the semi-annual report

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.G.8.a.

BACKGROUND/DISCUSSION

In August 2021, the Board approved major revisions to Board Policy III.G. Postsecondary Program Approval and Discontinuance. Revisions restructured the policy to include three levels of review, based on the nature of requested programmatic changes: full proposal, short proposal, and letter of notification. Additionally, revisions provide flexibility to the Board's executive director to delegate authority to designees for the approval of academic and career technical program changes. In accordance with newly revised Board Policy III.G.3.a.ii and 4.b., prior to implementation, the executive director or designee may approve actions related to academic and career technical programs or units as identified in those subsections.

Consistent with Board Policy III.G.9.a., the Board office is providing a semi-annual report of academic and career technical program requests from Idaho's public postsecondary institutions that were approved by the executive director or his designee between July 1, 2021, and December 31, 2021. A report of program change requests approved by the full Board for the same time period is also included for informational and contextual purposes.

ATTACHMENTS

Attachment 1 – Semi-Annual Report of Approved Program Requests

BOARD STAFF COMMENTS AND RECOMMENDATIONS

The report provides an overview of new academic or career technical programs and certificates approved by the executive director or his designee consistent with recently revised Board Policy III.G. This includes other instructional activity such as modifications to existing programs. Other non-substantial changes that require notification to the Board office are also included in the report.

Staff note several trends in program requests over the past five fiscal years:

- An increase in the number of undergraduate programs in FY21-22. A total of 9, approved by either the Board or Executive Director compared to 1 in FY20-21. This was in part due to the development of new cybersecurity programs and new online program offerings.

- An increase in number of degrees discontinued – 12 in FY21-22. These were primarily associate programs that were merged to create efficiencies or discontinued due to low enrollment.
- A decrease in the number of program modifications from 46 in FY20-21 –to 12 during the current academic year.
- An increase in the number of specialized certificates from 1 in FY20-21 to 4 in the current academic year with more in progress. These are new certificate types that were added to Board Policy III.E in August 2020. This certificate is awarded for completion of specific, industry-validated courses that are sequenced for the purpose of developing and upgrading skills in an occupation.

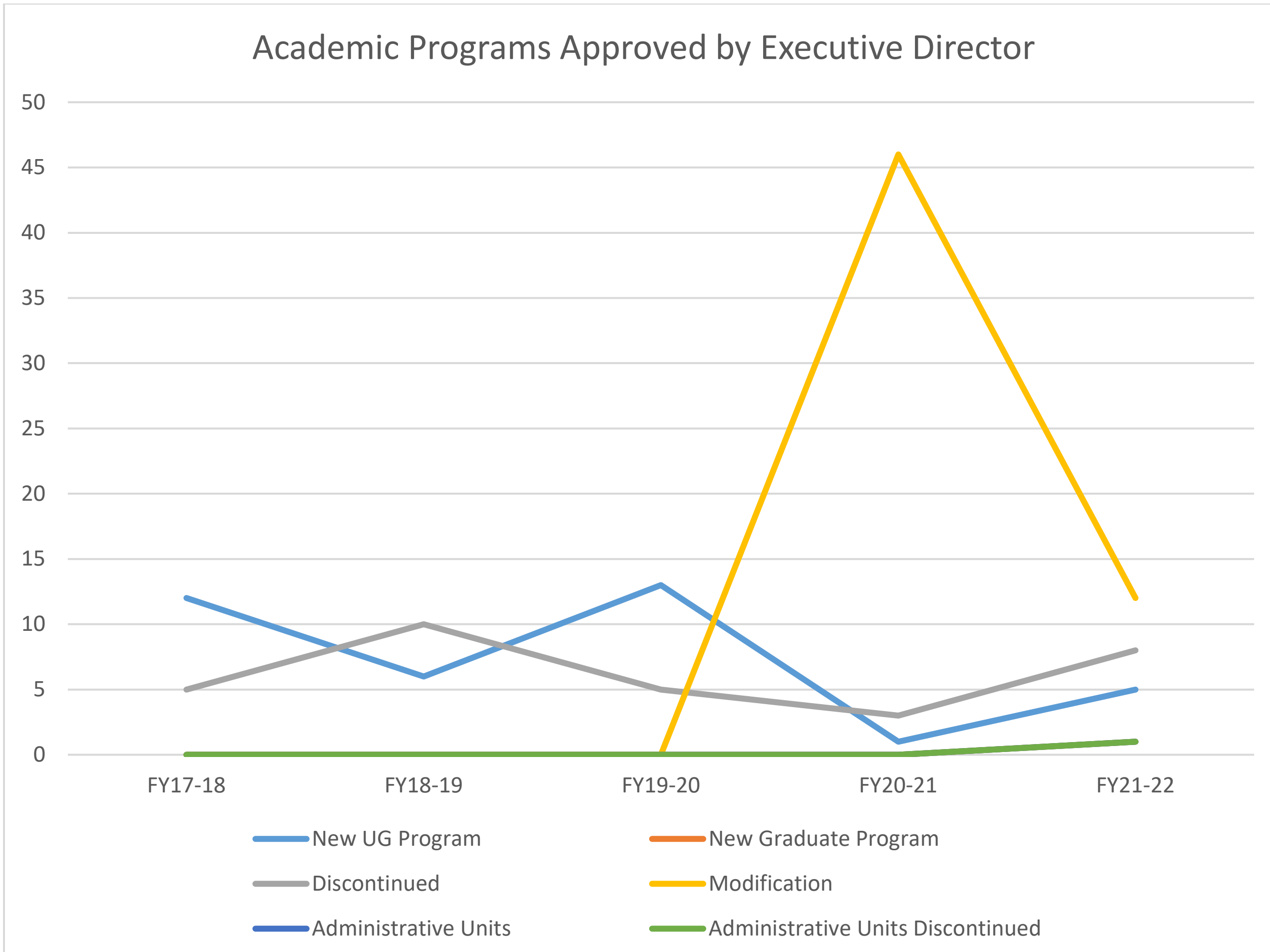
During the next reporting cycle, staff will be able to provide a comprehensive comparison of the impact policy amendments had on programs approved by the Executive Director or designee versus the Board.

BOARD ACTION

This item is for informational purposes.

ATTACHMENT 1

Semi-Annual Report of Approved Program Requests
July 2021 through December 2021



ATTACHMENT 1

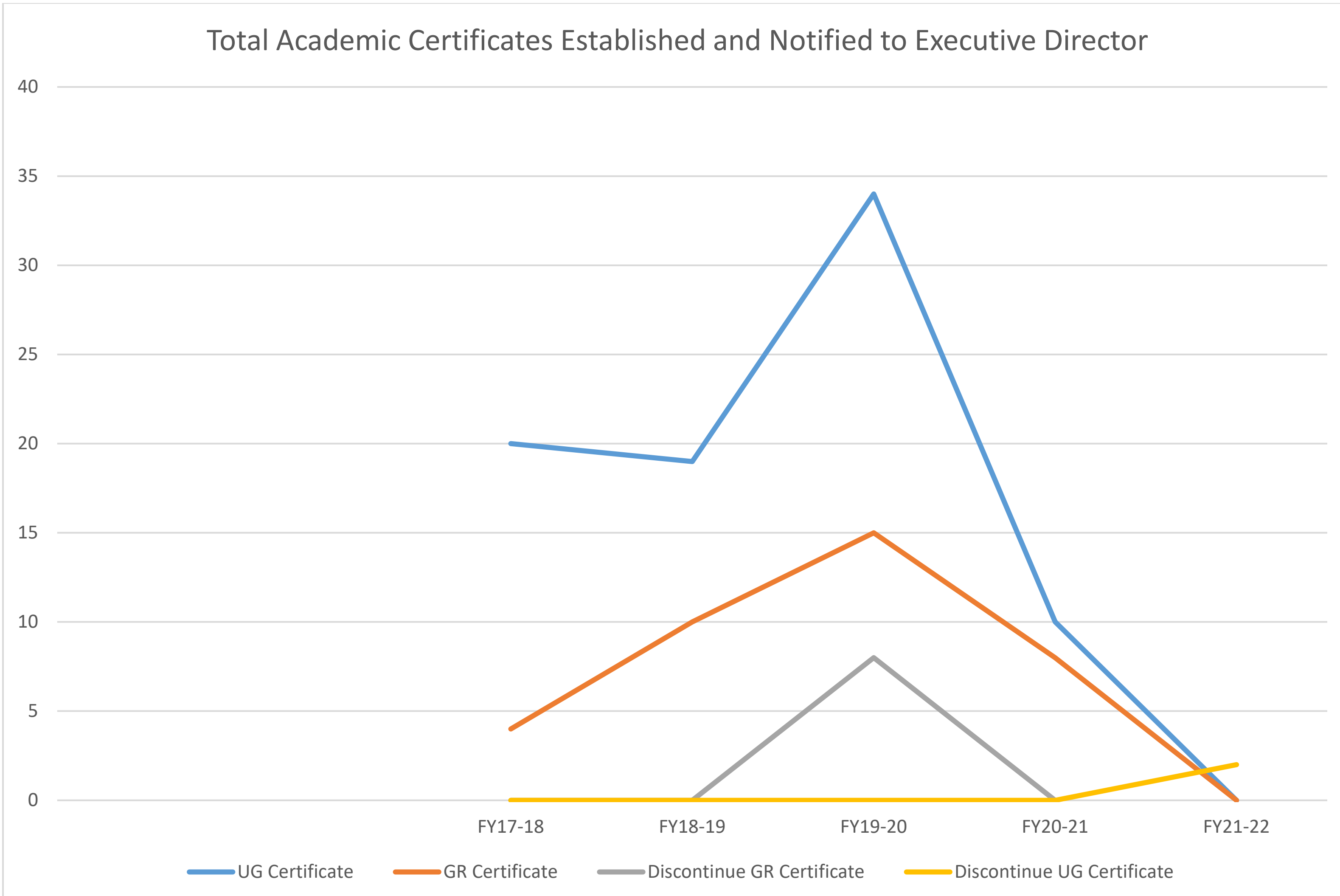
List of Academic Program and Unit Requests Approved by Executive Director

INST.	Status	Request Type	Program Title	Degree	Date
CSI	Approved	Discontinuance	Equine Studies	AA	7/19/2021
CSI	Approved	Discontinuance	Horticulture	AS	7/19/2021
CSI	Approved	Discontinuance	Equine Business Management	AS	7/19/2021
CSI	Approved	Discontinuance	Dance	AA	10/25/2021
CSI	Approved	New	Visual and Performing Arts	AA	10/25/2021
CWI	Approved	New	Honors Program	N/A	10/20/2021
CWI	Approved	Discontinuance	Transportation Management	AS	1/10/2022
ISU	Approved	Expansion	Ed Admin with Athletic Admin Emphasis (online)	M.Ed.	7/2/2021
ISU	Approved	Expansion	Education Administration with P-12 Education Administration emphasis (online)	M Ed	7/2/2021
ISU	Approved	Expansion	Education Administration (online)	Ed S	7/2/2021
ISU	Approved	Expansion	Educational Leadership (P-12 Education Administration) (online)	Ed D Emp.	7/2/2021
ISU	Approved	Expansion	Educational Leadership (Higher Education Administration emphasis) (online)	AA | Ed D Emp.	7/2/2021
ISU	Approved	Expansion	Elementary Education (online)	M Ed	7/2/2021
ISU	Approved	Expansion	Human Resource Development (online)	MS	7/2/2021
ISU	Approved	Expansion	Instructional Design and Technology (online)	M Ed	7/2/2021
ISU	Approved	Expansion	Instructional Design and Technology (online)	Ed D Emp.	7/2/2021
ISU	Approved	Expansion	School Psychology (online)	Ed S	7/2/2021
ISU	Approved	Expansion	School Psychological Examiner (online)	M Ed	7/2/2021
ISU	Approved	Expansion	Secondary Education (online)	M Ed	7/2/2021
ISU	Approved	New	Computer Engineering	BS	7/8/2021
ISU	Approved	New	Digital Media	BFA	7/8/2021
ISU	Approved	New	Respiratory Therapy - degree completion	BS	10/25/2021
ISU	Executive Director Approved	New	Electrical & Computer Engineering: Electrical Engineering concentration	MS	11/29/2021

ATTACHMENT 1

INST.	Status	Request Type	Program Title	Degree	Date
ISU	Executive Director Approved	New	Electrical & Computer Engineering: Computer Engineering concentration	MS	11/29/2021
LCSC	Approved	Discontinuance	Engineering	AS	7/28/2021
LCSC	Approved	Discontinuance Instructional Unit	Division of Movement and Sports Science	N/A	7/28/2021
LCSC	Approved	Discontinuance	English: Creative Writing	BA	7/27/2021
NIC	Approved	Discontinuance	Public Relations	AA	7/2/2021

ATTACHMENT 1



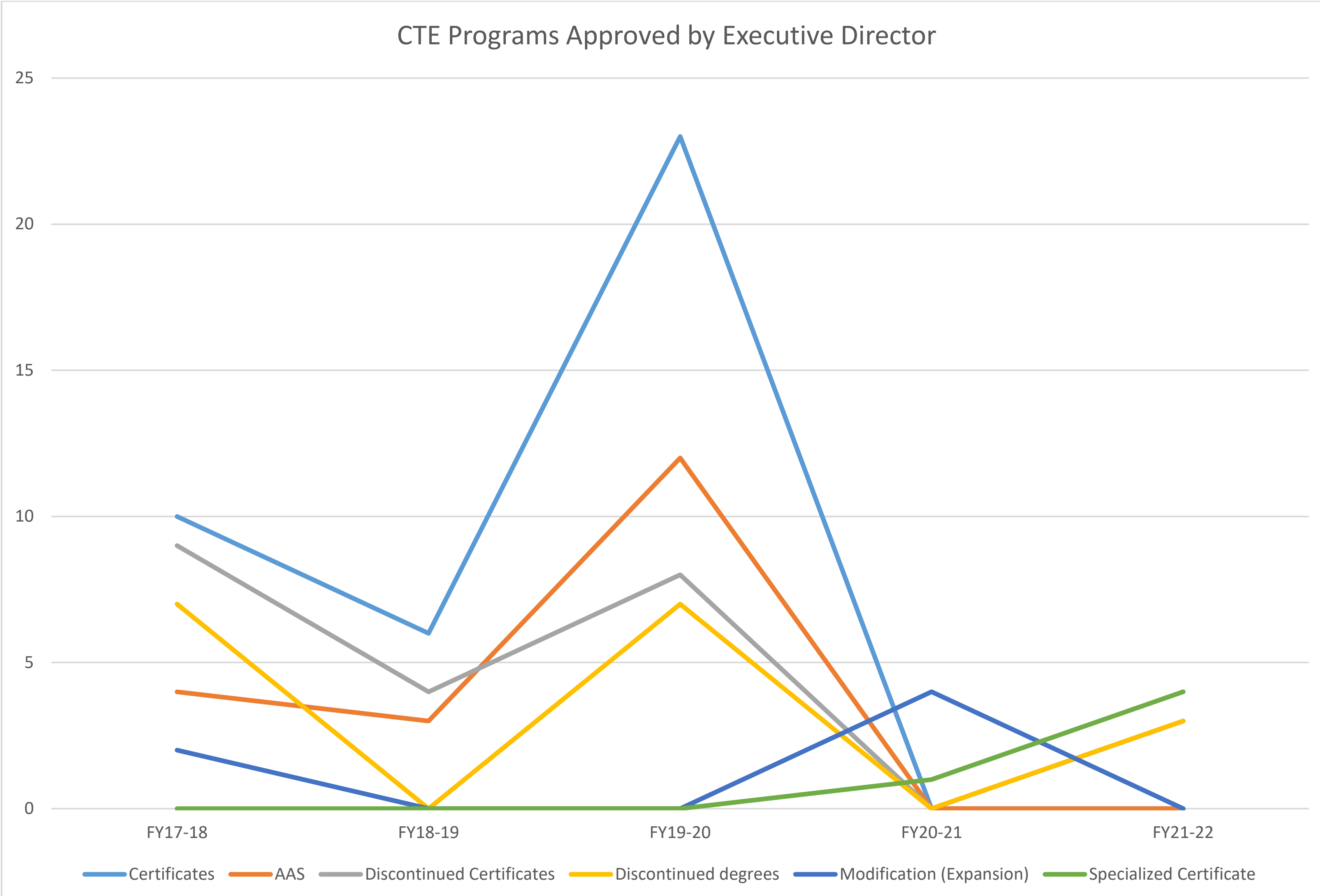
ATTACHMENT 1

List of Other Academic Program/Unit Changes Notified to Executive Director

The following program changes or additions do not require approval; however, they require notification to OSBE per policy III.G. prior to implementation.

INST.	Request Type	Program Title	Certificate	Date
BSU	Discontinuance	Early Childhood Intervention Services	Undergraduate Certificate	12/13/2021
BSU	Discontinuance	Special Education Services	Undergraduate Certificate	12/13/2021
UI	Clarification of Options offered	Master of Music Collaborative Piano • Composition • Music Education • Performance • Piano Pedagogy • Composition (Distance Learning) • Performance (Distance Learning)	Options	10/4/2021

ATTACHMENT 1



ATTACHMENT 1

New Career Technical Program and Unit Requests Approved by Executive Director (by Type)

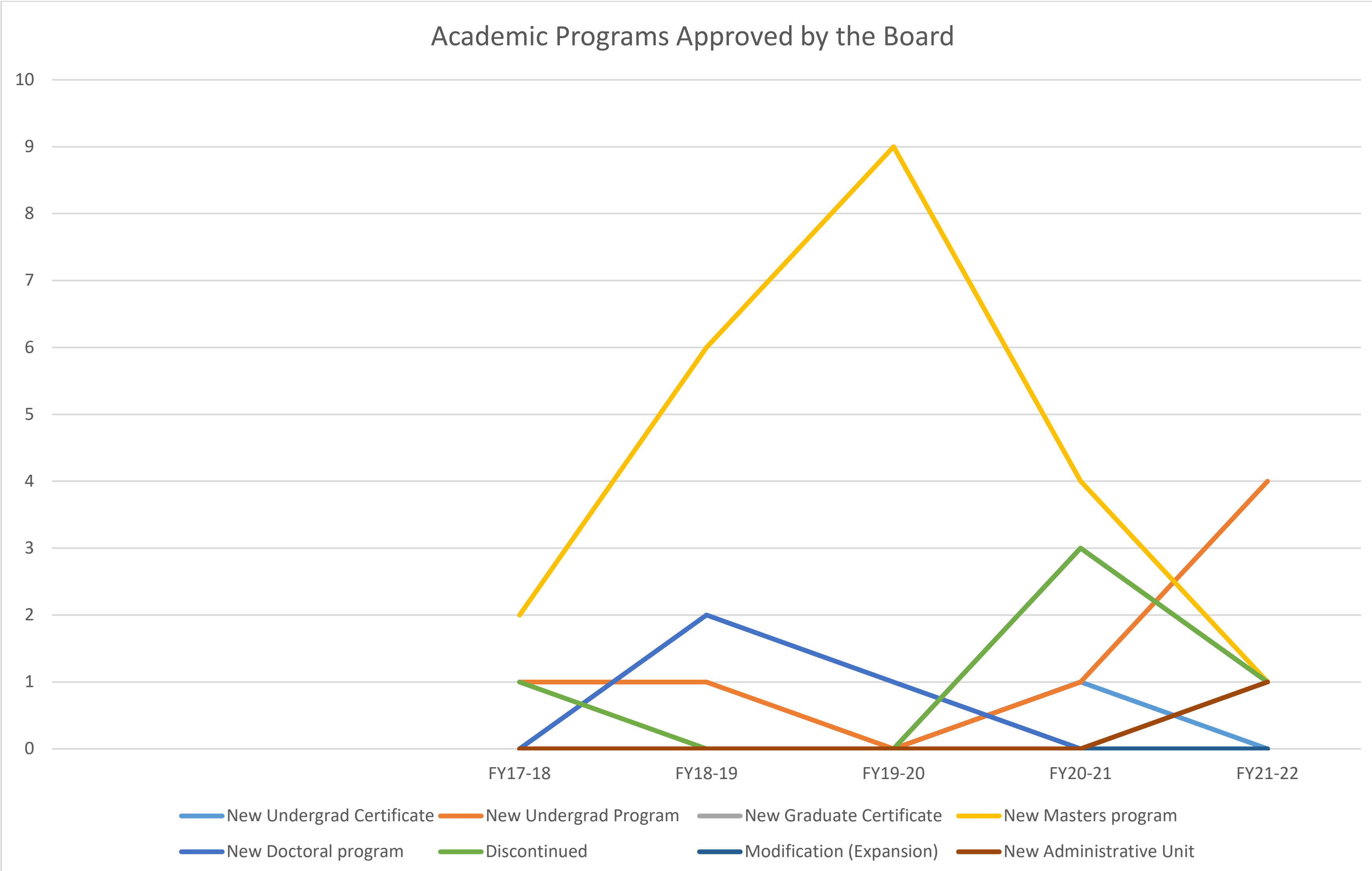
INST.	Status	Request Type	Program Title	Degree	Date
CSI	Approved	Discontinuance	Equine Studies	AAS	7/19/2021
CSI	Approved	Discontinuance	Equine Studies	ITC	7/19/2021
CSI	Approved	Discontinuance	Horticulture	AAS	7/19/2021
CSI	Approved	Discontinuance	Horticulture	ITC	7/19/2021
CWI	Approved	Discontinuance	Western States CAT Technician	AAS	7/29/2021
CWI	Approved	Discontinuance	Western States CAT Technician	ATC	7/29/2021
CWI	Approved	Expansion	Network and System Administration/Cloud Computing	Specialized Certificate	7/2/2021
ISU	Approved	New	Nuclear Welding	Specialized Certificate	7/28/2021
ISU	Approved	New	Barbering	Specialized Certificate	7/28/2021
ISU	Approved	New	Cloud Computing	BTC	10/25/2021

List of Other CTE Program Changes Notified to Executive Director

The following program changes or additions do not require approval; however, they require notification to OSBE per policy III.G. prior to implementation.

Instit.	Request Type	Program Title	Degree/Certificate	Date
CWI	Name change	Autobody Technology to Collision Repair Technology		12/20/2021
CWI	Name change	Horticulture to Horticulture Technology		12/20/2021

ATTACHMENT 1



ATTACHMENT 1

List of Academic Program and Unit Requests Approved by the Board

INST.	Status	Request Type	Program Title	Degree	Date
BSU	Board Approved	New	Institute for Advancing American Values	N/A	8/27/2021
BSU	Board Approved	New	Cyber Operations and Resilience	B.A.S.	10/25/2021
BSU	Board Approved	Discontinuance	Early Childhood Intervention	M.I.T.	7/19/2021
BSU	Board Approved	New	Digital Innovation and Design	B.A.	8/27/2021
ISU	Board Approved	Discontinuance	Theatre	MA	8/27/2021
ISU	Board Approved	New	Homeland Security and Emergency Management	MS	8/27/2021
ISU	Board Approved	New	Respiratory Therapy - degree completion	BS	10/25/2021
ISU	Board Approved	New	Listening and Spoken Language (online)	Graduate Certificate	10/25/2021
LCSC	Board Approved	New	Cyber Management	BA/BS	10/25/2021

SUBJECT

Higher Education Research Council Annual Report for Fiscal Year 2021

REFERENCE

February 2017	The Board was provided the annual update of the Higher Education Research Council for FY16 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 for FY17
June 2019	The Board was provided the annual update of the Higher Education Research Council for FY18
June 2020	The Board was provided the annual report of the Higher Education Research Council for FY19
June 2021	The Board was provided the annual report of the Higher Education Research Council for FY20

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 among the three Idaho public research institutions (Boise State University, Idaho State University, University of Idaho), and the Idaho National Laboratory. The most recent annual CAES report was provided with the FY20 HERC Annual Report provided to the Board in June 2021. Thus, no CAES report is included in this item.

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 ongoing input to the Higher Education Research Council on areas of focus and strategic direction, especially as it engages in the process of developing the next five-year higher education research strategic plan.

ATTACHMENTS

Attachment 1 – FY21 HERC Report Presentation
Attachment 2 – FY21 HERC Budget Allocation
Attachment 3 – FY21 Research Performance Measure Report
Attachment 4 – FY21 Research Activity Reports
Attachment 5 – FY21 Infrastructure Reports
Attachment 6 – FY21 Undergraduate Research Report
Attachment 7 – FY21 Idaho Conference on Undergraduate Research Report
Attachment 8 – FY21 IGEM Grant Final and Annual Reports

BOARD STAFF COMMENTS AND RECOMMENDATIONS

This report will be provided by the Chair of HERC, Dr. Christopher Nomura, Vice President for Research and Economic Development at the University of Idaho.

BOARD ACTION

This item is for informational purposes only.

Higher Education Research Council

Report on activities from July 1, 2020 - June 30, 2021
(Fiscal Year 2021)

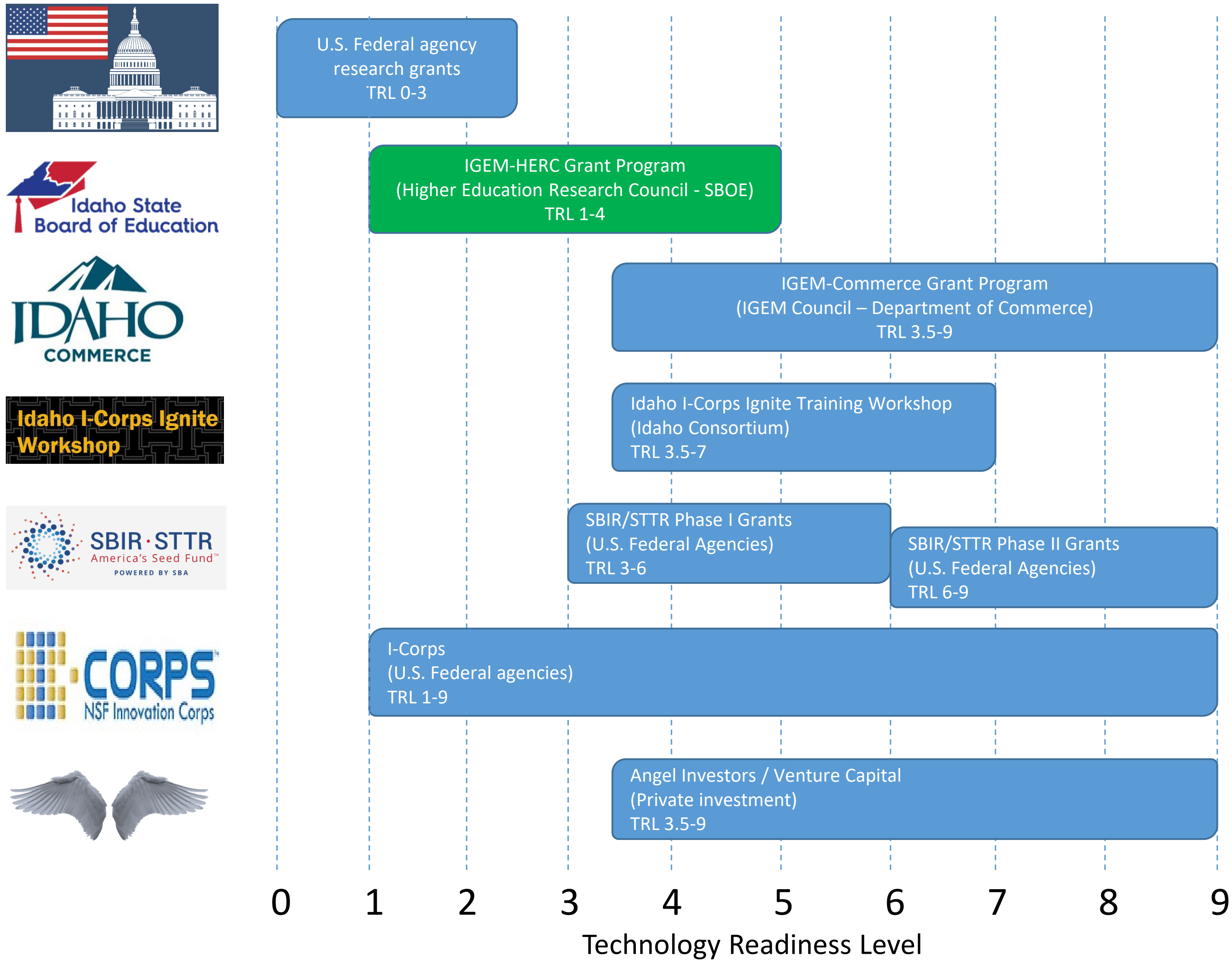
Dr. Christopher Nomura, Chair

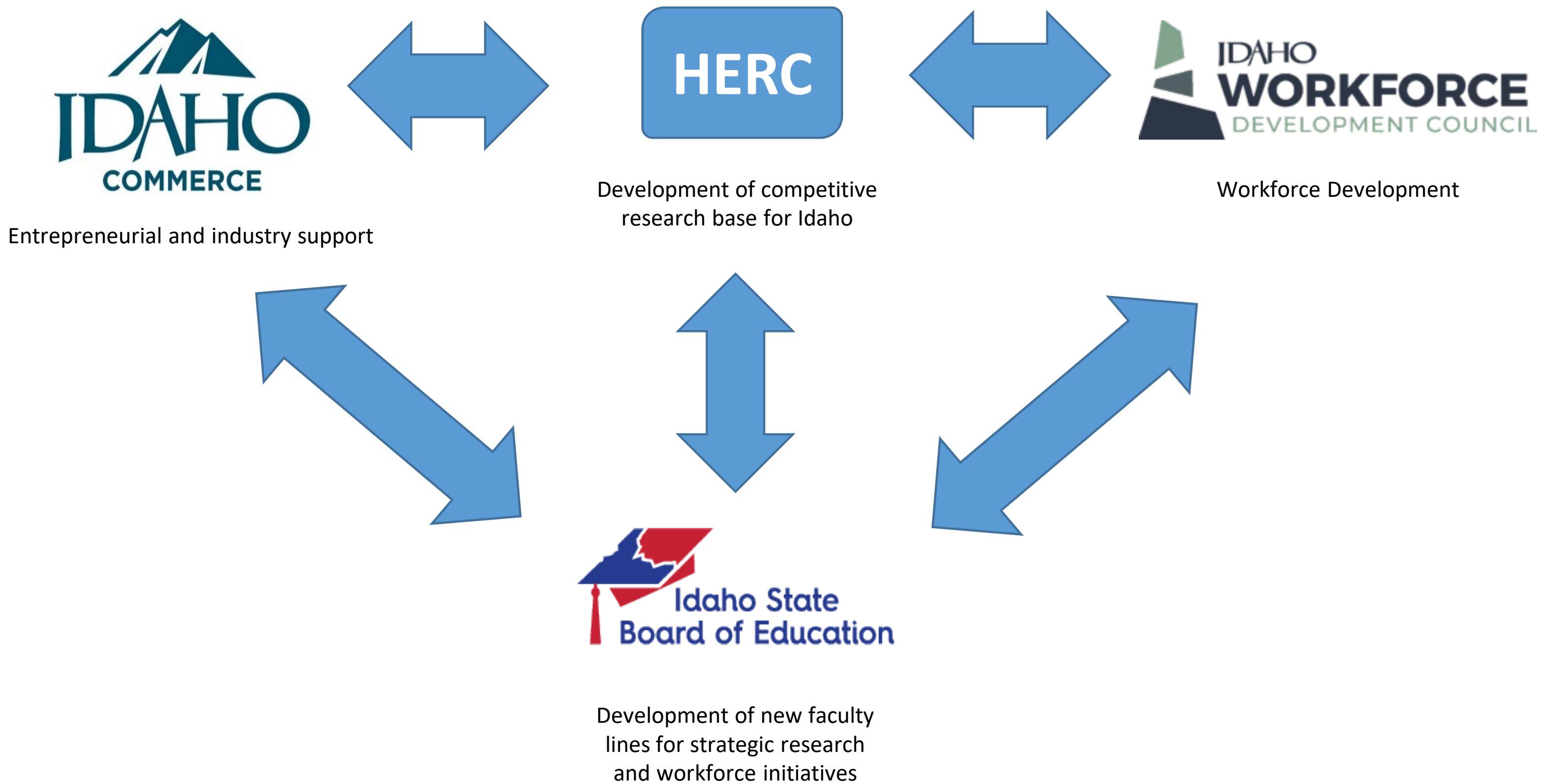
Attachments

- FY21 HERC Budget Allocation
- FY21 HERC Research Performance Measure Report
- FY21 Research Activity Reports
- FY21 Infrastructure Summary Reports
- FY21 Undergraduate Research Reports
- FY21 Idaho Conference on Undergraduate Research Report
- FY21 IGEM Grant Reports

HERC Mission

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


U.S. Federal agency research grants TRL 0-3
Idaho State Board of Education
IGEM-HERC Grant Program (Higher Education Research Council - SBOE) TRL 1-4
IDAHO COMMERCE
IGEM-Commerce Grant Program (IGEM Council – Department of Commerce) TRL 3.5-9
Idaho I-Corps Ignite Workshop
Idaho I-Corps Ignite Training Workshop (Idaho Consortium) TRL 3.5-7
SBIR·STTR America's Seed Fund POWERED BY SBA
SBIR/STTR Phase I Grants (U.S. Federal Agencies) TRL 3-6
SBIR/STTR Phase II Grants (U.S. Federal Agencies) TRL 6-9
CORPS NSF Innovation Corps
I-Corps (U.S. Federal agencies) TRL 1-9
Angel Investors / Venture Capital (Private investment) TRL 3.5-9
0 1 2 3 4 5 6 7 8 9
Technology Readiness Level


IDAHO COMMERCE
Entrepreneurial and industry support
HERC
Development of competitive research base for Idaho
IDAHO WORKFORCE DEVELOPMENT COUNCIL
Workforce Development
Idaho State Board of Education
Development of new faculty lines for strategic research and workforce initiatives

HERC Impact

HERC has invested just under $12.5M in 8 major projects since 2016.
These projects have resulted in…

$52.5M
External funding received

450+
Students involved in research projects

345
Jobs created in Idaho

205+
Peer-reviewed scientific articles published

12
Patents awarded or pending

4
Companies launched in Idaho

HERC Membership

Higher Education Representatives

Dr. Christopher Nomura (Chair), *University of Idaho*

Dr. Donna Lybecker, *Idaho State University*

Dr. Nancy Glenn, *Boise State University*

Fred Chilson, *Lewis-Clark State College*

Industry Representatives

Marianne Walck (Vice Chair), *Idaho National Laboratory*

Eileen Barber, *Keynetics*

Heather Messenger, *Life Sciences and Biotech Industry*

Douglas Sayer, *Premier Technology Inc.*

FY21 HERC Budget Allocation

Research Infrastructure Funds	$872,100
Matching Grants (EPSCoR)	$800,000
Undergraduate Research	$199,000
IGEM Grants	$2,001,000
Incubation Fund	$0
Administrative Costs	$2,700
Total	**$3,874,800**

Research Infrastructure

Funding to support science, engineering, and other research infrastructure

FY21 Infrastructure Budget - $872,100

Major line items:

BSU – High end research equipment and new hires

ISU – A Leica microscope for zebrafish research, and a UV-Vis/Fluorometer for the chemistry department

UI - Idaho Water Resources Research Institute Post Doc Fellow, and Northwest Knowledge Network equipment upgrades

LC State – Salary for a new Research Librarian, and library support/lab equipment

Undergraduate Research

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

FY21 UR Budget - $199,000

Student research projects supported in FY21:

- **BSU** – 17
- **ISU** – 7 (22 students involved)
- **UI** – 10
- **LC State** – 10

Idaho Conference on Undergraduate Research (ICUR)

Funding for two day undergraduate conference held each July

FY21 ICUR Budget - $30,000

FY21 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

FY21 IGEM Grant Budget – $2,001,000

Active Grants in FY21: 4

FY21 Active IGEM Grants

IGEM 19-001: Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management

University of Idaho – $696,000 – Year 3

IGEM 19-002: Nucleic Acid Memory

Boise State University – $662,500 – Year 3

IGEM 20-001: A Disaster Response Complex for Emergency Responders in Idaho

Idaho State University – $271,400 – Year 2

GEM 20-002: Cellulosic 3D Printing of Modular Building Assemblies

University of Idaho – $371,100 – Year 2

HERC Funded Projects in the News

- *IGEM 19-002 - Hughes (BSU): Nucleic Acid Memory*
  - *https://theconversation.com/dna-lite-brite-is-a-promising-way-to-archive-data-for-decades-or-longer-157856*
- *IGEM 20-001 - Mashal (ISU): A Disaster Response Complex for Emergency Responders in Idaho*
  - *https://www.eastidahonews.com/2021/09/isu-inl-host-disaster-response-training-for-oregon-idaho-national-guard/*
- *IGEM 20-002 - Baker/McDonald (UI): Cellulosic 3D Printing of Modular Building Assemblies*
  - *https://www.uidaho.edu/news/news-articles/news-releases/2021-fall/093021-woodwaste*

IGEM 19-001: 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
- **Key Outcomes:**
  - Co-I Donna Delparte (ISU) formed a spinoff company (I2IGeo) to develop commercialization pathway to use satellite and drone technology to assist growers in application of nutrients, herbicides, pesticides, and water.
  - The Stakeholder Advisory Board (SAB), with a number of industry and government groups, met to discuss commercialization and tech transfer opportunities for wastewater/energy planning.

IGEM 19-002: 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 limit
- Project aimed to 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
- **Key Outcomes:**
  - Creation of Nucleic Acid Memory (NAM) Institute to meet critical innovation, economic, and workforce development needs
  - Several products, patents, journal articles, software packages, and one new company
  - NAM was invited to join the DNA Storage Alliance

IGEM 20-001: 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
- **Current Status:** The DRC facility is fully developed, with the goal of becoming financially self-sustaining by August 2022. The DRC has already hosted numerous training events for local and regional groups and agencies and will continue to grow and expand.

IGEM 20-002: 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.
- **Current Status**: Significant progress on each of the four tasks identified as Year 2 deliverables. No private industry support yet, but are working toward provisional patent. Accepted into I-Corps Ignite program to provide support on business model development. First prototype printer has been designed and built, with successful single-layer prints. Have produced a hardboard product that looks to be competitive with other hardboards on the market.

Thank You

Idaho State
Board of Education

FY 2021 Allocation of HERC Funds

	Revised Total (5% holdback)	Original Total	FY2021	FY2020
	$3,874,800	$4,074,800		
HERC IGEM			$2,001,000	$2,066,500
Infrastructure Funds			$872,100	$850,000
Matching Grants (EPSCoR Match)			$800,000	$800,000
Incubation Fund			$0	$224,670
Undergraduate Research			$199,000	$217,000
Administrative Costs			$2,700.00	$2,700
TOTAL	**$3,874,800**	**$4,074,800**	**$3,874,800**	**$4,160,870**
BALANCE				2,330

		FY2021	FY2020
IGEM Funds			
BSU	IGEM 19-02	$662,500	$666,500
ISU	IGEM 20-01	$271,400	$525,100
UI	IGEM 19-01	$696,000	$700,000
UI	IGEM 20-02	$371,100	$174,900
LCSC			
Total IGEM		**$2,001,000**	**$2,066,500**
Research Infrastructure Funds			
BSU		$257,206	$250,000
ISU		$257,206	$250,000
UI		$257,206	$250,000
LCSC		$100,482	$100,000
Total Infrastructure		**$872,100**	**$850,000**
Matching Award Grants			
NSF-EPSCoR		$800,000	$800,000
Total Matching Grants		**$800,000**	**$800,000**
Targeted Research			
Idaho Incubation Fund (7th round)		$0	
BSU			$149,970
ISU			
UI			$74,700
Total Targeted Research		**$0**	**$224,670**
Undergraduate Research			
BSU		$51,000	$55,000
ISU		$51,000	$55,000
UI		$51,000	$55,000
LCSC		$16,000	$20,000
Idaho Conference for Undergraduate Research (ICUR)		$30,000	$32,000
One-time money			
Total Undergraduate Research		**$199,000**	**$217,000**
Administrative Costs			
FY21 Administrative Costs		$2,700	$2,700
Total Administrative Costs		**$2,700**	**$2,700**
Total Budget / Allocation		**$3,874,800**	**$4,160,870**

HIGHER EDUCATION RESEARCH COUNCIL - 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	FY2021	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	$170,635,458	NA	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	$13,187,742	NA	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	82	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	34	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	UI*/BSU/ISU - Dr. Karen Humes - Integrated Water, Energy and Waste Management			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	FY2021	Benchmark
Number of new sponsored projects involving the private sector.	165	163	172	202	206	193	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	FY2021	Benchmark
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	44	33	29	29	28	37	15% annual increase
Number of invention disclosures (including biomic varieties)	40	38	45	46	58	49	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	$ 2,626,859	10% annual increase
Number of startup companies.	8	1	1	1	0	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	FY2021	Benchmark
Number of undergraduate students paid from sponsored projects.	1,683	1,811	2,100	1,926	1,993	2,050	20% annual increase
Number of graduate students paid from sponsored projects.	636	716	656	592	536	530	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%	UI: 57.6% BSU: N/A ISU: 19.0%	20% annual increase
Number of faculty and staff paid from sponsored projects.	2,272	2,383	2,418	2,446	2,484	2,563	20% annual increase
K-20 Statewide Stratgic Plan Performance Measures	**FY 2016**	**FY 2017**	**FY2018**	**FY2019**	**FY2020**	**FY2021**	**Benchmark**
Percentage of students participating in undergraduate research.	48%	51%	UI: 61%, BSU: 37% ISU: 45%	UI: 58.4% BSU: 43.0% ISU: 37.7%	UI: 59.6% BSU: 43.0% ISU: 36.2%	UI: 55.5% BSU: 34.0% ISU: 37.0%	30%
Number of student internships	2,294	2,177	2,156	2,127	2,174	2,020	

Boise State University Sponsored Project Activity Report FY2021

Awards for the Period July 1, 2020 through June 30, 2021

Activity Type	Federal	State	Industry	Other	Total	% of Grand Total
Instruction:						
Sponsored Programs	$ 2,052,281	$ 430,680	$ -	$ 54,717	$ 2,537,678	
State Instruction Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal Instruction	$ 2,052,281	$ 430,680	$ -	$ 54,717	$ 2,537,678	3.88%
Research:						
Sponsored Programs	$ 37,731,137	$ 2,589,832	$ 268,008	$ 942,495	$ 41,531,472	
State Research Appropriations	$ -	$ 2,146,500	$ -	$ -	$ 2,146,500	
Subtotal Research	$ 37,731,137	$ 4,736,332	$ 268,008	$ 942,495	$ 43,677,972	66.85%
Other Sponsored Activities:						
Sponsored Programs	$ 14,182,940	$ 2,460,292	$ 20,000	$ 2,305,055	$ 18,968,287	
State Other Sponsored Activities Appropriations	$ -	$ 151,186	$ -	$ -	$ 151,186	
Subtotal Other Sponsored Activities	$ 14,182,940	$ 2,611,478	$ 20,000	$ 2,305,055	$ 19,119,473	29.26%
Grand Totals	**$ 53,966,359**	**$ 7,778,490**	**$ 288,008**	**$ 3,302,267**	**$ 65,335,124**	
Percent of Grand Total	***82.60%***	***11.91%***	***0.44%***	***5.05%***	***100%***	***100%***

Expenditures for the Period July 1, 2020 through June 30, 2021

Activity Type	Federal	State	Industry	Other	Totals	% of Grand Total
Instruction:						
Sponsored Programs	$ 2,155,923	$ 1,279,610	$ -	$ 100,097	$ 3,535,631	
State Instruction Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal Instruction	$ 2,155,923	$ 1,279,610	$ -	$ 100,097	$ 3,535,631	6.23%
Research:						
Sponsored Programs	$ 31,730,192	$ 1,413,133	$ 575,859	$ 999,771	$ 34,718,954	
State Research Appropriations	$ -	$ 909,527	$ -	$ -	$ 909,527	
Subtotal Research	$ 31,730,192	$ 2,322,660	$ 575,859	$ 999,771	$ 35,628,481	62.81%
Other Sponsored Activities:						
Sponsored Programs	$ 11,589,364	$ 4,605,868	$ 90,308	$ 1,193,585	$ 17,479,125	
State Other Sponsored Activities Appropriations	$ -	$ 78,277	$ -	$ -	$ 78,277	
Subtotal Other Sponsored Activities	$ 11,589,364	$ 4,684,144	$ 90,308	$ 1,193,585	$ 17,557,401	30.95%
Grand Totals	**$ 45,475,479**	**$ 8,286,414**	**$ 666,167**	**$ 2,293,452**	**$ 56,721,513**	
Percent of Grand Total	***80.17%***	***14.61%***	***1.17%***	***4.04%***	***100%***	***100%***

Idaho State University

Office for Research

Award Breakdown by Funding Agency Type and Project Type

July 1, 2020 through June 30, 2021

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	5,331,972	1,226,296	2,614,801	3,401,359	12,574,428	26%
Training and Instruction	3,900,773	481,457	992,935	153,016	5,528,181	11%
Other/Public Service	23,045,775	5,901,471	854,623	1,031,105	30,832,974	63%
Totals	32,278,520	7,609,224	4,462,359	4,585,480	48,935,583	100%
Percent of Total	66%	16%	9%	9%	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 FY21

Idaho State University

Office for Research

Expenditure Breakdown by Funding Agency Type and Project Type

July 1, 2020 through June 30, 2021

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	3,018,237	2,989,176	2,265,994	462,219	8,735,625	37%
Training and Instruction	3,443,803	1,445,316	1,155,985	138,667	6,183,771	26%
Other/Public Service	3,799,739	4,452,442	525,523	17,694	8,795,397	37%
Totals	10,261,778	8,886,933	3,947,502	618,580	23,714,793	100%
Percent of Total	43%	37%	17%	3%	100%	

File Name: ISU OR Annual Expenditures FY21

NOTE: The FY21 Research Activity Report for the University of Idaho will be available after February 28, 2022

Their institution does not close out federal data for FY21, which is the data used for this report, until January 31 of each year when they submit their NSF HERD Survey results

The FY20 Research Activity Report included (next page) is the most recent report at this time

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%**	

FY2021 INFRASTRUCTURE REPORT SUMMARY - Boise State University

Detailed Allocations	
Library Support	
Graduate Research Assistantships/Research Associates	
Post Doctoral Fellows	
Technician Support	
Maintenance Contracts	
Research Equipment	157,200
Competitively Awarded Summer Research Support	
Start-Up Funds for New Hires	100,000
Incentives to Reward Faculty for Research Achievements	
Other	
Total Allocation	257,200

FY 2021 INFRASTRUCTURE REPORT SUMMARY – Boise State University

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	

FY 2021 INFRASTRUCTURE REPORT SUMMARY – Boise State University

Notes:
Research Equipment:
HPC (High Performance Computing) Equipment and Software - $117,000
Vivarium Infrastructure / equipment - $7,735
Mainali Physics Lab - $32,465
TOTAL: 157,200

Startup
Cruz/Bittleston – Biology $100,000

FY2021 INFRASTRUCTURE REPORT SUMMARY - University of Idaho

	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$72,320	Idaho Water Resources Research Institute PostDoc Fellow
Technician Support	$27,911	Genomics Service Center
Maintenance Contracts	$0	
Equipment	$45,528	$36,528, Northwest Knowledge Network equipment upgrades; $9,000, ductless economy hood and security cameras for the Hagerman Fish Culture Experiment Station.
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$6,535	Excellence in Research Award
Other	$104,906	$2,343 for UI PostDoc/Faculty Mentor Award; $10,000, publishing support; $4,128, cost share for developing thermostat prototype for holistic climate control system. $88,435, supplies for Genomics Service Center
Total Allocation	$257,200	

FY2021 INFRASTRUCTURE REPORT SUMMARY - University of Idaho

	Detailed Allocations
Publications in Refereed Journals	11
Presenations at Professional Meetings and Conferences	11
Grants Received as a Result	
Grants Pending	
Student Participation	8
Faculty Participation	24
Other Participation	6
Patents Awarded	
Patents Pending	

NOTE: Other participation includes postdocs, research scientists, research specialists, and stakeholders.

FY2021 INFRASTRUCTURE REPORT SUMMARY - Idaho State University

ISU FY 2021	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$0	
Technician Support	$0	
Maintenance Contracts	$0	
Research Equipment	$219,112	The Leica microscope is being used in the only zebrafish research facility at Meridian ISU Health Sciences Center. The unique fluorescence feature of this versatile stereomicroscope makes it an ideal instrument for zebrafish research and an necessity for zebrafish facility day-to-day operations. Purchased a UV-Vis/Fluorometer and related accesories from Vernier Software and Technology for the Chemistry Department. Cage Washing sytem for Animal Facilities.
Competitvely Awarded Summer Research Support	$0	
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$0	
Other	$65,559	Computers, isolation frame, load cells, threaded rods, accessories, and other smaller items.
Total Allocation	$284,671	

FY 2021 INFRASTRUCTURE REPORT SUMMARY - Idaho State Univeristy

ISU FY 2021	
Publications in Refereed Journals	N/A• Z. Free, M. Hernandez, M. Mashal, and K. Mondal (2021). A Review on Advanced Manufacturing for Hydrogen Storage Applications. mdpi Journal Energies. (Under Review) • K. Hogarth, J. Cantrell, M. Mashal, and B. Savage (2021). 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) • M. Mashal, K. Gurung, M. Acharya (2021). Full-Scale Flexural Testing of Slabs Made of Modular Structural Concrete Insulated Panels, PCI Journal. (Accepted for Publication) • M. Mashal and B. Savage (2021). Bringing Precast Concrete to Classrooms, Issue 3/2021, Concrete Plant International North America and Worldwide Editions. • B. Durtschi, M. Mahat, M. Mashal, and A. Chrysler (2021). Preliminary Analysis of RFID Localization System for Moving Precast Concrete Units using Multiple-Tags and Weighted Euclid Distance k-NN algorithm, IEEE RFID, April 27-29, 2021, Atlanta, Georgia, United States.
Presenations at Professional Meetings and Conferences	2 presentations have been submitted to ARO national meeting
Grants Received as a Result	
Grants Pending	Two grant applications have been submitted to American Hearing Research Foudation and Idaho INBRE.
Student Participation	The zebrafish facility and research involve 3 PhD students, 3 rotating PhD students, and numerous PharmD students doing research rotations and taking research electives for the Biology Department. Summer research project - collaboration between Chemistry and Bilological Scienc es with UG Student (Carlyn Osterhout) Use of the intrument in Inorganic Chemistry Laboratory Course (F21). Ten Students in civil and environmental engineering and other engineering departments at ISU
Faculty Participation	2 (electrical and computer engineering; nuclear engineering)
Other Participation	Researchers from Idaho National Laboratory and the Center for Advanced Energy Studies
Patents Awarded	N/A
Patents Pending	Several provisional patent applications are underway.• M. Mashal (2020). “Ductile Connections for Pre-Formed Construction Element”, United States Non-Provisional Patent Application, 16/817,042. • M. Mashal (2019). “Ductile Connections for Pre-Formed Construction Element”, United States Provisional Patent, 62/883,173.

FY2021 INFRASTRUCTURE REPORT SUMMARY - Lewis-Clark State College

	Total $	Detailed Allocations	
Library Support	$30,000.00	$18,000 to 10-07-126104 (Ebsco Nature and Ebsco Cell); $12,000 applied toward Infobase Learning (Total cost $17,500; balance covered by LIB funds; Master Academic College and Health, Nursing Tech & Trade Education Collection; $2,000 to 126104 and $10,000 to 126105). See next tab for detail and PO numbers.	
IR&E Qualtrics License	$7,150.00	PO #586021 (funds transfer to IT which paid the expense)-Campus license for survey software-12 month Research License for Qualtrics, for use by faculty and the campus community	
SPSS campus-wide licenses	$6,484.60	PO #0405557-IT pd invoice on 6/7/21 for use by faculty; AA reimbursed IT	
Research Symposium	$10,000.00	Annual LC State Student Research Symposium	
Salary for Research Librarian	$49,916.00	50% of salary and fringe for Samatha Thompson-Franklin, Research Librarian, in support of undergraduate and faculty research efforts.	
Total Expenditures	$103,550.60	Expenditures above $100,500 FY21 allocation charged to provost's office appropriated account.	

	Detailed Allocations	
Publications in Refereed Journals		
Presentations at Professional Meetings and Conferences		
Grants Received as a Result		
Grants Pending		
Student Participation	Students utilize the Research Librarian and the purchased Library resources in coursework, undergraduate research activities, and in preparing for the annual Research Symposium.	
Faculty Participation	Faculty utilize the Research Librarian, the SPSS and Qualtrics software products, the purchased Library resources and assist students in preparing for the annual Research Symposium.	
Other Participation	Community members, faculty and staff emeritus, and alumni are invited to attend the research symposium each year.	
Patents Awarded		
Patents Pending		

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

Academic Year 2020-2021

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


Introduction

The Institute for Inclusive & Transformative Scholarship oversaw the HERC Undergraduate Research Fellowship at Boise State University Fall 2020, and Spring 2021. HERC funds were used to support Boise State undergraduate students who had minimal research experience with a 10-week mentored research opportunity during the fall and spring semesters. Funds provided by the Higher Education Research Council supported a total of 17 students across 9 different STEM disciplines.

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 $51,000 in supplemental funding to support STEM undergraduate research at Boise State University this year. Please see the table below of how stipends and travel awards were dispersed.

Stipends	Amount	Details
Fall Semester Research Stipends	$24,000	8 students at $ 3,000 each
Spring Semester Research Stipends	$27,000	9 students at $3,000 each
Total	**$51,000**	

Boise State Research Fellows Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major
Alan Chavez	M	Hispanic/Latino/a	Hispanic	Engineering Plus
Chithkala Dhulipati	F	NonHispanic/Latino/a	Asian	Applied Mathematics
Andrea Feci	M	NonHispanic/Latino/a	White	Chemistry
Pangea Finn	F	NonHispanic/Latino/a	Caucasian	Physics
Terra Green	F	NonHispanic/Latino/a	Caucasian	Anthropology
Sarah Goldrod	F	Hispanic/Latino/a	Caucasian	Mechanical Engineering
Julie Julison	F	NonHispanic/Latino/a	American Indian	Anthropology
Tyler Lantz	M	NonHispanic/Latino/a	Caucasian	Health Science
Rosana Lenhnart	F	Hispanic/Latino/a	Hispanic	Physics

ShaKayla Moran	F	NonHispanic/Latino/a	Caucasian	Biology
Nathan McGregor	M	NonHispanic/Latino/a	Caucasian	Physics
Ashley Maples	F	NonHispanic/Latino/a	Caucasian	Anthropology
Carmen Pemsler	F	Hispanic/Latino/a	Caucasian	Civil Engineering
Betsy Rosales	F	Hispanic/Latino/a	Caucasian	Electrical Engineering
Sierra Sandison	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering
Serena Sheldon	F	NonHispanic/Latino/a	Caucasian	Biology
Addie Totman	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering

Fall 2020 HERC Fellow Boise State Student Abstracts:

Chithkala Dhulipati
Faculty Mentor: Dr. Michal Kopera, Department of Computing, Boise State University

Research Title: Simulations of Multi-Layer Shallow Water Model

In this work, we ran test simulations of different scenarios of the multi-layer shallow-water model and visualized the results in ParaView. Further, the results were compared to the reference solution, the HYCOM model, to see if Galerkin methods are competitive enough with other established numerical methods used for ocean modeling. Initially, we simulated a two-dimensional wave in shallow water equations and then expanded it into a two-dimensional wave in a two-layer system. We designed the two-layer model such that each layer had adifferent density. Further, we set up a perturbation on the interface between the layers. We could see that the disturbance propagated in the interface between layers, with faster waves traveling on the surface.We visualized the simulation results in ParaView by using various filters like append attributes, calculator, and warp by a scalar. Exporting this state of the simulation into a Python script helped create a contour plot. We compared this plot to the reference solution.

Ashley Maples
Faculty Mentor: Dr. Shelly Volsche, Department of Anthropology, Boise State University

Research Title: Do Leopard Geckos Bring People Together Through Social Media?

For this project, I will be digging into the psychological reasoning behind why certain mindsets are drawn into owning a reptile. Not only will this study better the knowledge of pet owners but why an owner leans towards a reptile pet.

Nathan McGregor
Faculty Mentor: Dr. Daryl Macomb, Department of Physics, Boise State University

Research Title: VRI Light Curves of BL Lacertae Objects

BL Lacertae objects' (BL Lacs) relativistic jets are oriented close to our line of sight, producing a variation in flux density over time. The physical mechanisms behind these fluctuations are still poorly known. Variability surveys such as ours that combine high photometric accuracy, sufficiently long-time baselines, and a high number of observation epochs hold the promise of significant progress. We present a pipeline as well as light curves that form the basis of a long-term photometric variability study of BL Lacs. We have expanded on our first set of photometric observations of Markarian 501, producing light curves for new sources. All BL Lacs were imaged in three optical (VRI) bands from 2010 to 2015 using the 0.4m telescope at the Challis Astronomical Observatory (CAO) in Idaho. Astrometric calibration was performed on each image using Astrometry.net. Images that were recognized and calibrated formed the data for our analysis. Artifacts were removed by resampling and co-adding images using SWarp. For each co-added image, we generated an SExtractor catalog and computed an on-sky separation by matching field stars with star catalogs. We used this solution to match each source to reference catalogs for modeling light curves. Future research will focus on multiwavelength observations, cross correlating these VRI light curves with observations in other wavelengths to better understand the source structure and physical processes of BL Lacs.

ShaKayla Moran
Faculty Mentor: Dr. Leslie Atkins Elliott, Department of Curriculum, Instruction, and Foundational Studies, Boise State University.

Research Title: Building Theories by Building Things

In the science classroom, curriculum often engages students in science experiments with predetermined materials and scaffolded instructions in order to obtain a designated outcome. However, science experiments like this focus on the product of experiment but not the process of designing an experiment. Implicit in these labs is that the goal of the science classroom is to learn specific scientific content instead of learning how to build theories and develop experiments in support of those. If, instead, we want science classes that support students in developing, vetting and refining theories, our research suggests that increased student agency around materials and design is critical. As students make design choices in their experiments, they enter into a conversation with materials and design and these inform and shape their developing models in richly scientific ways. Through the use of student examples we will show how students can use materials in novel and authentic ways that improve their design practice and solidify their scientific theories.

Carmen Pemsler
Faculty Mentor, Dr. Kendra Kaiser, Department of Geosciences, Boise State University

Research Title: Energy Demand of the Yankee Building

Working with the Lab for Ecohydrological Applications and Forecasting (LEAF) in the Department of Geosciences at Boise State University, we were able to determine the energy efficiency of the Yanke Research Park Building. Two different models were reviewed to automate the process of creating change point models for monitoring the energy use over time using the computational tool, Python. The first model, a 2P model, reflected a single linear regression model when fitted against a â€œcooling shapeâ€□, where building energy use is positively correlated to outside air temperature. The second, a 3PC model (3P Cooling model), contains two slopes connected by a temperature change point. A changepoint was determined through iterations of the temperature data. Before the computed change point there is a zero slope and after the change point, a positive slope. This would take in consideration the building having no heating demand in cooler temperatures. We analyzed post-retrofit data provided by Idaho Power that included the hourly electricity use and the outside air temperature (OAT) from December 1, 2015 to December 1, 2016. The results from the OAT and electricity use data indicated that the Yankee building has some performance gaps in the way it utilizes energy.

Betsy Rosales
Faculty Mentor: Dr. Benjamin Johnson, Department of Electrical and Computer Engineering, Boise State University

Research Title: Wearable Bluetooth Interface for Flexible Piezoelectric Sensors

Polyvinylidene fluoride (PVDF) sensors are made of high-quality polymer that allows them to be extremely flexible when manufactured as thin sheets. Moreover, this low-density polymer exhibits piezoelectric properties, meaning it generates an electric charge in response to mechanical stress. Taken together, the flexibility and piezoelectric properties of PVDF sensors make them a promising solution for thin, lightweight wearable sensors that can be placed directly on the skin to monitor physiological activity. In this study, we established the viability of using a commercial PVDF sensor to detect physiological signals, such as arterial pulse. We integrated the PVDF sensor with a wireless Bluetooth low energy module to stream its voltage signal to a phone, resulting in a wearable sensor system for continuous data acquisition. We electronically connected our components with a printed circuit board (PCB) - designed using Eagle (AutoCAD). The sensor along with all our components were soldered onto the PCB to electronically connect and mechanically fasten them. This allowed the device to be solidified into a single piece making it easier and discrete to attach on to clothing.

Sierra Sandison
Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical & Biomedical Engineering, Boise State University

Research Title: Alleviating the Negative Effects of Imposter Syndrome in Engineering Students

Imposter syndrome and feelings of self-doubt are common, even in spite of one's level of success. These feelings and thoughts can have detrimental implications for the sufferers. The purpose of this study is to gather data on how common and/or severe feelings of imposter syndrome and self-doubt are among engineering students, and examine whether or not knowing that their peers and mentors suffer from similar feelings will help alleviate their own. Our hypothesis include, (1) Engineering students underestimate the rate at which their peers and mentors suffer from feelings of self-doubt and imposter syndrome and (2) These feelings may be alleviated by discussing them more and understanding how common they are in others. The research will include students watching a mini-documentary of their peers and faculty being interviewed on their own experiences with imposter syndrome, and taking a pre- and post-survey on their own experience with self doubt/imposter syndrome and whether or not hearing about others' experiences affected the way they think about these feelings. The goal is to use this data to encourage students and faculty to be more open about their feelings of self-doubt in hopes that it will help everyone understand that these feelings are common. In addition to the results being presented at undergraduate research conferences and possibly published, the documentary shown to survey participants will also later be shown on campus and on social media, along with a discussion of the results of the study. Students will be emailed a survey that will assess their feelings of self-doubt and imposter syndrome as it relates to their engineering identity. The survey will use the Clance IP Scale. The participants will be asked to watch an ~11 minute mini-documentary of their engineering peers and faculty being interviewed about their experience with imposter syndrome. After the documentary concludes, participants will be asked to complete a post-survey assessing how watching the documentary affected their own feelings and opinions about their own experience with imposter syndrome and self-doubt.

Serena Sheldon
Faculty Mentor: Dr. Eric Brown, Department of Chemistry and Biochemistry, Boise State University

Research Title: Design and Synthesis of a New Ligand Scaffold Containing a Hydrogen-Bond Donor for Making Zinc-Hydrosulfide Complexes

Carbonic Anhydrase (CA) is a metalloenzyme that is present within numerous organisms. Although CA is responsible for the reversible hydration of carbon dioxide to bicarbonate, its lesser known function is the activation of carbonyl sulfide (COS) to produce hydrogen sulfide (H_2S). H_2S is an important molecule in biomedicine since it is a signaling molecule/gastrotransmitter. H_2S is produced in the body and has been shown to inhibit the formation of free radicals that are associated with aging and age-related diseases. The activation of COS produces a zinc(II) hydrosulfide in the active site of CA. However, the mechanism and the effect of hydrogen bonding interactions on the desulfurization of the zinc-hydrosulfide, to produce H_2S, are not fully understood. Our poster will discuss the preparation of a ligand scaffold containing a hydrogen bond donor and its successful use to prepare a zinc-hydrosulfide complex from COS gas.

Spring 2020 HERC Fellow Boise State Student Abstracts:

Alan Chavez
Faculty Mentor: Dr. Mahmood Mamivand, Department of Mechanical and Biomedical Engineering, Boise State University.

Research Title: Phase-field Modeling of Fe-Cr-CO Spinodal Decomposition

Research on non-rare earth magnetic materials was done at Boise State University's Computational Materials Design Lab, directed by Dr. Mahmood Mamivand. The objective was to develop simulation models using MOOSE (Multiphysics Object Oriented Simulation Environment) to model spinodal decomposition in materials at the mesoscale. The MOOSE framework is an open-source, parallel finite element framework developed by the Idaho National Laboratory. MOOSE makes modeling and simulations more accessible to scientists that have little background in computer science. Simulation models using MOOSE were done on the FeCrCo alloy using the phase-field method and the results were compared to experimental results from multiple sources.

Next, simulations models were done using parameters from a different source compared to the original to make the simulations more quantitative for different compositions of FeCrCo. Simulation models were also done by implementing parameters that would take into consideration external magnetic field and demagnetizing energy of the alloy. When implementing new parameters found to create new simulation models for smaller compositions of CrCo in FeCrCo, it was initially thought that directly swapping parameters in the code would result in the expected spinodal decomposition. It was found that swapping parameters did not yield the results that we wanted. After debugging the code and using a mix of parameters from one source and another, results were still coming back inconclusive. After much thought, it was decided to instead focus on how the external magnetic and demagnetizing fields affect the spinodal decomposition of the alloy. Using the phase-field method and focusing on the total magnetic energy within the system, equations were found that would calculate the external magnetic field energy as well as the demagnetizing field energy. The external magnetic field energy was implemented first in the MOOSE code and it was found that it had little to no effect on the spinodal decomposition. This supports the argument that the spinodal decomposition will more likely be affected by the demagnetizing field energy of the system. Towards the end of the research, it was found that implementing the demagnetizing field energy proved to be more challenging than initially anticipated. Methods to overcome the challenges included simplifying the equations for the demagnetizing field energy and asking researchers from INL for insight on how to implement demagnetizing field energy in the MOOSE code. Future work will consist of successfully implementing the demagnetizing field energy along with the external magnetic field energy to create a more quantitative model that will allow us to compare the results with documented experimental results.

Andrea Feci
Faculty Mentor: Dr. Don Warner, Department of Chemistry and Biochemistry, Boise State University

Research Title: Rational Design of Small Molecule Lignads to Disrupt Protein-Receptor Interaction for the Treatment of Inflammatory Diseases

Overexpression of certain signaling proteins is the root cause of many inflammatory diseases, including skin, lung, and cardiac conditions, atherosclerosis, rheumatoid arthritis, as well as many types of cancer. Uncontrolled inflammation could be avoided by preventing those proteins —also known as cytokines— from binding to their membrane receptor so that the signaling is halted. To achieve that purpose, a drug could be designed to target the protein and change its structure; small molecule inhibitors (SMIs) can accomplish this job. These are ideally stable compounds with remarkable properties: membrane permeability, water-solubility, short half-life in the body, and ease of administration. This project focuses on developing a perfect drug that presents all the above properties, including optimal binding to the protein, which is quantified by a number called dissociation constant (K_D). A K_D is the ratio at equilibrium of the concentrations of drug and protein over the concentration of the drug-protein complex. Therefore, a lower K_D is indicative of tight binding and strong affinity. When this ratio is 1/100000, it is said to be in the low micromolar range, which is indicative of medium affinity. When this ratio gets a thousand times smaller, in the nanomolar range, the affinity of the ligand for the protein is very high. So far, over 50 compounds have been synthesized, with the lead compound having a 4.0 μM K_D score. For further improvement of the binding, 3D quantitative structure-activity relationship maps have been generated to intuitively summarize successful binding trends. Following those trends, a new generation of analogs is under development to lower the K_D to the nanomolar range and to improve the drug-likeness of the SMI.

Pangea Finn

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

Research Title: Mechanical Stress Modulates the Ionic Conductance of Bilayer Lipid Membranes

The modulation of the transmembrane voltage of receptor cells using mechanical stimuli is an essential component of touch and hearing senses. Such stimuli influence the conducting state of mechano-sensitive channels, which in turn adjusts the ionic permeation and consequently the transmembrane voltage. The necessity of ion channels in these transduction processes seems obvious due to the non-conductive nature of a lipid membrane. However, our electrophysiology experiments show that a bare, artificial lipid membrane exposed to mechanical stress allows the passage of inorganic ions. We concluded that lipid membranes may constitute an important component of the transduction mechanism under mechanical stimuli.

Sarah Goldrod
Faculty Mentor: Dr. Erin Mannen, Department of Mechanical and Biomedical Engineering, Boise State University

Research Title: Biomechanical Differences of Moms and Non-Moms

During and after pregnancy, mothers biomechanically adapt their walking to account for the additional load of their baby. For example, their posture may change, and mothers can experience pelvic and back pain when carrying loads during walking gait. The effects of holding a baby in arms during walking gait is not fully understood. Two biomechanics studies have been conducted to understand how the mechanical constraint of holding an infant can impact the ground reaction forces of the caregiver. Understanding the body loading patterns is important for determining loads at specific pain-generating joints. The biomechanical differences of non-Moms and Moms during gait conditions needs to be further investigated. The 2020 study, *Infant Carrying Method Impacts Caregiver Posture and Loading During Gait and Item Retrieval* had 10 non-Moms walk across a flat surface at a self-selected pace in two conditions: (1) unloaded (holding nothing) and (2) in-arms (holding mannequin in a self-selected position). The ongoing 2021 study has 11 Moms walk across a flat surface at a self-selected pace in the same two conditions with the exception of the mom holding their infant instead of a mannequin. Motion capture systems, VICON (2020 study) and Qualisys (2021 study) were used to collect data. Multiple embedded force platforms were used to collect the forces exerted on the participants during the walking gait conditions. The peak braking forces and the peak vertical impact forces were analyzed through MATLAB and statistical tests. Peak vertical impact force was significantly greater during the in-arms condition compared to the unloaded. There was no significant difference between the moms and non-moms. Understanding the different walking patterns of moms and non-moms can help guide future experimental designs. This will allow researchers to understand if studies on non-moms can apply to moms and may lead to the development of interventions when moms experience pain during walking gait. Further investigations will compare other aspects of the studies like spatiotemporal parameters (step length, step time, stance time, etc.). To improve this study more statistical tests will be conducted on other gait conditions to confirm there is no significant difference between moms and non-moms walking gait.

Terra Green
Faculty Mentor : Dr. Shelly Volsche, Department of Anthropology, Boise State University

Research Title: Not Just a Walk in the Park: Dog Park Ethograms of Human-Dog Dyads

Introduction: Previous research demonstrates differences in owner sex and gender influence interactions with one's dog. Dog size also plays a key role. Using human parenting and human-dog interactions literature, we suggest that human-dog interactions may take the form of parent-child interactions, and that this can be observed and demonstrated using dyadic ethograms.

Methodology: We recorded interactions between guardians and their dogs at public, off leash dog parks in Fall 2020. We then selected 30 second focal follows and coded with continuous sampling. Independent variables included the sex of the guardian, general age cohort of the guardian (e.g., young adult, elderly), and the size of the dog. Coded behaviors included different types of play (e.g., chase, fetch, rough and tumble), parallel walking, and training activities. We also coded for times in which either the human or the dog engaged with others outside the focal dyad.

Main Findings: Our findings did not demonstrate specific differences between men's and women's interactions with their dogs. We suspect this may be a by-product of the particular park where recordings were made. However, there is evidence that human-dog interactions at the park mirror parent-child interactions. Dogs spent much of their time focused on, or playing with, other dogs, while humans either watched over their dogs or interacted with other dog "parents."

Principal Conclusions and Implications for the Field: The use of ethogram methods in observing human-animal dyads is still relatively new. However, this study demonstrates the value of this methodological approach. We provide further evidence to suggest that humans shape their relationships with dogs in ways that parallel parent-child relationships.

Julie Julison
Faculty Mentor: Dr. Mikael Fauvelle, Department of Anthropology, Boise State University

Research Title: Portable Art in the Great Basin

When we think about archaeology in the Great Basin, we usually don't think about art. If we do it is in the form of rock art, of which there is plenty, but there is another type that commonly gets overlooked, portable art. There are basically three forms of these small creative objects in the Great Basin: ceramic figurines, incised stones, and small rocks that have had their shape altered into what is believed to mimic some type of anthropomorphic animal. I would propose that some of these items may have been misidentified in the past and would like to put forth an alternative hypothesis, with related evidence for consideration. There are three figurines in particular which I will argue, two of these effigies are possibly grasshoppers, while a third may be a predaceous diving beetle. In addition to these re-examinations, this study will be adding to the increased dialog concerning insects in the subsistence strategies of Native Americans in the Great Basin. The importance of these food resources are then transferred and reflected in these portable art objects from archaeological sites, which provide additional evidence of their significance.

Tyler Lantz
Faculty Mentor: Dr. Julie Oxford, Department of Biology, Boise State University

Research Title: Effects of Doxorubicin on Cardian Fibroblasts and the Extracellular Matrix

Cardiotoxicity has been associated with various types of chemotherapeutic drugs contributing to a plethora of cardiac insults and is a significant side effect when treating cancer. Many highly effective anticancer drugs are severely dose dependent, and at higher doses can lead to: cardiac arrhythmias, hypertension, and lethal cardiomyopathy. A well known example of this cardiotoxic side effect is Doxorubicin, a common chemotherapeutic used to treat cancers of the breast, ovary, bladder, and thyroid. Extensive research has shown that high doses of doxorubicin detrimentally alters the normal function of cardiac fibroblasts and cardiomyocytes. In contrast to the extensive research on the toxic effects of chemotherapeutics like doxorubicin in cardiomyocytes, little is known on the effects in cardiac fibroblasts and mechanisms of these drugs on the cardiac extracellular matrix (cECM). We show that doxorubicin has a direct impact on cardiac fibroblasts and in turn the function of the cECM, indicating that the cECM plays an important role in cardiac toxicity induced by doxorubicin.

Rosana Lenhart
Faculty Mentor: Dr. Heidi Wu, Department of Physics, Boise State University

Research Title: 3D Shapes of Galaxy Cluster in TNG Simulations

Galaxy clusters are the largest structure in the universe, and their observed gravitational lensing signal can be used to study the formation of structure in the Universe.Â The 3D shape of galaxy clusters impacts the gravitational lensing signal generated by the cluster. However, the 3D shape has primarily been studied in dark matter-only simulations--without taking into account the impact of the gas. IllustrisTNG is a public project containing 18 hydrodynamic simulations of large sections of the universe. We have written code to determine the 3D shape of the clusters contained in the simulations. This work compares how the shape is affected both by the resolution of the simulations and the gas in hydrodynamic simulations.Â We find that gas tends to make clusters more spherical, while higher resolution tends to make clusters more elliptical.Â This project will help us understand how gas impacts the 3D shape of galaxy clusters. Moving forward this data will be compared with other simulations in literature.

Addie Totman
Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical and Biomedical Engineering, Boise State University

Research Title: Using Sequential Art to Communicate Engineering Course Content

Course catalogs are notoriously hard to navigate, condensed, and confusing. In engineering especially, students rarely know what exactly a class entails until after they have enrolled and receive a syllabus. This can lead to students being discouraged by the courses they must take or drive away those that would like to pursue engineering but don't understand it. To combat this, we propose several full-page comics to illustrate the importance and content of selected engineering courses, written and drawn by a mechanical engineering student with knowledge of the classes that make up the base of the degree. The goal of these proposed comics is to demonstrate the basics of several courses while still being accessible to those who have not had previous experience. Comics have been used in classrooms to communicate complex ideas and are proven to increase understanding and connect to students better than text alone. They also can be a tool to promote diversity and show minority students that engineers can look like them.

TO: Idaho SBOE HERC

FROM: Deb Easterly, Ed.D, Asst. VP for Research

DATE: August 20, 2021

RE: ISU FY 21 Undergraduate Research SBOE HERC Funds Report

Even though COVID made research more difficult in 2020-21, the experiences the ISU undergraduate students had were beneficial. Students who might not have had a research experience were able to work with ISU faculty on projects in their disciplines.

This year ISU instituted a new process to spend the SBOE HERC undergraduate research funds. In *The Undergraduate Experience* (2016), the authors state, "undergraduate research is a process that, at its best, moves students to new levels as learners and inquirers. The relationship between mentor and protégée can be transformative because it is rooted in an ongoing, substantive interaction around an essential part of the academic enterprise, scholarly research" (p.48). This was the guiding theme of the program for this year. Awards were made to faculty who proposed not only a research project, but also one that included mentoring opportunities. Awards were made to four projects that included 2-3 undergrad students. Attached reports from students and faculty describe successful mentoring experiences.

Three awards were made later in the year that included 1-2 students. In doing this process, we were trying to set the stage for more of a mentored experience. Faculty had to commit to mentor plans. Students were ensured that they would be working with at least one other student and not on their own.

Twenty-two students were involved in the above-described process.

$10000 was awarded to the ISU McNair project to assist with attendance at conferences to make presentations and research projects of seven STEM students.

A camera and tablet were purchased for two students who were conducting research with a math professor via zoom because of COVID. This enabled the three of them to work on-line and share work with each other.

Three students were awarded registration fees to attend and present at the National Conference on Undergraduate Research.

The ISU Undergraduate research symposium was held virtually this year, because of COVID. A live session with speakers was held on Zoom and posters were available for viewing on ForagerOne. ISU students presented 23 posters.

Twenty-four ISU undergrads presented at the 2021 ICUR.

See the attached for reports on individual projects, including posters that were presented by students.

Prepared by Deb Easterly, EdD, Assistant VP for Research, Idaho State University

Idaho State University

College of Science and Engineering
Department of Civil and Environmental Engineering

2020-2021 Undergraduate Research Funds

June 24, 2021

Table of Contents

1.0 Basic Information

Funding Agency

Idaho State University - Idaho State Board of Education

Awarded Institution

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

Grant Period

2020-2021

Project Title

Structural Dynamics Lab / Shake Table Testing of Bridge Piers

Principal Investigator

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

Report Type

Final

2.0 Executive Summary

Undergraduate student funds were awarded for projects in the large-scale structural laboratories under the supervision of Dr. Mashal. Three engineering undergraduate students, Berenice Sosa Aispuro, Laura-Louise Alicke, and Rachel Brownell participated in the research activities. All funds were spent by the project deadline.

3.0 Description of Activities

The activities taken by the students are as follows:

1. Developing skills in operation of shake tables in the Structural Dynamics Laboratory
2. Preparing data acquisition and instrumentation for structural testing
3. Sizing, analysis and design of a cast-in-place concrete column for shake table testing
4. Building testing specimens
5. Calibrating instruments before testing
6. Design and construction of concrete, steel, and timber specimens/structures
7. Investigating structural performance of concrete and steel specimens under various loading conditions
8. Conducting small and large-scale testing
9. Interpreting testing data
10. Participating and presenting in the Undergraduate Research Conference

The laboratory work benefited the students in enhancing their technical and hands-on skills. This will greatly help the students in their graduate/professional career. All three students have shown interest in pursuing graduate school at Idaho State University (ISU).

One of the students, Laura-Louise will be starting her graduate program at ISU in the fall of 2021. Berenice is earlier in the program; however, she is planning to attend the graduate school. Rachel has been admitted to the graduate school at ISU, however she has decided to work in the industry for the time being. Rachel won one of the competitive 2021 American Society of Civil Engineers Southern Idaho Section Student Scholarships for her undergraduate research at ISU.

The research goals of the lab were significantly furthered. The students mostly accomplished the tasks they were given for design of specimens and testing of structural parts. Most of the activities described in the proposal were accomplished. Additional funds were provided by the Research Office at ISU that made it possible to involved Laura-Louise Alicke in the projects.

The supervisor, Dr. Mashal, enjoyed working with the three talented students. Regular Zoom meetings were held to answer students' questions and guide through the research. Furthermore, additional personnel from Dr. Mashal's research team were available to help the students with their large-scale testing needs in the structural laboratories at ISU. Next time, it would be better to involve more students earlier on if additional funding was available.

Undergraduate students testing specimens in the Structural Laboratory

4.0 Student Reports

Refer to Appendix A, a copy of the poster that the students presented at the Undergraduate Research Conference is also attached.

5.0 Report of Expenditures

Refer to Appendix B.

APPENDIX A

Undergraduate Research Experience
Berenice Sosa Aispuro

During the 2020-2021 school year, I was given the opportunity to work as an Undergraduate Research Assistant at Idaho State University's Structural Dynamics Lab. Here, I worked alongside Rachel Brownell. The plan for this project was to do shake table testing of two concrete bridge piers and then compare their performances. The first pier would be a cast-in-place pier, while the second pier would be made of low damage technologies, which consisted of precast concrete and dissipators. I created the AutoCAD drawings for this project. Throughout the duration of this project, I was able to learn about the different applications of precast concrete and dissipators. I was also able to assist in doing concrete pours. Working as research assistant has taught be how to work with others and how to maintain good communication with them. It also showed me what my weaknesses were as an engineering student and how to improve them. My experience did have an impact on my future plans. Before working on this project, I was not sure if I wanted to continue my education after getting my bachelor's degree. However, working in the lab and being able to work alongside graduate students, I have realized that I would like to go onto get a PhD. Working on this project has also helped me broaden my areas of interest.

Undergraduate Research Experience

Laura-Louise Alicke

This past year has most definitely been the most exciting and interesting years I have had at Idaho State University. I had the opportunity to work on several research projects as well as get some hands-on experience with the remodel of the new Disaster Response Complex (DRC).

In the fall of 2020, I had the chance to do some literature reviews as well as help with the write up of a proposal for renewable energy using Hydropower. I learned a lot about dams, siphons, and renewable energy in general. The main focus of this proposal was using recycled tires as an aquifer. Building on that, in the following semester I used plastic sheets and formed them into tubes, representing stacked tires. I made two sets, one which I filled the gaps with sand and another set which I left the gaps empty. Then we tested to see how much load they could withstand and it was proven that the set in which the gaps were filled with sand could withstand a much bigger load than the other set. This served as a miniature model of the aquifer made out of recycled tires.

In the fall of 2020, I also helped with the hollow core culvert project that Maria, a graduate student at ISU, was working on. For this project, we constructed a hollow core culvert and a box to go around it which was filled with sand. Then we tested how much load this culvert could withstand. I really enjoyed working on the research project and I learned a lot from it. We did multiple tests with it and tried to find ways to make it better. One of the main issues with the culvert were the connections filled with grout. Shear occurred directly on these connections, ultimately causing the culvert to fail. We were very interested in finding a way to fix these grouted connections. Therefore, we reconstructed the culvert, but this time I used an angle grinder to form a groove in the middle of each slab of hollow core. We left the box of sand off this time and only tested the hollow core culvert itself. Even though it did not perform as well as we were hoping it would, these connections did help. This project was very fun to work on and there are still a lot of things left to learn about hollow core culverts.

This spring semester of 2021, I have been working on the remodel of the Disaster Response Complex. At the beginning of the year, I sanded the walls and painted a lot of rooms. Then I also got the chance to build a ticket booth as well as put a lot of siding on the exterior walls. I also got to take photos when there were training events at the new complex. Since working at the DRC, I have gained a lot of handy-skills. I now know how to use a lot of tools and how to fix things. These are skills that I will be able to use for the rest of my life.

I have worked on a variety of things throughout this past year and I have gained a lot of knowledge and skills. As a civil engineering student, it is very important to not only get the concepts on paper, but also being able to see how everything is put together in the real world. Working on such diverse projects at the DRC has showed me the construction side of things and it has given me a better understanding of engineering as a whole. I believe that my time spent working here will benefit me greatly as I become an Engineer.

Figure 1. Hollow Core Culvert

This is the hollow core culvert that I worked on and added in the grooves into each slab to make the connections hold better. In this photo we were measuring the size of the crack in the slab, which occurred directly on the edge of the slab.

Figure 2. Ticket Booth

This is the ticket booth that I constructed with the help of a few other students.

Undergraduate Research Experience
Rachel Brownell

Throughout my research project I have learned many valuable lessons that will help me throughout not only my life, but my career as well. I have learned the importance of teamwork, leadership, time management, self-discipline, and independence. Working with my lab assistant, Berenice, has helped me learn how to work as a team as well as helping me gain experience in a working leadership role. My research project has allowed me to gain independence by not always having the answer provided for me, forcing me to resolve problems on my own.

I believe that all of these lessons have benefited me greatly. I will be able to carry these newly acquired skills over to my career, which will help me be a better employee. I will also be able to carry all of my knowledge I gained throughout my research project regarding dissipaters over to my job, which will be very beneficial considering that I plan on finding a job in the Seattle area, a very seismically active region.

Before I began my research, I planned on either finding a job in structural engineering or to do graduate school. My experience with my research project did not change any future plans that I had, I ultimately decided that waiting on graduate school was the best course of action for me.

Shake Table Testing of Concrete Piers with Cast-In-Place and Low Damage Precast Technologies

Rachel Brownell, Undergraduate Research Student; Berenice Sosa Aispuro, Undergraduate Research Student; Mustafa Mashal, Ph.D., P.E.

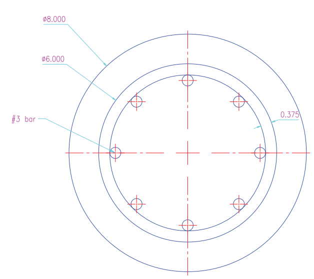
Department of Civil and Environmental Engineering

Contact: browrac3@isu.edu, berenicesosaaispu@isu.edu, mashmust@isu.edu

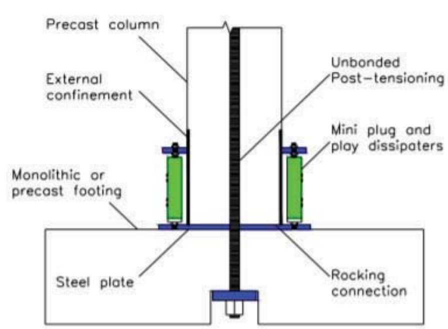
Idaho State University

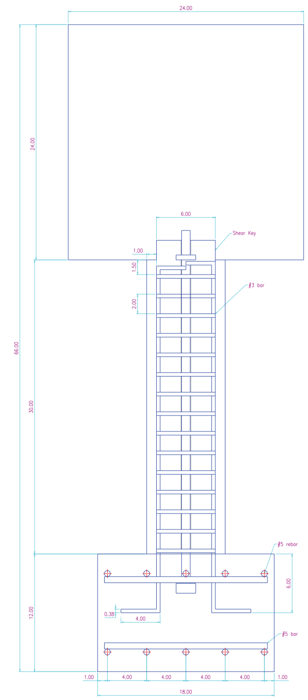
Summary of the Project

- Duration: 2020-2021
- Budget: $9,000.
- Dissipators are low damage technologies that assist in dissipating the energy from an earthquake to reduce damage
- The precast pier aims to achieve a better seismic performance compared to cast-in-place
- This research project will test two concrete piers on a shake table for earthquake resilience

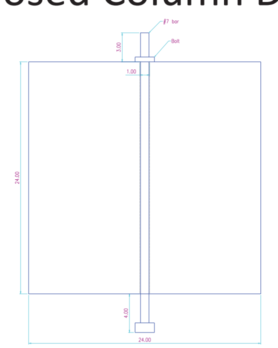


Column Cross-Section





Proposed Column Design



Modular Concrete Weight

Advantages of Concrete Piers with Low Damage Precast Technologies

- Less environmental impact
- Less traffic disruption
- Better quality
- Dissipators are low damage technology that can easily be replaced after an earthquake

Experimental Testing

- Testing of two columns
    1. Cast-in-place (benchmark)
    2. Proposed Precast column with low-damage technologies
- Testing will be done in ISU's Structural Dynamics Laboratory on a shake table
- The shake table will be able to simulate a real-life earthquake to test its earthquake resilience

In Progress

- Research project is still in beginning stages of design
- Construction of the specimens is planned for the following weeks
- Testing has not yet been completed
- The goal is to show that concrete piers with low damage precast technologies results in less damage than those without

Acknowledgments

Idaho State Board of Education

This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board

APPENDIX B

PAYROLL					Year-to-Date
					Transaction_Amount
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				4/2/2021	(450.00)
				4/16/2021	(750.00)
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				4/2/2021	(4.50)
				4/16/2021	(7.50)
			Sosa Aispuro, Berenice	11/13/2020	(0.66)
				11/27/2020	(0.22)
				12/11/2020	(0.22)
				12/24/2020	(1.54)
				1/8/2021	(1.10)
				1/22/2021	(2.20)
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MATERIALS AND SUPPLIES					Year-to-Date
					Amount
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	720_Services				0.00
		PCB PIEZOTRONICS, INC. BLADLAUR	BA000476	5/4/2021	(519.60)
		Subtotal			0.00
	730_Supplies	AMZN Mktp US 2T8GG9550 BLADLAUR	BA000451	11/11/2020	(33.12)
		NORCO INC CHUBBUCK CANTJARE	BA000451	11/11/2020	(44.68)
		THE HOME DEPOT #1807 CANTJARE	BA000451	11/11/2020	(174.81)
		Subtotal			(780.03)

TOTAL:	(8,956.52)

Office for Research – Undergraduate Research Funding
Final Report
Date: June 22, 2021

PI: Josh Grinath
Project: Plant responses to fire and legacies of nitrogen enrichment and shrub removal at ISU's Barton Road Ecological Research Area

Part 1

Description of Activities Undertaken: The research team 1) completed three seedbank germination experiments, 2) measured and compiled plant trait data, 3) set up seed addition treatments at the field site, and 4) monitored carbon fluxes at the field site.

The first germination experiment evaluated how fire altered the soil seedbank of the sagebrush steppe community at ISU's Barton Road Ecological Research Area (BR), and how this depended on the depth of seeds in the soil. The second germination experiment investigated how legacies of past nitrogen enrichment influenced the seedbank at BR, as well differences between shrub and inter-shrub areas within the experimental plots. The third germination experiment evaluated how legacies of past shrub removal affected the seedbank at BR, and whether differences between shrub and inter-shrub areas were persistent in the seedbank. In addition, the research team measured the mass of 610 seeds from 61 species that we were considering for seed addition treatments at BR. These data were combined with data that the students compiled from the USDA PLANTS database and other sources to parameterize a species selection model to choose native species expected to enhance resistance against exotic plant invasions. The team then seeded these native plants in different combinations into the experimental plots at BR to establish three new restoration treatments within the previous nitrogen enrichment and shrub-removal treatments. The team also set up new control plots within and outside the burned area and an auxiliary experiment to evaluate how the timing and rate of seeding would affect seedling establishment. Lastly, the team measured carbon fluxes in the field plots monthly through the spring, and measurements have continued through the summer.

How the Project Benefitted from the Funds: This grant supported 1) three undergraduate intern, and 2) five ISU Biology faculty, including two early career faculty, in forming a collaborative project, as well as 3) successfully obtaining a NSF RAPID grant (Award #2118125).

The funds supported salaries for three undergraduate women (Bryna Haile, Ashton Cowley, Miriam Weeks) to participate in research, who would not have been able to gain such research experience without financial support. All three of these interns graduated in May, 2021 and then transitioned into positions supported by the NSF grant mentioned above. The Undergraduate Research Funding was critical for developing the research and communication skills of the undergraduates, who each presented a poster on one of the seedbank germination experiments at ISU's Undergraduate Research Symposium and at ISU Biology's Research Roundup. All three students also received responsible conduct of research training through discussion in weekly lab meeting, individual meetings, and the RCR CITI training modules. Other trainings included lab safety, mentor-mentee relationships, and data management. These experiences helped to prepare the students for graduate school and biological careers. One student is starting a MS program this upcoming Fall, and another has just started work with a plant breeding company. In addition, one student is leading a manuscript with a graduate student involved with the project, and we expect that the project will result in additional authorship opportunities for the students as the team works to get results together.

This research project has brought together five Biology faculty (Josh Grinath, Kathryn Turner, Keith Reinhardt, Kathleen Lohse, Bruce Finney) in a new collaboration that is proving to be productive for all of our labs. This funding enabled our team to collect preliminary data (i.e. seedbank and plant trait data) that supported our proposal for a NSF RAPID grant entitled "Ecological memories and theory-guided recovery of post-fire steppe." Then after our proposal was recommended for funding, the Undergraduate Research Funding aided our team in establishing the time-sensitive field experiment. Altogether, these grants are especially important for supporting two pre-tenure faculty (Grinath, Turner) as they establish their research labs and recruit new students. These faculty members are also benefitting from the mentorship of more senior faculty in the collaborative team.

How the Research Goals of the Project were Furthered: The funding has enabled our team to test multiple hypotheses about plant responses to fire and legacies of nitrogen enrichment and shrub removal. These hypotheses were primarily in relation to seedbanks and carbon flux. We did not test hypotheses about the plant assemblage in the field, which was due to time constraints and low abundances of plants during the early Spring. However, we will be able to test these hypotheses using data that the team is collecting this summer. In our next proposal for Undergraduate Research Funding, we intend to focus on testing fewer predictions that are better matched to the phenology of the study system.

Part 2

SBOE Undergraduate Intern - Report for ISU's Office for Research

Project: Plant responses to fire and legacies of nitrogen enrichment and shrub removal at ISU's Barton Road Ecological Research Area
Faculty Lead: Josh Grinath

Student Name: Miriam Weeks
Date: 31 May 2021
Faculty Mentor: Dr. Kathryn Turner/ Dr. Josh Grinath

What did you learn from your internship experience?

I learned many aspects of teamwork and group interactions that I did not get in my previous research. Working together and communicating as a group can be difficult, but in the end was very rewarding. So many original ideas were proposed, and problems were solved in this group setting. Having a common goal of gaining knowledge was amazing, and it helped us work together to answer our research questions and grow as scientists. Working with my dedicated peers, as well as inspiring professors/ mentors helped my love for science grow.

How did this research experience benefit you?

This research helped to expand my understanding of experimental design and the need for consistent variables. This was a great way for me to see and perform the steps of the scientific process that can seem very vague or theoretical in a classroom/ structured setting. This also made me admire those scientists who study the same thing year after year to get results. I love this area and the native plants here so much more now. I want to tell everyone about them and protect them from other plants that would push them out.

How has this research experience changed your future plans, if at all?

While I do not wish to continue in the field ecology aspect of this research, I do want to continue researching and working with native plants. I love native plants and how well adapted they are for growing here and for working with other native organisms, especially pollinators. I want to encourage the use of native plants. In the future, I want to better understand the genes that help them survive and work to allow the endangered ones to survive better. This experience made me want to work in situations where I can be with a small team of like-minded individuals that will help me and science grow.

Poster:

Effects of fire on seed bank persistence in sagebrush steppe

Miriam Weeks

Background

A seed bank is both a glimpse of history, the past vegetation in an area, and a nest egg for the future, an indication of the regenerative potential of an area. There is still much we don't know regarding soil seed banks and their persistence after major ecological disturbance. We also lack an understanding of the effects of lesser disturbance on these seed banks. It is vital that we increase our understanding of these seed banks to help our ecosystems better adapt and regenerate after disturbances.

Research Site

Our study was done at the Idaho State University Barton Road Ecological Research Area in Pocatello, Idaho (pictured above). The area is a sagebrush steppe ecosystem with Artemisia tridentata (sagebrush) being the dominant shrub. Other native and exotic plants, both annual and perennial, were present before the August 2020 fire.

Hypotheses

- Fire will have a larger effect on seeds in more shallow soil strata
- The shallow strata will have greater abundances of invasive plant seeds than native plant seeds

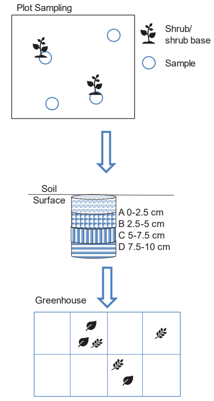
Experimental design

Soil collection—Barton Road Research site

- Four samples taken from each of the long-term experimental plots (control, low nitrogen, high nitrogen, and shrub removal)
- Unburned samples taken from an area adjacent to the burn with the same vegetative community, comparable to the control plots before the fire
- Undershrub and interspace samples taken.
- Soil samples collected in 2.5 cm depth increments from 0 cm to 10 cm in depth, making four soil strata which were homogenized, air dried, and sieved

Greenhouse emergence experiment

- Sieved soil was placed into divided trays on top of a layer of potting soil in a layer of ½ cm to 1 cm deep
- Seedlings removed approximately weekly
- Unknown specimens were repotted and grown to an identifiable stage

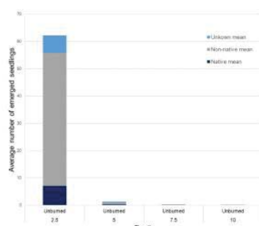


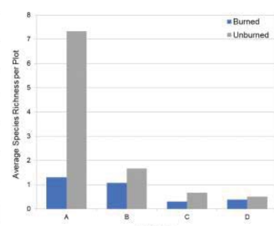
Results

The dominance of non-native seeds does not appear to persist into the deeper strata (as shown in the bottom left graph). The average species richness was much greater for the unburned area over all depths (bottom right graph). The difference was very stark in the shallowest layer. The unburned strata A had a high level of species richness compared to the burned strata A. This suggests that the fire did affect the seeds in the shallow soil strata. The deepest strata does not appear to have the same level of seed viability as little to no growth was seen.

Future work

Due to the work done with this project, a basic seedling guide for species that could potentially be found at the Barton Road site was created. This guide can be used in future vegetative surveys. Additional work is being done with the replicate samples that were gathered. The samples underwent a cold treatment to break dormancy and induce germination.





Idaho State University

This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board of Education Higher Education Research Council through Idaho State University

SBOE Undergraduate Intern - Report for ISU's Office for Research

Project: Plant responses to fire and legacies of nitrogen enrichment and shrub removal at ISU's Barton Road Ecological Research Area
Faculty Lead: Josh Grinath

Student Name: Bryna Haile
Date: 5/30/2021
Faculty Mentor: Dr. Joshua Grinath

What did you learn from your internship experience?

This internship was a valuable experience for me. I learned through this internship how to conduct greenhouse and laboratory experiments. I was also given the opportunity to learn how to identify Idaho's native plants as just mere seedlings. This internship opened my eyes to the world of plant science research. Lastly, this internship taught me how to properly organize, present, and discuss my research.

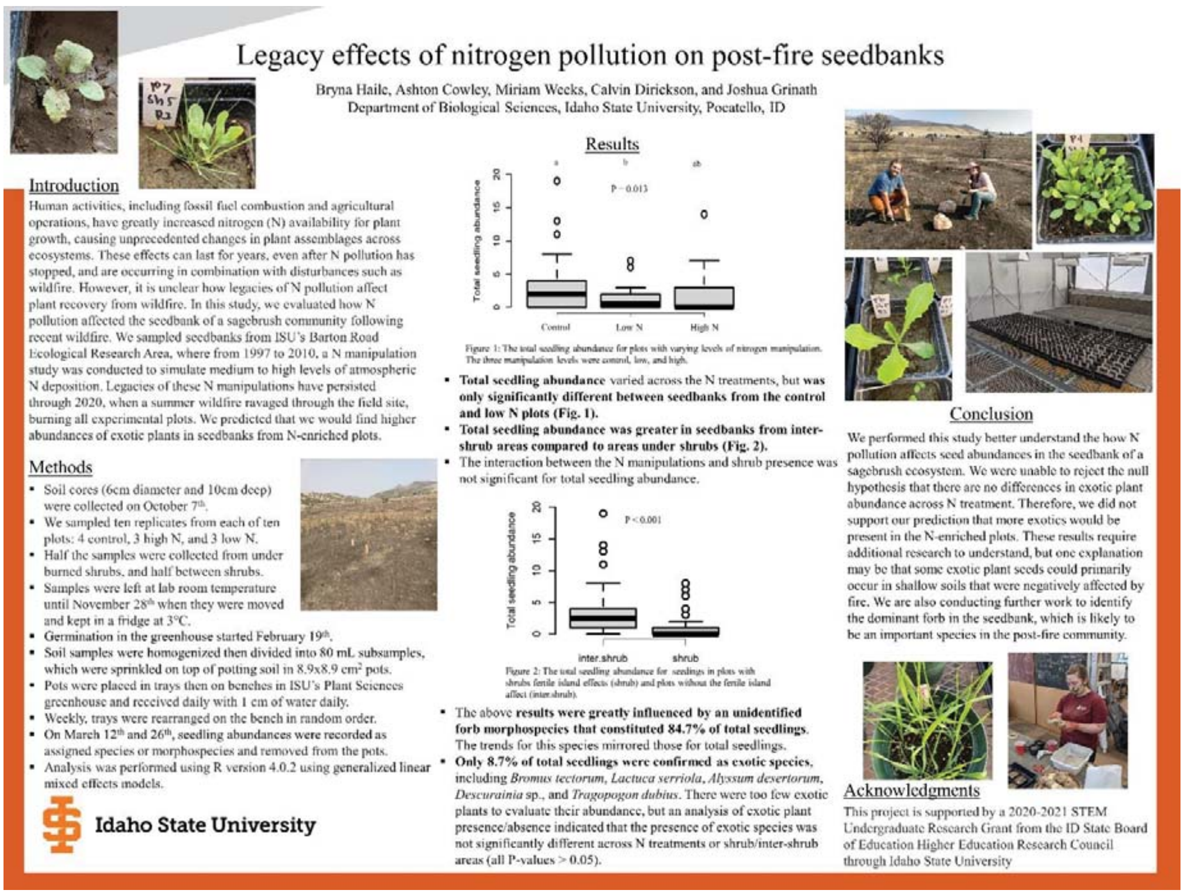
How did this research experience benefit you?

This research benefited me by teaching me how to conduct research. I will be able to use the skills I have learned through this research for the rest of my academic career and beyond. This research also benefited me by improving my plant knowledge which I will be able to use in the future.

How has this research experience changed your future plans, if at all?

This research experience did not change my future plans. It did, however, confirm my plans for my future. This experience proved to me that I do want to go to graduate school for plant and soil sciences and I want to do laboratory/greenhouse-based research in the future. Luckily this experience did not change my mind and I am able to continue my passion for plant research this fall while completing my masters.

Poster:



Legacy effects of nitrogen pollution on post-fire seedbanks

Bryna Haile, Ashton Cowley, Miriam Weeks, Calvin Dirickson, and Joshua Grinath
Department of Biological Sciences, Idaho State University, Pocatello, ID

Introduction

Human activities, including fossil fuel combustion and agricultural operations, have greatly increased nitrogen (N) availability for plant growth, causing unprecedented changes in plant assemblages across ecosystems. These effects can last for years, even after N pollution has stopped, and are occurring in combination with disturbances such as wildfire. However, it is unclear how legacies of N pollution affect plant recovery from wildfire. In this study, we evaluated how N pollution affected the seedbank of a sagebrush community following recent wildfire. We sampled seedbanks from ISU's Barton Road Ecological Research Area, where from 1997 to 2010, a N manipulation study was conducted to simulate medium to high levels of atmospheric N deposition. Legacies of these N manipulations have persisted through 2020, when a summer wildfire ravaged through the field site, burning all experimental plots. We predicted that we would find higher abundances of exotic plants in seedbanks from N-enriched plots.

Methods

- Soil cores (6cm diameter and 10cm deep) were collected on October 7th.
- We sampled ten replicates from each of ten plots: 4 control, 3 high N, and 3 low N.
- Half the samples were collected from under burned shrubs, and half between shrubs.
- Samples were left at lab room temperature until November 28th when they were moved and kept in a fridge at 3°C.
- Germination in the greenhouse started February 19th.
- Soil samples were homogenized then divided into 80 mL subsamples, which were sprinkled on top of potting soil in 8.9x8.9 cm^2 pots.
- Pots were placed in trays then on benches in ISU's Plant Sciences greenhouse and received daily with 1 cm of water daily.
- Weekly, trays were rearranged on the bench in random order.
- On March 12th and 26th, seedling abundances were recorded as assigned species or morphospecies and removed from the pots.
- Analysis was performed using R version 4.0.2 using generalized linear mixed effects models.

Idaho State University

Results

Figure 1: The total seedling abundance for plots with varying levels of nitrogen manipulation. The three manipulation levels were control, low, and high.

- **Total seedling abundance** varied across the N treatments, but **was only significantly different between seedbanks from the control and low N plots (Fig. 1).**
- **Total seedling abundance was greater in seedbanks from inter-shrub areas compared to areas under shrubs (Fig. 2).**
- The interaction between the N manipulations and shrub presence was not significant for total seedling abundance.

Figure 2: The total seedling abundance for seedlings in plots with shrubs fertile island effects (shrub) and plots without the fertile island affect (inter.shrub).

- The above **results were greatly influenced by an unidentified forb morphospecies that constituted 84.7% of total seedlings.** The trends for this species mirrored those for total seedlings.
- **Only 8.7% of total seedlings were confirmed as exotic species,** including *Bromus tectorum*, *Lactuca serriola*, *Alyssum desertorum*, *Descurainia* sp., and *Tragopogon dubius*. There were too few exotic plants to evaluate their abundance, but an analysis of exotic plant presence/absence indicated that the presence of exotic species was not significantly different across N treatments or shrub/inter-shrub areas (all P-values > 0.05).

Conclusion

We performed this study better understand the how N pollution affects seed abundances in the seedbank of a sagebrush ecosystem. We were unable to reject the null hypothesis that there are no differences in exotic plant abundance across N treatment. Therefore, we did not support our prediction that more exotics would be present in the N-enriched plots. These results require additional research to understand, but one explanation may be that some exotic plant seeds could primarily occur in shallow soils that were negatively affected by fire. We are also conducting further work to identify the dominant forb in the seedbank, which is likely to be an important species in the post-fire community.

Acknowledgments

This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board of Education Higher Education Research Council through Idaho State University

SBOE Undergraduate Intern - Report for ISU's Office for Research

Project: Plant responses to fire and legacies of nitrogen enrichment and shrub removal at ISU's Barton Road Ecological Research Area
Faculty Lead: Josh Grinath

Student Name: Ashton Cowley
Date: 26 May 2021
Faculty Mentor: Josh Grinath

What did you learn from your internship experience?

I learned how to properly organize and plan a field experiment in real time. I saw what can go wrong, as well as what goes beautifully right. I learned a lot about native plant identification, which was my favorite part of the research. I also learned the importance of taking very specific notes and to collect data more often.

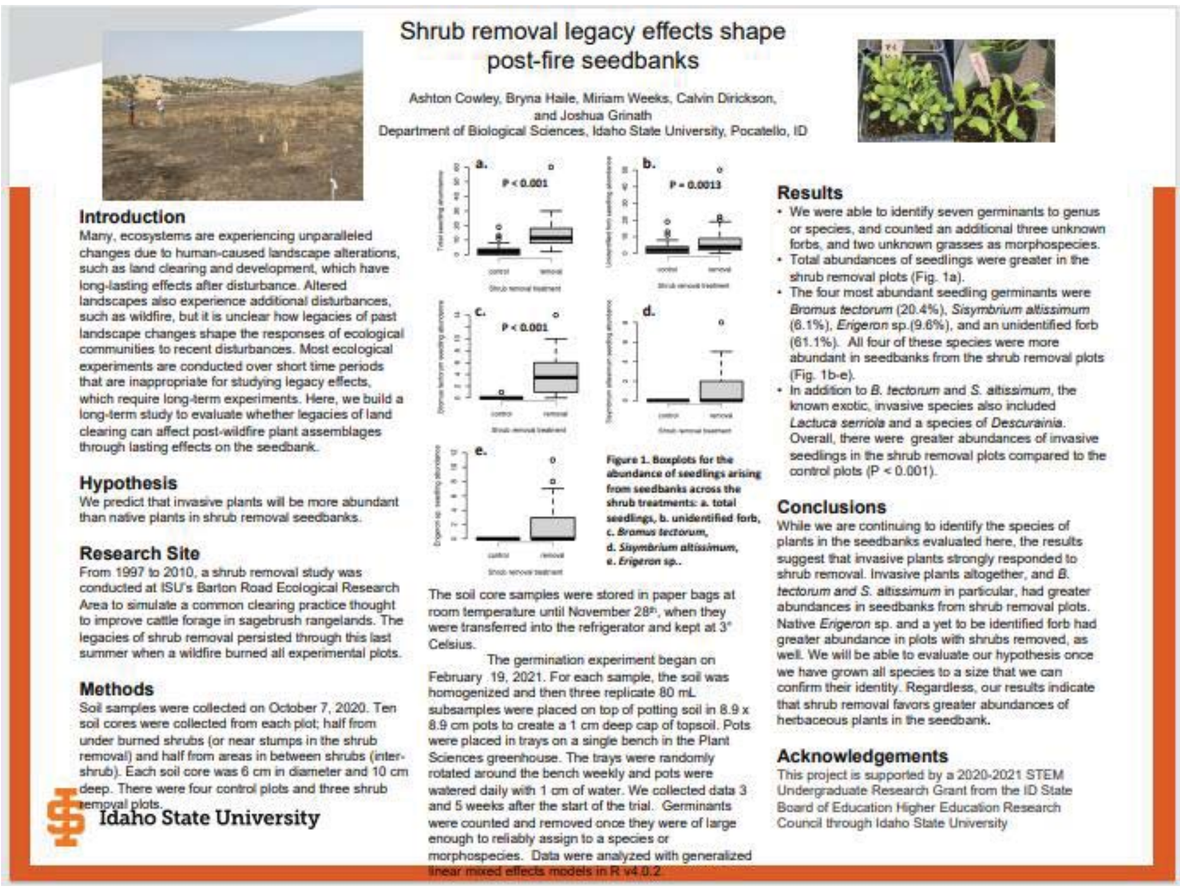
How did this research experience benefit you?

I learned how to work with an assortment of different people in a very challenging environment, not only physically but, it has also been interesting getting reassimilated into a non-Covid society. I met many incredible people along the journey with bright minds who helped me to improve my ways of thinking.

How has this research experience changed your future plans, if at all?

Not really.

Poster:


Shrub removal legacy effects shape post-fire seedbanks
Ashton Cowley, Bryna Haile, Miriam Weeks, Calvin Dirickson, and Joshua Grinath
Department of Biological Sciences, Idaho State University, Pocatello, ID
Introduction
Many, ecosystems are experiencing unparalleled changes due to human-caused landscape alterations, such as land clearing and development, which have long-lasting effects after disturbance. Altered landscapes also experience additional disturbances, such as wildfire, but it is unclear how legacies of past landscape changes shape the responses of ecological communities to recent disturbances. Most ecological experiments are conducted over short time periods that are inappropriate for studying legacy effects, which require long-term experiments. Here, we build a long-term study to evaluate whether legacies of land clearing can affect post-wildfire plant assemblages through lasting effects on the seedbank.
Hypothesis
We predict that invasive plants will be more abundant than native plants in shrub removal seedbanks.
Research Site
From 1997 to 2010, a shrub removal study was conducted at ISU's Barton Road Ecological Research Area to simulate a common clearing practice thought to improve cattle forage in sagebrush rangelands. The legacies of shrub removal persisted through this last summer when a wildfire burned all experimental plots.
Methods
Soil samples were collected on October 7, 2020. Ten soil cores were collected from each plot; half from under burned shrubs (or near stumps in the shrub removal) and half from areas in between shrubs (inter-shrub). Each soil core was 6 cm in diameter and 10 cm deep. There were four control plots and three shrub removal plots.
Idaho State University
a. P < 0.001
b. P = 0.0013
c. P < 0.001
d.
e.
control removal
Shrub removal treatment
Figure 1. Boxplots for the abundance of seedlings arising from seedbanks across the shrub treatments: a. total seedlings, b. unidentified forb, c. Bromus tectorum, d. Sisymbrium altissimum, e. Erigeron sp..
The soil core samples were stored in paper bags at room temperature until November 28th, when they were transferred into the refrigerator and kept at 3° Celsius.
The germination experiment began on February 19, 2021. For each sample, the soil was homogenized and then three replicate 80 mL subsamples were placed on top of potting soil in 8.9 x 8.9 cm pots to create a 1 cm deep cap of topsoil. Pots were placed in trays on a single bench in the Plant Sciences greenhouse. The trays were randomly rotated around the bench weekly and pots were watered daily with 1 cm of water. We collected data 3 and 5 weeks after the start of the trial. Germinants were counted and removed once they were of large enough to reliably assign to a species or morphospecies. Data were analyzed with generalized linear mixed effects models in R v4.0.2.
Results
• We were able to identify seven germinants to genus or species, and counted an additional three unknown forbs, and two unknown grasses as morphospecies.
• Total abundances of seedlings were greater in the shrub removal plots (Fig. 1a).
• The four most abundant seedling germinants were Bromus tectorum (20.4%), Sisymbrium altissimum (6.1%), Erigeron sp.(9.6%), and an unidentified forb (61.1%). All four of these species were more abundant in seedbanks from the shrub removal plots (Fig. 1b-e).
• In addition to B. tectorum and S. altissimum, the known exotic, invasive species also included Lactuca serriola and a species of Descurainia. Overall, there were greater abundances of invasive seedlings in the shrub removal plots compared to the control plots (P < 0.001).
Conclusions
While we are continuing to identify the species of plants in the seedbanks evaluated here, the results suggest that invasive plants strongly responded to shrub removal. Invasive plants altogether, and B. tectorum and S. altissimum in particular, had greater abundances in seedbanks from shrub removal plots. Native Erigeron sp. and a yet to be identified forb had greater abundance in plots with shrubs removed, as well. We will be able to evaluate our hypothesis once we have grown all species to a size that we can confirm their identity. Regardless, our results indicate that shrub removal favors greater abundances of herbaceous plants in the seedbank.
Acknowledgements
This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board of Education Higher Education Research Council through Idaho State University

Part 3

We spent a total of $8,618.15 out of the $9,000 award. This total is divided among:

$150 for greenhouse supplies
$100 for greenhouse bench rental
$8,368.15 for student intern salaries (including fringes)
$8,618.15 total

These funds have supported research by three undergraduate interns (Bryna Haile, Ashton Cowley, Miriam Weeks). The funds spent on greenhouse supplies and bench space supported the three seedbank germination studies that were primarily conducted by the interns.

We were unable to use the remaining funds for several reasons. First, appropriate plants were not available for foliar chemistry analyses, as initially planned. Second, we then decided to spend the funds to partially support the purchase of a freezer to house plant tissue samples that we are collecting this summer for chemical analysis; however, the delivery of this freezer was unexpectedly delayed and the purchase could not be reconciled prior to the June 1st deadline of this grant. By the time we learned of this delay, it was too late for us to purchase additional research supplies in support of the project.

John Dudgeon <johndudgeon@isu.edu>

Tue, Jun 1, 3:51 PM

to Debra

John Dudgeon had two students who were recipients of SBOE undergraduate funding in 2020-21. Spring 2021 B.A. graduate Pamela Pascali worked in the CAMAS laboratory and learned obsidian sourcing using portable x-ray fluorescence analysis (pXRF), becoming an experienced user of this equipment. She used this skill set to create preliminary data for her M.S. thesis research, beginning fall 2021. She also used this experience to submit and be awarded an NSF Graduate Research Fellowship in the prehistoric archaeology of the Snake River Plain. She also constructed a user guide for pXRF operations, to be adopted by ISU Environmental Health and Safety.
Spring 2021 B.A. graduate Kateea Peterson used SBOE funding to learn inductively coupled plasma mass spectrometry (ICP-MS) in the CAMAS laboratory, and used this skill set to analyze a variety of material types, including human and animal bone, which she is planning to carry forward to her M.S. thesis research studying the mechanisms of deterioration and alteration of buried bone in fall 2021. She became very experienced in ICP-MS setup, calibration and operation, so much so that she was able to help bring another ICP-MS into operation, and has become the 'go to' instrumentalist for this new mass spectrometer in the CAMAS laboratory.

Description of Activities

1. STEM related research employment over the course of the academic year for two students
    a. Makenzie Kohler
        i. Scientific journalism (sample attached)
        ii. STEM research (poster attached)
    b. Dalene Hunter
        i. STEM Research (poster attached)
2. Virtual conference attendance for three STEM students
    a. Makenzie Kohler
    b. Dalene Hunter
    c. Pamela Pascali
3. Supplemental research stipends for six graduating STEM students at $700 each.
4. Supplies for students engaged in the TRIO McNair Summer Research Institute program

Report of Expenditures

	Travel	Salary	Benefits	Stipends	Materials	MO. TOTAL	TOTAL	Remain
July						$0.00	$0.00	$10,000.00
Aug						$0.00	$0.00	$10,000.00
Sept						$0.00	$0.00	$10,000.00
Oct		($88.00)	($7.83)			($95.83)	($95.83)	$9,904.17
Nov		($253.00)	($22.52)			($275.52)	($275.52)	$9,628.65
Dec		($456.50)	($40.63)			($497.13)	($497.13)	$9,131.52
Jan		($1,200.00)	($12.10)				($1,212.10)	$7,919.42
Feb		($607.20)	($6.08)				($613.28)	$7,306.14
Mar		($862.40)	($8.63)		($597.00)		($1,468.03)	$5,838.11
April		($1,273.80)	($12.74)	($4,200.00)			($5,486.54)	$351.57
May		($220.00)	($2.20)		($129.37)		($351.57)	$0.00
June							$0.00	

Student Report

The following students benefitted from activities in this account and their research posters are attached:

1. Hannah Aken (Microbiology)
2. Rosemary Anibogwu (Chemistry)
3. Jacob Diehl (Biochemistry)
4. Peggy Hodges (Mechanical Engineering)
5. Dalene Hunter (Anthropology)
6. Makenzie Kohler (Biology)
7. Pamela Pascali (Anthropology)

Stories behind the science: Breaking barriers

From an ear infection to meningitis, one germ is responsible and an Idaho State University student is helping solve the problem.

Hannah Aken, a college senior majoring in microbiology, has been attending ISU since 2017 and has taken full advantage of the opportunities available to her, even before starting college. Hannah grew up in a small Idaho town and said, “Outside of education, growing up in Idaho Falls I felt was really nice.”

Being the first person in her family to go to college, Hannah faced the challenge of figuring out where to begin. Coincidentally, her best friend’s boyfriend at the time was in a program called TRIO on the ISU Pocatello campus. With the excitement of an “opportunity of no parents for seven weeks” during the summer before senior year of high school, the program was too much to pass up and Hannah joined.

“TRIO is a program that helps you get to and through college,” Hannah explains. “They have programs at the high school level that help first generation and low income or underrepresented students get to college or get to secondary education,” she continued. That seven weeks she had away from her parents was actually a research program for high school students called the SEED Internship. It was during this time that Hannah discovered her passion for science. And now she had the support she needed in order to pursue that passion.

While taking a microbiology course at ISU, Hannah became enamored with living creatures we cannot see with the naked eye- microbes. “There's these little things, but you can't see them. You can't feel them, but they make you totally sick. They can kill you. They can ruin the ecosystem, they can mess with anything in our daily lives.” she said. Hannah’s thirst for knowledge, specifically in studying pathogens (disease-causing microbes), pushed her to pursue scientific research. In the summer of 2019, Hannah was accepted as a fellow into the Idaho Idea Network of Biomedical Research Excellence (INBRE) program, which is funded by the National Institutes of Health (NIH).

During the program, Hannah studied the pathogen *Streptococcus pneumoniae* under Dr. Julia Martin at ISU. *S. pneumoniae* is a bacterium that in minor situations, causes an ear infection, but can be as severe as pneumonia and meningitis. Hannah specifically looked at the effects of magnesium, a transition metal, on the capsule of the bacterium. Magnesium has been found to be a structural component of the capsule. “The capsule is an outer coating that the bacterium forms in order to protect itself from being killed from the host's immune system,” she explains, “and so [the capsule is] harmful for us, because then it lets the bacteria live longer in our body.” By looking at how different quantities of magnesium impact capsule growth, Hannah was able to determine that the more magnesium the bacteria had access to, the thicker the capsule. After ten weeks of pipetting samples, growing cells, and performing assays, Hannah's skills and confidence grew and her passion for microbiology was solidified.

Hannah has since completed a second research internship and has presented at 5 different conferences across the U.S. "One of the most enlightening feelings is going to a conference and being like, this is what I did. And being able to explain all of it, I mean, like, look at what I made, look at this thing. Like I did all this. And it's just so gratifying." she says with a gleam in her eye. Hannah's college experiences have led her on an exciting career path and her next adventure is charging head-on into a Ph.D. program.

Hannah has applied to multiple graduate school programs in microbiology and immunology and currently has two offers for interviews. She applies in hopes to one day be able to become a primary investigator in her own lab studying pathogens and the human immune response to them. She is also excited to seek out opportunities to further nurture student's interest in science and promote diversity at an institution with limited resources. Hannah, as she put it, went "blindly into college" and has since succeeded in every opportunity presented to her with the TRIO program by her side. In a few years, she just may be the person who helps reveal the inner workings of the microbe causing those pesky ear infections.

Fun fact corner:

Astrology sign: Aquarius, bordering Capricorn

Biggest influence: Her father who pushed her to work hard and be proud of what she has achieved

What she does when nobody is watching: Dances around the house

One thing she has never done living in Idaho: Milked a cow

A Multilayered Approach to Predict Metal-Binding Sites in the Pneumococcal Phosphoglucomutase Protein

Hannah J. Aken[1], Michael L. Johnson[2], and Julia E. Martin[1]

[1]Department of Biological Sciences, Idaho State University, Pocatello, ID 83209
[2]Department of Immunobiology, University of Arizona, Tucson, AZ 85724

Abstract

Phosphoglucomutase (Pgm) is an important enzyme that functions to bridge sugar metabolism to capsular polysaccharide formation in *Streptococcus pneumoniae*. Preliminary data using a mag-fura-2 metal-binding competition assay reveals that pneumococcal Pgm binds 2 metal ions per protomer, despite literature showing a single metal-binding site for other characterized Pgm family members. In this study, we focus on identifying the second metal-binding site in the pneumococcal Pgm. I-TASSER was used to generate a structural model of the pneumococcal Pgm. A multi-protein sequence alignment comparing pneumococcal Pgm and other bacterial Pgm proteins using multiple bioinformatics programs validated the known highly conserved metal-binding motif DXDXDR, as well as several other potential metal-binding motifs. We share information here on two of these secondary predicted metal-binding motifs. One motif is found downstream of the Pgm active site and the other is located near the C-terminus of the protein. These preliminary data set the foundation for further biochemical and phenotypical analysis of mutant Pgm protein.

Introduction

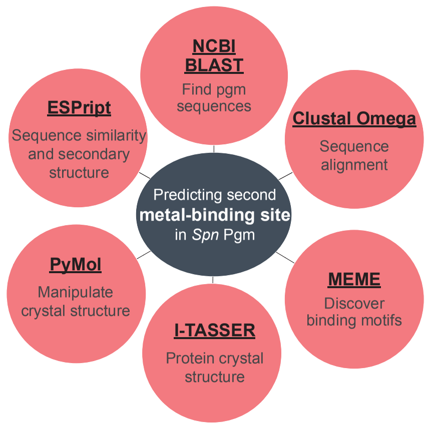
- *Streptococcus pneumoniae* is a major human respiratory bacterial pathogen that causes sinusitis, otitis media, and the major diseases pneumonia, meningitis, and bacteremia[10].
- Phosphoglucomutase is a ubiquitous enzyme involved in sugar metabolism and is found in all domains of life[9]. In pathogenic bacteria, Pgm is necessary for polysaccharide capsule biosynthesis. The capsule is an important virulence factor used to evade the host immune response[10].
- Preliminary studies show that apo-Pgm (metal-free) binds 2 metals ions: one high affinity binding site in the nanomolar range and one low affinity binding site in the micromolar range (McFarland and Martin, data not published).
- Pgm has one known, conserved metal binding site motif DXDXDR that is shared by all PGM/PMM family members.

Hypothesis

Based on our preliminary data, we hypothesize that phosphoglucomutase contains a second metal-binding site.

- **Can we identify the location of a secondary metal-binding site based on similarities among Streptococci?**
- **Can we identify the location of a secondary metal-binding site based on similarities among other bacterial species?**

Methods and Materials



Results

1. Pneumococcal Pgm metal-binding sites

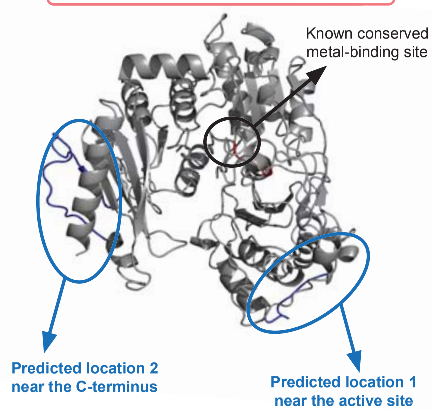


Figure 1: Cartoon of predicted structure model of *S. pneumoniae* Pgm generated by I-TASSER software. The locations of conserved and predicted metal-binding motifs are circled.

2. Predicted metal-binding motif 1 is located near the active site

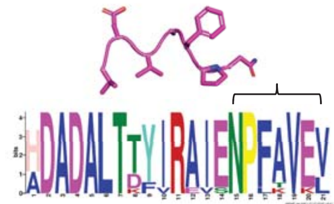
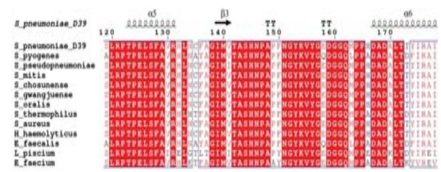
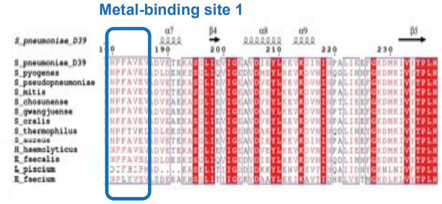


Figure 2: Motif given by MEME-suite for the predicted metal-binding site number one. 21 residue wide motif from 166 to 186. Includes close-up view of loop structure where binding may occur. Residue numbers 180-186.



Metal-binding site 1



Multi-sequence alignment of pneumococcal Pgm and other Streptococci and non-streptococcal bacterial species. Blue border represents predicted metal binding site one. Conserved amino acids among the organisms are highlighted in red.

3. Predicted metal-binding motif 2 is located near the C-teminus

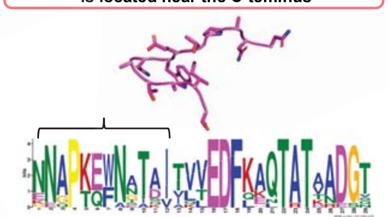
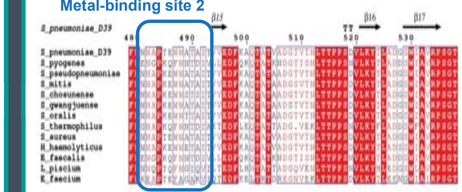


Figure 3: Motif given by MEME-suite for the predicted metal binding site number two. 29 residue wide motif from 481 to 509. Includes close-up view of loop structure where binding may occur. Residue numbers 481-493.

Metal-binding site 2



Multi-sequence alignment of Pgm in Streptococci and non-streptococci species. Predicted metal-binding site two shown circled in blue. Conserved amino acids among the organisms are highlighted in red.

Conclusion

Using multiple bioinformatics software applications and databases, we were able to identify several potential metal-binding sites in the pneumococcal Pgm. Two of which are discussed in this study. Each contain amino acids that are likely to bind a metal cation. This data sets the foundation for future biochemical and physiological studies of Pgm.

Future Work

- Use site-directed mutagenesis to mutate specific metal-binding residues (Glu, Asp, Arg, Asn) to alanine in the predicted metal-binding sites in Pgm.
- Measure metal-binding affinity of Pgm variants using the mag-fura 2 metal-binding competition assay and determine affect on Pgm activity *in vitro.*
- Assess affect on capsule biosynthesis and growth using pneumococcal mutants expressing variant.

Acknowledgements

This research is supported by funding from the Ronald E. McNair Post Baccalaureate Achievement Program at Idaho State University, which is sponsored by the Department of Education (P217A170169).

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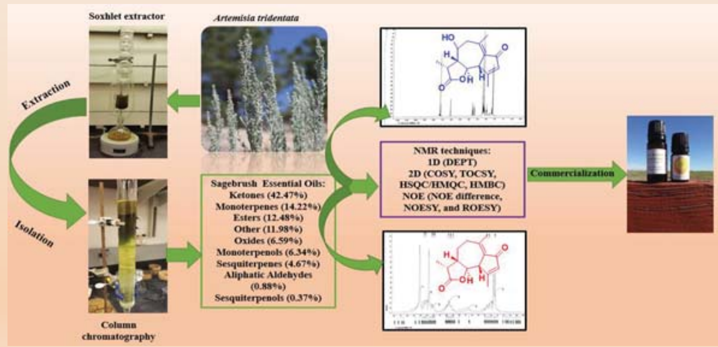
Identification and quantification of sesquiterpene lactones (SLs) in *Artemisia tridentata (big sagebrush)* and its chemical modification

Rosemary Anibogwu, Dr. Karl De Jesus, Dr. Rene Rodriguez, Dr. Kavita Sharma

Department of Chemistry, Idaho State University, Pocatello, ID, 83209, sharkum2@isu.edu

Introduction

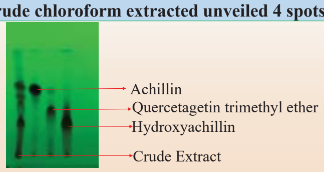
Artemisia (sagebrush) is an aromatic shrub native to a variety of habitats and climates, which range from cold desert conditions to the Intermountain region of the United States. *Artemisia* is a medicinal shrub due to its capacity to alleviate human afflictions such as internal bleeding, headaches, external infections, and respiratory malfunctions. Terpenoids such as sesquiterpene lactones (SLs), phenolic acids, flavonoids, sterols, fatty acids, lignans, and acetylenes constitute major classes of phytochemicals in *Artemisia tridentata*. SLs are fifteen carbon terpenes formed from the incorporation of three isoprene units, followed by cyclization and oxidative transformation to make a cis or trans-fused lactone. The γ-lactone ring, usually with a α-methylene group, is a significant characteristic of SLs. Their molecular structure may present hydroxyls, esterified hydroxyls, or epoxide groups. Some SLs occur in glycosylated form, and a few contain halogen or sulfur atoms. Several SLs in cancer clinical trials have properties that enable them to target tumor and cancer stem cells while sparing normal ones.



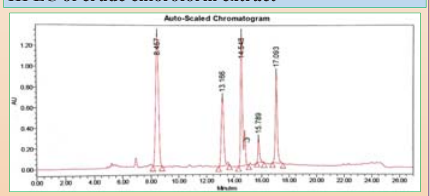
Workflow: Extraction → Isolation → Purification → Characterization → Modification

Results and Discussion

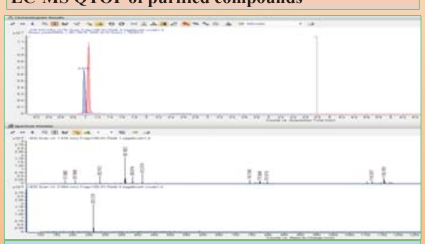
Thin Layer Chromatography (TLC) analysis of the crude chloroform extracted unveiled 4 spots



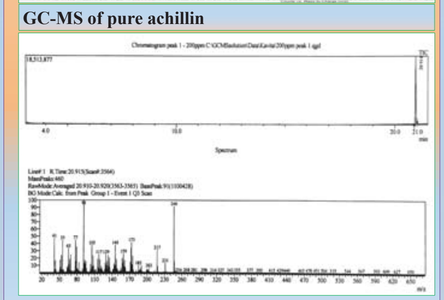
HPLC of crude chloroform extract



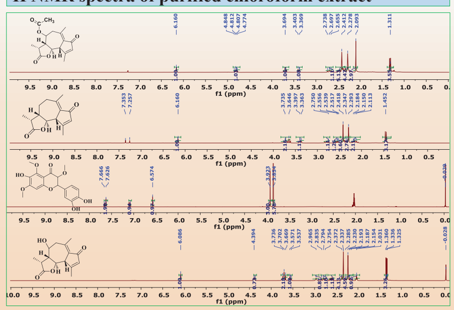
LC-MS QTOF of purified compounds



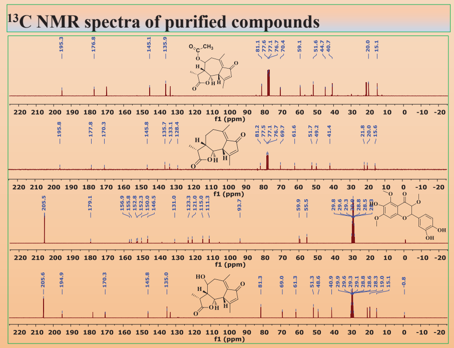
GC-MS of pure achillin



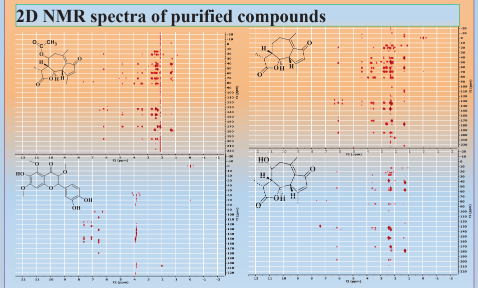
^1H NMR spectra of purified chloroform extract



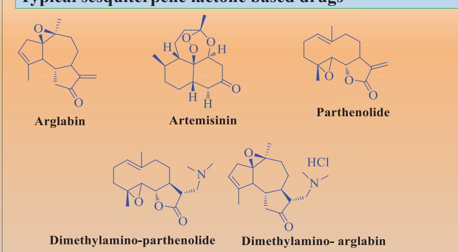
^{13}C NMR spectra of purified compounds



2D NMR spectra of purified compounds



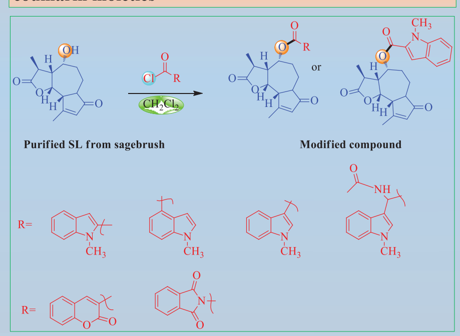
Typical sesquiterpene lactone based drugs



Antioxidant activity of extracted compounds

The antioxidant activities of the crude extract and three pure compounds were evaluated in terms of their peroxyl radical-scavenging by Ferric Reducing Ability of Plasma (FRAP) and 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) methods. The crude extract showed an antioxidant activity of 18.99 ± 0.51 µmol TEg^{-1} FW for FRAP and 11.59 ± 0.38 µmol TEg^{-1} FW for DPPH. Achillin, Hydroxyachillin and Quercetagetin trimethyl ether showed the activity as 13.03, 15.90 and 14.02 µmol TEg^{-1} FW respectively for FRAP assay. The four purified compounds have been submitted to the National Cancer Institute 60 cancer cell line screen for further study.

Modification of pure SLs with indole, phthalimide and coumarin moieties



Future Plans

Looking forward, there still remains much work to be done, but this investigation intends to create a platform for sagebrush to be used in pharmaceuticals and nutraceuticals. The chemically modified SLs compound will be used in antitumor studies and also for alleviating human diseases such as cancer, based on structure-activity relationship (SAR).

Acknowledgements

This study was carried out with the support of Office for Research and Department of Chemistry of Idaho State University, Center for Advanced Energy Studies (CAES), and Idaho National Laboratory (INL). This research is also partially supported by funding from the Ronald E. McNair Post Baccalaureate Achievement Program at Idaho State University, which is sponsored by the Department of Education (P217A170169).

Pocatello | Idaho Falls | Meridian | Twin Falls

FRET Analysis of an Engineered Halophilic Peptide

Jacob Diehl, Chris Brininger, & Caryn Evilia
Department of Chemistry, Idaho State University, Pocatello Idaho, 83209

Introduction

It is still unknown exactly how halophilic protein tolerates and function in an extreme ionic environment. We have some "rules", like an increased amount of acidic residues and a small hydrophobic core. However, it is not known if one could engineer a *de novo* halo-tolerant protein if these rules were satisfied. In an effort to elucidate the functionality and folding behaviors of these proteins under these extreme circumstances, a peptide was developed to mimic many of the traits that are shown to stabilize the halophilic proteins in native conditions. These peptide were designed to form alpha helices with an unstructured region in between when exposed to hypersaline conditions. Once formed, these alpha-helices interact with each other due to the hydrophobic bands containing tryptophan and alanine residues. This would cause the N and C termini to come within close proximity to each other, thereby providing an opportunity to utilize Förster Resonance Energy Transfer (FRET). By attaching fluorophores to the N and C termini, the salt-dependent folding behaviors can be directly observed. Our results show that the peptide design exhibits behavior comparable to halophilic proteins. Under low salt conditions, the peptide adopts a rather loose structure but becomes more structured as salt concentration increases. This project provides useful insight into halophilic features/adaptations and protein-folding behaviors. By designing peptides based on our understanding of halophilic proteins, we hope to learn how proteins not only tolerate extremely ionic conditions but also how they could withstand other extremes as well.

Results

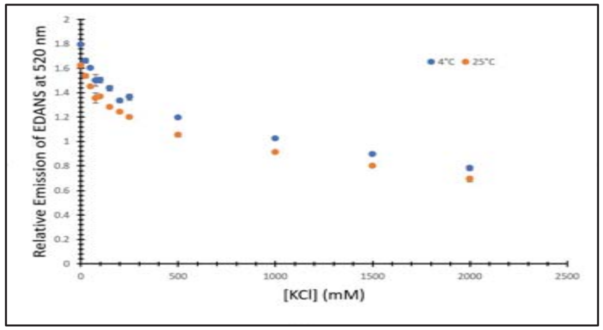


Figure 3: The relative emission of EDANS's fluorescent signal at 520 nm is plotted versus concentration of KCl at 4°C (blue) and at 25°C (orange). Measurements were taken in triplicate with standard deviation representing error. Both datasets indicate a decrease in EDANS emission as KCl concentrations increases, with the 25°C dataset displaying lower values at every concentration relative to the 4°C dataset.

Conclusions

The results depicted in Figure 1 indicate that as the EDANS/Dabcyl labeled peptide is exposed to increasing saline conditions, the intensity of the EDANS signal decreases; however, it seems that this decrease plateaus past 2.0 M KCl indicating that given enough KCl the peptide may achieve maximally structured state. Lastly, it is apparent that the signal intensity of every point in the 25°C dataset relative to the 4°C dataset is consistently lower in magnitude.

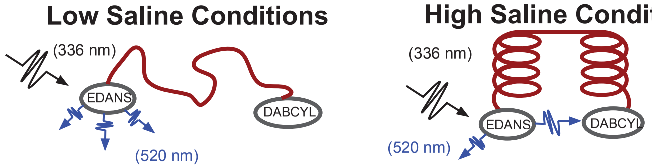
Acknowledgments

This research is supported in part by funding from the Ronald E. McNair Post Baccalaureate Achievement Program at Idaho State University, which is sponsored by the Department of Education (P217A170169). Other sources of funding include the Idaho State University Department of Chemistry, Career Path Internship Program at Idaho State University, the Idaho State University Office of Research, and the United States Army Research Office.

References

1. Guo, Jiubiao, et al.(2015): Spectral properties of EDANS-Dabcyl pair [45] and the flowchart of the experimental design. PLOS ONE. https://doi.org/10.1371/journal.pone.0114124.g001
2. Brininger, Chris, BS/MS technical paper, Idaho State University, May 2019. p.6.

Methods



DABCYL is quenching EDANS's fluorescent signal.

Figure 1: Diagram of the peptide's proposed folding behavior under low and high saline conditions. The fluorophores EDANS and Dabcyl where attached to either end of the peptide. This fluorophore/peptide system was excited at 336 nm., EDANS (peak excitation wavelength at 336 nm) acts as a FRET donor, and when excited, it emits photons at 520 nm. These photons are then absorbed by Dabcyl which acts as a FRET acceptor. Dabcyl's peak excitation wavelength is 472 nm. As. When exposed to environments increasing in salinity, the peptide adopts a more defined secondary structure. As a result the fluorophores come closer in proximity resulting the quenching of EDANS's fluorescent signal. Experiments where conducted at 25°C and 4°C.

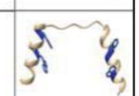
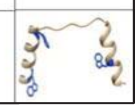
Original Sequence n-ESVYIPVYPDDYENVGDPQAADVDASLDRARQMREANDDLEDADFDP-c	
Peptide 1 n-AEDAWEDAWEDAEEGPPDDPPGAEWAEDWAEDAEE-c	
Peptide 2 n-AEWDEADEEWSPPGPSEAEEWDDDAK-c	
Peptide 3 n-AEADEWAEDAESGPPDDPPGADWEEAAEDDWDAK-c	

Figure 2: Models and sequences of the designed peptides. The designs of each peptide are composed of two alpha helices spanned by a single unstructured connector. The first iteration of the peptide (pep 1) was adapted from a non-conserved sequence in Arginyl-Synthetase from *H. Salinarum.* Tryptophans were introduced into the design to coerce the peptide to form a "hydrophobic lock" when in the presence of a highly saline environment. The design of pep 2 resembles that of pep 1; however, the alpha helices and the connecter were truncated. Peptide 3 consists of the truncated alpha helices from pep 2 and the original connecter from pep 1.

Analytical Study of Steady-State Flow Within the Compression Stage of a Westinghouse Single Loop Jet Engine

Peggy Hodges, Dr. Marco Schoen
Department of Mechanical Engineering, Idaho State University, Pocatello, Idaho, 83209, USA

Abstract

This research investigates the development of a Matlab™ program that predicts air velocity inside any jet engine at any stage along the axial compressor section as a function of rotor speed. Because the tolerances inside a compressor are small, it is difficult to take measurements of the conditions on the inside. Measurements from the tip, the midpoint, and the base of each blade of the 11 stage Westinghouse J34 were taken using a SolidWorks™ program containing the exact measurements. Using the velocity triangle method of analysis, the absolute, relative, axial and horizontal air velocities were calculated as a function of blade speed. This was then programed into Matlab™ and code was written to produce tables and graphs representing the respective air velocities. It was discovered that after the fourth stage the velocity dropped significantly. Future studies will include, adding a user-friendly interface for ease of access, adding an algorithm for optimization, adding calculations for measuring pressure, and testing the accuracy of the program using the compressor to collect data. Should the program be accurate, the program will be a useful tool to for aerospace engineers in various applications.

Background

There exists an obscure program called NEWRAP written in Fortran that was developed at NASA. This software works with independent variables and has the option to optimize dependent variables. The purpose of the software is to aid in the overall testing of regression [1]. As Fortran is a precursor to Matlab™, the languages both focus on the use of matrices and allow for the use of algorithms to optimize dependent variables. While access to this software was not found, the paper depicting the intended uses of the software is available online [1]. Using a similar concept, and an optimization algorithm programmed by Dr. Marco Schoen as a basic guide.

In order to complete this task, the velocity triangle method of analysis is being used as a structure for the code calculating the air velocity as a function of rotor speed. [2,3]. The Matlab™ webpages serve as a directory for solve conflicts in coding.

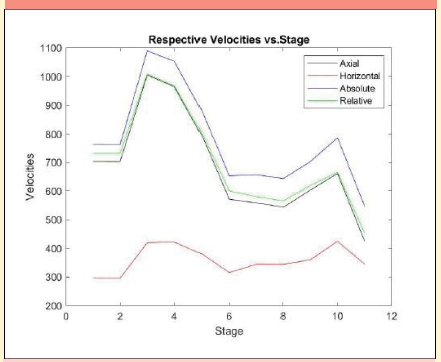
Methods

- Measurements of the blade angles with respect to the axial directions have been taken.
- Hand calculations were completed using the velocity triangle method of analysis.
- Matlab™ code written and tested against the hand calculations
- Data computed by Matlab™ program was compared to data collected by SoldWorks™ for the same compressor

Figure 1: Image of a physical Westinghouse J34 jet engine

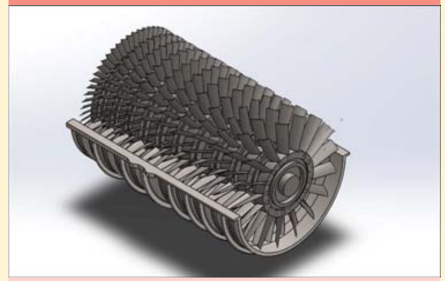
This is the Westinghouse J34 jet engine housed at Idaho State University's Measurement and Control Engineering Research Center. This is the compressor that is modeled in the SolidWorks™ program and is used to test the Matlab™ program.

Figure 3: Graph of air velocities at the base of the blades as a function of rotor speed



This is a graph of the plotted data calculated using the velocity triangle method of analysis that is the base for the Matlab™ program. Axial being axial air velocity, Horizontal being horizontal air velocity, Absolute being absolute air velocity, and Relative is relative air velocity with respect to the moving rotors.

Figure 2: Image of Solidworks software used to gather measurements



This is an image of the completed SolidWorks™ model of the Westinghouse J34 with the top housing removed for ease of measurements. This same model is the basis for comparison for the data collected from the Matlab™ program currently.

Table1: Image of the Table produced by the Matlab program

MATLAB Command Window 1 of 1

Axial	Horizontal	Absolute	Relative
702.49	295.96	762.28	731.52
702.3	295.69	762.01	731.41
1005.3	419.51	1089.3	1008.5
964.5	421.7	1052.7	967.67
794.06	380.21	880.4	803.05
571.19	315.74	652.64	600.17
558.58	344.53	656.28	579.81
543.25	344.14	643.09	565.17
603.3	359.95	702.52	619.34
661.04	424.72	785.72	665.31
424.71	344.48	546.85	452.29

Where Relative is wrt the blade

This is the table produced and presented in the Matlab™ program for the data imputed by the user. This is the data that is being plotted in the graph. Axial being axial air velocity, Horizontal being horizontal air velocity, Absolute being absolute air velocity, and Relative is relative air velocity with respect to the moving rotors.

Acknowledgements

I would like to thank the following people for their support during my research: Dr. Marco Schoen, Idaho State University Department of Mechanical Engineering; Dr. Shannon Kobs-Nawotniak, Idaho State University Honors Program; Dr. Denise Tambasco, Reinalyn Echon, and Laticia Herkshan, TRIO McNair Scholars Program.

This research is supported by funding from the Ronald E. McNair Post Baccalaureate Achievement Program at Idaho State University, which is sponsored by the Department of Education (P217A170169).

Results

A quick inspection of the graphs and tables presented in Figure 3 and Table 1 show that the respective air velocities decrease drastically around stage 4 of the Westinghouse J34 housed at Idaho State University. This data matches to data collected from the SolidWorks™ program. Furthermore, because of the design of the Matlab™ program, it can predict the velocity at the base, the midpoint, and the tip of each rotor and stator. The capability to upload files containing the camberline and blade chord angles will allow a user to use the software for any compressor.

Future Research

To test the accuracy of the data produced by the Matlab™ program, and therefore accuracy of the program, the Westinghouse J34 is currently being outfitted with high precision sensors to collect pressure and air velocity measurements inside the compressor. Should that data match the calculations produced by the Matlab™ software, it can be concluded that the software accurately predicts the air velocity inside the compressor as a function of rotor speed.

As it was discovered that the velocity drops, the question of pressure was raised. What happens to the pressure as that decrease in velocity occurs? Currently equations are being calculated for the change in pressure across the system assuming the system is adiabatic and the compressor is in steady state. More measurements of the compressor must be taken, specifically of the area in order to find mass flow rate. Once the calculations are completed, they will be added to the Matlab™ program with the option of optimization as well.

Currently the software is lacking the algorithm for optimization and the user-friendly interface, but that will be added in the upcoming months after the pressure equations are added to the structure of the code.

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Idaho State University

Students' Cultural Relationship with their Masks

Dalene Hunter
Mentor: Dr. Katherine Reedy

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RONALD E. MCNAIR POST-BACCALAUREATE ACHIEVEMENT PROGRAM

Abstract

The novel virus, COVID-19, shook the world for the majority of 2020. This was especially true in the case of university students. As universities themselves tried to find ways to bring students back to school in the Fall 2021 semester, they were faced with several challenges. One of which was the need to mandate the use of face coverings, or masks, for all students on campus. This study examines the feelings and perspectives that students have on a cultural level towards their mask wearing through qualitative interviewing.

Introduction

Because the coronavirus only emerged in late 2019, very little research has been done on the cultural aspect of the pandemic. Many people have been, rightfully, focused on the virus and its affects on the physical, rather than the cultural changes it elicits. However, there are likely many changes that are happening in the base levels of social groups that will impact them greatly going forward.

Masks, in America, were discouraged to start with. There are many theories and approaches as to why this was, but most of them are not relevant to the fact that it happened. The initial discouragement has led to some conflict and controversy over wearing the masks themselves. This is further exasperated by the president of the US refusing to wear one himself.

Several states, cities and municipalities have introduced mandatory mask policies. Furthermore, individual institutions, corporations, and stores have also created their own mandates. Among these were many universities that pulled students back for in-person instruction for the Fall 2020 semester. Idaho State University is among those universities with in-person instruction and mask mandates. Students have developed opinions and cultural constructs around their masks. Study of these ideas is necessary, and that will be what my project accomplishes.

Literature Review

Finding background on this project is especially difficult because of the timeliness of the project. Academia is well known for being slow to produce research, and the pandemic has not helped to speed up that process. Because of this, there is little to no previous research on masks. Thus, finding related literature is its own challenge. A proxy was taken in order to develop these ideas, but many of the related things are lacking the extra context that also influences the mask situation making them their own unique item of study. My review starts with an examination of the pandemic in general and the progression of masks and the official statements on them in America. After that, it jumps into revision on hijab, school uniforms, and other enforced clothing items. None of these capture issues that are necessarily pandemic related.

Methods

My project will make use of qualitative interviewing to get at the cultural perspectives that students have in relation to their masks. I believe that this is the best way to get rich data from students that has the least amount of bias from me as a researcher. Since masks have been such a heavily politicized issue in American media, any survey written for distribution would be inherently biased in some manner and may not elicit quality results and thought of students. It would also require that I, as a researcher, make predictions about the sorts of things student will want to talk about and the feelings they will have about these issues, which I do not feel qualified to do. Especially since there is so little research on the issue to base any questions off of to start.

For these same reasons, an open-ended approach will also be taken. While general themes of cultural responsibility and individuality will be addressed, students will be able to take their responses in the direction they wish, and I will encourage this through prompting questions based on their responses.

Interviews will be recorded, and transcriptions produced first by software, then edited and fixed by myself. The recordings will be kept, with changed names for participants for six months for accuracy, then they will be deleted and only the completely anonymized transcripts will be kept. Analysis will link the students' responses together and make larger comparisons and claims about the cultural feeling students experience in regard to their masks.

Acknowledgements

This research is supported by funding from the Ronald E. McNair Post Baccalaureate Achievement Program at Idaho State University, which is sponsored by the Department of Education (P217A170169).

Spontaneous Weight-Bearing Locomotion in Preweanling Male and Female Rats

Makenzie Kohler, Aimee L. Bozeman, Alleyna C. Martes, and Michele R. Brumley
Department of Psychology, Idaho State University

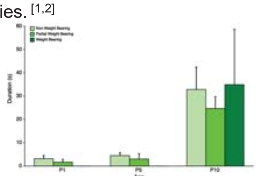
TRIO Ronald E. McNair Post-Baccalaureate Achievement Program
IDAHO INBRE IDeA Network of Biomedical Research Excellence
Idaho State University

Background

Rats are often used in biomedical science to investigate development, mechanisms, and recovery of motor behavior following an injury. [1,2,3]

During the first two postnatal weeks, rats increase their weight-bearing activity, as they shift in locomotor strategies. [1,2]

A previous study in our lab showed hindlimb weight-bearing behaviors increased from postnatal day 5 (P5) to P10. Achilles tendon properties also changed during this period.



How weight-bearing and tendon properties change after the onset of quadrupedal walking starts (P10), has not been reported. Although there are no sex differences in locomotion from P1 to P15 [2], females show more locomotion on P28 [4].

Here we investigate the ongoing development of hindlimb weight-bearing activity in male and female rats, from P15-P20.

Methods & Experimental Design

Independent Variables

Age: P15 Male *n=10*	Age: P20 Male *n=10*
P15 Female *n=10*	P20 Female *n=10*

Individual rats were placed in a clear Plexiglas box to examine spontaneous locomotion in an open-field.

Behaviors was recorded for a 20-minute observation session, and scored using Datavyu.

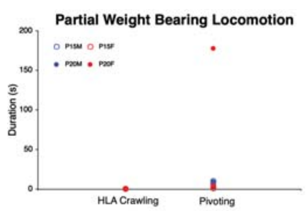
After testing, rats were euthanized and hindlimbs were dissected. Mechanical properties of Achilles tendon were evaluated with a small capacity bioreactor (left) at University of Idaho.

Hindlimb Activation level	DEFINITION
Non Weight-Bearing	No weight on hindlimbs during locomotion i.e. Pivoting, Crawling, Hindlimb Kick
Partial Weight-Bearing	Hindlimbs are not fully activated as weight is distributed over other supporting body parts. i.e. Forelimb supported sitting, Partial Rearing, Stretching
Full Weight-Bearing	Hindlimbs are completely activated and support full body weight. i.e. Walking, Standing, Rearing

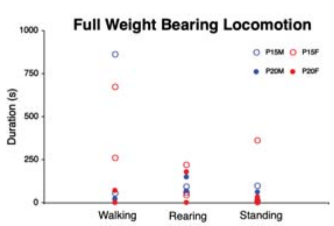
Behavioral Results and Conclusions

Original Scoring Code

Partial Weight Bearing

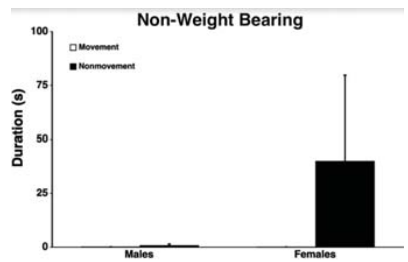


Full Weight Bearing

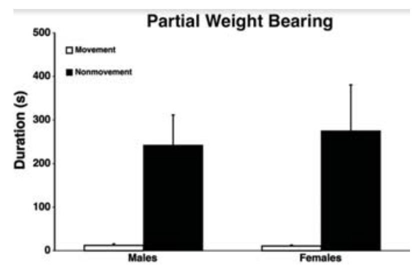


New Scoring Code

Non-Weight Bearing

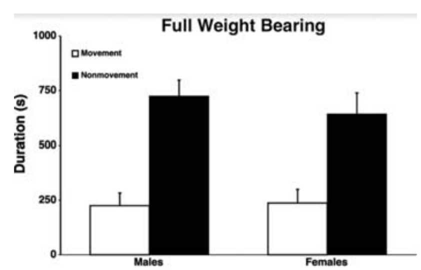


Partial Weight Bearing

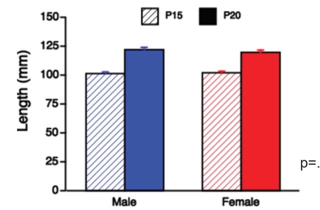


Rat pup being tested for spontaneous locomotion in a temperature-controlled open field.

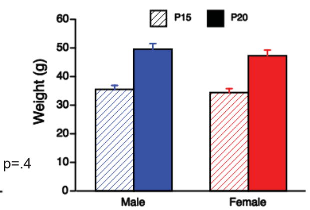
Full Weight Bearing



Body Length



Body Weight



Rats at age P15 show no significant sex differences in duration of locomotion with all levels of hindlimb activation.

P15 and P20 rats show no sex differences in both body length and body weight.

As hypothesized, P20 rats have significantly higher body length and bobdy weight than rats at age P15.

References & Acknowledgments

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[2Swann, H. E., & Brumley, M. R. (2019). Locomotion and posture development in immature male and female rats (Rattus norvegicus): Comparison of sensory-enriched versus sensory-deprived testing environments. *Journal of Comparative Psychology, 133*(2), 183-196.
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Supported by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under Grant #P20GM103408 and (in part) by funding from the Ronald E. McNair Post Baccalaureate Achievement Program at Idaho State University, which is sponsored by the Department of Education (P217A170169).

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Expanding the Obsidian Database

Pamela Pascali & John Dudgeon, Ph.D.
Idaho State University, Department of Anthropology

CAMAS
Center for Archaeology, Materials, and Applied Spectroscopy
We See Things Differently

Introduction

There are obsidian artifacts that have been found at sites in the Snake River Plain that cannot be matched to previously identified sources from the same area. Once we understand the scope of possible obsidian sources, we can begin to trace the movement of obsidian.

Methods

From each site, 3 individual obsidian samples were analyzed using pXRF and LA-ICP-MS. Those averages were then compared with elemental data against each other and a known source standard.
We performed sourcing analysis to determine which sources are from the same event and therefore the same family group source.
Patterns of family groups appear when the major elements are graphed against one another (Figure 1).

Positive Source Grouping

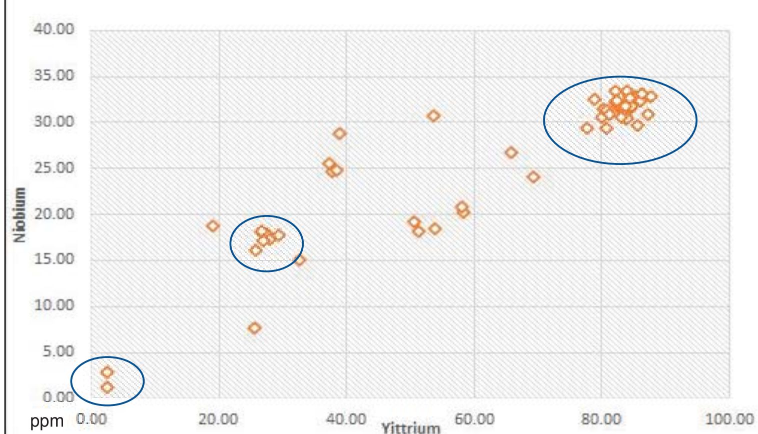

Figure 1. Discrete groups appear in bivariate comparison of pXRF data.

Contact Us!

Follow the QR code to my research website

Pam Pascali andepam3@isu.edu
John Dudgeon, Ph.D. dudgeon@isu.edu

Further Research

This research is ongoing and we hope to identify more unique sources of obsidian surrounding the Snake River Plain.

A larger project of incorporating source geochemical data, scratch test data, movement of material, and museum collection inventories is being planned.

Acknowledgements

Research is supported by funding from the **Ronald E. McNair Post Baccalaureate Achievement Program** at Idaho State University, which is sponsored by the Department of Education (P217A170169), the CAMAS Laboratory through **National Science Foundation Grants** Nos. BCS 1216310 & 1523409, and the Idaho State University Office for Research.
References available upon request.

Ronald E. McNair Baccalaureate Program Reflection Paper

From "what the heck is graduate school" to the "monthly budget worksheet" for moving to graduate school, the McNair program has helped guide me through the process of getting to and through graduate school and has helped build my confidence in continuing my education. Initially, graduate school seemed like a very daunting objective and goal to reach towards. However, the first year of McNair helped me feel more organized when it came to applying and searching for graduate programs. I liked that the first year felt appropriately paced and gave a great introduction to the materials required for graduate school without diving into too much detail about each thing. Also, I felt like the material about research was all beneficial and well-paced. Surprisingly, when it came time to start the summer portion of the program, I felt more confident and excited than I originally anticipated.

The summer program was tough. There were many times where I felt unable to accomplish certain tasks on time and times where I was down on myself for not doing enough. However, the personal insight I gained during the summer is incomparable to anything else I have experienced. I think the summer research portion of the program is essential for students to get a real taste of what graduate school is like. I was scared that I wasn't cut out for graduate school but once I was able to see my work in the form of a poster and a paper, along with presenting at conferences, I knew I had the drive and desire to earn a Ph.D. One of the most beneficial things practiced through the summer program was the documents for graduate school applications. Having multiple chances for revisions from different people was very beneficial in the growth of not only my documents, but my writing skills as well. One thing I would like to see changed in the summer program is the number of classes dedicated to GRE preparation. Many of the courses were very helpful in learning about how to properly take the GRE and the questions that come with it. I think that the information in the writing workshops specifically, could be combined into shorter lessons to cover the same material in a shorter amount of time.

Having the opportunity to share my research at the UMBC TRIO McNair Scholars research symposium and the Kansas McNair Heartland conference helped me gain confidence in my scientific speaking skills and helped me gain insight into different ways to present research. I felt like the digital format of the conferences took away from the more fun aspects of conferences but perhaps the most important part, research presenting, was sufficiently maintained. I was still able to hear about different research going on in different areas across the US and watch individuals with different levels of expertise share their work. I was able to take some insight for myself and work on improving my own methods of sharing my research. Although I wasn't able to travel for the conferences or meet (in-person) other McNair scholars, the conferences were still helpful. I hope future McNair cohorts can attend these conferences in-person and experience the magic of science up close.

For the final year of McNair, I felt like the program was still there to help, but that it was time for the students to put their work out there and take the next big step, applying for grad school. While I did not get accepted into the programs I applied for, McNair never left my side and was there every step of the way. When I messed up an application and did not realize until post-submission, my McNair cohort and staff were there to keep me from going mental. When I got my first call for an interview, the cohort was there celebrating with me. When I felt put down and unaccomplished after receiving all program decisions, McNair was there to remind me of all I have accomplished to get to where I am as a first-generation college student. I have one recommendation for activities for future cohorts: interview practice. I think students in the future will benefit from practicing the interview process for graduate school programs.

For the fall semester, I plan on obtaining a job in the microbiology field to gain more experience in a clinical setting. I intend to do that for a minimum of 1 year. At that point, I will reapply for Ph.D. programs that seem fitting at the time.

Rosemary Anibogwu

05.05.2021

I attended the Idaho Conference on Undergraduate Research (ICUR) in the summer of 2020. This was a virtual conference and it enabled me to exercise my presentation skills and interact with peers and professors during the question session. This conference enabled me to learn about the phenomenal work my peers are involved in and left me more knowledgeable in the end.

The TRIO staff were very much invested in helping each student successfully complete the application process for graduate school. I was especially appreciative of the various sources of feedback I received when writing the first draft of my personal statement for the first school I applied to. The feedback was painstakingly detailed which assisted me in being more mindful of the tonality of my diction and limiting the extraneous details.

The TRIO McNair program improved my understanding of what research entails by their meticulous treatment and coverage of specific details like what research integrity entails, how to craft meaningful research questions, and the non-linear path of research. Discussions about the research process in class helped recalibrate expectations and emphasize nuances that would have otherwise been glossed over when researching in the lab.

One of the most impactful and valuable aspects of this program (there are many, but I will limit myself) that I cherish ceaselessly is the level of transparency that is available to each student. I never once sensed duplicity in Dr. Denise Tambasco or any of the TRIO staff I had the pleasure of interacting with. I have always sensed that the information being conveyed was genuine and if there was a disruption in arrangements previously agreed upon, Denise would always strive to explain what was going on, what caused the disruption, and what was being done to rectify the situation moving forward. I am convinced that everything that was done in this program was truly in the best interest of the students. Finally, I must admit that the stipend provided to me during this program has played a notable role in my research by enabling me to purchase items necessary for my research.

Jacob Diehl

- Information about any conferences you attended and the benefit of attending

I attended the 28th Annual UMBC McNair Research Conference in the fall of 2020. This conference was the best virtual conference I have attended so far. I got to present my poster live in front of a group of about ten people. I got helpful feedback as well as encouragement from those who watched my presentation. I found the encouragement to be particularly meaningful because it came from other McNair Scholars. The conference was held over a website that had large number of rooms associated with a zoom link. Before the conference, a document outlining room assignments, times, and topics of the presentation was distributed. Two other conferences I attended during my time in the program were the annual spring 2020 and 2021 meetings of the American Chemical Society. Both meetings were held in a virtual format. For the 2020 meeting, I essentially uploaded my poster to the ACS website where people could browse all the uploaded posters. This was the same for the 2021 meeting, but in addition, I was able to attend a virtual live poster session where I was able to present my research poster. Unfortunately, it was not well attended, and I did not present my poster to anyone.

- Support or guidance received that assisted in your grad school application process

The guidance that immediately comes to mind is the help I received navigating the process of receiving application fee waivers. I ended up saving around $400. Other guidance that I found very useful was the timeline for the entire graduate school application process. It allowed me to be much more organized as well as reduced lots of anxiety that I probably would have experienced. Lastly, the emotional support that I received from the staff was pivotal in the process of finishing the applications. I started having cold feet, and I was worried that I was not prepared to enter grad school as the deadlines came closer. However, I was able to pull through in large part of the support that I received from the staff.

- How the program improved or informed your understanding of research

Coming into the program, I had some research experience already under my belt, but there were many things that I still did not know. My largest deficit was with writing, but through the courses required by the program, I developed an understanding of how important this skill is. As a result, I have become mush more dedicated to working on my writing skills. One thing I did know about research that was reaffirmed in my experience in the program I that things do not allows work out, and that failure is not something to be ashamed of, but an opportunity to learn and improve. Pursuing a career in research will be filled my many instances of failure as well as disappointment; however, pushing the boundaries of the known world requires one to try and keep trying despite the possible failures that might result.

- Aspects that were particularly helpful

One aspect that I found particularly helpful was the humble brags. Someone like myself hates being the center of attention and talking about my accomplishments but being able to sell yourself is a critically important skill in the professional world. In addition to the benefit, the humble brags gave me an opportunity to express congratulations and pride for my fellow scholars in the cohort which I feel contributed to the development of the peer-to-peer relationships within the cohort.

- What your plans are for the Fall.

I will be attending Notre Dame University pursuing a Ph. D. in Biochemistry.

- Any other information you think would be important for someone to understand regarding the TRIO McNair Scholars program

Beyond being a community of underrepresented populations bettering themselves through research in order to ultimately better society as a whole, I think its critical that people understand that diversity of background and perspective is essential to solving any kind of problem and the TRIO McNair Scholars program epitomizes this idea.

Having lived in an "Old Fashioned" low income, uneducated home, I was raised to believe that women are not as capable as men. While my life experience has taught me otherwise, there are some stigmas that I could not shake, such as the idea that I wasn't smart enough or good enough to get a PhD. The Trio McNair program, and particularly Dr. Denise Tambasco, has shattered that misconception.

Initially, I believed that graduate school would cost me a lot of money. I had to pay to go to college for my undergraduate degree, there would be *no way* I could afford to pay more money for my PhD, let alone get accepted to a school. In the beginning, I prepared myself to return the McNair stipend but through the training and guidance the McNair program offered I found myself not only prepared for graduate school, but actually excited to be attending a program I love.

There are so many ways that the McNair program has helped me that it's difficult to count them all. When I first started the program, I had such public speaking anxiety, that I cried when talking to authority figures. Dr. Tambasco can attest to this claim. Through a high frequency of poster presentations, research presentations, and elevator pitches, not only have I gotten over my public speaking anxiety, but now I'm a strong public speaker. This has helped me beyond measure as I have had several interviews with potential graduate advisors and have had a large number of senior presentations, including poster presentations.

The poster creation and review process offered by the McNair staff has made me conference ready. While the ICUR and MKN Heartland conferences I attended were entirely virtual, it was apparent that McNair has provided excellent training when observing poster presentations of my peers. These experiences have helped me in my senior classes as conferences are common among working mechanical engineers.

As someone with anxiety and imposter syndrome, I believed that I would not be able to get into a program that shifted focus from my current degree. I am a mechanical engineering major and I desperately want to work on astronautics, particularly mechanical engineering applications in space. As I have not had any education for conditions outside of the Earth's atmosphere and I don't have above a 3.5 GPA, I believed I was undesirable in mechanical engineering, let alone a specific sub set of aerospace. These fears drove me to apply to 18 different graduate school programs. Not only did Dr. Tambasco rationally talk me through these fears, but she was also a letter writer for me. Between her and ABD. Reinalyn Echon, I was able to polish my personal statements and applications and was actually approached by a professor with a financial offer at a college that was within my top 3 choices.

My McNair summer research, experience in conferences and writing research papers, has given experience in my desired career path and attracted a research advisor and program that is a perfect fit for me. Before the McNair program, I knew that I wanted to pursue a career in research, but didn't know at all what that would look like. After the McNair program, not only was I excelling in my many required senior technical writing assignments, but I also knew that research in my desired field is exactly what I was hoping for in a career. I'm confident in my career path as a researcher for aerospace and that attending Virginia Tech in the Fall for my PhD program is the correct choice for me.

Speaking to others attempting to attend graduate school, I can see a definite difference in my knowledge and training compared to those not in the McNair program. I can see a clear difference in my technical writing and poster making skills compared to my classmates in those same senior courses. The McNair program has made me a better engineer, and a better researcher and I am very thankful for all the hard work that the staff has put into the program to help me excel. If I could offer any areas that could be improved, I wish that there was a workshop on how to approach professors when interested in their research. I also wish that there was some way that students can be reassured that even if they have a GPA that is below 3.5 and that they want to shift to a specific focus, they are not undesirable. But of course, until I experienced it, I don't think I would have believed it.

The Trio McNair Scholars program has helped me start down a path I believed was unachievable. Not only am I in a PhD program, but I will receive covered tuition and a stipend that will allow me to focus my time on my research. The program has given me the impossible, and for that, I'm forever thankful.

Dalene Hunter

McNair Program Reflection

The McNair program has been critical to my development over the last two or so years I've participated in the program. In a time when the entire world came to a halt, I felt like McNair was one of the only things helping to drive me forward in my battles to maintain my academic standing. While enjoyable to ponder and use, artsy language that gives vague mentions of the ways that the McNair program has helped me is sort of useless in terms of actually getting funding for the program or improving it. My goal here is to outline what McNair is to me personally, and why it was useful.

From a practical standpoint McNair was the first place that I actually learned about research. I had not done any research before being accepted into the program and had little understanding of what it entailed. Without the classes I took with McNair, I'm unsure if I would have ever actually completed any research. While I had nebulous ideas of what research was, the details of literature reviews, and problems statements, and such were out of my reach. Much of this would have been difficult to self-teach because of the principle that one does not know what they do not know. This helped me greatly in my ability to plan, propose, and conduct research all on my own after my summer aspirations fell apart, but also helped me greatly in landing a lucrative internship with the Smithsonian over that aforementioned summer. I believe that McNair's lessons in how to propose and at least start on research are part of the reason why I was successful in proposing my own project, and getting an extremely busy faculty member to agree to mentor me. At the very least, McNair set me up to be a very low-maintenance mentee.

The McNair program also helped to expose me to other people's research. While I only got to attend one conference in my time with McNair as a result of the pandemic, I appreciated the support. As it turns out, even virtual conferences are extremely expensive events. I went to the virtual McNair Scholars Conference hosted by the University of Maryland, and although the virtual experience was exhausting, and likely lacked in a lot of the fun that otherwise may have been possible, it was useful. I had no idea what any type of conference was like going in, and through learning how to present and seeing the structure I learned a lot. I look forward to trying the experience again, face to face next time.

Finally, in terms of applying to graduate school, McNair was priceless to me. I came into the program with no idea what the GRE was, how to ask for letters of recommendation, how to write a personal statement, or any of the other parts of the process. I was lost and would have floundered terribly had I not worked with the McNair program. As it was, the pandemic severely changed the game for me in terms of where I could apply, and I don't know if I would have gotten anything done had I not had the help of the McNair program.

Unfortunately, as I write this I'm not where I had hoped to be two years ago when I started McNair. I applied to six graduate schools and saw rejections from all of them. Although it is counterintuitive, this is probably the single thing McNair has helped me the most with. I have had an extremely hard time separating myself and my personal value from these rejections. I struggle to realize that this isn't necessarily my fault and just another example of how a massive pandemic and other factors have affected my situation. McNair has helped me to see that there is a chance for me to try again with graduate school and that I'm not alone in this struggle. As of right now, I have postponed my graduation, added a minor to my degree, and I'm continuing in the McNair program for another year, hoping that I can improve in the next year or so and become a better applicant in a slightly better situation to be applying.

McNair Research Funding Reflection

During my McNair research internship in the summer of 2020, I decided that I wanted to pursue a career in science journalism. Under the guidance of Dr. Denise Tambasco, I learned that it was best to reach out to graduate schools before the application period started. When I did this, I was told by a program director that I needed to try and get experience in the journalism field to be a solid candidate. After learning this, I came up with an idea to highlight student scientists for the Idaho State University News, with a lot of inspiration coming from my McNair cohort. Soon after, I reached out to the biology department on campus and became an intern under Dr. Rhesa Ledbetter writing the news column “Stories Behind the Science”. McNair offered to fund this internship for me to help increase my success as a graduate school applicant. I was not expecting to be funded, and with McNair’s help I was able to have extra money to cover graduate school application costs as well as personal living expenses. The experience I got writing my articles was critical in my graduate school applications and the effort was successful as I am now going to graduate school for science journalism

Eventually, I started being funded through the biology department for my writing, but funding for my undergraduate research assistant position had run out. I was extremely stressed out, as my research position had been my main source of income for over two years. After learning the funding was gone, I reached out to Dr. Tambasco to ask if there was any way that I could be funded through McNair and luckily, I was. Being funded for my research helped me to finish my project that had been ongoing for the past year and a half before graduating in April of 2021. By being paid to boost my experience, I was able to live more comfortably as well as becoming more skilled in the areas I am pursuing in graduate school.

Pam Pascali

Reflection

My Experience with McNair

This fall I will be starting my graduate school career at Idaho State University in the Anthropology M.S. program. I will be focusing on the archaeological sciences and fortunately, my area of interest has a lot of opportunity for research through ISU's facilities. I was awarded a National Science Foundation Graduate Research Fellowship which will start in the fall as well and it fully funds my grad school for 3 years, which will allow me to gain more laboratory experience and help set me up to get into a Ph.D. program.

The TRIO McNair Scholars Program allowed me to learn the process of research design and how to execute it as well. I had the drive to do research but lacked the opportunities and knowledgeable mentorship to get started on the path that would set me up for grad school. With the help of my director, honors mentor, and TRIO mentors I learned the skills needed to start researching, find funding, and get into grad school.

While this year was not great for conferences the TRIO staff and other McNair programs did everything they could to make our conferences meaningful. In 2020, I presented at the TRIO McNair Conference online and it was a good experience learning early in the pandemic to navigate those online spaces. However, in the spring of 2021, when the conference came around again, I was getting ready to graduate and I was also exhausted from being online 24/7 that the conference was not as helpful for me. I felt similarly to our own McNair Symposium at ISU, in that 2020 was in person and much more helpful to an incoming student than the 2021 symposium was (fully online) to an outgoing student. Much of my complaints are aimed at the fact that zoom fatigue is real, and it hinders how much we can take away from conferences online. I did have the opportunity to attend my professional conference in 2019 before I was in McNair and so I can see the benefit of attending conferences and practicing presenting your research and I was very excited to return with my research and start networking for grad school information before Covid happened. I think some of the biggest benefits are gaining experience presenting your research, feeling confident in it, being able to answer questions on the spot, networking with other researchers, networking for grad school opportunities, and practicing just being in a professional environment.

The support I received through the program was great. I appreciated the opportunities we had to learn from other McNair scholars and Graduate Assistants as well as Dr. Tambasco and Dr. Kobs-Nawotniak. Having mentors from all aspects of the college experience was helpful because we have a whole support group behind us and always knew someone with experience in the area we had questions. Being able to reach out to Sandra and ask about social media questions, reaching out to Reinalyn about presenting research, and Shannon about the honors program really covered a lot of questions that came up for me.

Shanna Barber
Mentor: Devaleena Pradhan

Working in the lab this previous Spring 2021 and Fall 2020 with the help of this grant has helped to shape my future career, teach me about the things I love to do in a lab setting, and given me a lifetime of knowledge. In being able to be in the lab I have learned many things, but just the tip of the iceberg has been the increase in my ability to communicate confidently in front of a scientific audience and to my peers and lab mates. The time spent gave me skills I needed to learn how to read and write scientifically and helped to expand my comfort zone. I learned how to network, how to research grad schools and reach out to colleagues and peers, and I think most importantly it helped to solidify my love for science and for lab work.

Not only did it do all these things but it also helped me to narrow down the areas of study that I am most interested in. I have always wanted to go to grad school for Marine Biology and have always wanted to study marine species. Being able to look into grad schools and research helped me to see how amazing the research that others are doing and helped me to see the never-ending possibilities that come with science. I have been becoming more confident in networking and the idea of pitching my own research ideas to others has become less nerve wracking to me over time and as I have had more exposure. I never thought I would enjoy behavioral endocrinology the way that I have and it has sparked my creativity and allowed me to think outside the box, asking questions and even reading outside papers just for fun. Being able to be a part of the Society of Behavioral Neuroendocrinology (SBN) conference was so exciting! Getting to meet new people, answer questions, and hear about other research was the pinnacle of my summer thus far and left me craving more.

In the future, I am not as set on the semantics of the name of my degree but more the experience I will receive and the types of research opportunities I will be able to have in the career field. The choices I am considering are Marine Biology, Neuroethology, and Evolutionary Behavioral Toxicology. I want to learn about the evolutionary and behavioral pressures that cause predatory and defensive evolutionary traits like venoms - I would like to learn about how they work and how they affect the body. I have even considered going back later for a Masters in Biomedical Sciences.

This has been an amazing opportunity that I could not be more grateful for. It poised me to do better and be better in my field and gave me the confidence to know that not only CAN I do this, but I also love doing the things that being in science entails.

Barber, S., White, K.J., Pradhan, D.S. (2021, April). *Genital Papilla Plasticity in Lythrypnus dalli*. Undergraduate Research Symposium, Idaho State University

Barber, S., White, K., Pradhan, D.S., &. (2021, June 28). *Genital Papilla Morphogenesis in Gravid Female Bluebanded Gobies, Lythrypnus dalli*. Society of Behavioral Neuroendocrinology.

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Anna Jirik
Mentor: Devaleena Pradhan

The number of things I have learned this past semester of Spring 2021 through being a part of Dr Pradhan's lab are innumerable, but I will try to highlight and summarize some of them in the best way possible. An important skill that I have begun to develop is how to communicate with peers and mentors in a lab setting. This has been my first time ever working in a lab, so I definitely had to adjust to the work environment, however now I feel pretty comfortable being in the lab. Communication is important in any career, and I am grateful that I now know how to appropriately and effectively communicate with fellow researchers. In addition to learning important skills, I have also learned more about myself. Thanks to my lab work, I have discovered that I really enjoy the hands-on work that lab work requires, and that I actually learn really well when a concept is presented to me in the context of a study that I am actively participating in. Finally, I have learned a lot about endocrinology, from how hormones work in organisms to that fact that it is a very important and interesting facet of biology. I plan to learn more about endocrinology in the future.

Aside from being a means of part-time income, my job as a research assistant provided me with lots of benefits; many of which are intangible. Being in the lab environment around fellow biologists every week never failed to bring motivation to my attitude. I am very much a future-oriented person, so being reminded of what I want to do- graduate school- and working in a job that will bring me closer to that goal improved my overall mood. Another invaluable benefit from this job was the lab experience I gained. Now that I feel competent about working in a research lab, I will be more likely to be accepted into other labs, and come into them with prior knowledge and experience. Lastly, I gained professional but close relationships with my mentor, grad students, and fellow undergraduates. I enjoyed working with each and every person, and loved spending our free time discussing science with them. I am lucky to have been able to work with such compassionate, ambitious, and supportive people.

This experience did not really change my future plans at all, but rather helped to further cement them as personal goals. I have always been fascinated by the idea of working in a research lab, and this job not only taught me what it is like, but that this is what I want to do as a career. As long as I can remember. I have wanted to go to graduate school, but I usually assumed it would be for a master's degree. By talking with graduate students, I have been able to learn what graduate school is like. I know that a PhD program is definitely for me, and I will strive to turn this goal into a reality. With this lab experience, I am much closer to achieving this goal than I was even half a year ago.

Society for Behavioral Neuroendocrinology conference (Monday, June 28 to Friday, July 2) poster:

Jirik, A. M., Wooding, A. P., and Pradhan, D.S. Effect of Seasonal Changes and Thermal Stress on Cortisol and Glucose Levels in Wild Redband Trout

Name: Melissa Rivas
Mentor: Devaleena Pradhan

I have many positive learning experiences since November 2020 in Dr. Pradhan's lab. I gained a new skill essential in the histology field. This semester we focused on using a new instrument, the Cryostat. This instrument has a chamber that maintains a low temperature for preserving frozen tissue samples. The Cryostat has a sharp blade for clean and thinner slices, making it possible to see under the microscope.

However, before tissue can be cut and analyzed, it must be prepared to be embedded ready to slice in the Cryostat. Our lab had two previous protocols. Another lab mate, Ian Curnutt, and I took good points from both protocols and merged them into one final protocol I and went through some troubleshooting to figure out this technique. We based on fail and success criteria. Through all this process, I learned that lab work demands discipline, patience, and perseverance. The type of tissue our lab worked with were brains and gonads from the bluebanded goby (Lynthrypnus *dalli)*. The tissue samples were previously fixed in ethanol. To revert the ethanol from the selected tissue, we performed three different washes solutions made of ethanol and sucrose. After the washes, we let the tissue rest for 24 hours in a 100% sucrose solution. We again performed other washes but used sucrose 10% concentration and Optimal Cutting Temperature compound (OCT) in three different ratios. The next part, now sucrose, needs to be reverted and replaced for OCT to preserve the tissue's integrity at the moment to be sliced by the Cryostat. The tissue is placed in 100 % OCT in their respective mold and stored in the -80 F for 24 hours. It took a lot of time perfectionating the first part of the protocol. I learned how to handle the tissue very gently and recognized testes and ovaries.

For the second part of the protocol, which was to section tissues, we worked very closely with Dr. Heather Ray. In the second part of the protocol, after 24 h, the tissue solidifies enough and is ready for slicing in the Cryostat. Before working with the tissue must be placed inside the Cryostat chamber for 2 h. The tissue has to adjust to the cryostat temperature; if not, the tissue will become brittle. I proceeded to cut the tissue and place it in a microscope I slide. This experience was precious because it taught me that collaboration and communication are essential in the research field, and learning how to communicate with professionals will make our work more effective.

I had the opportunity to interact with the graduate students from Dr. Pradhan's lab. One of them is Katrina White. She currently focuses on investigating the role of steroid hormones like cortisol, ketotestosterone, and estradiol in the Bluebanded goby. The behavior and phenotype of this fish are highly regulated by social structure. Katrina taught me to use competitive analysis tools like the ELISA kit. Together we worked on enzyme immunoassay data for posters. The samples were Water Borne Hormone and three different brain regions from the Blue-banded Goby. We presented the data from the water-borne hormone in a poster named *"The Plasticity of Social Status: Stress Hormones in a Hermaphroditic Fish"* at the Society for Integrative and Comparative Biology (SICB). In the same conference, I was co-author in another poster presented by Kaysen Christensen, *"Stuck in a Bucket: The Effect of Confinement Stress on Cortisol Levels in Brook Trout (Salvelinus fontinalis)."*

Our lab continued exploring changes in the physiological response to stress in the brain, and we presented that data at the Society for Behavioral Neuroendocrinology (SBN) virtual conference. I'm a co-author of two posters for the SBN conference. One poster was presented by Katrina White "*Brain Region-Specific Concentrations of Sex steroids During Aggressive Encounters in a Hermaphroditic Fish."* Daniel Youngerman presented the second poster, *"Social Status and its*

Effect on Cortisol in the Brain of the Blue-banded Goby." I worked with Daniel on an extensive data set of the different regions of the brain and the status of the Blue-banded Goby. Through this process, I have learned about data analysis and data interpretation. It was something I did not know about before joined to Dr. Pradhan's Lab.

Two significant achievements I recently had. I submitted my application for the INBRE program back in November, and I got an award for this summer. Thanks to that, I'm able to continue learning about behavior and hormones in the lab. I also applied for the "Welcome Initiative Award" at SBN, and I received the award.

I value that all these experiences during my time spent in Dr. Pradhan's Lab. have improved my problem-solving skills and reinforced my research interest. I have been motivated to learn more deeply about hormones. Observing the Bluebanded goby's brain under a microscope made me ask how important it is to understand the role of hormones can regulate behavior. I'm looking forward to learning more about it, and in the process, I would like to improve to be a great researcher in the future.

Client Info:	Dr. Kathleen Lohse/Tej	Phone:		Sample info: --------------	soil
	Idaho State University	E-mail:	klohse@isu.edu		
	Biological Sciences			No. of samples: ---------------	46
				Run started: -------------	3/24/2021
ISODAT File ID:	Lohse-Tej sediment 3-24-2021			Run Ended: ----------------	3/25/2021
Lab No:	V-122343 V-12398			Data Reported: -----------	3/25/2021

Lab ID	Sample ID	Amount (mg)	Ampl 28 mV	Ampl 44 mV	$\delta^{15}N$ air ‰	$\delta^{13}C$ VPDB ‰	Weight %N	Weight %C	Comments
V-122343	deci 0-5	8.74	1467	1553	3.41	-26.03	0.34	4.17	
V-122344	deci 5-10	9.25	1038	3690	5.01	-25.69	0.23	2.59	
V-122345	Deci 10-20	9	855	2958	5.35	-25.56	0.20	2.13	
V-122346	Deci20-30	8.5	723	2519	6.02	-25.56	0.18	1.93	
V-122347	Deci 30-50	9.22	686	2425	7.59	-25.38	0.15	1.71	
V-122348	Deci 50-75	8.9	588	2004	5.97	-25.25	0.16	1.46	
V-122349	Deci 75-100	8.78	1610	1592	5.80	-25.07	0.14	1.18	
V-122350	Deci 100-115	8.4	1256	2336	5.85	-25.03	0.12	0.80	
V-122351	Deci 115-130	8.94	1130	4647	5.85	-24.91	0.12	0.76	
V-122352	Deci 130-145	9.2	1042	3988	5.63	-25.20	0.10	0.64	
V-122355	deci 145-160	8.91	842	3066	5.87	-24.82	0.09	0.49	
V-122356	deci 160-175	9.32	644	2633	5.72	-25.04	0.09	0.40	
V-122357	deci 175-190	8.95	700	2806	5.28	-25.31	0.09	0.45	
V-122358	deci190-205	9.17	668	2977	5.05	-25.69	0.09	0.47	
V-122359	RIPA 5-17	8.53	1336	15210	4.17	-24.95	0.30	10.66	
V-122360	RIPA 17-37	8.92	1146	13208	4.77	-24.63	0.26	9.79	
V-122361	RIPA 37-45	9.03	645	9859	4.77	-25.22	0.14	3.31	
V-122362	RIPA 45-58	9.16	524	6292	4.63	-25.55	0.10	2.05	
V-122363	RIPA 58-70	8.84	655	10440	5.56	-25.31	0.14	3.61	
V-122364	coni 0-5	9.19	1880	16222	3.27	-25.56	0.41	6.81	
V-122367	coni 5- 10	27.46	5035	6383	4.04	-25.40	0.37	5.98	
V-122368	coni 10-15	29.6	2729	3221	4.96	-25.37	0.20	2.59	
V-122369	coni 15-30	26.29	1705	6776	6.35	-25.16	0.14	1.71	
V-122370	coni 30-40	27.5	1474	5781	6.58	-25.04	0.11	1.37	
V-122371	coni 40-50	26.6	1160	4473	6.73	-24.78	0.09	1.09	
V-122372	coni 50-60	27.51	998	3720	6.52	-24.72	0.07	0.88	
V-122373	coni 60-70	27.03	1075	4049	6.16	-25.01	0.08	0.98	
V-122374	coni 70-80	28.8	861	3039	6.06	-24.84	0.06	0.69	
V-122379	coni 80-85	28.12	726	2573	6.04	-24.31	0.05	0.60	
V-122380	coni 85-95	29.37	735	2420	6.26	-24.21	0.05	0.54	
V-122381	coni 95-105	49.73	1193	4083	6.49	-24.21	0.05	0.53	
V-122382	coni 105-125	49.7	1353	5331	5.31	-24.83	0.06	0.70	
V-122383	coni 125-147	50.29	972	3126	6.30	-24.14	0.04	0.41	
V-122384	coni 147-157	49.76	832	2394	5.99	-24.14	0.03	0.31	
V-122385	coni 157-162	50.07	820	2580	6.13	-24.16	0.03	0.33	
V-122386	coni 162-170	50.435	853	3394	6.07	-23.98	0.03	0.43	
V-122387	coni 170-180	50.159	999	3529	5.82	-24.33	0.04	0.45	
V-122388	coni 180-189	49.717	835	2605	6.02	-24.14	0.03	0.33	
V-122391	sage 0-5	49.757	3904	4284	3.15	-26.70	0.17	2.08	
V-122392	sage 5-10	50.32	3773	4144	2.72	-26.80	0.16	2.02	
V-122393	sage 10-20	50.55	3381	3674	3.32	-26.62	0.14	1.75	
V-122394	sage 20-30	50	3190	3302	4.21	-26.19	0.13	1.59	
V-122395	sage 30-40	50.64	2360	8048	5.20	-25.88	0.10	1.08	
V-122396	sage 40-60	50.78	2064	5489	6.65	-24.89	0.08	0.71	
V-122397	sage 60-80	49.43	1115	3122	5.66	-24.03	0.05	0.41	
V-122398	sage 80-100	49.933	1437	3753	5.91	-24.54	0.06	0.49	

Lab ID	Sample ID	Amount (mg)	Ampl 28 mV	Ampl 44 mV	$\delta^{15}N$ air ‰	$\delta^{13}C$ VPDB ‰	Weight %N	Weight %C	Comments
V-122330	ISU Peptone	0.538	3672	3600	11.64	-19.11	14.16	42.38	
V-122333	ISU Peptone	0.512	3481	3434	11.62	-19.11	14.17	42.66	
V-122336	ISU Peptone	0.524	3536	3493	11.53	-19.08	14.14	42.49	
V-122339	ISU Peptone	0.528	3593	3536	11.60	-19.10	14.18	42.85	
V-122354	ISU Peptone	0.549	3679	3634	11.61	-19.09	14.1	42.5	
V-122376	ISU Peptone	0.547	3692	3656	11.59	-19.15	14.27	43.23	
V-122390	ISU Peptone	0.527	3568	3534	11.63	-19.04	14.13	42.8	
V-122400	ISU Peptone	0.539	3734	3716	11.58	-19.11	14.27	43.18	
V-122404	ISU Peptone	0.548	3736	3700	11.60	-19.11	14.2	42.74	
				avg	11.60	-19.10	14.18	42.76	
				stdev	0.03	0.03	0.06	0.30	
V-122334	Acetanilide	0.557	2682	1704	-1.07	-28.57	9.79	70.14	
V-122337	Acetanilide	0.579	2820	6402	-1.09	-28.46	10.01	71.14	
V-122340	Acetanilide	0.572	2734	6217	-1.05	-28.50	9.79	69.76	
V-122377	Acetanilide	0.561	2671	6095	-0.91	-28.55	9.95	70.23	
V-122405	Acetanilide	0.554	2643	6024	-0.99	-28.56	9.7	69.55	
				avg	-1.02	-28.53	9.85	70.16	
				stdev	0.07	0.05	0.13	0.61	
V-122335	ISU Clay	25.484	2602	8850	7.44	-25.09	0.21	2.31	
V-122338	ISU Clay	25.315	2498	8452	7.45	-25.14	0.2	2.2	
V-122341	ISU Clay	25.437	2564	8646	7.45	-25.18	0.21	2.25	
V-122378	ISU Clay	25.313	2533	8610	7.35	-25.20	0.21	2.28	
V-122406	ISU Clay	25.233	2402	8268	7.20	-25.13	0.2	2.16	
				avg	7.38	-25.15	0.21	2.24	
				stdev	0.11	0.05	0.01	0.06	
V-122332	ISU Glycine	0.548	4383	2535	1.00	-41.46	16.69	29.28	
V-122342	ISU Glycine	0.515	4276	2479	0.99	-41.58	17.99	30.74	
V-122366	ISU Glycine	0.519	4337	2530	1.05	-41.45	17.91	31.3	
V-122375	ISU Glycine	0.505	4215	2458	0.95	-41.52	17.76	31.34	
V-122402	ISU Glycine	0.516	4445	2597	1.01	-41.47	18.16	31.88	
V-122403	ISU Glycine	0.549	4591	2666	1.00	-41.53	17.73	31.1	
				avg	1.00	-41.50	17.71	30.94	
				stdev	0.03	0.05	0.52	0.89	

A description of the activities undertaken, how the lab/project benefited from the funds, how the research goals of the lab/project were furthered. Include your thoughts on the mentoring portion of the project. Did you complete the activities described in your proposal? What might you do differently next time?

Funding through SBOE greatly helped my lab train a new generation of female scientists. As per my plan, I had identified 2 students prior to the application and also put my efforts to recruit a third student. I have been meeting these students regularly and actively executed a mentoring plan in association with my graduate students. These students have assimilated in my lab in a **very** strong way. It is difficult to imagine what the fall semester will be like, when they do not have this funding source and are wanting to continue their projects in my lab.

The specific projects that I had planned for these students slightly changed during the course of the award period. While my students Shanna Barber and Melissa Rivas worked on the bluebanded goby project as per the proposal, Anna Jirik focused on the GEM3 project. This was primarily due to delays for the development of the fish room. All three students also helped with setting up the fish room for gobies so they were able to learn a lot of valuable fish husbandry skills.

Each of the students had unique experiences during this award period:
The highlight was that I had started Shanna with a very mundane task – something that was designed so that she could work remotely (this was especially important to recognize because she is a single mother of 4 children). She was able to turn that around and was able to come up with her own research idea based on the observations she was making. I thought it was a very interesting idea and it is important for students to be creative in their thinking so I allowed her to pursue this line of investigation rather than filling the need for the project I had needed help for. During this experience, I realized that I also needed to put a lot more time than previously planned in order to execute this project appropriately. My graduate student, Katrina White also greatly helped mentor, but this was a very independent project.

Melissa is invaluable in my lab – due to her impeccable pipetting skills she developed during her CPI experience at MRCF, she was able to contribute to multiple projects. Some laboratory assays require several hours to complete and through this funding she was able to dedicate large blocks of time. In addition, Melissa went out of her comfort zone to develop protocols, analyze and interpret data, and present her work. She has worked with a number of other students and I have seen a big change in her confidence level and ownership of her science. I think she is undecided on the specific area of research she wants to pursue in graduate school; she does need to decide soon so that she can complete her applications this fall.

Anna joined my lab in her freshman year – it is never too early! The initial part of her experience included understanding overall research approaches and activities in a lab setting. Due to her enthusiasm and dedication, she has made excellent progress and is planning for the ways she can continue participating in my lab.

From reading their individual reports and my interactions with them, overall, each of these students learned how to work individually and part of a team. They have developed confidence, comradery, a sense of belonging in the sciences and a scientific identity – elements that are critical in shaping a researcher's mind.

Regarding funding, all of the money was used for student hourly pay and supplies. We had proposed for Shanna to get science diver certification, however, due to COVID-19, the training was canceled.

Undergraduate researchers are important to train; they are not getting that exposure in their course work. As a result, much of what could be taught in a classroom to multiple students at once is not possible and individually teaching all the information to students is extremely challenging due to other responsibilities I have – it just takes up drastically more time than what I plan for.

Students also work on their own time and so multiple students have different availabilities and when they work at the last minute for deadlines, it is overwhelming for me as PI. It makes it extremely difficult to train them while also meeting my other responsibilities. It takes much longer to teach students scientific design, hypothesis testing, analysis, and writing. Undergraduate students also are learning to manage time during this process and are unable to estimate time it takes to gain skills and make their own schedules. This is especially important to consider because when coursework and grades are the primary reason undergraduates are in college, exams and assignments are always prioritized; research is secondary or even performed last after other commitments are taken care of. In future, it would be good if there are avenues by which undergrads in this program get more set deadlines and are also taught complementary skills through biweekly workshops.

Finally. having an identified path for income supplementation for the next step for these high achieving undergraduates take in their research pathway is extremely important. My students have been benefitting from this income and they do not stop with research in the fall. Independent problems and senior theses are additional ways to continue research, however, those have finite timespans as well.

Project Supervisor: Dr. Samantha Blatt
Funded Student: Marissa Mullin
Department: Anthropology

Project Supervisor Summary

I was awarded $1600 in SBOE Undergraduate Research Funds in March 2021 after being declined funding initially from a proposal submitted for $9000 with Dr. John Dudgeon. Due to the budget change from what was requested and a late award, the initial proposed project was no longer possible. Nevertheless, a new project became a successful collaboration with undergraduate Anthropology major, Marissa Mullin, who is now able to continue this path of research for her honor's thesis.

The project undertaken with these funds supported the testing and analysis of human remains discovered and excavated on a private farm on the outskirts of Pocatello, Idaho in 2015. Though reviewed after discovery in order to eliminate the possibility of forensic significance to the satisfaction of law enforcement, the remains were not previously rigorously analyzed. Pulling from the osteological and bioarchaeological background of the biological anthropology program at ISU, the project applied skills taught in anthropology courses to a real case study with many discoverable unknowns. Marissa Mullin was selected as a temporary employee student to complete this project under my mentorship because of her skillset and enthusiasm (particularly on the short notice of this award).

This project began with familiarizing the student with standard and particular lab protocols and safety and orienting her to the ways in which laboratories follow safety standards and documentation of daily activities. Though already familiar with human osteology and ethical practices of working with human remains from previous course work, Marissa and I discussed the ethical concerns of retaining humans remains as part of a legacy collection without proper analysis and without due diligence of repatriation is warranted or possible. Therefore, the ultimate goal of this project was to conduct minimally invasive analysis of the remains to help in cultural/temporal identification of these remains for reburial/repatriation. This goal involved reconstruction of the biological profile from the remains.

Under supervision, the student learned to follow the standard and the most currently accepted procedures to the discipline to estimate components of the biological profile such as ancestry, sex, age, stature, pathology, and taphonomic modifications. She learned to observe and record metric and morphometric traits, photo document the entire skeleton, document preservation, assess pathological, traumatic, and habitual markers of bone, and how to interpret the data being collected. This also included becoming familiar with analytical software used in the discipline such as Fordisc, ADBOU (TA2 and TA3), and Osteomics and the ways in which to interpret and report their statistical read-outs. These analyses and data culminated into a working draft of a forensic/bioarchaeological report. In this way, Marissa has gained hands-on experience in the components, process, and procedures of report writing which is applicable to forensic, museum, and cultural resource management careers.

This is still an ongoing project. Marissa will further develop this report with historical contextual research in order to build an Osteobiography for her honor's thesis, which will combine the technical data, cultural historical context related to this data, and a fictive narrative of the individual. This project was particularly furthered by these funds since they supported not only her employment in data collection, but testing through the University of Arizona AMS laboratory for a radiocarbon date to narrow the temporal range of individual (upon which a historical context can be gleaned) as well as carbon and nitrogen isotopes to capture dietary information from the individuals adulthood.

Prior to the start of this project, the goal for these funds was to support the reconstruction of the biological profile. That has been successfully completed and is in draft form. We are currently still awaiting the radiocarbon and isotope results, but this will contribute to Marissa's honors thesis as well as the planned student presentations of this project. This project has been accepted as part of a symposium on historical and forensic skeletal analyses in Idaho at the Idaho Heritage Conference in September 2021. Marissa will present as the main author of this project there and is planning to present a poster at the ISU Undergraduate Research Forum next spring. Since, these planned conferences occur after the due date of this report, the presentation/poster are not included here. Instead, the drafted report of this project (authors by the student and myself) is attached. This report, when finalized will become part of the archives of the Idaho State Historic Preservation Office and be sent to the involved law enforcement agency (Bannock County Sheriff) for record. Additionally, I intend to include Marissa and several other students as authors to a published report after completion.

I believe that my mentoring of this project has been successful, though incomplete. With more time and funds, I would have liked to employee more than one student and be able to be further along with the historic/cultural component of the project by arranging for the student to get in-person assistance and training with a librarian and Idaho Historic Preservation representative. I would also have liked to scheduled more reading and discussion meetings with the student to dive into some of the development of the methods she was learning. Finally, in the future, I would like to maintain more regular documentation of my mentoring meetings with the student and encourage further CITI trainings.

Table 1. Future Plans for this Project.

Date	Activity
July 2021	Interview landowners where remains were found
August 2021	Meeting with Idaho experts on California-Oregon Trail Integrate AMS and isotope results into drafted report
September 30 2021	Idaho Heritage Conference presentation
October-November 2021	Historical research 2nd draft of technical report
December 2021-January 2022	Draft of fictive narrative based on historical and technical data
March 2022	Final draft Honors thesis defense
April 2022	ISU Undergraduate Research Symposium poster
June-August 2022	Draft and submit manuscript for publication

A draft of the report is attached. As an ongoing case, this report is not to be disseminated further and since it is not complete and is only a draft, does not represent to final conclusions of the research. Images of human remains were not included in this draft for ethical reasons and maps or indications of the scene location were omitted.

Student Perspectives on the Benefits of the SBOE Undergraduate Research Funds: On the Path to Identifying the Pocatello Pioneer

Student Introduction

My name is Marissa Mullin and I am an undergraduate majoring in anthropology with a specific interest in forensic anthropology and bioarchaeology. I am currently in junior standing and anticipate graduating in 2022 with honors. I was given the opportunity to be funded as an employee in Dr. Blatt's lab this spring in order to contribute to a project involving the skeletal analysis and osteobiography of human remains discovered on Larson Farm outside of Pocatello, Idaho in 2015. This purpose of this report is to outline the skills I learned and direct benefits to me as a student as the result of funding through the SBOE.

Skills Learned

Starting at the beginning of this project, I first became familiar with the frustrations that come with this field/line of work and how vital information and paperwork can be lost in communication or removed from our possession entirely. When the remains that we are analyzing were first discovered in 2015, the team that unearthed them did not complete professional reports, take quality photos, or document analysis accurately. To make matters more complicated, the identification process seemed to be discarded entirely and the team who was working on said remains either graduated or otherwise left them to collect dust in a box. Six years later, Dr. Blatt was contacted by the family who originally uncovered the remains on their property and the search to find out who John Doe was started back up. However, we were left with no solid research and a pile of unsorted bones.

This is when I learned the process of starting research from scratch. We began diving into all the information we were provided with; we reread correspondence emails about the original recovery of the remains, we took quality photos of each bone and placed them anatomically together to gauge how many were missing, and we carefully looked over each bone for soil staining, sun bleaching, trauma and other irregularities that could aid in identification. My journey of independent sex, age, stature and weight estimations began and I used as many references as possible to provide accurate information, however, I still came up short in a few areas. This is where I learned to humble myself and recheck my work with Dr. Blatt on FORDISC. After discovering how to operate the program, and the numbers coming out nearly identical every time, I found out the importance of having someone (preferably one who has lots of experience) check over your work and help you find out where you made mistakes, so you can correct yourself in the future.

Overall, this project has given me more knowledge in osteology and the identification of remains, but it has also provided me with an experience to do research with professionals in a lab setting and how to correspond with people who could provide resources that would aid this type of project.

Table 2. Skillset Achieved Through this Project.

Skill	Specific Tasks
Skeletal Analysis	Biological profile, 14C and isotopes sampling and interpretation, taphonomy, trauma, FORDISC, MaMD, photography, data collection, metrics, nonmetrics
Historical Context	Searching historical maps and documents, Oregon-California trail history of eastern Idaho, constructing a fictive osteobiography from technical data
Report Writing	Technical writing, formatting, creating figures and tables, legal issues and NDA practices and ethics regarding sharing data and photos
Disseminating Research	Abstract writing, preparation of professional presentation, presentation experience

Beneficial Experience

This research experience has benefitted me and my educational goals by connecting me with so many unique individuals who have provided me with resources and support. I truly wouldn't have the opportunity to have met so many talented and hardworking people without having worked on this project. Another beneficial aspect is that of my confidence levels when presenting the information regarding this case in a professional and logical manner. The experience I have gained through writing reports, sending emails and presenting facts to professors and researching students alike has boosted my confidence astronomically. In addition,
the information learned on how to investigate specific issues connected to the project has shown to be quite useful in a variety of non-related situations and will continue to be so in the future.

This initiative also aided in the development of self reliance. I've been encouraged to seek out my own solutions and forge my own path. While I was introduced to methods of skeletal analysis in courses, this was my first application of those skills and being able to see the complications and limitations of these methods in a real setting and learning how to then best use these methods. Because I'm demonstrating that I can be trusted to take on a task and complete it independently, this allows me to better understand my own strengths and shortcomings, as well as how I might improve them. Lastly, my organizational skills have improved as well because of this project. These abilities are required in the lab to boost production and guarantee that goals are routinely fulfilled, as well as to assist a team function well by maintaining operational efficiency.

Table 3. Benefits and Products.

Expected Date	Beneficial Product of Project
August 2021	Finalized report with biological profile
September 2021	Presentation at Idaho Heritage Conference
April 2022	ISU Undergraduate Research Symposium
April 2022	Honors thesis defense
Summer 2022	Preparation of manuscript for publication as co-author

Future Plans

While we are still waiting for test results from this project and historical analysis is still underway, I am using this project to complete an honors thesis and plan to graduate in the coming year. A draft of the report being generating from this project is attached as part of this larger SBOE report.This thesis will expand the work done from this project and I hope better prepare me for advanced studies in anthropology in graduate school. Dr. Blatt and two other undergraduate students and I will be presenting the findings of this project as part of a symposium organized by Dr. Blatt at the Idaho Heritage Conference in September 2021, entitled, "Archaeology Session: Bodies, Burials, and Bootleggers: Studying the Dead in Idaho". In spring 2022, I plan on presenting my findings from this project and those expanded from my honors thesis at the ISU Undergraduate Research Symposium as a poster. Ultimately, I will be a co-author with Dr. Blatt and others on a publication of the osteobiography resulting from this project which will help me develop professionally and increase my chances of being accepted into graduate school.

This project has been one of the most beneficial and exciting experiences of my college career primarily because this is exactly the type of work that I want to go into. Research based work in a lab with lots of different aspects to analyze in a set of remains fascinates me and this undertaking has given me a glimpse into what that would be like. This project has helped me to really understand the ties of bioarchaeology with forensic anthropology and the deep contextual component that bioarchaeology adds to a biological profile. The adventure of investigative work and science to prove where someone is from or how old they were at the time of death to narrow down possible identities is incredible and I have had a passion for this since middle school. If anything, this project has fulfilled many dreams of mine and cemented that love for anthropology in me. Of course, other students and Dr. Blatt have aided me along the road, but the dedicated role models they have provided have truly pushed me to continue in this profession and seek graduate school while pursuing a degree in forensic anthropology.

Funding Expenditures

Materials and Supplies

Description	**Vendor**	**Cost $**
14C for tooth dentin sample	University of Arizona AMS Lab (#3654)	383
CN ratio for tooth dentin sample	University of Arizona AMS Lab (#3654)	30
Total Materials and Supplies		413

Student Paid Hours (Marissa Mullin @ $13/hr)

Paid Period Dates	Hours	
5/16/21-5/28/21	80 total (40 hrs/week and 8 hrs/day)	
5/30/21- 6/1/21	11 total	
Total Hours Paid Work	91	
Total Paid Student Wages (pre-tax)	91 hrs x $13/hr=	1183

Total		**1596**

Idaho State University

Department of Anthropology
Idaho State University
921 South 8th Avenue, Stop 8005
Pocatello, Idaho 83209-8005

Forensic Anthropology Report: [redacted]

To: [redacted]
Bannock Co. Sheriff's Office
5800 South 5th St.
Pocatello, ID 83201

From: Dr. Samantha H. Blatt, Ph.D.
Department of Anthropology
921 S. 8th Ave. Stop 8005
Pocatello, ID 83209

RE: Analysis of [redacted] (Bannock County, ID)

Final Report Date:

Introduction

On Saturday, February 13, 2021, Dr. Samantha Blatt from the Idaho State University (ISU), Department of Anthropology, was contacted by [redacted] of Inkom, Idaho in regards to a set of human remains that was recovered from the Larson property on August 23, 2015 [redacted] The remains were reported to have been found by the Larson grandchildren. Bannock County Sheriffs and ISU personnel confirmed that the remains were human. Though a report was generated in 2015, it was incomplete and not shared with the landowners or law enforcement.

Recovery and Curation

The remains were recovered from the scene on August 23, 2015 by former ISU forensic anthropologist, Dr. Kyra Stull, ISU lecturer Christian Petersen, and two anthropology graduate students. Arriving at the scene, remains were found protruding from a 6-foot tank of earth behind an outbuilding on the property, which was rimmed by a 4-foot wood corral fence. The landowner state that the bank was made while removing earth with a backhoe approximately 30 years prior and that the fence was built around the same time. The Larson grandchildren had subsequently created a hole penetrating horizontally into the bank and discovered bone.

[Figure- Google map image of area and scene]

Upon arrival at the scene, Dr. Stull noted that the left ribs and right humerus were protracting from the hole and several other bones had been removed by the landowners. ISU personnel took the initial step to screen the backfill earth removed by the landowner and several more bones were found. Then, a more systematic excavation proceeded. Since the position of the fence limited the direction of recovery of the remains, excavation began with shovels from the fence line and proceeded vertically to the depth of the initial discovery. The depth of the remains was not recorded by Stull, but excavation proceeded with trowels when the cranium was unearthed, which was followed by slow excavation of the bones of the upper torso. Once the skeleton was pedestalled and removed, the walls of the burial feature were extended out 4 inches in all directions and screened to ensure complete recovery. Mapping or precise photography of the recovery was not completed and so the full archaeological context of the remains is unknown. No datum depths were recorded. No organic or inorganic artifacts were recovered with the remains.

[Figure- photographs of recovery in order to estimate depths]

Remains were transferred to the research laboratories at Idaho State University after recovery. There is no documentation of formal transfer of the remains from the Bannock County Sheriff's Office, however, the landowners stated that when they contacted the Sheriff's Office in 2021, they were told the remains were considered to not be of forensic value, possibly "150 years old," and kept at ISU. Ultimately, transfer and accessioning of the remains will need to be conducted formally.

Methods

Anthropological analyses performed and conclusions reached are dependent on the quality and quantity of the remains and the needs or analytic requirements for a case. For this case, the Items were examined macroscopically, morphoscopically, metrically, as well as isotopically.

Results

Inventory and Condition

The recovered elements (see homunculus) are consistent with one adult individual. The remains are roughly 60% complete with the left and right lower legs, feet, left clavicle, left hand, left humerus, left scapular, some vertebrae and the mandible missing postmortem. Additionally, the dentition was limited to 6 teeth in the maxilla and there was post-and ante-mortem dental loss.

Primary burial, laying supine with head on the right side. Legs were removed before recovery effort so it is impossible to assess if they were extended or flexed. The positioning of right humerus and elbow joint suggests that hand was place on top of the body (but the hands were not preserved).

[Figure- homunculus image of the skeleton]

[Figure- photographs of the dentition with dental inventory]

Taphonomic Alterations

There is surface soil staining and root etching on nearly every bone, including the cranium, humerus, scapula, ribs, vertebrae, and phalanges. There is also sun bleaching on the distal portions of each femur, indicating that the legs were uncovered for a long period of time. Postmortem rodent tooth marks on the skull.

[Figure- photograph of gnawing marks and root etching]

[Figure- photograph of bleaching]

[Figure- photograph of cranium during recovery with roots penetrating]

Radiocarbon and Isotopic Results

Results are pending.

[Figure- isotopic triangle with points for isotope results]

Trauma and Pathology

Analysis still underway.

[Figure- cut marks on MT1]

[Figure- Cut mark on rib]

[Figure- cut marks on two vertebrae]

[Figure- arthritic changes on the right transverse processes of vertebrae]

[Figure- arthritic eburnation of joints]

Biological Profile

Sex

Non-metric features associated with sexual dimorphism were scored independently of each other based on descriptions and diagrams from Buikstra and Ubelaker (1994). The cranial features such as the supraorbital margins, nuchal area, brow ridges, frontal, and mastoid are moderately robust overall (scoring 3's and 4's across the board) and most consistent with male morphology. Sex was then estimated using logistic discriminant function equations (Walker 2008) using non-metric scores of the glabella and mastoid. These results (4.674) also indicated that the features were consistent with male.

Additionally, craniometric analyses were conducted using Fordisc software Ver. 3.1.314 (Ousley and Jantz 2019). All of the 27 cranial measurements (excluding the mandible) were used in Fordisc could be included in the analysis (given the state of preservation). Craniometrics were first evaluated using all eight modern groups in the Fordisc databank, from both sexes, with Forward Wilks stepwise selection with default parameters. Assuming that this individual belongs to one of those groups in the databank, the combined posterior probabilities indicate that the individual is 99.97% likely to be male.

The pelvis was also assessed for morphological features. The pelvis overall is elongated and narrow with a narrow greater sciatic notch. The sacrum is also elongated. These features are consistent with male pelvic morphology (Walker 2005).

Based on the above analyses and in agreement with previous reports, the cranium is consistent with a MALE.

Ancestry

Using Fordisc software Ver. 3.1.314 (Ousley and Jantz 2019), metric analysis and non-metric morphological estimation of sex (see above), the same 27 cranial measures were selected using Forward Wilks stepwise selection with default parameters. Mandible metrics were not included as the mandible was absent. Using the Forensic Databank (FDB) with all male and female groups from modern populations available, F typicalities were highest for Hispanic Male (0.030). Assuming this individual belongs to one of the FDB groups, even though they are close to the sectioning lines distinguishing other groups, they are 57.7% likely, according to combined posterior probabilities, to be a Hispanic Male.

However, context and condition of the remains suggest that this individual would be better represented through a historic population data bank rather than FDB. Therefore, the same craniometrics were compared against the Howells modern and historic collections within Fordisc. Males and females were initially pooled. F typicalities were highest for the BERM (western European) group (0.018). When analyzed using only modern and historic male groups from Native American, European, and African populations, ISU15-005 was most consistent with a 19th Century White Male (with a posterior probability of 92.9% and F typicalities of 0.046).

Ten macromorphoscopic traits (based on shape) were also assessed according to (Hefner 2009, 2018) using Osteomics and MMS 1.61 software which uses the Macromorphoscopic Databank. This method categorized the cranium as 74.59% American White (95% CI).

Based on the above analyses, and assuming that this individual belongs to one of the groups available in the Howells databank, the cranium is most consistent with a MALE of broadly EUROPEAN ancestry.

Age

Age estimation was based on the auricular surface of the right innominate (Meindl and Lovejoy 1989) and to a lesser extent using cranial suture closure (Meindl and Lovejoy 1989; Nawrocki 1998). Assessment of the deterioration of the auricular surface (Meindl amd Lovejoy 1989) yielded an age of 50 years. Scoring the cranial sutures of the ectocranial, endocranium, and palate (Nawrocki 1998) produced composite scores for suture closure of the cranial vault (27-55 years) and lateral-anterior (35-55 years) sites along the cranium. A summary age of these methods results in an estimated age of 27-55 years.

A combination of the auricular morphology and cranial suture closure was assessed using ADBOU 2.0 (Boldsen et al. 2002, 2011) which provides a likely age range from a database of known ages using transition analysis. Using a white/male mortality model and forensic hazards model, this method resulted in an age range of 17-81.9 years with a point estimate of 41.5 and 41.4 years respectively (95% CI). The corrected point estimate was 33.6 years of age.

Given the arthritic changes in the vertebrae and joints, it is likely that ISU15-005 had an overall age range of about 33-55 years.

Stature

Stature was estimated from the maximum lengths of the right humerus (309 mm) and left radius (231 mm) using regression formulae for white males (Trotter and Gleason 1952). Estimation from the humerus resulted in a stature of 162.83 (5'4'')- 171.97 (5'8''). Estimation from the radius resulted in a stature of 162.3 (5'4'')- 171.63 (5'8''). The overall stature estimation range for ISU15-005 is 5'4''- 5'8''.

Identifying Traits

Still in progress…

Historical Context

Still in progress…

Summary

Still in progress…

The cranium most likely represents a MALE, 33-55 YEARS OLD, of broadly EUROPEAN ancestry. The trauma is consistent with peri-mortem sharp force trauma, but other trauma cannot be excluded. There is not direct evidence for the cause of death.

Recommendations

Still in progress…

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Name of lab/project: Identify the structural determinants of metal selectivity for the major pneumococcal virulence factor Pgm

Name of faculty lead, email: Julia E. Martin, martjul8@isu.edu

Final progress report description:

Our *expected outcomes* of this project were to have defined the structural determinants selective for metal-binding in Pgm, while increasing exposure of undergraduates to research and enhancing ISU's biomedical research enterprise. Three undergraduates were supported by these funds. The students worked collaboratively towards completion of two aims: 1) identify the potential metal-binding sites of the pneumococcal Pgm using a multilayered bioinformatics approach and 2) Biochemically assess the metal binding affinity, stoichiometry, and activity of select Pgm mutant proteins. Students completed aim 1 by identifying two conserved metal-binding residues and 6 potential metal-binding residues within the Pgm protein sequence using amino acid sequence alignments and structural protein modeling. Students constructed DNA oligos that were used in site-directed mutagenesis to exchange out the select amino acid to the non-metal binding amino acid alanine. All mutant Pgm plasmid constructs were sequence verified for correct mutation. These plasmids were transformed into *Escherichia coli* for protein overexpression and purification. Students successfully purified one mutant Pgm construct (R308A) before the end of the funding period. The data generated thus far was used to help write project objectives for a recent NIH NIAID R15 grant application that is currently under review.

There were a number of challenges encountered that I did not anticipate. These challenges prevented my team from completing aim 2 as proposed. First, commitment to the research project by students was interrupted repeatedly by various events, including COVID-19 regulations, quarantine process, and academic schedules. Second, extensive initial training was required since each student had very little to no research experience. Although time consuming, I worked independently with each student to train them in proper microbiological techniques. Each student now has a better understanding of microbes and a skill set that will be useful in other laboratory settings. Finally, I was not able to recruit students until mid-academic year. Many students were still cautiously approaching their academics due to the COVID-19 pandemic that was occurring. In all, I think the students accomplished a lot given that this was their first hands-on wet-lab research experience. I am glad to have to this opportunity.

I believe that my mentoring interaction made a significant impact on each of the students, particularly in strengthening their self-confidence to perform research and/or a higher degree. During down time when waiting for materials to incubate, solidify, dissolve, *et cetera*, we would discuss research challenges, time management, life-work balance, and graduate school.

If I was given another opportunity to apply for such funding, I would request that the start the funding application be due and awarded within the first month of the fall term. This would allow for better recruitment and more time to focus on the project. Maybe I was slightly naïve in thinking students would be eager to participate in research during COVID-19. Given the student schedule constraints during the academic year, it might be even more rewarding to have been able to extend the funding into the summer.

Students supported by funds received:

The funds received supported three undergraduate students working directly under my supervision. This was the first hands-on wet lab research experience for each of the students. The students worked collaboratively to accomplish the first several goals of the project to identify potential metal-binding residues within the pneumococcal Pgm using several bioinformatics approaches and to begin site-directed mutagenesis to generate plasmids expressing mutant Pgm proteins for further study. Each student has expressed interest in continuing to work in the lab next academic year.

Crystal Lovato, B.S. Microbiology/Music

- Junior standing at ISU, preparing to apply to graduate programs Fall 2022
- Trio-McNair Scholar
- INBRE Research Summer Fellow 2021
- As a result of this research experience, Ms. Lovato will pursue a Senior Honors Research Thesis project related to this topic under my supervision

Camille Hansen, B.S. Microbiology

- Junior standing at ISU, preparing to apply to graduate programs Fall 2021
- INBRE Research Summer Fellow 2021
- As a result of this research experience, Ms. Hansen is now excitedly gathering information about graduate programs across the U.S. for which she would like to apply

Rejeesh Gautam, B.S. Biology-Biomedical Sciences

- Senior
- As a result of this research experience, we have discussed types of research opportunities and career paths.

Dissemination of research data:

Each undergraduate student presented a poster at the ISU Undergraduate Research Symposium (see below, undergraduate presenter names are underlined). Two of the students, Crystal Lovato and Camille Hansen, were selected to participate in the INBRE Research Summer Program at ISU. These two students will continue to work on this project through the summer. Results will be presented at ICUR, at the annual INBRE Summer Conference in Moscow, ID, and at either the ABRCMS or the SACNAS national undergraduate conference.

- <u>Rejeesh Gautam</u>, Crystal Lovato, and **Julia E. Martin**. (2021) *Identifying the second metal binding site in the pneumococcal phosphoglucomutase.* ISU Undergraduate Research Symposium, virtual poster.
- <u>Crystal Lovato</u>, Rejeesh Gautam, and **Julia E. Martin**. (2021) *Identifying the structural determinants of metal selectivity for the major pneumococcal virulence factor Pgm*. ISU Undergraduate Research Symposium, virtual poster.
- <u>Camille Hansen</u> and **Julia E. Martin**. (2021) *Correlating bacterial capsule production with phosphoglucomustase activity in Streptococcus*. ISU Undergraduate Research Symposium, virtual poster.

Independent student reflection description start on page 4 after financial report.

Undergraduate Research Funds, FY21 – Interim Financial Report:

Funding spent on materials and supplies to support research project.

Transaction date	Vendor	Reason for Expenditure	Amount ($)
12/3/20	Fisher Scientific	DNA oligos for SDM	84.00
1/31/21	Fisher Scientific	DNA oligos for SDM	17.48
2/28/21	Fisher Scientific	Mag-fura-2	522.07
2/19/21	Fisher Scientific	DNA oligos for SDM	75.93
2/19/21	Fisher Scientific	Media	46.14
3/9/21	Fisher Scientific	Media	46.14
3/25/21	Cytiva	Protein purification	208.24
Total			$1000

Funding spent to support undergraduate research assistants (URAs) for research project.
Student names: Crystal Lovato, Camille Hansen, and Reejesh Gautam

Total spent from 10/25/20-3/20/21: $1111. 60

Anticipated amount needed to support URAs until end of funding period 6/1/21 (based on current average student hours worked): $2000.

Independent Student Reflections on Research Experience:

Submitted by Reejesh Gautam

First of all I would like to acknowledge, my advisor Dr. Martin and SBOE for providing me mentoring and funds to experience this research opportunity. I had very less clue about my academic future in the beginning but since I started experiencing the laboratory opportunity, I have developed a handful of plans and progression towards my academic success. Since, this was my first research experience, I was unsure about how research lab works. But with this exclusive experience, I now have evolved with lot of problem solving skills, better understand published works, learn to balance collaborative and individual work, determine the area of interest, and jump start my career as researcher. I was unaware about laboratory equipment and imagining as a researcher was just limited to my dreams. With this research experience, I can now stand out of day-dreaming and I am able to mark my friendship with the laboratory equipment, report writing, explaining and presenting my research work. It has definitely helped me booming up my research career. Like a breakthrough, I am able to break down the barrier between the theoretical and practical life sciences. I feel blessed to have my advisor guiding me through every steps of experiment, colleague researchers for providing me with unconditional support and Idaho State University for having all these gems covered under biological department. After this research experience, I can see myself as an upcoming microbiologist, has strengthened my future plans and has provided me a gateway to success. My advisor has always been on my side when needed and her support has helped me stand out in the crowd and get recognized. I was passionate about pathology, virology, and overall bacterial life cycle. This research has helped me with in hand experience and strengthened to unleash my capacity to work more on these projects.

Undergraduate Research Funds FY21
Final lab/project report

Submitted by Crystal Lovato

Working in Dr. Martin's lab has been a wonderful experience and has really set the bar for my expectations of a research experience. I was able to learn new techniques such as SDS-PAGE gel construction and protocol, protein purification, and competition assay protocols. I have also had tremendous instruction on academic writing, poster construction and presentation from Dr. Martin.

This research experience has shown me how much time and dedication goes into producing usable data for the health field. I have grown as a writer, presenter, and as a student because of the hours I have spent in the lab. One of the most beneficial parts of this experience has been Dr. Martin's advice on my path after my undergraduate education. She has helped me identify graduate programs that fit my interests, application tips, and has given me an insight on what the Graduate experience will truly be like.

The time I've spent in Dr. Martin's lab has truly helped me solidify my dreams of entering the research field. I have always thought working in a lab would be the most rewarding job for me, but actually having the opportunity to do so has shown me that it's not just the wet lab experience that excites me but, also the search for answers and the process of finding them through deep thought and problem solving.

I would also like to recognize Dr. Martin's amazing talent for advocacy. She has helped many under-represented students like myself see that the road to a successful career isn't as hard to reach as it has seemed. She has inspired me to be more confident in myself and not let my identity as a latina woman be something that holds me back, but something that propels me forward.

Undergraduate Research Funds FY21
Final lab/project report

Submitted by Camille Hansen

Research is completely different than how I imagined it. Rather than one eye opening discovery, it's a gradual process that introduces more questions and hypotheses. Although the experience taught me important molecular techniques such as site-directed mutagenesis and constructing bacterial strains, I never anticipated the significance of working in a lab. I had to learn patience with myself. As an undergraduate arriving with a limited understanding of the project, I made a lot of mistakes. I have always been someone that excels within the limits of the comfort zone and rarely ventures outside my self-imposed limit. Making mistakes is actually important-- without them I would never have the determination to improve. I am very appreciative to my mentor, Dr. Martin, for being supportive as I have slowly improved in my understanding of the techniques and subjects.

For the past three years, I have been planning to attend graduate school. Working in the lab has provided me with a skill set that will be important in the years to come. I have improved simple techniques such as pipetting accurately and running an agarose gel that I otherwise did not know was a barrier in my learning. Reading literature relating to the subject has also introduced me to other ideas and avenues that have intrigued me.

Being involved in Dr. Martin's research has been challenging but very rewarding. I look forward to being in graduate school and researching something new. I have always been captivated by bacteria and researching Streptococcus has cemented those plans as I find myself looking into potential graduate schools. Microbiology is a fascinating field that I am anxious to investigate in my career plans.

Identifying the Second Metal-Binding Site in the Streptococcus Phosphoglucomustase

Idaho State UNIVERSITY

Reejesh Gautam, Crystal Lovato, and Julia E. Martin
Department of Biological Sciences, Idaho State University, Pocatello, ID 83209 USA

Abstract

Phosphoglucomutase (Pgm) is an enzyme that bridges glycolysis to capsular polysaccharide biosynthesis, a key virulence determinant in Streptococcus pneumoniae. Previous research using a mag-fura-2 competition assay revealed that Pgm is most active with manganese and binds two metal ions per protomer, despite literature showing a single conserved metal-binding site. In this study, we will elucidate the location of the second metal-binding site in Pgm. Site-directed mutagenesis will be used to selectively mutant potential metal-binding residues to the non-metal binding residue alanine in Pgm. Mutant Pgm proteins will be purified to homogeneity from Escherichia coli cells. The metal affinity and stoichiometry will be determined in vitro for apo-(metal free) Pgm mutant proteins and compared to wild type Pgm. Mutant Pgm proteins that show loss of metal binding and reduced specific activity will suggest that the targeted residue likely participates in metal binding, thereby playing a role in activation of Pgm. These data will ultimately be paired with in vivo bacterial capsule production to demonstrate the effects of metal –binding on Pgm activity and its relevance to the virulence of S. pneumoniae.

Introduction

Streptococcus pneumoniae is an opportunistic bacterial pathogen that asymptomatically colonizes the nose and throat of healthy humans. To establish asymptomatic colonization or carriage, the pneumococcus must adopt a state of homeostasis with the host's defense systems and the constant barrage of disruptive events caused by inhalation and other microbial competitors. Dysbiosis (microbial imbalance) or a change in host factors can lead to mucosal dysfunction, permitting the pneumococcus access to other parts of the respiratory tract (1-3). A key virulence determinant for survival and pathogenesis of the pneumococcus in the host is the production of capsular polysaccharide (CPS) (4-8).

Since thicker CPS levels are unfavorable for pneumococcal colonization but necessary for evasion of the host defense systems,, it is postulated that CPS expression must be precisely regulated. Our recent results demonstrate that pneumococcal cells can adjust CPS production levels in response to the nutritional metal ion pool, more specifically to bioavailable Mn/Zn ratios (Fig. 1A). We show that dysregulation of overall metal homeostasis directly affects the metallation status of the pneumococcal Pgm, ultimately affecting production of sugar precursors for CPS formation. In S. pneumoniae, glycolysis is connected to the CPS biosynthetic pathway via the phosphoglucomutase Pgm. Pgm is a metal-dependent phosphotransferase that catalyzes the reversible isomerization of glucose 6-phosphate (G6P) to glucose 1-phosphate (G1P) (Fig. 1B). G1P is required to generate UDP-glucose, a sugar nucleotide precursor for CPS biosynthesis in most S. pneumoniae strains .

Similar to characterized PGM/PMM family enzymes, we find that the pneumococcal Pgm can bind a variety of metal ions, but only Mn(II) leads to robust enzyme activity. More interesting is the fact that we observed two metal ion binding events per Pgm monomer. This contrasts with solved crystal structures of PGM/PMM family members, which have been shown bound to a single Mg(II) ion. A multi protein sequence alignment comparing pneumococcal Pgm to select PGM/PMM family homologs reveals both shared conserved and nonconserved regions that could account for different enzymological properties. The pneumococcal Pgm amino acid sequence harbors the single conserved metal-binding motif (DXDXDR) found among all PGM/PMM family enzymes. In this study, we will elucidate the location of the second metal-binding site in Pgm.

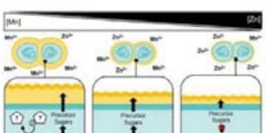


Fig. 1A. **Schematic overview of the effects of cellular Mn/Zn ratios on CPS production by pneumococcus.** Dysregulation of Mn/Zn homeostasis directly influences the metallation status of the Mn-utilizing phosphoglucomutase Pgm, thereby affecting sugar precursor production necessary for CPS formation. High Mn/low Zn ratio induces a state of hyperactivation for Pgm resulting in thicker CPS (left), while low Mn/high Zn leads to inactive Pgm thereby restraining sugar precursor production and limiting CPS formation (right).

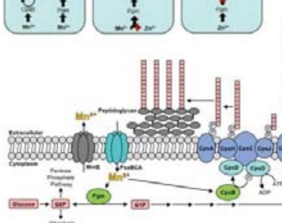


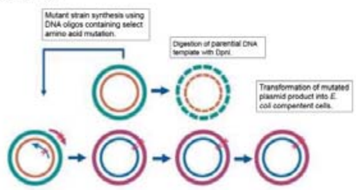
Fig. 1B. **Schematic overview of capsular polysaccharide biosynthesis in S. pneumoniae.** Intracellular Mn homeostasis is maintained by the combined activities of the Mn-specific importer PsaBCA and exporter MntE. Intracellular Mn can serve as a metal cofactor in variety of metalloenzymes), including the phosphotyrosine protein phosphatase CpsB and the putative metal-dependent phosphoglucomutase Pgm. These enzymes, amongst many others, play a role in CPS biosynthesis.

Hypothesis/Question

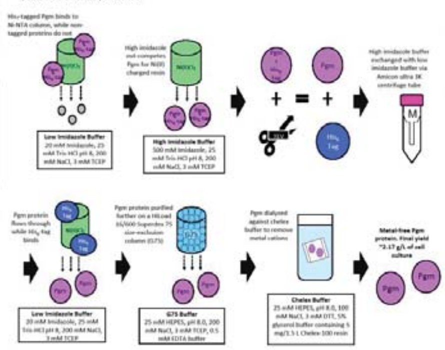
We hypothesize that the mutation N482A in Pgm will alter metal binding affinity and stoichiometry using mag-fura-2 metal binding competition assay.

Methods and Materials

Pgm Mutant Plasmid Construction: Site-directed mutagenesis was used to generate amino acid substitutions in Pgm on plasmid pHis-Pgm. All resulting plasmid constructs were DNA sequence verified and examined for expression.



Pgm Mutant Expression and Purification: Overnight *E. Coli* BL21 cells harboring pHis-Pgm(N482A) were diluted 1/100 onto fresh LB medium containing 100 µg/mL ampicillin and grown aerobically at 30°C, shaking. At approximately 0.6 OD_{600}, 1 mM isopropyl β-D-1-thiogalactopyranoside was added to induce *S. pneumoniae* Pgm-N482A protein synthesis at 18C for 20 h. One liter of cells were harvested by centrifugation. Cells were suspended in 25 mM Tris-HCl, pH 8.0 and disrupted by sonification on ice (½ in. probe at 60% power for 10 cycles, 15 s pulse). Cell debris was removed by centrifugation and the following protein scheme was performed:



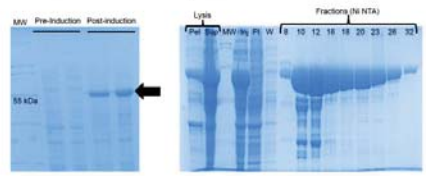
Acknowledgements

This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board of Education Higher Education Research Council through Idaho State University.

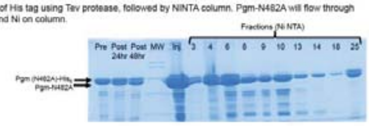
Preliminary Results

STEP 1
Expression test for pHis-Pgm-N482A) induced by IPTG at 18C for 20 h.

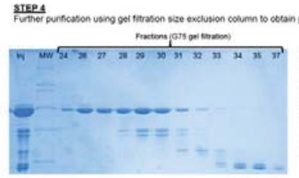
STEP 2
NiNTA column used to enrich for His-tagged Pgm-N482A protein.



STEP 3
Cleavage of His tag using Tev protease, followed by NiNTA column. Pgm-N482A will flow through and not bind Ni on column.



STEP 4
Further purification using gel filtration size exclusion column to obtain pure Pgm-N482A protein..



Glossary
MW = Molecular Weight
Pel = Cell Pellet after lysis
Sup = Supernatent after lysis
Inj = Injection for column
Ft = Flow Through
W = Wash
Pre = Pre Tev Protease
Post = Post Tev Protease

Future Research

Use purified Pgm-N482A in mag-fura-2 metal binding competition assay to determine the affinity for metal and the number of metal binding events. Compare these data to wild type Pgm.

If we find, Pgm-N482A fails to bind 2 metal ions, then this will suggest that N482A participates in directly binding metal ions and may be part of the second metal binding site.

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Undergraduate Research Funds FY21
Final lab/project report

Idaho State University

Identifying the Structural Determinants of Metal Selectivity for the Major Pneumococcal Virulence Factor Pgm

Crystal L. Lovato, Reejesh Gautam, Julia E. Martin
Department of Biological Sciences, Idaho State University, Pocatello, ID 83209 USA

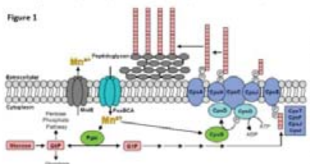
Abstract

Streptococcus pneumoniae (*Spn*) Pgm is a manganese-dependent phosphoglucomutase that bridges glycolysis with the bacterial capsule biosynthesis pathway. Based on structural and biophysical characterization of other PGM/PMM family proteins, *Spn* Pgm is predicted to bind at least one metal ion. However, we find that apo-Pgm can bind up to two metal ions per protomer. As such, Cellular Mn/Zn ratios can directly modulate Pgm specific activity but the actual mechanism by which these metals bind to Pgm is not clear. Using a multi-protein sequence alignment and bioinformatics approach, we identify several potential metal-binding pockets in Pgm. In this study, we use site-directed mutagenesis to replace select potential metal-binding residues with the non-metal binding residue alanine in Pgm to generate mutant Pgm proteins, which will be purified to homogeneity in apo (metal free) form. Mutant Pgm Proteins will be tested for metal-binding affinity and stoichiometry using a mag-fura-2 metal competition assay. Reduced metal affinity and Pgm activity will suggest that the select mutated residue likely participates in metal binding and is required for Pgm activation. These data will guide future *in vivo* assessment of mutant Pgm on capsule production, a key virulence determinant for colonization and survival of *Spn* in the human host.

Introduction

Streptococcus pneumoniae (Spn) is a Gram-positive bacteria that causes sinusitis and otitis media, and the severe invasive disease pneumonia, bacteremia, and meningitis. The capsule polysaccharide (CPS) that surrounds the *Spn* cell body is a key virulence determinant for growth and survival in the human host. Thinner CPS allows exposure of antigens and adhesins for colonization, while thicker CPS prevents phagocytosis and clearance by the host immune response system. Previous studies in our lab have demonstrated that manganese/zinc (Mn/Zn) ratios affect CPS expression levels in *Spn* via activation of the phosphoglucomutase (Pgm).

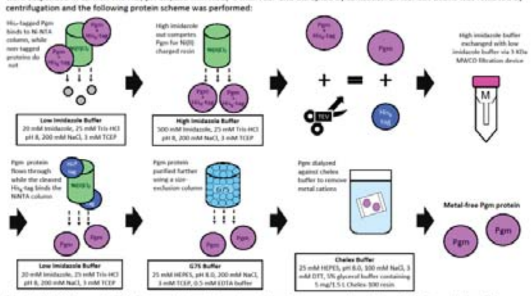
Figure 1



Pgm is an enzyme that branches glycolysis with the CPS biosynthesis pathway. Pgm is a metal-dependent enzymes that catalyzes the conversion of glucose-6-phosphate to α-glucose-1-phosphate, a precursor sugar for CPS formation (see Figure 1 to the left). Current lab data has established that, unlike other PGM/PMM family proteins, the *Spn* Pgm binds two metal ions per protomer. These metal ions are used to modulate Pgm enzyme activity, thereby regulating CPS expression levels. Using bioinformatic approaches, we identified that *Spn* Pgm harbors the known conserved metal binding motif DXDXDR found among all PGM/PMM family members. In this study, we plan to elucidate the location of the second metal binding region in *Spn* Pgm.

Methods and Materials

Pgm Expression and Purification: Overnight *E. Coli* BL21 cells harboring pHis-Pgm were diluted 1/100 onto fresh LB medium containing 100 µg/mL ampicilin and grown aerobically at 30°C, shaking. At approximately 0.6 OD_{600}, 1 mM isopropyl β-D-1-thiogalactopyranoside was added to induce *S. pneumoniae* Pgm protein synthesis at 18C for 20 h. One liter of cells were harvested by centrifugation. Cells were suspended in 25 mM Tris-HCl, pH 8.0/200 mM NaCl/ 3 mM TCEP and disrupted by sonication on ice. Cell debris was removed by centrifugation and the following protein scheme was performed:



Site-directed Mutagenesis: DNA oligos containing select amino acid mutation were used in site-directed mutagenesis to mutate *pgm* on the pHis-Pgm plasmid. Parent template plasmid DNA was digested by DpnI. The remaining mutant plasmid was then transformed into *E.coli* DH5a chemically competent cells and selected for ampicillin resistance. All plasmid mutants generated were confirmed by sequencing.

Mag-fura-2 Metal Competition Assay: A 10mm blackened quartz cuvette was used to analyze the reaction in a UV-Visible spectrophotometer. Equal concentrations of mag-fura-2 (MF2) and apo-Pgm or apo-Pgm mutant purified protein were mixed in 25 mM metal-free HEPES buffer, pH 8.0. Known metal ion (Mn or Zn) concentrations were titrated in the reaction was monitored at 366nm and 325nm. The titration was performed to completion and the data was then analyzed and fitted by the Dynafit program for affinity and number of binding events.

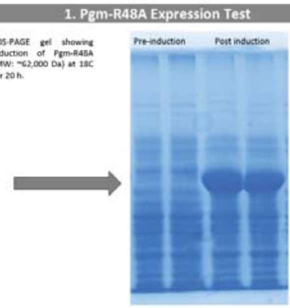
Hypothesis

We hypothesize that the R48A Pgm variant will reduce the binding affinity or the number of binding events, thereby reducing Pgm specific activity and CPS expression.

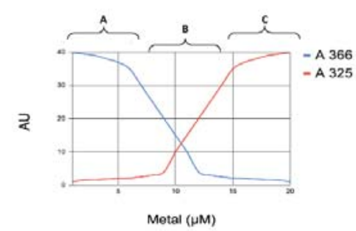
Results

1. Pgm-R48A Expression Test

SDS-PAGE gel showing induction of Pgm-R48A (MW: ~62,000 Da) at 18C for 20 h.



2. Pgm-R48A Metal Binding Affinity



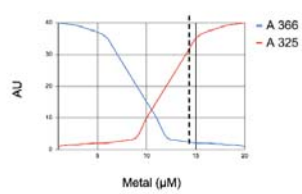
Predicted metal-binding curve used to calculate the metal-binding affinity of Pgm-R48A:

A) Pgm protein is predominantly binding the metal and outcompeting MF2.

B) MF2 and Pgm protein are equally competing for the metal ions.

C) MF2 is predominantly binding the metal ions because all spaces in Pgm are occupied.

3. Pgm-R48A Metal Stoichiometry (Binding Events)



As the equilibrium of the titration begins to favor MF2 and the reaction comes to completion, we can use the turning point to determine the number of metal binding events. We can use the known concentrations of MF2 and Pgm protein to calculate the number of metal binding events. For example, in the above graph we see the turning point for each curve around 15 µM metal. In this reaction, the MF2 concentration used was 5 µM (MF2 can only bind a single metal ion, thus 5 µM metal will be bound to MF2). We can subtract 5 µM from 15 µM to yield 10 µM metal remaining.. Since Pgm was present in the reaction at 5 µM also, we can then divide the remaining metal ion concentration of 10 µM by 5 µM Pgm. This yields 2. Thus, Pgm protein is binding 2 metal ions per protomer in the reaction.

Predicted Outcomes

- Loss or reduction in metal-binding/stoichiometry, when compared to wild-type Pgm, suggests that that the residue R48 may participate directly in metal-binding to activate Pgm.
- If there is more than 1 binding event due to the R48A mutation, there will be a clear ration of more metal to Pgm

Future Directions

- Perform MF2-protein assay to determine the affinity and the number of metal binding events the Pgm-R48A variant, as well as other variants
- If decreased metal-binding, then measure Pgm specific activity to determine the effect of the mutation on enzyme activity
- If decreased specific activity is observed, then assess CPS expressions levels *in vivo* after constructing a the *pgm* mutant strain

Acknowledgements

This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board of Education Higher Education Research Council through Idaho State University.

References

McFarland, A. L.., *et al* 2021 *J Bacteriol.* (accepted 4/3/2021)

Undergraduate Research Funds FY21
Final lab/project report

Correlating bacterial capsule production with phosphoglucomutase function in *Streptococcus*.

Camille Hansen and Julia E. Martin
Department of Biological Sciences, Idaho State University, Pocatello, Idaho 83209 USA

Idaho State University

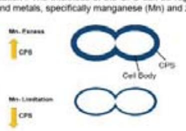
Abstract

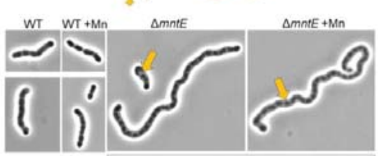
Capsular polysaccharide (CPS) is a key virulence determinant for Streptococcus pneumoniae growth and persistence in the human host. High (thicker) CPS expression levels prevents surface antigens from recognition and phagocytosis by host immune response cells, while a thinner CPS allows S. pneumoniae to colonize the host. Previous studies reveal a direct role for cellular Mn/Zn ratios in the regulation of CPS biosynthesis via direct activation of the phosphoglucomutase Pgm. This metal-dependent enzyme can bind up to two metal ions, despite literature showing a single conserved metal-binding site. In this study, we propose to identify the second metal-binding site in Pgm. Predicted potential metal-binding residues identified using a multi-protein sequence alignment and bioinformatics approaches will be mutated to the non-metal binding residue alanine. Allelic replacement of wild type pgm with mutant pgm constructs using counter antibiotic selection will be generated. These S. pneumoniae strains expressing mutant Pgm proteins will be assessed for CPS expression levels and adherence ability. Strains that show reduced CPS levels but adhere well will suggest reduced Pgm activity, and thereby indicate that the mutated residue is required as a potential metal-binding residue in Pgm. These results will enhance our understanding of how Pgm functions to modulate CPS.

Introduction

- *Streptococcus pneumoniae* is a Gram-positive bacterium that commonly colonizes the nasopharynx of healthy individuals, persisting as a harmless bacterial commensal. Despite a largely asymptomatic colonization, *S. pneumoniae* remains the leading contributory agent of the life-threatening, invasive diseases: pneumonia, bacteremia, and meningitis[1,2].
- Capsular polysaccharide (CPS) is used by the bacteria to increase virulence and promote colonization[1]. High (thick) CPS levels help bacterial cells evade phagocytosis and the host immune response system, whereas low (thin) CPS levels expose antigens and other protein that help cells attach for colonization[3]. The thickness of the CPS can be regulated by the availability of oxygen, carbohydrates and metals, specifically manganese (Mn) and zinc (Zn)[1,4].

Cartoon model of Mn levels affecting CPS expression levels in *S. pneumoniae*.





Phase contrast showing increased CPS production in Mn-stressed (ΔmntE) cells compared to wild type (WT) cells. Pneumococcal dark cell bodies are surrounded by gray capsule (designated by orange arrow).

- Studies show that the regulation of metals within the cell is critical for the survival of *S. pneumoniae*. Phosphoglutamase Pgm has a direct effect of the biosynthesis of CPS. Metal ions play an important role in regulating Pgm enzyme activity. This enzyme catalyzes the conversion of glucose-1-phosphate to glucose-6-phosphate, a critical precursor sugar needed to for the biosynthesis of CPS. Recent evidence in our lab has demonstrated that Pgm can bind two equivalents of metal ions per protomer, despite previous all previous PGM/PMM family members binding a single metal ion.

Hypothesis

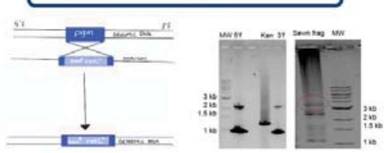
We hypothesize that *S. pneumoniae* strains expressing *pgm* mutant alleles that are incapable of binding Mn(II) will show decreased CPS expression levels similar to WT cells.

Materials and Methods

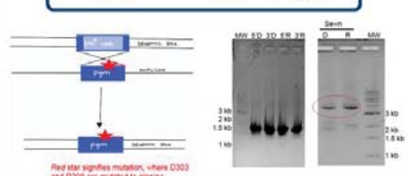
Bacterial Strain Construction: *S. pneumoniae Δpgm* mutants were derived from wild type *S. pneumoniae* serotype 2 D39 strain IU1781. All mutant strains were constructed by gene deletion replacement and antibiotic counterselection using the Janus *kan-rpsL+* cassette. Briefly, the 0.8- to 1-kb regions upstream and downstream of *pgm* (SPD_1326) were amplified from genomic DNA using inner primers containing regions flanking the Janus kanamycin resistance cassette (*kan-rpsL+*). The two outside fragments generated were then joined together with the inner *kan-rpsL+* fragment. The final PCR product was transformed into competent *rpsL1* pneumococcal cells using standard techniques. Bacteria were grown on trypticase soy agar II plates containing 5% (vol/vol) defibrinated sheep blood (TSAII-BA). The plates were incubated at 37°C in an atmosphere of 5% CO2. For antibiotic selections, TSAII-BA plates contained 250 µg/ml kanamycin or streptomycin.

Site-directed mutagenesis was used to generate amplicons containing allelic substitutions in *pgm*. Briefly, complementary primers were designed so that the mutation of interest was located in the center of the sequence. Overlapping fragments generated by PCR were joined together and transformed into competent *Δpgm* cells. Bacterial cells were selected for streptomycin resistance and screened for kanamycin sensitivity, signifying replacement of *kan-rpsL+* with mutant *pgm* allele. All resulting constructs were confirmed by DNA sequencing.

1. Deletion of *pgm*



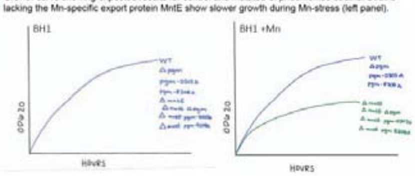
2. Site directed mutagenesis of *pgm*.



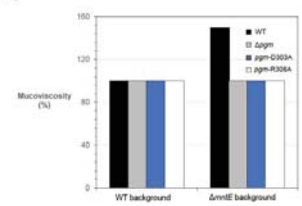
Red star signifies mutation, where D303 and R309 are mutated to alanine.

Predicted Results

Growth curve showing expected results for control and mutated *S. pneumoniae* strains. Strains lacking the Mn-specific export protein MntE show slower growth during Mn-stress (left panel).



Cells unable to export Mn (*ΔmntE*) also show higher mucoviscosity (increased CPS levels). The addition of *Δpgm in ΔmntE* strain should prevent this increase from occurring and thus should resemble WT cells even in the presence of Mn-stress. If our mutant strains look similar to *ΔmntE Δpgm*, then the data would suggest that these particular amino acids that have been mutated to non-metal binding amino acid alanine likely are important for Pgm function and possibly participate in metal binding.



Future Work

- Complete bacterial strain construction.
- Analyze growth behavior under different metal conditions.
- Measure the effects of metal on capsule expression using mucoviscosity assay.

Acknowledgements

This project is supported by a 2020-2021 STEM Undergraduate Research Grant from the ID State Board of Education Higher Education Research Council through Idaho State University.

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2. Lisher, J. P., *et al.* (2013) *Front. Cell. Infect. Microbiol.* 3: 91.
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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 1, 2021

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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 FY2021, 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 10 SURF awards during the summer of 2021.

Funding provided by the State Board of Education/Higher Education Research Council also allowed the Office of Undergraduate Research to support an additional undergraduate researcher during the academic year. This was accomplished through a competitive Undergraduate Research Grant awarded to the student during the spring semester of 2021. This grant supported a semester-long research project under the guidance of a faculty mentor. This grant was in the amount of $1,000 for materials and supplies and other project-related expenses.

Almost all of UI students supported by State Board of Education funds attended and presented the results of their projects at the Idaho Conference on Undergraduate Research (virtual conference) in July of 2021. One student was unable to attend the ICUR conference due to the fact that her project required her to be in the field collecting data at the time of ICUR. In lieu of presenting at ICUR, this student will present the results of her work at the UI Undergraduate Research Symposium in April 2022.

As noted above, the SURF awards include $1,000 each for project-related supplies. This year some of our student awardees did not spend the entire amount of their project funds. The on-going pandemic hampered some of the travel and conference presentations our students had planned and budgeted for. These unspent project funds are being returned to the SBoE.

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/HERC. 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 Spring 2021 Undergraduate Research Grant
Grant Recipient: Jeffrey Badigian, Biological Sciences, University of Idaho
Faculty Mentor: Paul A. Rowley, Assistant Professor, Department of Biological Sciences
Project Title: Antifungal Killer Toxin Production by Opportunistic *Candida glabrata*

Project Description

This project began to identify antifungal killer toxin production in the opportunistic fungal pathogen *Candida glabrata*. This commensal organism is becoming a more and more frequent cause of vulvovaginal candidiasis, being the current second most common causal organism of this illness. Isolates had been known to secrete antifungal killer toxin proteins, proteins that are used by various organisms for competitive advantages amongst other uses. The encoding origin of these proteins was unknown and debated to be either genomically encoded or encoded on dsRNA viral satellites. The satellites then repurpose the transcriptional machinery of co-infecting dsRNA Totivirus to propagate and express themselves. Totivirus has been found to increase the virulence of other fungal pathogens, so the potential benefits *C. glabrata* may be acquiring from both toxin production and the totiviruses demanded further exploration.

Project Accomplishments

To begin, 133 *C. glabrata* isolates from around the world were screened for killer toxin production; 18 killers were found, 16 of which were of clinical origin. The organisms that were the most sensitive to this toxin were the isolates that were most closely related to *C. glabrata,* suggesting a potential use for niche competition. The next step was to perform a dsRNA extraction to attempt to look for viral infection. All killer isolates, including the representative type strain *C. glabrata* CBS 138, tested negative for dsRNA infection. To begin the search for the encoding origin of these proteins within the *C. glabrata* genome, homologs of other known killer toxins were searched for. Four homologs to the *Saccharomyces paradoxus* K62 killer toxin were identified within the *C. glabrata* genome, a toxin that our lab has previously determined that *C. glabrata* isolates have a unique resistance to. Two of these homologs have been cloned into a nonkiller yeast, and both have yielded an active killer toxin when ectopically expressed. The other two remain to be cloned.

PHYRE, a protein folding recognition software, was used to determine a preliminary secondary structure of these four homologs, and they showed similarities to aerolysin-like toxins, a class of proteins known to be virulence factors for pathogenic organisms and have shown extreme toxicity against human cells. When grown on unbuffered media at pH 5.6, *C. glabrata* isolates have shown hemolytic activity, but when screened on media buffered to pH 7.2, this hemolytic activity disappeared. Killer toxins are more active at acidic pH values, so this hemolysis assay suggests that these killer toxins may show toxicity to human cells, though more research is still needed.

Summary of Budget Expenditures

Supplies	**Cost**
Restriction enzymes	$122.76
dNTP mix for PCR identification	$62.21
Hydrogen peroxide	$27.95
Syringes	$46.15
PCR tubes	$158.88
Kirby Bauer discs	$36.25
Syringes	$50.32
Miniprep kit for plasmid isolation of the homologs	$253.52
Yeast extract for use in yeast media preparation	$241.96
TOTAL	$1,000.00

Conference Presentations

I presented a poster of my project at the 2021 Idaho Conference on Undergraduate Research (ICUR). I will also present my work at the UI Undergraduate Research Symposium in April of 2022.

Acknowledgements

I greatly appreciate the support that was provided by the State Board of Education/HERC as well as the University of Idaho's Office of Undergraduate Research through this spring semester Undergraduate Research Grant. This was a tremendous opportunity for me, and I truly value this experience in conducting research. This included a chance to collaborate with other students in science all across Idaho through the ICUR symposium which was a wonderful experience to be a part of. The Office of Undergraduate's support and that of the State Board of Education/HERC made this project and experience possible and is something I greatly appreciate and am thankful for.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Isaac Blake, Chemical Engineering, University of Idaho
Faculty Mentor: Matthew Bernards, Chemical and Biological Engineering, University of Idaho
Project Title: Synthesis of Polyampholyte Tissue Engineering Hydrogels via Ultra-Violet Light

Abstract: Polyampholyte hydrogels display promising properties to promote healthy regeneration of tissue due to their inherent ability to bypass the body's foreign body response. Research proving these claims has been based on chemically initiated hydrogels; however, more research needs to be conducted on hydrogels photopolymerized using UV-A light. All hydrogels used in this research were created with a constant w/v ratio of the photoinitiator LAP. Four polymerization times were tested for antifouling properties as well as shore hardness and percentage swelling. Initial formulation procedures were created, however, no antifouling properties comparable to chemically initiated hydrogels were reported. It was also found that UV photopolymerization times exceeding 1.5 minutes did not result in significantly different harness and swelling properties.

Project description: The main goal of the research conducted this summer was to create procedures for the synthesis of UV photoinitiated hydrogels. The Bernards lab has historically created hydrogels using liquid chemical initiators to start the polymerization chain reaction. However, using UV type A light to start polymerization has many potential benefits over chemical initiators. Briefly, UV photoinitiators require far less time to polymerize and are significantly less cytotoxic to living cells. Cytotoxicity is a very important thing to consider as one end goal of this research is cell encapsulation within a hydrogel for tissue repair scaffold purposes. The first thing that must be verified if a scaffold wants to be implanted in vivo is biocompatibility. The autoimmune response known as the foreign body response is responsible for removing anything deemed foreign in the body. The first step in this process is coating of a scaffold in non-specific proteins, often called "fouling". To remain biocompatible with the body, our hydrogels must be antifouling. To evaluate the antifouling properties of the gels made, each gel was exposed to a fluorescently tagged protein known as bovine serum albumin (FITC BSA). If the gel was in fact nonfouling, then no protein should be present on the surface after rinsing with a buffer solution. Along with antifouling properties, swelling and shore hardness was also measured. Because hydrogels are porous and contain many negatively/positively charged elements, they are subject to swelling when in the presence of other ions or water. Hydrogel volume was measured before and after a 24 hour soak in a phosphate buffered saline (PBS) solution. To measure harness, a shore durometer type OO was used. These instruments measure the resistance of a surface to an applied force. With all the above methods described, data was collected and is presented below.

Data: Antifouling results for the photoinitiated gels have not yet been successful. Figure 1 shows a comparison of photoinitiated gels to their chemically initiated counterparts, which have been proven to be antifouling. It is easy to see the bright green on the photoinitiated gels which implies the presence of the protein that has adsorbed to the surface. Our group has many hypotheses as to why this could be happening and have testing plans for the future. Both swelling and hardness results (Figures 2 and 3 respectively) show the same general trend. This trend was that after 1.5 minutes of UV light exposure time, the data starts to taper off and no significant change is observed. The most likely reason for this is that the gel has stopped polymerizing and all free radicals that could be created already have. In the future, testing will be done with increased amounts of photoinitiator or cross linker.

Figure 1: Photoinitiated gels (left) antifouling vs. chemically initiated gels (right)

Figure 2: Volume swelling as a function of UV exposure time

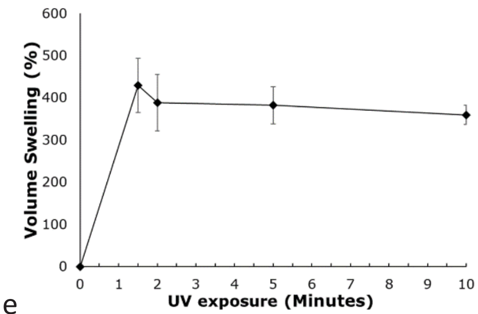
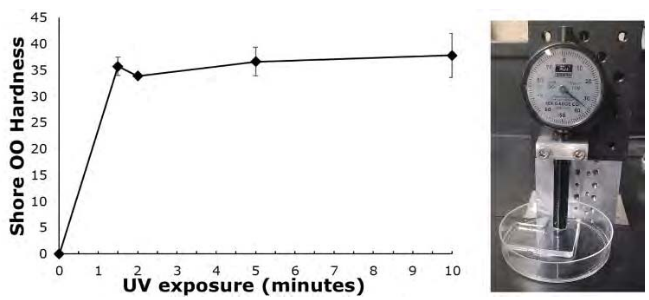


Figure 3: Shore OO Hardness as a function of UV exposure time



<u>Budget Expenditure:</u>
Reusable biopsy punch: $565
Lab consumables: $435 (includes gloves, pipet tips, scintillation vials, well plates, TCPS dishes)
Stipend: $4,000
TOTAL: $5,000

<u>Conference Presentation:</u> I presented this research ICUR in July 2021. I will also be presenting a complete summary of findings at the UI Undergraduate Research Symposium in the spring of 2022 and at the NW Biomechanics conference in April of 2022.

<u>Acknowledgement:</u> I genuinely appreciate the opportunities I received through the Summer Undergraduate Research Fellowship supported by the Idaho State Board of Education/HERC. This summer research opportunity was momentous for my academic and personal endeavors. Without the support from the Idaho State Board of Education/HERC I would not otherwise have been able to have had this tremendous opportunity. Thank you.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Sarah Burgett, Wildlife Resources Major, University of Idaho
Faculty Mentor: Janet Rachlow, Professor, College of Natural Resources, University of Idaho

Project Title: Unexpected properties of habitat altered by ecosystem engineers: A pygmy rabbit case study

Abstract

Ecosystem engineers are species that influence availability of resources by physically altering the environment. Due to these physical changes, they may influence functional properties of habitat including visibility. Habitat structure can conceal animals from predators, but it may also disrupt sightlines, thus reducing an animal's ability to gather visual information. Pygmy rabbits (*Brachylagus idahoensis)* are ecosystem engineers in the sagebrush-steppe ecosystem of the western USA. They significantly influence the growth of vegetation by burrowing, browsing, and defecating within their habitat. However, no study has examined whether pygmy rabbit activity might also alter visibility. My objective was to measure how pygmy rabbit activity influences these functional habitat properties. I estimated visibility in habitat patches around burrow sites using lidar. I am now evaluating if pygmy rabbits influence visibility by comparing active and inactive burrow sites as well as quantifying visibility as a function of duration of burrow occupancy (i.e., number of years during which the burrow system was used). Preliminary results from 23 of the 40 patches suggest that duration of burrow occupancy results in larger viewsheds, however, the analyses are ongoing. Final results are pending due to the large volume of data collected. I expect to submit a manuscript detailing results of the project for publication in a peer-reviewed journal by spring 2022.

Project Description

Introduction

Ecosystem engineers modify habitat structure, which can influence habitat properties including availability of resources for other species (Jones et al. 1997). Beavers (*Castor canadensis*) are a well-studied example of an ecosystem engineer; by cutting down trees and building dams they alter the hydrology of an area and create new wetlands (Jones et al. 1996). Although the activities of ecosystem engineers are known to modify habitat structure, it is unclear how changes in structure might influence properties of habitat that serve important functions for wildlife (e.g., provisioning of thermal shelter, security, or physical protection).

Visibility, the visual information accessible to animals in their environment, is one functional habitat property that is influenced by habitat structure. Vegetation that blocks sightlines alters the area from which visual information can be gathered. All the available sightlines and their spatial extents constitute the 'viewshed' (Aben et al. 2018). Animals as diverse as greater sage-grouse (*Centrocercus urophasianus*) and anoles (*Anolis aeneu*) are known to select habitat based on viewshed (Aspbury and Gibson 2004, Eason and Stamps 1992). Activities of ecosystem engineers that change vegetation structure may modify visibility. Such effects are likely to be especially pronounced for herbivorous ecosystem engineers.

Pygmy rabbits (*Brachylagus idahoensis*) are ecosystem engineers endemic to the sagebrush-steppe of the American West. They are obligate burrowers that use burrow systems year-round. By defecating and urinating around their burrows, they add nutrients to the soil promoting sagebrush growth. Pygmy rabbits also browse sagebrush shrubs throughout the year and forage seasonally on herbaceous plants, changing the habitat structure. Because burrow systems can be occupied for decades, the cumulative effects on sagebrush growth and reproduction increase over time (Parsons et al. 2016). These structural alterations to the vegetation likely modify the viewshed available to animals in the sagebrush-steppe ecosystem.

The goal of this study was to investigate if and how pygmy rabbits alter the viewshed around their burrow systems. My objectives were to 1) contrast size and variability of viewsheds in habitat patches with and without pygmy rabbit burrows; and 2) test whether duration of burrow occupancy is related to these viewshed properties. ***I hypothesized that pygmy rabbits would increase the viewsheds around their burrow systems through herbivory, and because sagebrush is a slow-growing plant, the effects would increase over time.*** I predicted that a) habitat patches with occupied burrows would have greater and more variable viewsheds than habitat patches without burrows, and b) the size and variability of the viewshed would increase with duration of occupancy. Alternatively, because nutrients are added to soil by fecal pellets, increased duration of use could result in greater understory regeneration around long-occupied burrows. If this is the case, I predict that there will be a non-linear relationship in which the viewshed will increase initially and then decrease as duration of occupancy increases. Finally, I also expect that viewshed size will be negatively related to the distance from the burrow entrance because pygmy rabbits spend more time browsing close to the safety of their burrows.

Methods

Study Site

This study was conducted at Dr. Rachlow's long-term study site in the Lemhi Valley of eastern Idaho where she has collected census data on pygmy rabbit burrows from 2002 to 2018. The vegetation of this site is dominated by sagebrush, mostly Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) (Sanchez et al. 2009). At this site, rabbit burrows occur almost exclusively within mima mounds, which defined the habitat patches surrounding burrows.

Field data collection

I determined the level of pygmy rabbits' activity (active or inactive) at censused mounds using methods established by Parsons et al. (2016) by looking for signs of digging and pellets. The last census was completed in 2018, and I assumed that mounds active in 2018 that were also active in my survey were continuously active during the intervening years. Using the census data and my survey, I divided the mounds into 4 categories (occupied for 4-6, 7-9, and 10-20 years, and unoccupied in all years). I randomly selected 10 mounds in each category for analysis.

At active mounds, I randomly selected one burrow entrance, and at all mounds, I randomly selected 3 sites for habitat sampling. At each site, lidar data characterizing 3D habitat structure were gathered using a Leica BLK360 terrestrial laser scanner placed at the eye height of a pygmy rabbits (~15 cm above the ground surface).

Because rabbit activity is known to influence sagebrush growth and regeneration, I also measured the three tallest shrubs to estimate shrub height on the mounds and counted the number of seedlings (<10 cm) in a 0.25m^2 plot at each site. I also measured the radius of the mounds to quantify patch size as a covariate.

Data Processing and Analysis

I am estimating the viewshed at each site using the R package *viewshed3d*, which measures the distance that sightlines travel in every direction from the position of an animal within 3D lidar data (Lecigne et al. 2020). I will compare how the viewsheds change between and within the mounds using ANOVAs. I will also analyze the effects of duration of occupancy on the size and variation of viewsheds using generalized linear models.

Results

This summer, I collected data at all 40 selected mounds, which included 150 lidar scans. I am continuing to process data, due to the large volume. At this time, I have calculated the viewsheds at 23 of the mounds, totaling 92 of the150 lidar scans. Preliminary data analyses suggest that viewsheds increase with duration of occupancy as expected

I plan on finishing data processing and analysis during the fall and will continue refining my manuscript for submission to a peer-reviewed journal (e.g., *Ecosphere)* in spring 2022.

Summary of Project Accomplishments

I spent 4 weeks at the field site where I assessed, selected, and collected data from 40 mounds. I learned how to collect lidar and habitat data. Also, I participated in data collection for another project, which provided me with additional field research experience, including trapping and handling pygmy rabbits, and using radio telemetry. When not in the field, I learned how to process lidar data and used the *viewshed3d* package to compute viewsheds. I also attended the Idaho Conference of Undergraduate Research and presented preliminary results of my research.

Summary of budget expenditures

Travel	$950
Stipend	$4,000
Total	**$4,950**

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Acknowledgement: I truly appreciate the generous support provided the State Board of Education/Higher Education Research Council 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/HERC, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Joshua Carey, Forestry and Sustainable Products, University of Idaho
Faculty Mentor: Lili Cai, College of Natural Resources, University of Idaho

Project Title: Effect of Lauric Arginate on the Growth and Morphology of Wood Decaying Fungi

Abstract

Bio-based preservatives represent one of the most promising solutions for next-generation wood protection due to their sustainability, low environmental impacts and comparable antimicrobial efficiency to current non-bio-based counterparts. Herein, we reported the effects on the growth and morphology of Lauric Arginate (LAE), a fully biobased antimicrobial compounds, against four common wood decaying fungi using a soil block test alongside a series of light and fluorescence microscopy observations. Wood cubes of poplar and pine were treated with different concentrations of LAE, and their weights recorded, they were then placed in a culture bottle containing a feeder strip of one of four test fungi (two white rot and two brown rot). These bottles were then incubated for eight weeks, and their weights recorded again. During the incubation period, a set of microscopy observations was conducted on test fungi that had grown from a malt agar media that had been amended with low levels of LAE. These experiments revealed that, while LAE does prohibit mass loss due to fungi in our pine samples, it does not in poplar samples. Furthermore, no significant morphological changes could be detected at the cellular level during a microscopy test.

Project description

Soil Block Test

Conducting a soil block test requires sample pieces to be cut into cubes measuring 14mm on each side, these cubes are cut out of two types of wood, a hard wood and a soft wood. For this experiment Southern Yellow Pine and Poplar were used as our test species. These cubes then had their oven-dry weight recorded before being treated with one of our three types of LAE (LAE 20, 2X and 25) each corresponding to a different concentration of lauric arginate that's suspended in the solution. After treatment the cube's wet weight is recorded and they are oven dried again to determine mas gain due to treatment. After acclimating back to relative humidity, the samples are ready to be placed in culture bottle for incubation. The culture bottles are constructed by being filled halfway with soil that has been autoclaved and sifted to remove any impurities they are then inoculated with feeder strips of one of our four test fungi and allowed a gestation period before our samples are introduced to allow for the fungi to take a foothold in its new eco system. In order to introduce the samples, simply place the cubes on top of the overgrown feeder strips and label the bottle. The assembled bottles need to be placed in an incubation chamber for eight weeks to allow the fungi to overtake the new material. After the incubation period the samples are removed from the bottle and cleaned of all fungi growing around the cube. The samples are then weighed again to determine their final mass loss and compare it to the control.

Microscopy analysis

All microscopy observation starts with the same structure for slide preparation, the main idea is to encourage the test fungi to grow off a piece of amended malt agar media and onto a microscope cover slide that can then be removed and transferred onto a clean slide and observed. In order to achieve this goal a specific construction was followed: inside of a petri dish a moist piece of filter paper is placed to provide water to the growing fungi, on top of that is a microscope slide resting on two slices of plastic netting to separate it from the filter paper, a square of amended malt agar media is placed on top of the slide which is then inoculated with test fungi by placing a small tuft of mycelium on each of the four side faces, finally a cover slide is placed on top of the malt agar square and the petri dish is sealed. After allowing the fungi to grow from the amended malt agar for a day or two depending on its rate of growth, the cover slide is removed and is either placed directly onto a clean slide or dyed beforehand depending on if the sample is to be used for light or fluorescence microscopy. These slides are then carefully recorded, and sample pictures are taken of the new growth tips that represent the morphology of the observed sample. These pictures are then carefully examined for key differences between the amended and control groups to shed light on LAE's effects on the fungi's morphology and how it may disrupt fungal growth.

Results and discussion

Upon reviewing the pictures taken during the microscopy trial, no clear morphological difference between the control fungi and the fungi that had grown off amended media. This could likely be due to the low concentrations of LAE that were used in the media, however when the concentration of LAE was increased no growth could be observed. These results lead to the conclusion that LAE is a fungistatic as opposed to a fungicide. The compound inhibits the growth of fungus without directly damaging any mycelium. Upon reviewing the results of the soil block test, the observed pine samples behaved as expected with a mass loss of 20% less than the control in the amended samples. However, the observed poplar samples saw an increase in mass loss of about 10% in the amended cubes. This could be caused by morphological differences between the two species of wood, or LAE's interaction with poplar once impregnated into the wood. Most likely, it is due to the preservative leaching from the poplar samples and into the soil.

Budget Information

- Provided by a USDA NIFA grant (~$1000)
    - Culture Bottles
    - Petri Dishes
    - Microscope Slides
    - 4000 ml beakers
    - Raw Poplar & Pine
- Caliper to measure the dimensions of the wood samples ($15.99)
- Parafilm to wrap the petri dishes ($168)
- Stipend ($4,000)

  TOTAL spent: $4,183.99

Acknowledgement

A special thanks to the Idaho State Board of Education/HERC for making all of this possible by providing funding via the SURF grant. It was a tremendous experience to be able to take part in, and without their support I would not be able to take part in this research.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Morgan Flynn, Movement Sciences, University of Idaho
Faculty Mentor: Chantal Vella, Professor, Dept. Movement Sciences, University of Idaho

Project Title: Associations between screen time and glycemic control in adults with and without type 2 diabetes

Abstract

PURPOSE: To assess the associations between screen time (ST) and glycemic control, as measured by glycated hemoglobin levels (HbA1c), in middle-aged to older adults with and without type 2 diabetes. **METHODS:** Adults (mean$\pm$SD: age: 47.5$\pm$17.4y, BMI: 29.5±7.4 kg/m^2) participated in the study. ST was subjectively measured through an 18-item screen-time questionnaire that categorized ST into weekday, weeknight, weekend, and background. Total sedentary behavior (SB) was subjectively measured using the Sedentary Behavior Questionnaire. A finger stick blood draw was completed to measure HbA1c. Participants completed a food frequency questionnaire online using the NIH Diet History Questionnaire III. Pearson correlation and linear regression analyses were used to assess the associations among the variables while controlling for age, sex, and dietary intake. **RESULTS:** Most participants were non-Hispanic white (80%), non-smokers (91%) and had family history of type 2 diabetes (43%). On average, participants spent 484.6 ±162.9 min·d^{-1} in SB (50% of the waking day). Of this time, 446.7 ± 168.4 min·d^{-1} were spent on a screen, with 45.0 ± 23.4 min·d^{-1} occurring during the weeknight. Participants engaged in background ST 111.1 ± 132.8 min·d^{-1}. Positive correlations ($p<0.05$) were found between HbA1c and weeknight ST (r= 0.409), and background ST (r=0.451). **CONCLUSIONS:** Participants spend large amounts of their day engaged in SB, which is consistent with national data. Moreover, of this time spent in SB, the majority is spent looking at a screen. Our preliminarily findings suggest that increased ST, particularly weeknight and background ST, is associated with higher HbA1c and risk of type 2 diabetes.

Project Report

Project Description

The aim of this project is to assess the associations between screen time and glycemic control, as measured by HbA1c. In addition, we hope to examine if these associations are different across healthy individuals in comparison to individuals with type 2 diabetes. We hypothesize that higher amounts of screen time will be associated with higher HbA1c, indicating worse glycemic control in both healthy and type 2 diabetic participants. We also hypothesize that excessive screen time may impact glycemic control of those with type 2 diabetes more than those who are healthy.

Previous studies have determined a childhood association between screen time and insulin resistance, with a paucity of data on this topic in adults. Children spending 3+ hours on a screen were found to have an increased resistance to insulin, which impacts glycemic control, in comparison to children spending only 1-2 hours on a screen (Nightingale, Rudnicka, Sattar, Cook, Whincup, & Owen, 2017). The importance of this proposed study is to determine whether various forms of screen time have a negative impact on glycemic control within an adult population. Moreover, having two participant groups, diabetic and non-diabetic, allows us to see if the associations between screen time and glycemic control vary among healthy and diseased individuals. For example, we will be able to determine if a given amount of screen time impacts glycemic control more in healthy or type 2 diabetic individuals. We can do this by looking at the slope of the relationship between screen time and glycemic control in each sample via statistical tests of interaction. For this study, we will also measure dietary intake and physical activity through surveys, as these factors can influence HbA1c. These findings will be significant in providing preliminary data to support recommendations for screen time reduction to decrease risk for future health complications.

Summary of Project Accomplishments:
Over the course of summer 2021, we have successfully recruited and completed data collection on 35 participants (13 men and 22 women), of which 26 were healthy controls, 4 had prediabetes, and 3 had type 2 diabetes. Unfortunately, there were not enough participants to look at differences in associations between healthy and type 2 diabetes participants so all participants were grouped together for analyses. The mean age and body mass index of our participants was 47.5 ± 17.4 y and 29.5 ± 7.4, respectively. Most participants were non-Hispanic white (80%), non-smokers (91%) and had family history of type 2 diabetes (43%). Our preliminary findings show significant correlations between screen time and HbA1c. By separating the type of screen use (e.g., weekday, weeknight, weekend, and background), we show a positive correlation between weeknight screen time ($r= 0.409$) and HbA1c. Moreover, background screen time ($r=0.451$) is also correlated with HbA1c. To better understand these associations, our regression analysis controlled for age, sex, and family history of type 2 diabetes. The associations between weeknight screen time and background screen time remained significant even with these variables controlled for ($p<0.05$). Comparatively, when we controlled for diet (total energy intake and total sugars), the associations, except the associations with background screen time, were reduced to non-significance ($p>0.05$). As a result, we see the impact that diet poses on glycemic control. Our preliminarily findings suggest that increased screen time, particularly weeknight and background screen time, is associated with higher HbA1c and risk of type 2 diabetes.

This SURF grant allowed me to develop hands-on skills needed to work as a research assistant. I've gained administrative experience in participant scheduling and data entry. Moreover, I was given the chance to run study visits, ranging from explaining questionnaires to collecting physical data such as height, weight, and finger-stick blood draws. Lastly, I furthered my knowledge in statistical analysis. While putting together my poster, I developed a better understanding of correlation and significance. All of which was due part to the large amount of group work put in to succeed. Not only did I meet with my supervisors to review what I wrote, but my public speaking abilities were put to the test. The different types of ICUR sessions allowed me to practice a variety of ways to present my research. With the support of my mentors and the funds from the SURF grant, my research abilities had flourished. As I continue my career in research, I will be able to thank all those who supported my undergraduate studies.

Summary of Budget Expenditures: The $1,000 provided for supplies was spent on supplies to collect blood samples and assay kits to measure HbA1c. This award included a $4,000 stipend. TOTAL: $5,000

Conference presentation: I presented a poster of my work at the UI Undergraduate Research Symposium in April 2017 and at the Idaho Conference on Undergraduate Research in July 2017.

Other Pertinent Information: This research project is a part of a larger study investigating the influence of physical activity, sedentary behavior, and diet on the gut microbiome and diabetic neuropathy. I will continue helping on this project through the fall.

Acknowledgement: I truly appreciate the generous support provided the State Board of Education in the form of an Undergraduate Research Grant 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 Research Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship - Summer 2021

Fellowship Recipient: Julianna Martin, Geological Sciences, University of Idaho
Faculty Mentor: Elizabeth Cassel, Department of Geology and Geography
Project Title: Recurrence Intervals of Glacial Lake Missoula Flooding Events Using Radiocarbon Dating

Abstract

The Great Missoula Floods were a series of cataclysmic floods caused by ice dam breakages on Glacial Lake Missoula during the late Pleistocene, 21,000 to 14,000 years ago. The periodic breaks and reformations of the Purcell Lobe of the Cordilleran Ice Sheet allowed floodwaters to move west following the Columbia and Snake rivers. These floods massively impacted the geomorphology and sedimentation of Idaho, Washington, and Oregon, creating the infamous Channeled Scablands of eastern Washington. The exact ages of these floods and the interval at which they occur are currently not well known, thus the drivers of these ice dam breakages have been loosely hypothesized. I sampled organic carbon from two locations to act as a source and sink record of the floods in order to date them, three samples were taken from each location to be dated. These samples were processed and pretreated in the Tectonics and Basin Analysis Lab on the University of Idaho campus but dating results have not yet been returned. By measuring stratigraphic sections in both Missoula lacustrine deposits and Pasco Basin flood deposits, flow properties of the floods dictate composition and layering of the sediment with sands followed my clays being indicative of a new flooding periods, giving us insight into the number of flood intervals between extracted samples. Once dates are returned, I will be able to correlate flooding periods to a paleoclimate record in order to establish any climatic drivers of ice dam breakage. Due to the timeline of my research, my presentation has been pushed back to October of 2021 and a final poster has not yet been constructed.

Project Accomplishments

1. Field training, procedurals, and preliminary data

Part of my project plan was to examine potential sampling locations based on the position of the glacial lake and flood deposits in the northwestern United States. I established the Glacial Lake Missoula lacustrine deposits in and surrounding Missoula, Montana, and flood deposits in the Pasco Basin, Washington as my primary sampling locations for field work. I also used this period to explore possible sampling techniques to maximize sample outputs and to limit modern carbon contamination.

2. Sample and data collection

Once at the field sites, I measured the stratigraphic section of each sampling location to establish water level changes and the introduction of new sediments via flooding events. In order to identify carbon within the deposits, I used hydrogen peroxide to react with any carbon present. Sampling was accomplished to minimize the amount of modern carbon contamination using nitrile gloves and storage in either plastic or glass containers. Other measures such as external sediment and root removal were used to limit the amount of contamination of modern carbon from the outcrops the samples were taken from.

3. Sample processing and pretreatment

I processed each sample in lab, extracting organic carbon and chemically pretreating them using an acid-base-acid reaction series as preparation for Carbon 14 lab testing through Kecks-CCAMS lab. Seventeen samples were extracted and processed, the best three from each sampling location were chosen for carbon dating based on their carbon content and stratigraphic location. Sample blanks and a date control sample were also prepared in the lab to be sent in with the original six samples.

Results

No official results will be found until C14 dating results are returned and analyzed. At that point I will use those dates to establish flood intervals and investigate possible climatic drivers for flooding events.

Summary of Budget Expenditures

Supplies:	**Cost**
Hydrogen peroxide (sampling)	$10
Potassium Hydroxide (pretreatment)	$30
Services:	
Carbon 14 Testing (6 samples)	$620
Subtotal (supplies)	**$660**
Stipend	**$4,000**
TOTAL	**$4,660**

Conference Presentation

Due to the timeline of my research and as I outlined in my proposal, I was in the field collecting data at the time of ICUR. I will be presenting at the UI College of Science Student Research Expo in October of 2021 and the UI Undergraduate Research Symposium in Spring 2022.

Acknowledgments

I would like to thank the State Board of Education/HERC for supporting undergraduate researchers like me via the Summer Undergraduate Research Fellowship. It has been a transformative learning experience that would not have been possible without the support of the SBOE. Thank you!

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Shalom Masango, Mechanical Engineering, University of Idaho
Faculty Mentor: Matthew Swenson, Mechanical Engineering, University of Idaho

Project Title: Evaluation of fatigue properties in rolled and formed aluminum sheet metal

ABSTRACT

Aluminum components manufactured from sheet metal are used in numerous applications including electronics enclosures. Due to the limited data for fatigue properties of aluminum, engineers who create structural designs using aluminum sheet metal and formed sheet metal components have less data. The goal of this research is to use the sheet metal fatigue testing equipment to identify the fatigue properties of both flat and formed aluminum sheet materials. The experiment involves a proper set up of the device including sample loading, dimensional setup and centering, force measurement, software programming, and cycling verification. Each experiment is expected to span for several days. As this occurs, sample preparation for subsequent tests and data analysis will occur in parallel. Five separate sample sizes will be conducted on both flat sheet metal samples and formed sheet metal specimens. From this equipment, fatigue properties (S-N curves) will be generated for Aluminum alloy 5052 for both flat and formed sheet metal. This study will provide a methodology that will be formed for ongoing research of alternative aluminum alloys and other sheet metal materials.

PROJECT DESCRIPTION

The goal for this research is to obtain S-N curves on both flat and formed aluminum sheet metal. A machine designed and made by former University of Idaho students is used during this process. This work was adopted from prior Capstone teams. Continuation of this topic was carried on due to limited data for fatigue properties of aluminum for engineers who create structural designs.

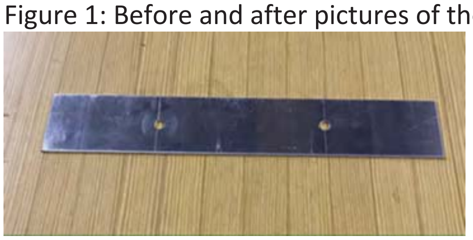
Method

1. Sample loading between rollers
2. Dimensional setup and centering of the rollers from 4.5 inches to 9 inches
3. Force measurement of the load cell
4. Software programming using Python and Raspberry Pi monitor
5. Cycling verification of the center rollers

Five separate samples were ran for each spacing. More runs would have been made if the number of cycles recorded for each run were not 15% within each other. The duration for the aluminum sheet metal to break ranged from 4 minutes to 60 hours. The machine does not have an automatic stop switch therefore it was not run overnight. In some cases, the machine ran overnight on the first day of sample loading as it would take more than 16 hours for the metal to break.

SUMMARY

Figure 1: Before and after pictures of the sheet metal after undergoing fatigue



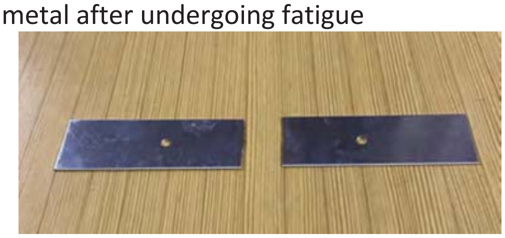


Figure 2: S-N curve for flat metal

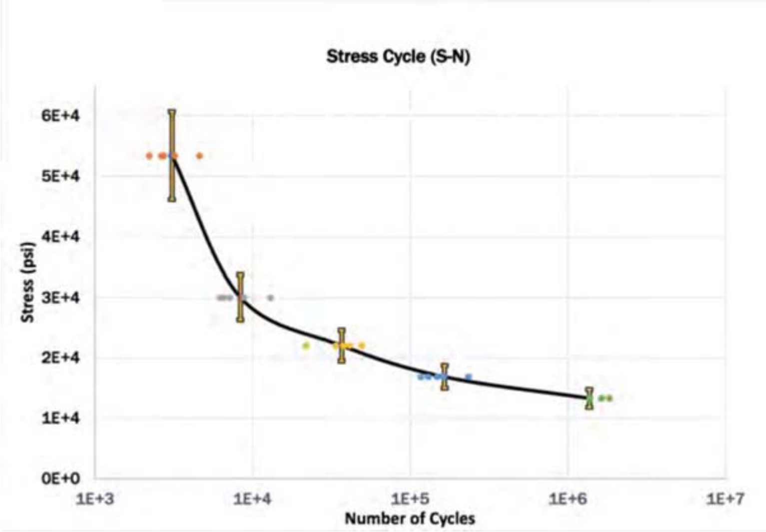
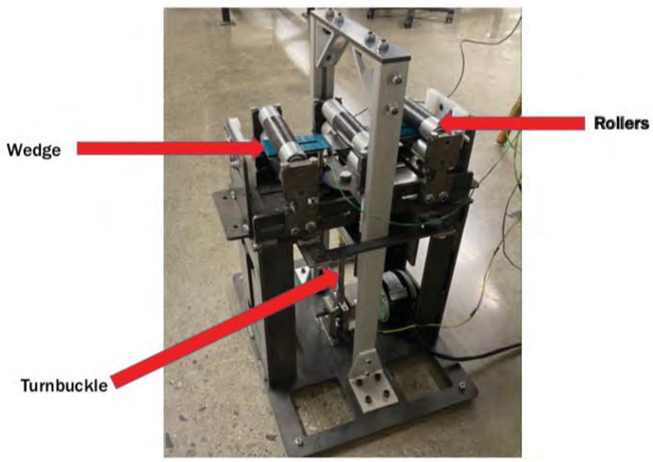


Figure 3: Stress Fatigue Machine



<u>Modifications</u>

A few modifications to the design were made for the break detection. A wedge was designed and 3D printed for a more visible separation when the metal breaks. All 6 rollers were wrapped with electrical tape to reduce conduction.

<u>Challenges</u>

Due to time constraints, there was little work done on the formed metal. It took a long time for the biggest spacings to break. A new turnbuckle was made from the machine shop for the formed metal and a durable wedge to hold the metal together.

Summary of Budget Expenditures:

Supplies:	**Cost**
Motor Drivers	$26.98
Sample Prep Supplies (Allied)	$342.60
PLA	$29.65
Sample Prep Supplies (UI ChemStores)	$50.52
Sample Materials	$74.52
Electrical Tape	$1.13
Stipend	**$4,000**
TOTAL	**$4,525.40**

Conference Presentation: I presented a poster of my work at the 2021 Idaho Conference on Undergraduate Research in July.

Acknowledgement: I am thankful for the financial support from the State Board of Education and Higher Education Research Council that made this Summer Undergraduate Research Fellowship from the Office of Undergraduate Research possible. Without this grant I would not be able to conduct this study. I am very thankful for the help from my mentor Dr. Matthew Swenson.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Lenah Matz, Movement Sciences, University of Idaho

Faculty Mentor: Joshua Bailey, Assistant Professor, Department of Movement Sciences

Project Title: The effects of Sure Squat on lifting mechanics for individuals with a history of resistance training and non-resistant training.

Abstract: Context: The occurrence of knee valgus, anterior pelvic tilt, and subsequent quadricep dominance while lifting can lead to injury and hindered performance. Historically, a lumbar assistive device can be used to correct lifting form and increase performance. However, the additional correction of knee valgus and resulting quadricep dominance could also aid in injury prevention and performance improvement. Objective: To investigate the effects of an external corrective lifting device on muscle activation patterns and movement mechanics. It is hypothesized that while wearing the corrective device, movement mechanics will change causing adjustments in muscle activation patterns. Methodology: 12 apparently healthy participants completed both sessions, 9 with a history of resistance training (at least 1 year of free-weight training) and 3 without a history of resistance training in the last year. Data collection consisted of two sessions: 1) consenting, screening, familiarization of the corrective device and establishment of 5 repetition maximum (5RM) for lifting tasks (BS: Back Squat; DL: Dead lift). 2) performance of 3 trials of each task at multiple intensities (Body weight, 50% 5RM, and 100% 5RM). Device condition order was counterbalanced with odd participants performing each task without the device first and even participants performed with the device first. During session two, twelve Delsys surface electromyography (sEMG) sensors were attached to six muscle bellies bilaterally: Rectus Femoris, Bicep Femoris, Adductor Longus, Gluteus Maximus, Gluteus Medius, and Erector Spinae groupings. Movement mechanics were assessed using an 8-camera Vicon motion capture system synced with two AMTI force platforms. Participants were additionally instrumented with a full-body passive reflective marker set to represent skeletal motion. To ensure accuracy between models, reflective markers representing the pelvis (L/R ASIS, L/R ILCT, L/R PSIS) were measured from the marked points on the ground to ensure similar placement between conditions. For the BS and DL conditions, foot positions were outlined on the force platforms to reduce influence of foot position on differences between conditions. Participants self-selected their grips and shoe ware and asked to maintain that choice through subsequent trials. Following the completion of all tasks in both device conditions, participants completed a questionnaire about their thoughts on the device. Conclusion: It appears from the initial data that those who were in the non-resistance training identified a benefit using the device. It is unclear whether there is a benefit in lifting mechanics due to the data still being processed. From participant self-perceived device-aid during a task non-resistance trained individuals reported an increased awareness of form while wearing the device.

Project Accomplishments:

1. Assessment of difference in perceived aid from correction between populations with and without a history of free-weight resistance training.
    a. This was accomplished through a survey administered after successful completion of session 2. A notable amount of participants reported a perceived performance aid from the external corrective device; additional participant responses reported satisfaction based on questions regarding comfort, donning and doffing, and perceived fit. Though the population without a history of free-weight resistance training reported varying perceptions on device-performance aid. Overall, from the free-response questions provided in the survey participants had mixed reviews on if *Sure Squat* helped them during the tasks.
2. Assessment of muscle activation pattern and magnitude differences, lower extremity and trunk kinematics, and lower extremity joint moments between conditions of with and without the external lifting device.

a. The muscle activation and the movement mechanic data are currently being processed. To assess the differences between device conditions, dependent t-tests will be conducted on all movement mechanic dependent variables. Muscle activation patterns will be assessed in terms of muscle activation onset and root mean squared values within phases of the tasks.

Summary of Budget Expenditures:

Item	Unit cost	Units	Total cost
Rogue 45lb Ohio power bar	$ 280.00	1	$ 280.00
Oso Magnetic Rogue Barbell Collars	$ 70.00	1	$ 70.00
210lb Rogue US-MIL Spec bumber	$ 435.00	1	$ 435.00
B&L engineering -double sided tape	$ 15.00	5	$ 75.00
B&L Engineering - shipping	$ 9.82	1	$ 9.82
Cover-roll	$ 10.75	5	$ 53.75
Leukotape	$ 13.90	5	$ 69.50
Stipend	$ 4,000.00	1	$ 4,000.00
TOTAL			$ 4,993.07

Conference Presentation: I presented this research in part at the Idaho Conference of Undergraduate Research (ICUR) in July 2021. I will also be presenting my work at the U of I Undergraduate Research Symposium in April 2022 and at the NW Biomechanics conference in April of 2022.

Acknowledgement: I truly appreciate the opportunities I received through the Summer Undergraduate Research Fellowship program supported by the Idaho State Board of Education and the Higher Education Research Council. Participating in this summer research project was a tremendous experience for me and one for which I am grateful. Without the support from the Idaho State Board of Education I would not otherwise have been able to have had this tremendous opportunity, thank you.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Gabriel Nelson, Materials Sciences, University of Idaho
Faculty Mentor: Mark F. Roll, Assistant Professor, Material Sciences Engineering, University of Idaho

Project Title: Synthesis of mesoporous silica nanoparticles for use in extrusion polymerization

Abstract- A polymer synthesis technique called extrusion polymerization uses mesoporous silica particles to crystalize polymers as they form. This technique circumvents postprocessing usually required to produce such materials. The goal of this project was to synthesize mesoporous silica particles using a variety of different techniques to study the effect of mesoporous silica nanoparticle structure on extrusion polymerization. Mesoporous silica nanoparticles were synthesized using TEOS and CTAB with the addition of structure directing salts. These salts produced structure variations that will lay the groundwork for variability in future extrusion polymerization experiments. Synthesized mesoporous silica was characterized using XRD.

INTRODUCTION

"Arrays of silica nanochannels (ASNCs) are ordered mesoporous silica particles with hexagonal prismatic shape.[1]" These ordered mesoporous silica particles are synthesized in a process called "liquid-crystal templating"[2] in which micellar rods self-assemble into an array of cylinders that become the template for silica that is introduced into the system. After the silica is attached, the organic templates are removed leaving ASNCs.

These ASNCs can be used to conduct a special kind of polymerization reaction called "extrusion polymerization." In this reaction, ASNCs act as a solid support for catalysts that drive polymerization reactions. Once a polymerization reaction is catalyzed this way the polymer will grow through the narrow channels of the ANSC which restricts the polymer's tendency to coil. This restriction produces extended polymer chains and, combined with the order created by the honeycomb structure of ASNCs, synthesizes crystalline polymer fibers.[3] This process circumvents the usual postprocessing steps, such as extrusion or spinning, usually needed to synthesize similar crystalline polymer fibers.[3]

The goal of this work was to synthesize highly ordered ASNCs using different preparation techniques to identify the effect of their structure on extrusion polymerization that will be conducted in future research. Syntheses were conducted with the addition of $CaCl_2$, $BaCl_2$, and TBABr that demonstrated varying effects on the structure of ASNC particles. These structural differences lay the groundwork for variability for future extrusion polymerization.

RESULTS AND DISCUSSION

Characterization

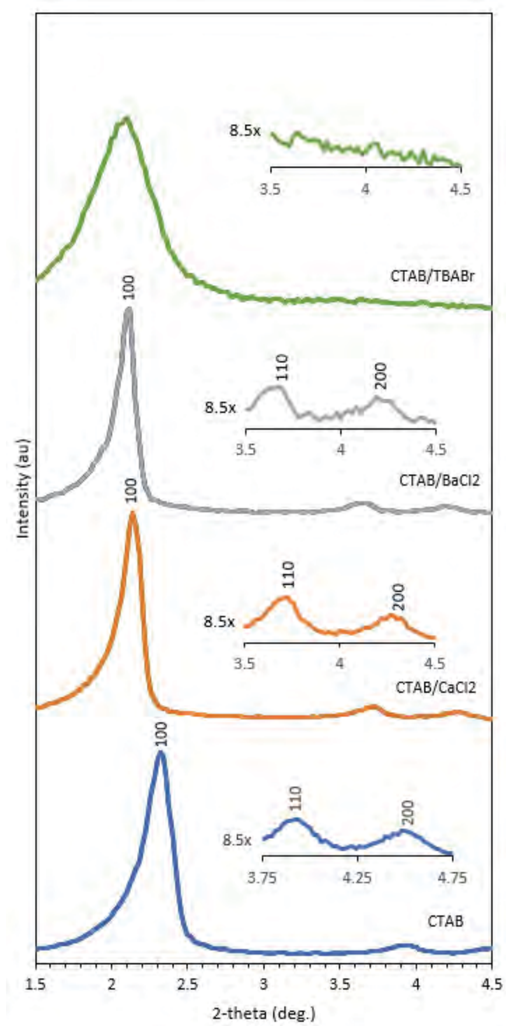


Fig. 1 XRD Patterns for uncalcinated ASNCs synthesized with CTAB/TBABr, CTAB/$BaCl_2$, CTAB/$CaCl_2$, and CTAB. Graphs are offset for clarity.

Powder X-ray diffraction powder patterns (Fig. 1) show 3 peaks that can be indexed to the (100), (110), and (200) reflections on a hexagonal unit cell. The pore center distance *a* was calculated using Bragg's law ($\lambda n = 2d\sin\Theta$) and eqn (1).[4]

$$\frac{1}{d^2} = \frac{4}{3}\left(\frac{h^2+hk+k^2}{a}\right) + \frac{l^2}{c^2} \qquad (1)$$

Table 1 Data derived from XRD

	d_{100} (nm)	*a* (nm)
CTAB	3.81	193
CTAB/$BaCl_2$	4.17	231
CTAB/$CaCl_2$	4.13	227

Effect of structure directing salts on yield

Reaction time and the presence of structure directing agents significantly impact the yields of ASNC synthesis. Syntheses with CTAB/$CaCl_2$, CTAB/$BaCl_2$, and CTAB/TBABr show greater yields overall. Additionally, longer synthesis times also have larger yields (Table 2).

Table 2 Yield Data

	Reaction time (m)	ASNC:surfactant yield ratio
CTAB	90	0.178
CTAB	240	0.247
CTAB/$BaCl_2$	95	0.344
CTAB/$CaCl_2$	95	0.320
CTAB/TBABr	97	0.171
CTAB/TBABr	160	0.280

EXPERIMENTAL

Recrystallization of CTAB

CTAB was recrystallized to remove impurities from the surfactant. A recrystallization procedure[5] was developed that recovered an average of 82.5% of the initial CTAB mass as crystals and performed equally efficiently at larger scales.

Synthesis of ASNCs

ASNCs were synthesized (with CTAB) using a procedure laid out by Zucchetto and Brühwiler. For a typical synthesis, recrystallized CTAB (4g, 11 mmol) was dissolved in a mixture of distilled H_2O (76mL, 4.2 mol) and hydrochloric acid (37%, 60 mL) by stirring for 10 min in an Erlenmeyer flask. Once the CTAB was fully dissolved in solution, a structure directing salt was added, stirred until dissolved, then filtered. The solution was cooled to 0°C in an ice bath for 30 min, followed by the slow addition of cold TEOS (2 mL, 9 mmol) and additional stirring for 30 s. The mixture was left at 0°C in the ice bath for 90 min then filtered and washed with H_2O. Amounts of 1.5g (13.5 mmol) of $CaCl_2$, 2.81g (13.5 mmol) of $BaCl_2$, and 9.67g (30 mmol) of TBABr were used in the syntheses as structure directing salts. $CaCl_2$ took 25 minutes of stirring to fully dissolve into the mixture while the mixture had to be heated and stirred for ~10 minutes to dissolve the $BaCl_2$ and TBABr. Additional experiments were conducted in which the reaction was left in the ice bath for up to 4 hours.

During the reaction the mixture progressively gets milkier until solid precipitates begin to fall out of the solution and onto the bottom of the flask. Initially, the reactions were filtered directly after they were taken out of the ice bath; however, more precipitates formed in the filtration waste overnight and were collected again. Further analysis is required to determine if these secondary precipitates are structurally different from the ASNCs acquired in the initial filtration.

FUTURE WORK

The second half of the research still needs to be conducted. The two major experiments that remain are attaching polymerization catalysts to lab synthesized ASNCs and conducting extrusion polymerization reactions using lab synthesized ASNCs. Analysis will be done to identify catalyst attachment along with material analysis of polymers synthesized with the ASNCs. Anticipated characterization techniques are XRD, GPC, NMR, electron spectroscopy, and DSC.

ACKNOWLEDGEMENTS

This work was supported by the Idaho State Board of Education in the form of a Summer Undergraduate Research Fellowship and included $1,000 for project related expenses and a $4,000 student stipend.

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3 Keisuke Kageyama, Jun-ichi Tamazawa and Takuzo Aida, Extrusion Polymerization: Catalyzed Synthesis of Crystalline Linear Polyethylene Nanofibers Within a Mesoporous Silica. *Science* 285 (5436), 2113-2115.

4 Suryanarayana C., Norton M.G. (1998) Crystal Structure Determination. II: Hexagonal Structures. In: X-Ray Diffraction. Springer, Boston, MA. https://doi.org/10.1007/978-1-4899-0148-4_5

5 For the recrystallization process CTAB (2g) was dissolved in heated methanol (6 mL). This solution was slowly added to ethyl acetate (75 mL) that had been heated to the point where it just started bubbling. Once fully dissolved, the solution was removed from heat and left to sit overnight so CTAB would crystallize out. Filtered and washed with ethyl acetate.

6 Björk, Emma M. Synthesizing and Characterizing Mesoporous Silica Sba-15: A Hands-on Laboratory Experiment for Undergraduates Using Various Instrumental Techniques. *J. Chem. Educ.* 2017, 94, 1, 91–94 doi:10.1021/acs.jchemed.5b01033.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2021

Fellowship Recipient: Riley Parr, Chemistry, University of Idaho
Faculty Mentor: Dr. Mark Roll, Assistant Professor, Department of Material Science and Engineering
Project Title: Stereospecific Emulsion Polymerization of Isoprene

Background: The United States synthetic rubber program is a significant historical and scientific event that took place from 1939-1945. At the beginning of World War II, the natural supply of rubber was cut off from Southeast Asia. The United States and its allies had to come up with a solution to this very quickly as much of the infrastructure in these countries depended on rubber. In addition to this, the U.S., and other militaries required huge amounts of rubber to build new vehicles and equip their soldiers. This made designing synthetic rubber one of the top priorities of scientists around the world. During this six-year time period several companies and thousands of scientists were able to design a general-purpose synthetic rubber called GR-S rubber and manufacture enough of this rubber to meet the needs of the U.S. and its allies. GR-S rubber is still one of the most used rubbers today. (American Chemical Society, 1998)

Intro: GS-R rubber is synthesized by copolymerizing emulsions of styrene and butadiene. This process is called emulsion polymerization and it is the same process that is being used in the Roll lab to make rubber. The connections between the polymer chains can be altered, this is known as stereoregularity. These stereospecific polymerizations are important because only one well defined backbone is produced. This means that the material properties of the rubber can be altered depending on which functional groups are added to change the geometries. (Hill, McDonald, and Roll, 2021)
The goal of this project is to lower the glass transition phase, reexamine the GR-S catalyst system using the cationic surfactants, and analyze the stereochemistry (cis vs. trans) Synthetic rubber works for a lot of the applications of natural rubber, but it is falters in terms of stereochemistry and molecular weight. Specifically, it does not have the ideal chemical structure, and the molecular weight is significantly lower than we'd like it to be.
Surfactant is a contraction for "surface active agent" This is a molecule that lowers the surface tension of a liquid, or the interfacial tension between two liquids. (Britannica, 2020). An emulsion (figure 1) is a mixture of two liquids that are normally immiscible by dispersing the lesser of the two liquids among the other liquid. An example of this would be oil and water, and emulsions usually become opaque even if the two liquids are clear. In an emulsion the monomer (isoprene in our case) becomes surrounded by the surfactant and creates what is called a micelle (figure 2). When the initiator (hydrogen peroxide) is added, these micelles polymerize the monomer within them and create polyisoprene

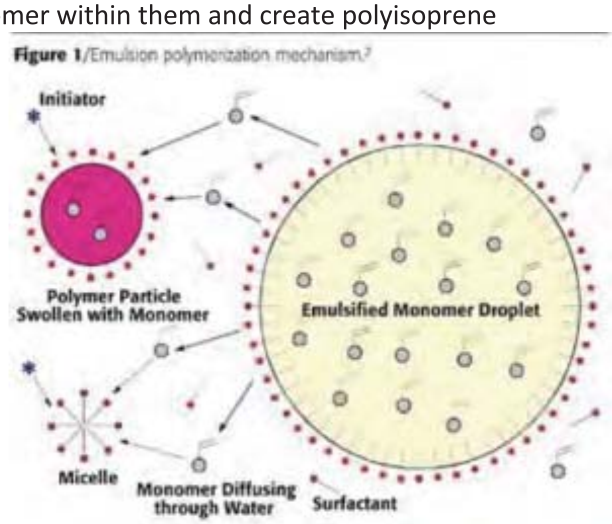


Figure 1

Experimental Procedures

Recrystallization of Cetyltrimethylammonium bromide (CTAB)

The recrystallization ratio is 2g CTAB/ 4.5g methanol/ 75 mL ethyl acetate

1. Heat the ethyl acetate (75 mL) until bubbles start to appear.
2. Put the CTAB (2g) in a small beaker and slowly drop in methanol while stirring and heating until the solution turns clear (should require ~6 mL methanol).
3. When the ethyl acetate solution begins to bubble, slowly add the CTAB/methanol solution to the ethyl acetate using a pipette.
4. Allow the solution to stir and heat for a little bit longer, then remove from hotplate, cover with tinfoil, and let sit overnight (or until the CTAB has fully crystallized out).
5. Vacuum filter the solution to separate the CTAB crystals from the ethyl acetate.
6. Place CTAB crystals in vacuum pump to remove remaining ethyl acetate.

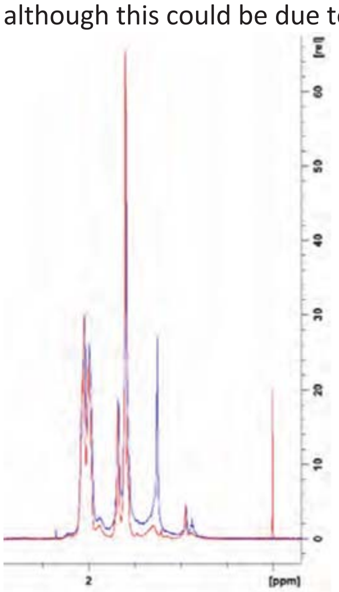
Emulsion Polymerization of Isoprene

First make a surfactant solution by mixing 1.5g CTAB, 1.5g sodium pyrophosphate, 0.125g ferric sulfate, and 50g water. Sonicate this solution prior to use to de-gas it. Prepare the isoprene by adding barium oxide as a desiccant, and then filter this out with a filtered drip pipette.
To start the emulsion polymerization reaction, mix the surfactant solution, the isoprene and hydrogen peroxide in the following ratio:

5mL isoprene:10mL surfactant solution:0.2mL hydrogen peroxide

3.405g isoprene:10.625g surfactant solution:0.222g hydrogen peroxide

Then allow this to stir and react overnight.
When the reaction is complete, precipitate the polyisoprene in methanol and then filter out the solids.
When the isoprene polymerization reaction had finished, it was precipitated in methanol and then vacuum filtered and weighed. A small amount of the polyisoprene was left stuck on the sides of the reaction vial. This will have slightly influenced the reported yield values as some of the material was left behind. The polyisoprene resisted dissolving in methanol, limonene and chloroform, however it did dissolve in toluene. This allowed us to remove the leftover material from the reaction vials.
We attempted to use a few different surfactants for the polymerization of polyisoprene, but only CTAB has worked so far. In addition to CTAB, we also used Tetrabutylammonium Bromide (TBABr) and didecyldimethylammonium bromide (DDABr). The TBABr did not create an emulsion with the isoprene and was therefore unable to polymerize. And the DDABr did not fully dissolve in the surfactant solution, although this could be due to impurities in the DDABr from the manufacturer.



To the left is the NMR spectra of the Polyisoprene that was synthesized in the roll lab using the CTAB method (blue) against the NMR spectra of Polyisoprene that had been previously synthesized. As you can see, the spectra very closely match, meaning we have created a polymer that has the ideal structure that we are looking for.

Budget: Approximately \$250 was spent on safety equipment, including gloves, and coats; \$225 was spent on laboratory reagents, catalysts and solvents; \$75 was spent on miscellaneous parts and supplies; and \$450 was spent on purchasing monomers for polymerization and their precursors. This fellowship included a \$4,000 stipend. TOTAL: \$5,000

Acknowledgement: I truly appreciate the support provided by the State Board of Education/HERC that allowed me to carry out research this summer. This has been a summer of huge growth for me, and it would not have been possible without support from the SBOE/HERC. Thank you so much!

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Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2021

Fellowship Recipient: Danielle Yama, Biological Sciences, University of Idaho
Faculty Mentor: Paul A. Rowley, Professor, Department of Biological Sciences

Project Title: The Investigation of the Suicidal Phenotypes of K1 "Killer Toxin" Truncations in *Saccharomyces cerevisiae*

Abstract: Common antifungal treatments such as fluconazole or miconazole are becoming less effective in treating fungal infections. The diminishing efficiency of such treatments is due to fungal pathogens developing an increased resistance to antimycotic drugs. Therefore, the use of antifungal "killer toxins" has become a recent focus of research in understanding how to combat these fungal infections in place of current antimycotics. This project examined the lethal effects of the K1 toxin to provide a better understanding of the K1 mechanism of action against fungi. K1 is a heterodimeric protein which consists of two different polypeptide chains: "alpha" (α) and "beta" (β) which are linked by a single disulfide bond. It has been previously reported that the isolated α-domain of the K1 toxin (K1-α) is able to cause cell death when ectopically expressed by yeast cells. We have confirmed this phenotype by first cloning and then expressing the isolated K1-α domain in *Saccharomyces cerevisiae* using a galactose-inducible expression plasmid. This caused lethality when cells were grown on galactose media which induced the expression of K1-α. To understand the host proteins that are important for K1-α lethality, the systematic gene deletion collection library of non-essential genes in *S. cerevisiae* is now being screened for suppressor mutants. We have identified clones that appear to be resistant to K1-α expression and are in the process of identifying the gene deletions. This will lead us to a better understanding of the mechanism of action of the K1-α toxin and why it is cytotoxic to yeasts.

Project Accomplishments

1. One of my goals was to determine which genes in *Saccharomyces cerevisiae* that when knocked out, would cause resistance to K1-α.

The yeast genome deletion collection library consists of strains of S. cerevisiae, each of which has a single non-essential gene that has been knocked out. When transforming this deletion collection library with the lethal construct, K1-α, I was able to find suppressor mutants that were resistant to this construct. By using the barcodes present in each strain from the deletion collection library, I was able to determine what those genes were that were knocked out.

Results: Some of the gene knockouts that were identified and confirmed played roles in salt tolerance, functions as components of the nuclear pore complex, degradation of cyclin-dependent kinase PHO85, DNA binding, transcription, and control of transcription factors.

2. Generate K1-[SS]α lethal construct which includes a galactose inducible plasmid, URA3 marker, and K1-[SS]α gene.

I had successfully cloned the K1-[SS]α gene, but I am currently undergoing the process of creating the pCR8 vector which would include the K1-[SS]α gene as well as the URA3 marker and a galactose inducible plasmid. My goal is to confirm the lethality of this construct so that I will be able to use it to transform the entire genome deletion collection library with K1-[SS]α using the same processes that I used when working with K1-α. I have not generated any results yet for this part of the project since I must still confirm that what I've generated is a lethal construct.

3. Determine which genes in Saccharomyces cerevisiae that when knocked out, would cause resistance to K1-[SS]α.

My goal is to transform the entire genome deletion collection library with K1-[SS]α and determine if there are mutants that are resistant to K1-[SS]α. I plan to begin this process once I've generated the lethal construct that includes the K1-[SS]α gene.

4. Compare the mechanisms of action of K1 toxin domains K1-α and K1-[SS].

I plan to compare the mutants that are resistant to K1-α to those mutants that are resistant to K1-[SS]α. This will show insight into the differences in the mechanisms—if there are any—between the two different constructs and provide us with a better overall understanding of the K1 killer toxin.

Summary of Budget Expenditures

Supplies	**Cost**
Primers	$123.20
UltraFlux SnapStrip, PCR Tube, 8-strip 0.2mL	$79.44
Trichloroacetic acid, BioXtra	$44.05
Aspirating Pipet, 2mL capacity, polystyrene, PK 400	$144.80
Nitrile Gloves	$123.31
Antifungal for transformations	$201.00
Bleach and PEG	$113.62
Gel run purple ladder and restriction enzymes	$111.04
Subtotal Supplies	$940.46
Stipend	$4,000.00
Total	$4,940.46

Conference Presentation: I presented a poster of my project at the 2021 Idaho Conference on Undergraduate Research (ICUR) and will also present my work at the U of I Undergraduate Research Symposium in April of 2022.

Acknowledgements: I acknowledge and greatly appreciate the support that was provided by the State Board of Education and Higher Education Research Council as well as the University of Idaho Office of Undergraduate Research in the form of a Summer Undergraduate Research Fellowship (SURF). I was able to gain valuable insight and experience in conducting research through this opportunity. Presenting at ICUR was also an incredible experience for me. The Office of Undergraduate's support and that of the State Board of Education made this project and experience possible and is something I greatly appreciate and am thankful for.

University of Idaho
College of Science

Antifungal Killer Toxin Production by Opportunistic *Candida glabrata*

Jeffrey T. Badigian, Lance R. Fredericks, Mark D. Lee, and Paul A. Rowley
University of Idaho Department of Biological Sciences, University of Idaho, Moscow, Idaho, USA

Candida glabrata and Killer Toxins

Candidiasis affects ~150 million people annually; *Candida glabrata* has recently emerged as the second most common cause of this illness, afflicting ~28 million people[1]. *C. glabrata* has been known to produce antifungal killer toxin proteins that inhibit the growth of competing fungi. The origin of these toxins in *C. glabrata* is unclear and could be either genomic, or via dsRNA viral satellites with help from a coinfecting dsRNA Totivirus[4]. **This work aims to elucidate the origins and activity of killer toxins in *C. glabrata*.**

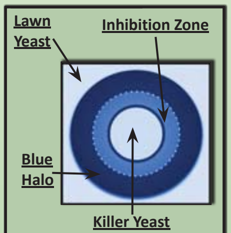

Figure 1. A diagram of a killer assay.

Killer Screening

Killer toxin production was screened for in 133 *C. glabrata* isolates using 25 yeast lawns (Figure 1). 18 *C. glabrata* isolates (13.53%) exhibited killer toxin activity, 16 of which were clinically isolated (Figure 2).

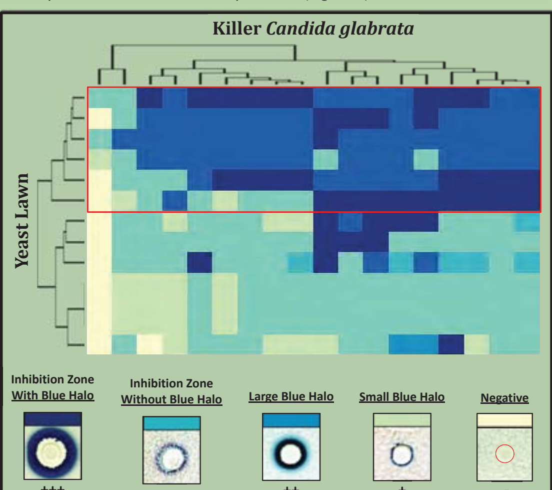

Figure 2. A cluster diagram showing only the killer *C. glabrata*, sensitive lawns, and degree of sensitivity each lawn has to the toxin. The red box illustrates the 6 most closely genetically related yeast lawns to *C. glabrata*; namely *Candida nivarensis, Candida castellii, Nakaseomyces delphensis* X2, *Nakaseomyces bacillisporus*, and *Kazachstania spencerorm*.

Viral Screening

To determine if the toxin is virally encoded, a dsRNA extraction searching for the dsRNA satellites and totivirus was attempted on select killer *C. glabrata*; the positive control *Saccharomyces cerevisiae* YJM1307 was included. All isolates tested negative for viral infection, including type strain *C. glabrata* CBS 138 (Figure 3).

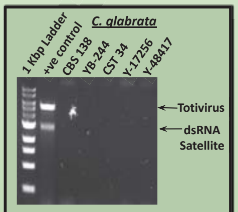

Figure 3. Results from attempted *C. glabrata* dsRNA extraction.

Killer Toxin Genomic Search

Four homologs to a *Saccharomyces* K62 toxin were identified within the *C. glabrata* genome[3]. PCR diagnostics was used to determine which isolates contained these homologs which have been temporarily named K62-like toxins (Figure 4).

Killer *Candida glabrata*

K62L Homolog	WSCI 20	WSCI 21	WSCI 22	WSCI 24	WSCI 25	WSCI 26	WSCI 33	WSCI 36	WSCI 51	AR0323	AR0328	AR0334	ATCC 2001	CBS 138	CST 34	Y-17256	Y-48417	YB-244	BG2
Gene A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Gene B	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gene C	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gene D	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-

Figure 4. A table describing the K62-Like homolog prevalence in killer *C. glabrata* isolates and non-killer *C. glabrata* BG2. The negative control *S. cerevisiae* BY4741 was used.

Protein Expression

Two of the K62-like homologs were cloned into a non-killer yeast strain *S. cerevisiae* BY4741. Both clones ectopically expressed an active killer toxin, indicated by the methylene blue zones (Figure 5).

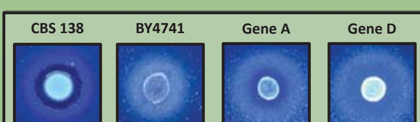

Figure 5. Killing activity of the ectopically expressed homologs, the killer yeast *C. glabrata* CBS 138, and the non-killer *S. cerevisiae* BY-4741.

Killer Toxin Structure Modeling

Secondary structure modeling using PHYRE suggests that this *C. glabrata* K62-Like toxin is an aerolysin-like toxin; toxins known to be cytotoxic to humans, and are known virulence factors for human pathogens (Figure 6). These toxins are secreted as monomers that bind a target cell membrane, undergo a conformational change, and oligomerize to create the final pore forming toxin[2].

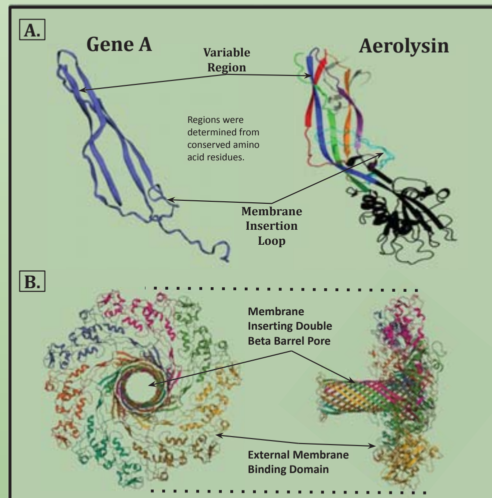

Figure 6. A.) 3D PHYRE results of a K62-Like homolog compared to the determined Aerolysin monomeric structure (PDB 1PRE). B.) The final aerolysin pore forming heptamer with each color indicating the placement of each monomer (PDB 5JZT).

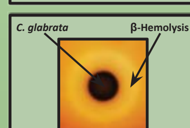

Figure 7. *C. glabrata* exhibiting hemolytic activity[5].

C. glabrata isolates have been previously shown to cause hemolysis when screened on acidic media at pH 5.6[5] (Figure 7). When we screened at pH 7.2, there was no evidence of hemolytic activity, suggesting limited cytotoxicity of these proteins to human cells.

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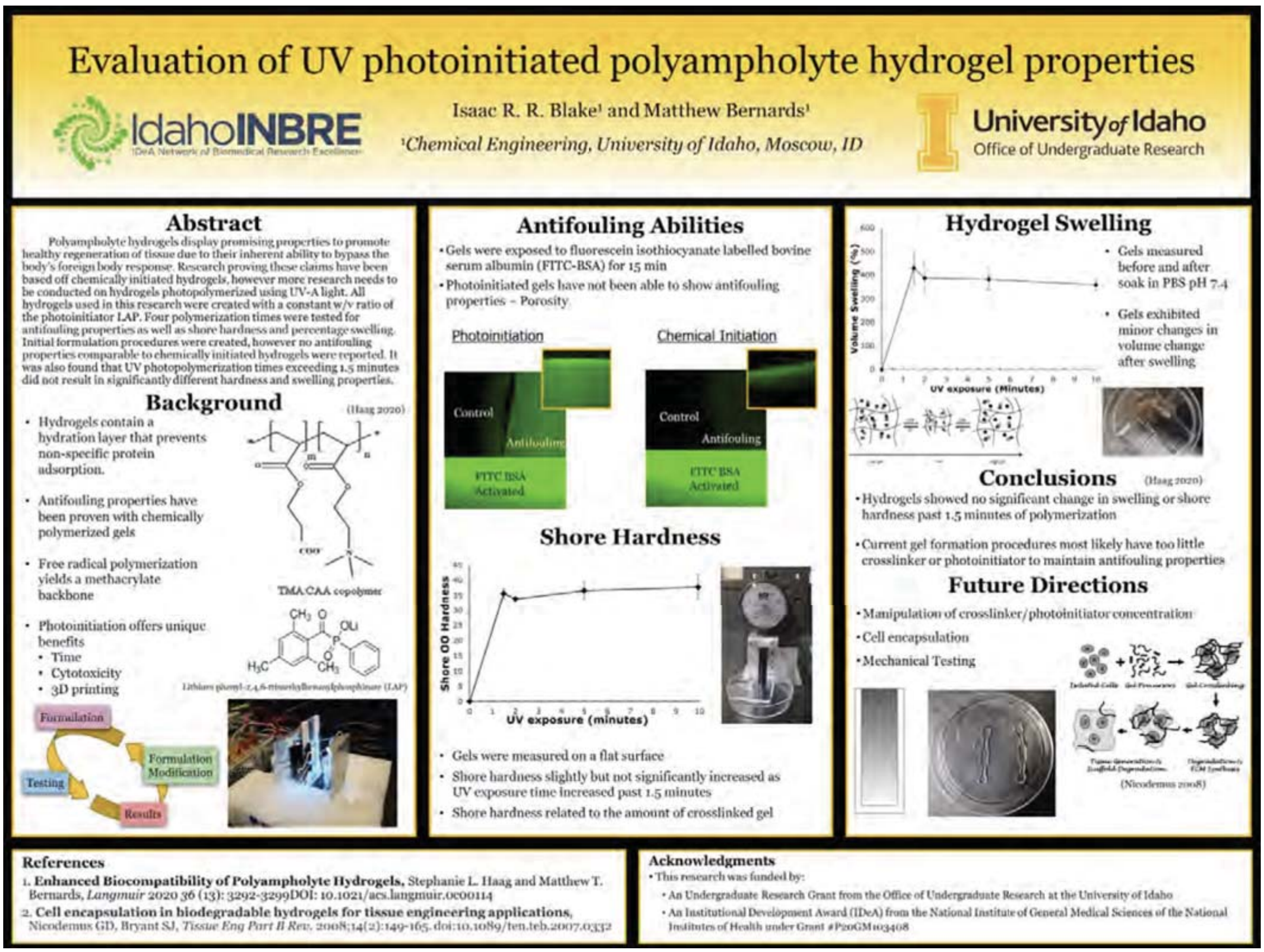
Funded by the University of Idaho College of Science Office of Undergraduate Research


Evaluation of UV photoinitiated polyampholyte hydrogel properties
IdahoINBRE
Isaac R. R. Blake1 and Matthew Bernards1
1Chemical Engineering, University of Idaho, Moscow, ID
University of Idaho
Office of Undergraduate Research
Abstract
Polyampholyte hydrogels display promising properties to promote healthy regeneration of tissue due to their inherent ability to bypass the body's foreign body response. Research proving these claims have been based off chemically initiated hydrogels, however more research needs to be conducted on hydrogels photopolymerized using UV-A light. All hydrogels used in this research were created with a constant w/v ratio of the photoinitiator LAP. Four polymerization times were tested for antifouling properties as well as shore hardness and percentage swelling. Initial formulation procedures were created, however no antifouling properties comparable to chemically initiated hydrogels were reported. It was also found that UV photopolymerization times exceeding 1.5 minutes did not result in significantly different hardness and swelling properties.
Background
(Haag 2020)
• Hydrogels contain a hydration layer that prevents non-specific protein adsorption.
• Antifouling properties have been proven with chemically polymerized gels
• Free radical polymerization yields a methacrylate backbone
• Photoinitiation offers unique benefits
• Time
• Cytotoxicity
• 3D printing
TMA CAA copolymer
Formulation
Formulation Modification
Testing
Results
Antifouling Abilities
• Gels were exposed to fluorescein isothiocyanate labelled bovine serum albumin (FITC-BSA) for 15 min
• Photoinitiated gels have not been able to show antifouling properties – Porosity
Photoinitiation
Chemical Initiation
Control
Antifouling
FITC BSA Activated
Shore Hardness
Shore OO Hardness
UV exposure (minutes)
• Gels were measured on a flat surface
• Shore hardness slightly but not significantly increased as UV exposure time increased past 1.5 minutes
• Shore hardness related to the amount of crosslinked gel
Hydrogel Swelling
Volume Swelling (%)
UV exposure (Minutes)
• Gels measured before and after soak in PBS pH 7.4
• Gels exhibited minor changes in volume change after swelling
Conclusions
(Haag 2020)
• Hydrogels showed no significant change in swelling or shore hardness past 1.5 minutes of polymerization
• Current gel formation procedures most likely have too little crosslinker or photoinitiator to maintain antifouling properties
Future Directions
• Manipulation of crosslinker/photoinitiator concentration
• Cell encapsulation
• Mechanical Testing
(Nicodemus 2008)
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Acknowledgments
• This research was funded by:
• An Undergraduate Research Grant from the Office of Undergraduate Research at the University of Idaho
• An Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under Grant #P20GM103408

Effect of Lauric Arginate on the Growth and Morphology of Wood-Decaying Fungi

Josh Carey, Courage Alorbu, Lili Cai
Department of Forest, Rangeland and Fire Sciences, University of Idaho, Moscow, ID 83844, USA

ICUR USDA NIFA University of Idaho

Introduction

- Products used to make lumber rot-resistant serve one main purpose, to stop bacterial and fungal growth to prevent contamination of a structure. This can drastically increase the lifespan of a structure and preserve its structural integrity.
- Most common products that are used for this purpose are copper or arsenic based witch can cause negative heath and environmental effects to those in close contact.
- LAE is a non-toxic anti-microbial compound that's been rated safe for human consumption.
- LAE is used in hundreds of products across the country for its anti-microbial properties including food packaging, cosmetics, and dental products.
- We believe that LAE could serve as a replacement for the potentially toxic wood preservatives that are commonly used today.

Malt Agar Test Method

Malt agar dishes amended with 3,6,9,12 and control inoculated with test fungi → Photos taken every 48 Hours for 14 days → Area calculation using ImageJ software

Figure 1: Flowchart of malt agar test method

Microscopy Method

Figure 2: Diagram of a prepared microscopy sample

- All replicates were constructed as seen to the left
- After a growth period all cover slides were removed and transferred to a clean slide to be observed.

Fungal Area Growth

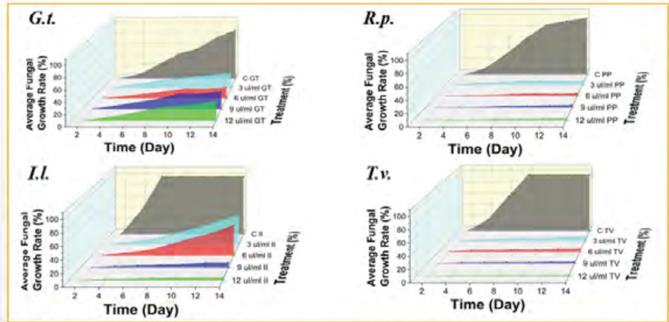

Figure 3: 3D line graph depicting the area growth of test fungi over a two-week period. This was obtained by charting the area from the pictures taken during the growth period. The data was then separated by species and charted.

Microscopy Pictures

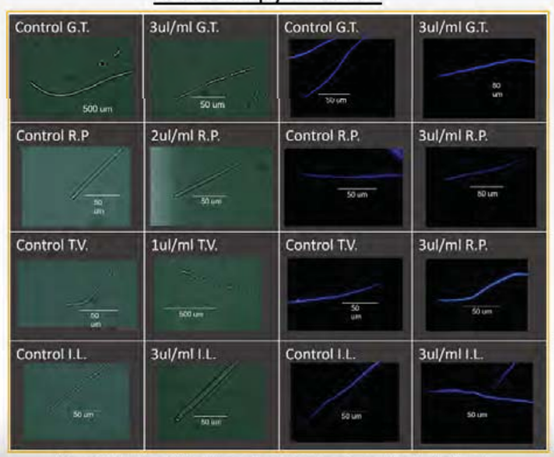

Figure 4: A selection of photos taken under a microscope of amended and control fungal groups.

Malt Agar (14 Day Samples)

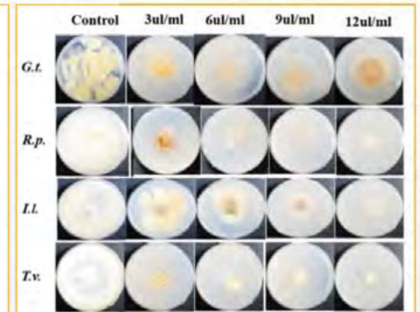

Figure 5: A selection of pictures taken during the growth period that we felt best represented the growth of each fungi across all concentrations of LAE.

Results

- I.L., R.P., and T.V. all experienced over a 90% drop in area between the control and 12ul/ml groups
- G.T. only saw a 68% drop in area coverage
- No significant morphological change could be detected between a control and amended fungal culture in either a light or fluorescence microscopy test.

Conclusion

- LAE has proven effective at limiting the growth of 3 out of 4 test fungi
- GT is more resistant than other fungi
- In areas where brown-rot fungi are more common LAE may not be an ideal wood preservative
- More experimentation needs to be done to determine if LAE is effective when impregnated into wood.

Acknowledgements

Funding Provided by the University of Idaho Office of Undergraduate research SURF grant.

University of Idaho

Unexpected properties of habitat altered by an ecosystem engineer: A pygmy rabbit case study

Sarah Burgett, Rachel Stein, Janet Rachlow
University of Idaho, Department of Fish and Wildlife Sciences, College of Natural Resources

Introduction

- **Ecosystem Engineers** are species that influence availability of resources by physically altering the environment[1].
- By burrowing, browsing, and defecating, pygmy rabbits (*Brachylagus idahoensis*) modify the vegetation structure of the sagebrush-steppe ecosystem[2] thereby altering habitat properties including concealment and visibility.
- Vegetation structure can provide concealment but also reduce visibility, which changes the range at which visual information can be gathered[3].
- Visibility can be quantified by estimating the **viewshed**, which describes all the accessible sightlines and their spatial extents[4].
- No studies have investigated how ecosystem engineers might influence viewsheds within the landscapes they inhabit.

Objectives and Hypotheses

Objectives:
1) Quantify both visibility and concealment around burrow systems used by pygmy rabbits.
2) Evaluate how duration and intensity of use by rabbits affect visibility and concealment around burrow systems.

Hypotheses:
1) Pygmy rabbit activity alters viewsheds around their burrow systems.
2) Because rabbits spend more time close to burrows, their affect on viewsheds will increase with greater proximity to burrow entrances.

I predict that viewsheds will be:
1) greater at occupied versus unoccupied habitat patches;
2) positively correlated with duration of burrow occupancy; and
3) more extensive close to burrow entrances.

Figure 1. A) Location of my study site, Cedar Gulch (~130 ha), in the Lemhi Valley in eastern Idaho. B) Photo of the sagebrush vegetation at the study site.

Methods

- Estimate **duration of burrow occupancy** (4-20 years) using annual census data collected at the study site (Fig. 1) and select occupied (n = 30) and unoccupied (n = 10) patches for sampling.
- Quantify habitat structure using a **terrestrial laser scanner** at the burrow and at three randomly selected sites per patch.
- Estimate **viewsheds** using the R package, ***viewshed3d***[5].
- Measure **concealment** using **image classification** (Fig. 3).
- Collect other measurements (size of the habitat patch, number of seedlings at sites, and sagebrush heights) as potential covariates.

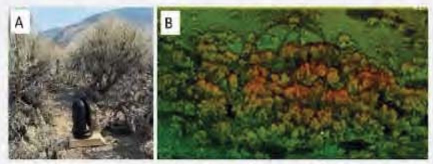

Figure 2. A) Terrestrial laser scanner in the sagebrush-steppe. B) A lidar point cloud of sagebrush vegetation on a mima mound gathered by a terrestrial laser scanner.

Figure 3. A) Red sphere that approximates the size and shape of a pygmy rabbit (B) used to estimate concealment via image analysis that quantifies the percent of the sphere obstructed in a photo.

Preliminary Results

- Classified duration of burrow occupancy into 3 categories (4-6, 7-9, and 10-20 years).
- Collected and analyzed data from 23 of 40 patches to date.
- Burrows of intermediate duration of occupancy (7-9 yrs) had the highest mean viewshed values (Fig. 4).
- The means (+ SD) of the 3 categories were: 4-6yrs: **260.2** (± 21.0); 7-9yrs: **296.9** (± 22.7), and 10-20yrs: **275.2** (± 30.3).
- Field work will be completed during July, and data analyses are ongoing.

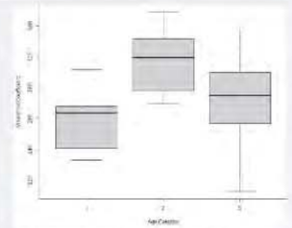

Figure 4. Box plot showing preliminary results of visibility measured as the viewshed coefficient at burrows occupied by pygmy rabbits for differing durations: Category 1= 4-6yr, Category 2 = 7-9 yr, and Category 3 = 10-20 years (n = 23 burrows).

Next Steps

- Once all the data have been collected and processed, I will analyze it to determine if and how pygmy rabbit activity alters the viewsheds around their burrows.
- I will analyze how visibility changes with respect to distance to the closest burrow and duration of occupancy simultaneously.
- In addition, I will analyze how concealment changes with my predictor variables.
- I will prepare a manuscript for submission to a peer-reviewed journal that explores this ecosystem engineering behavior.

Acknowledgements

Thank you to the **Office of Undergraduate Research at the University of Idaho** for funding this project.

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ASSOCIATIONS BETWEEN SCREEN TIME AND GLYCEMIC CONTROL IN ADULTS WITH AND WITHOUT TYPE 2 DIABETES

MR Flynn, OB Balemba, R Geidl, CA Vella
Exercise Physiology Research Laboratory, Department of Movement Sciences, University of Idaho

Abstract

PURPOSE: To assess the associations between screen time (ST) and glycemic control, as measured by glycated hemoglobin levels (HbA1c), in middle-aged to older adults with and without type 2 diabetes. **METHODS**: adults (mean±SD: age: 49.1±18.4y; 70.8) participated in the study. Screen time was subjectively measured through an 18-item screen-time questionnaire. Total sedentary time was subjectively measured using the Sedentary Behavior Questionnaire. A finger stick blood draw was completed to measure HbA1c. Participants then completed a food frequency questionnaire online using the NIH Diet History Questionnaire III. Pearson correlation analyses were used to assess the simple and partial associations among the variables while controlling for age, sex, and dietary carbohydrates. **RESULTS**: The majority of participants were non-Hispanic white (88%), non-smokers (88%) and had family history of Type 2 diabetes (46%). On average, participants spent 509.6 ±160.9 $min \cdot d^{-1}$ in sedentary behavior (SB; 53% of the waking day). Of this time, 444.8 ± 156.9 $min \cdot d^{-1}$ were spent on a screen. Participants engaged in background screen time 135.7 ±149.09 $min \cdot d^{-1}$. Significant positive correlations ($p<0.05$) were found between HbA1c and total SB ($r= 0.615$), and ST ($r=0.578$), and Background ST ($r= 0.572$). **CONCLUSIONS**: Participants spend large amounts of their day engaged in sedentary behavior, which is consistent with national data. Moreover, of this time spent in sedentary behavior, the majority is spent looking at a screen. Our preliminarily findings suggest that increased screen time is associated with higher HbA1c and risk of type 2 diabetes.

Background

Screen-based sedentary behaviors, such as smartphone and tablet use, have significantly increased in recent years. Engaging in screen time has been shown to promote unhealthy behaviors, such as snacking, and has been linked to an increased risk for chronic diseases, such as cardiovascular disease and diabetes (Wang, Li, & Fan, 2019). To reduce these health impacts, researchers have focused their studies on how individuals with type 2 diabetes are able to control glycemic levels through regular physical activity. What researchers are discovering is that a lack of physical activity and increases in total sedentary behavior are associated with higher amounts of time spent on a screen, which may impact glycemic control (O'Brien, Issartel, & Belton, 2018). Although there is a paucity of data on this topic, new research is emerging and demonstrating a relationship between screen time and glycemic control, but much is still unknown. The findings from this study will help bridge the literature gap regarding screen time and its role in an individual's level of sedentary behavior and their glycemic control.

Purpose

To investigate associations between screen time and glycemic control in adults with and without type 2 diabetes.

University of Idaho
College of Education, Health and Human Sciences

Methods

Participants were adults aged ≥ 18 years with and without type 2 diabetes

Exclusion criteria: irritable bowel syndrome, Crohn's, ulcerative colitis, celiac disease, colon cancer, multiple sclerosis, Parkinson's disease, Alzheimer's disease, type 1 diabetes, or currently pregnant or breast feeding.

Measurements:

- Visit 1
  - Self-Reported Questionnaires:
    - Health History Questionnaire
    - Sedentary Behavior Questionnaire
      - *Estimates and totals amount of sedentary behavior spent over multiple activities.*
    - Screen Time Questionnaire
      - *Quantifies the use of modern screen-based devices.*
    - International Physical Activity Questionnaire (IPAQ)
      - *Used to obtain comparable data on health–related physical activities at work, home and leisure.*
  - Height, weight.
  - Finger stick blood draw assessing hemoglobin A1c
  - Food frequency questionnaire using the NIH Diet History Questionnaire III
- Analysis: Pearson correlation analyses were used to assess the simple and partial associations among the variables while controlling for age, sex, and dietary carbohydrates.

Results

A total of 24 adults participated in the study, 7 men and 17 women. Three (13%) participants had type 2 diabetes and 11 (46%) had a family history of type 2 diabetes.

TABLE 1. Descriptive statistics for the sample

VARIABLE	MEAN ± SD	RANGE
Age (y)	49.1 ± 18.4	21.0-79.0
BMI (kg/m^2)	30.5 ± 7.6	14.5-56.9
Sedentary Behavior ($min \cdot d^{-1}$)	509.6 ± 160.9	250.7-882.9
Screen Time ($min \cdot d^{-1}$)	444.8 ± 156.9	120.0-660.0
Background Screen Time ($min \cdot d^{-1}$)	135.7 ± 149.0	0-720.0
Leisure PA (MET $min \cdot d^{-1}$)	189.2 ± 150.6	0-478.3
HbA1c (%)	5.6 ± 0.8	4.9-8.2
Glucose (mg.dL^{-1})	102.5 ± 37.4	77-268
Energy Intake (kcals)	1794.3 ± 731.9	712.4-3572.1
Total Carbohydrates (g)	187.2 ± 90.2	75.9-362.4
Total Fats (g)	78.7 ± 33.8	27.4-170.9
Total Protein (g)	77.9 ± 31.7	26.1-162.6

BMI, body mass index; PA, physical activity; HbA1c, glycated hemoglobin

Results cont.

TABLE 2. Partial correlations between sedentary behavior, screen time and markers of glycemic control.

VARIABLE	HbA1c (%)	Glucose (mg/dL)
Sedentary Behavior ($min \cdot d^{-1}$)	0.615*	0.740*
Screen Time ($min \cdot d^{-1}$)	0.578*	0.520*
Background Screen ($min \cdot d^{-1}$)	0.572*	0.782*

*$p<0.05$ controlling for age, sex, and carbohydrate intake; HbA1c, glycated hemoglobin

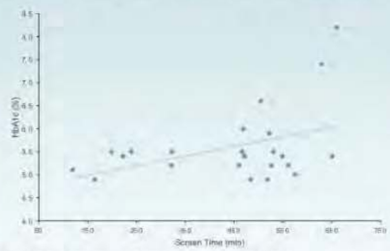


FIGURE 1. Correlation between screen time and HbA1c

Discussion

- Participants spent the majority of their waking day engaged in sedentary behavior, which is consistent with national data.
- The majority of time engaged in sedentary behavior is spent looking at a screen.
- On average, most of an individual's total screen time was spent on a computer/laptop.
- Our preliminarily findings suggest that screen time is associated with glycemic control and risk of type 2 diabetes.
- Further research is needed to develop successful interventions to reduce screen time and sedentary behavior in adults.

EVALUATION OF FATIGUE PROPERTIES OF ALUMINUM SHEET METAL

OBJECTIVE

Develop similar stress cycle (S-N) curves for structural aluminum alloys commonly used by Schweitzer Engineering Laboratories and other manufacturers. Help engineers make educated designs with aluminum with the aid of the S-N curve.

BACKGROUND

- Adopted work from prior Capstone teams
- Limited data for fatigue properties of aluminum for engineers who create structural designs

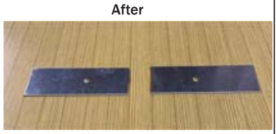
MATERIAL

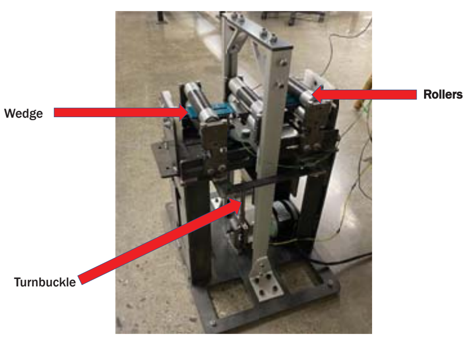
5052 H32 Aluminum

EQUIPMENT

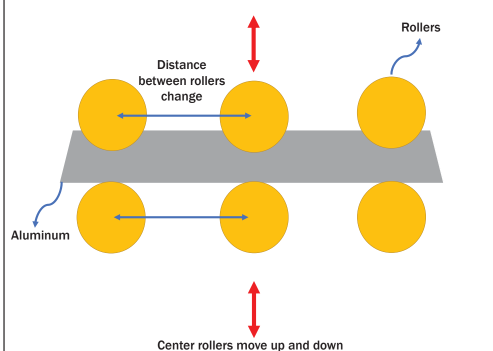
Before

After





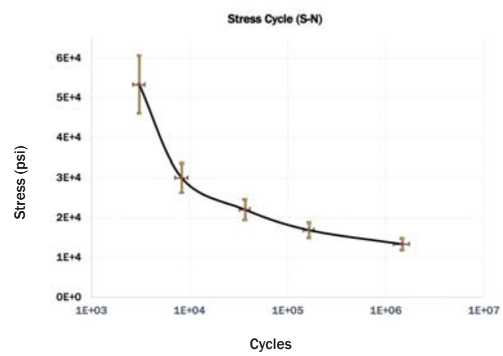
FLAT METAL



OPERATION OF MACHINE

- Python codes are entered on a Raspberry Pi computer to read data when the machine is running.
- An Arduino board is used to run the motor with C language.
- The middle rollers move up and down, putting force on the aluminum sheet metal.
- The Raspberry Pi records the number of cycles that the sheet metal goes through and the current flowing through the circuit.
- A break detection code reports a “break”. This is when current no longer flows through the circuit because of a break detection.
- Stress of the metal is calculated using the following factors:
  - force required to deflect input deflection
  - total length
  - sample thickness
  - moment of inertia

RESULTS



SUMMARY

- *Modifications:*
  - Wedges were 3D printed to physically separate the pieces after failure
  - Rollers were strapped with adhesive tap to reduce conduction
  - Design for the formed aluminum was improved upon for durability
  - Turnbuckle was made shorter to allow the design of the formed aluminum to accommodate the new setup
- Spacings of the rollers range from 2.25” to 4.5”
- It takes about 4 minutes to 60 hours for the aluminum to break after a certain number of revolutions

FUTURE WORK

- Machine should automatically shut off after detection of sample failure
- Run more samples for the formed aluminum sheet metal
- Noise reduction

ACKNOWLEGMENTS

Lead Student: Shalom Masango
Advisor: Dr. Matthew Swenson

University of Idaho

University of Idaho
Department of Movement Sciences

THE EFFECTS OF AN EXTERNAL LIFTING DEVICE ON LIFTING MECHANICS

University of Idaho
College of Education, Health and Human Sciences

Lenah Matz[1], Youngmin Chun[1], Devin Green[1], Nickolai Martonick[1], Cory Johannsen[2], Lukas Krumpl[1], Joshua Bailey[1]
[1]Department of Movement Sciences, University of Idaho, [2] School of Medicine, University of Washington

ABSRACT:

The participants were recruited for this study to investigate the effects of muscle activation patterns and movement mechanics through utilizing a wearable external corrective device, *Sure Squat*, which focuses on the lumbar and distal thigh regions while lifting. Additional comparison between recruited populations will be done to identify any practical changes.
Currently the mechanical data for this study is being processed; however, qualitative reports from participants who successfully completed both sessions are presented. A total of 12 participants have successful completed both sessions, 9 with a current history in free-weight resistance training, and 3 without a history of free-weight resistance training in the last year.

A

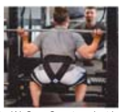
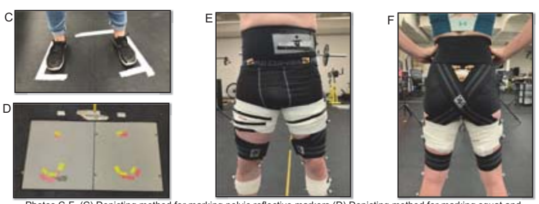



Photo (A) *Sure Squat* product in use

B

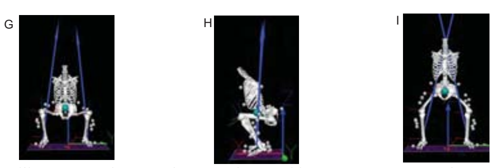
Photo (B) *Sure Squat* product

METHODS:



Photos C-F. (C) Depicting method for marking pelvic reflective markers (D) Depicting method for marking squat and dead lift foot positioning (E) Anterior view with *Sure Squat* (F) Posterior view with *Sure Squat*

- Recruitment: Participants were recruited using a convenience sample.
- Session 1: Consent, screening, and familiarizing participant with protocols and activities. Activities: : countermovement jump (CMJ), drop jump into a countermovement jump (DCMJ) from 30 cm and 50 cm, determined 5RM (Repetition Maximum) for back squat (BS) and dead lift (DL).
- Session 2: Completion of all tasks with and without *SureSquat* device (CMJ, DCMJ, BS (BW,50% & 100% 5RM), & DL (50% & 100% 5RM). Motion capture [Vicon] and muscle activation [Delsys surface electromyography (sEMG) sensors] were collected for 3 trials each to assess potential mechanical differences between conditions. Following completion of all tasks, participants completed a questionnaire to assess their feedback of the device.
  - sEMG locations: Rectus Femoris, Bicep Femoris, Adductor Longus, Gluteus Maximus & Medius, and Erector Spinae groupings.



(G)Visual3D graphic, frontal plane of squat, base of movement (H) Visual3D graphic, sagittal plane of squat, base of movement (D)Visual3D graphic, frontal plane of squat, assent of movement

DISCUSSION:

- ***Mixed reviews of product aid during all tasks were reported across participants***
- ***Mechanical changes are being analyzed***
- ***Future product development planned***

PURPOSE:

To investigate the effects on muscle activation patterns and movement mechanics through utilizing an external corrective device focusing on the lumbar and distal thigh regions while lifting.

BACKGROUND:

- Lifting heavy loads can insight an increased risk of injury, of specific concern: lumbar and knee pain and injury (4,5,1,2)
- External assistive devices have a corrective mechanical effect on lifting mechanics (1,3,4,7)
- Outside of performance, an additional need is identified for external assistive devices targeting workplace ergonomics (5)
- Project significance can advance current knowledge on knowledge on optimizing performance, increasing ergonomic practices in the workplace, and overall injury prevention when employing an external assistive device to the act of lifting loads.

RESULTS:

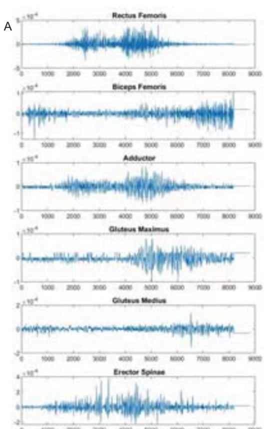
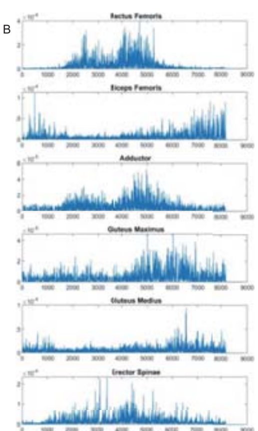
Figure A


Figure B


'It may take more time to get comfortable with the device.'

"Great idea, but doesn't work for me. I felt no difference"

'It helped by keeping my knees from dipping in during the squat.'

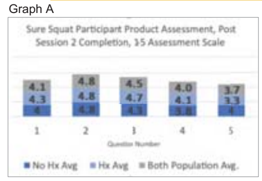
Graph A


Table A

***Sure Squat* Product Assessment Question Topic**
1 Rating of Perceived Comfort While Using
2 Rating of Perceived Ease of Donning and Doffing
3 Rating of Perceived Fit
4 Rating of Perceived Product Feedback and Support While Using
5 Rating of Potential of Personal Future Use

Figures A-B. (A) sEMG signal demeaned, full back squat, unilateral (B) sEMG signal rectified, full back squat, unilateral.

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ACKNOWLEDGEMENT: Funding: Summer Undergraduate Research Fellowship (SURF) program, University of Idaho Office of Undergraduate Research.

University of Idaho

Synthesis of mesoporous silica nanoparticles for use in extrusion polymerization

Gabriel Nelson, Riley Parr, and Dr. Mark Roll
Department of Materials Science and Engineering, University of Idaho, Moscow, ID

INTRODUCTION

- Arrays of silica nanochannels (ASNCs) are a versatile tool in fields such as "sensor technology, drug delivery, catalysis, imaging, and light-harvesting" (1).
- The project focus is to synthesize ASNCs and find which synthesis techniques yield the best structure for extrusion polymerization.
- Extrusion polymerization is a process in which catalysts are attached to ASNCs, which forces the polymerization through the ASNCs and produces desirable material properties in the resulting polymer (2).

EXPERIMENTS

•Recrystallizing CTAB
•Synthesized P123 structured ASNCs
•Synthesized CTAB structured ASNCs with and without structure directing salts
•X-ray diffraction characterization of ASNCs

FUTURE WORK

•Heat treatment of ASNCs to remove organic material
•Scanning electron microscopy
•Attaching catalysts to ASNCs and conduction polymerization

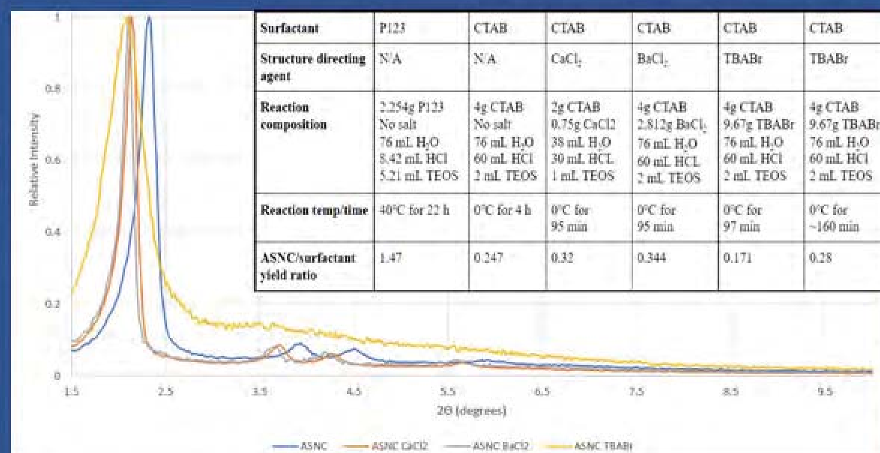
ACKNOWLEDGEMENTS

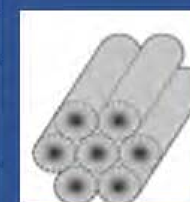
This work was supported by the University of Idaho Office of Undergraduate Research SURF grant

RESULTS AND DISCUSSION

•The table below shows a summary of different ASNC synthesis experiments
•The images (3) represent the surfactant micelles forming into a hexagonal array in silica
•The graph shows the results of x-ray diffraction characterization, which gives us information about the structural organization of our silica

Surfactant	P123	CTAB	CTAB	CTAB	CTAB	CTAB
Structure directing agent	N/A	N/A	$CaCl_2$	$BaCl_2$	TBABr	TBABr
Reaction composition	2.254g P123 No salt 76 mL H_2O 8.42 mL HCl 5.21 mL TEOS	4g CTAB No salt 76 mL H_2O 60 mL HCl 2 mL TEOS	2g CTAB 0.75g CaCl2 38 mL H_2O 30 mL HCL 1 mL TEOS	4g CTAB 2.812g $BaCl_2$ 76 mL H_2O 60 mL HCL 2 mL TEOS	4g CTAB 9.67g TBABr 76 mL H_2O 60 mL HCl 2 mL TEOS	4g CTAB 9.67g TBABr 76 mL H_2O 60 mL HCl 2 mL TEOS
Reaction temp/time	40°C for 22 h	0°C for 4 h	0°C for 95 min	0°C for 95 min	0°C for 97 min	0°C for ~160 min
ASNC/surfactant yield ratio	1.47	0.247	0.32	0.344	0.171	0.28





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(3) Emma Björk, Synthesizing and Characterizing Mesoporous Silica SBA-15: A Hands On Laboratory Experiment for Undergraduates Using Various Instrumental Techniques, Journal of Chemical Education, 2017. 94(1), pp.91-94.

Stereospecific Emulsion Polymerization

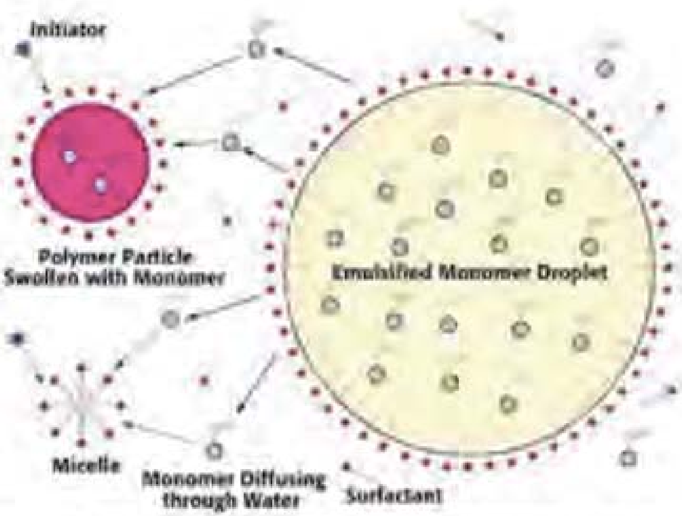
University of Idaho

INTRODUCTION

Until 1945 our main source of rubber was from plantations in southeast Asia. Around this time a general-purpose synthetic rubber (GS-R) was developed. This rubber is synthesized by polymerizing isoprene in soapy water. Even today though, we cannot match the quality of natural rubber in our synthetic versions. The focus of this project is to synthesize a rubber with a lower glass transition temperature than the current market standard.

APPROACH

An emulsion of the monomer and water is created using a surfactant The surfactant used here is CTAB, and the monomer is Isoprene The figure from (Ron Lewarchik, The Fundamentals of Emulsion Polymerization, 2016) below shows the primary processes in this reaction



Current Work

The type of surfactant we are using is called CTAB, it is most commonly used as a topical antiseptic
The CTAB is in a powdered form when we receive it, but it must be recrystallized to be used in the polymerization process, to do this, we:

1. Dissolve the CTAB in methanol
2. Heat up ethyl acetate to increase the solubility limit
3. Fully dissolve the CTAB in the ethyl acetate
4. Allow the ethyl acetate to slowly cool down

As the ethyl acetate cools down, the solubility limit decreases drastically, this causes the CTAB to crash out of solution in a crystalline form. This material can then be collected for use in future polymerizations. The yield for the CTAB recrystallization was consistently about 80%

The polymerization was conducted with the following steps.

1. Degas solution with the sonicator
2. Mix the surfactant solution and the monomer
3. Add hydrogen peroxide
4. Stir at room temperature for 12 Hours
5. Precipitate in Methanol to collect material

FUTURE EXPERIMENTS

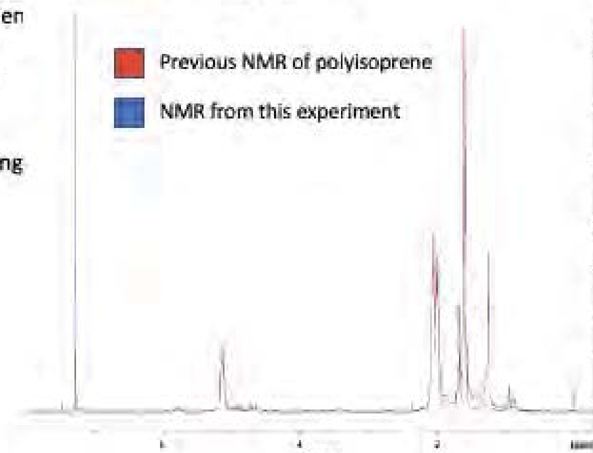
- Continue improving Isoprene Polymerizations
- Obtain more NMR data on new polymerizations and determine microstructure

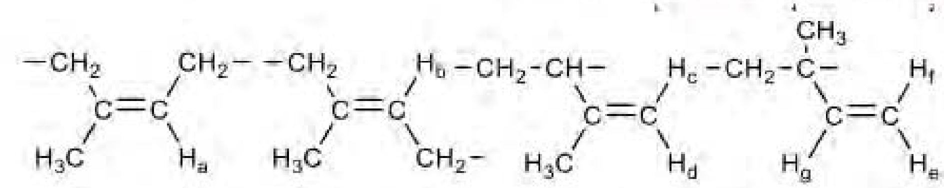
RESULTS

Poly-Isoprene Yields

Over our first four reactions, the yields increased from 26% to 54%.

The proton NMR below indicated that polyisoprene was formed.





cis-1,4- *trans*-1,4- 3,4- 1,2-

References: Acknowledgement of The Office of Undergraduate Research at the University of Idaho for Funding and Support
Friedmann, G.; Brosse, N. Stereospecific Emulsion Polymerization of 2-Phenyl-1,3-Butadiene. *European Polymer Journal* **1991**, *27* (8), 747–749. https://doi.org/10.1016/0014-3057(91)90002-6

University of Idaho Department of Biological Sciences

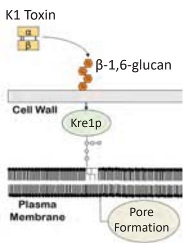
Investigation of the Suicidal Phenotypes of K1 "Killer Toxin" Truncations in *Saccharomyces cerevisiae*

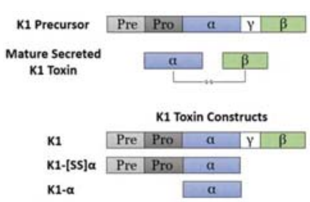
Danielle Yama, Mason Shipley, and Dr. Paul A. Rowley
University of Idaho, Department of Biological Sciences

NSF

INTRODUCTION

The current focus of this research within the Rowley lab is on the K1 "killer toxin" produced by *Saccharomyces cerevisiae* yeasts. Common antifungal treatments such as fluconazole or miconazole are becoming less effective in treating fungal infections such as *Candida glabrata* and *Candida albicans*--opportunistic pathogens that can cause life-threatening bloodstream infections in individuals with compromised immune systems. Therefore, use of antifungal "killer toxins" such as K1 has become a recent focus of research in understanding how to combat these fungal infections. K1—an antifungal protein secreted by *S. cerevisiae*—first binds to β-1,6-glucan at the cell wall and then interacts with Kre1p which is thought to lead to the formation of pores within the membrane and causes cell apoptosis. We do not fully understand the mechanism of suicide by these K1 protein domains. To fill this knowledge gap, we will test whether the deletion mutant strains of *S. cerevisiae* that represent a systematic collection of all non-essential gene deletions can suppress the suicidal phenotype of K1-α and K1-[SS]α which are responsible for mediating the toxic effect.. This will provide insight into which non-essential gene deletions will provide resistance against K1-α and K1-[SS]α. This will lead us to better understand the mechanism of action of K1.



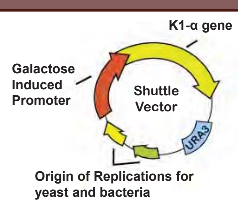


HYPOTHESIS

We hypothesize that the deletion of specific nonessential genes in *S. cerevisiae* strains will yield suppressor mutants that are resistant to K1-α or K1-[SS]α toxins. We expect those genes involved in ER protein export, protein transportation, or membrane function may prevent the lethality of *S. cerevisiae* cells due to K1-α or K1-[SS]α.

AIM 1: VALIDATE THE LETHALITY OF K1-α AND K1-[SS]α IN S. CEREVISIAE

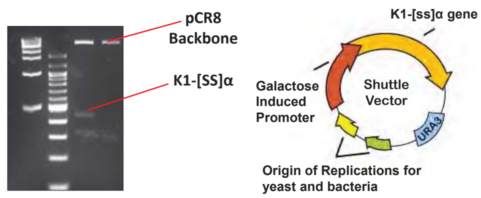
To confirm the toxic effects of K1-α and K1-[SS]α in the Rowley Lab at the University of Idaho, we constructed our own expression plasmid. The K1-α gene was introduced into a galactose-inducible expression plasmid containing the auxotrophic selection marker URA3 and used to transform the wild type BY4741 strain of *S. cerevisiae*.



S. cerevisiae strain BY4741 was transformed with K1-α. Cells that were plated on media containing dextrose were expected to show growth (left) while cells plated on media containing galactose would induce the galactose-promoter, causing the expression of K1-α, resulting in lethality (right).

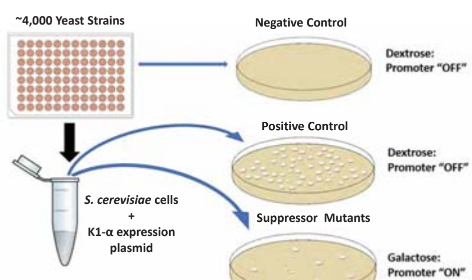
BY4741 strain of *S. cerevisiae* transformed with K1-α

K1-[SS]α has been isolated and cloned using the PCR8 vector. *Escherichia coli* was then transformed with the K1-[SS]α construct and will undergo gateway cloning in order to create the full expression plasmid including the galactose induced promoter and origin of replication for yeast and bacteria. BY4741 *S. cerevisiae* strain will then be transformed with K1-[SS]α following the same process as K1-α.



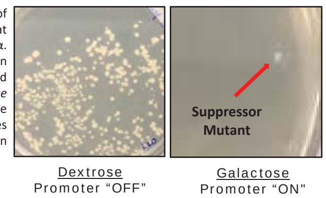
AIM 2: IDENTIFY WHICH NON-ESSENTIAL GENES WITHIN S. CEREVISIAE THAT CAUSE RESISTANCE TO K1-α AND K1-[SS]α

We transformed the entirety of the genome deletion collection library with K1-α. This library consists of ~4,000 different *S. cerevisiae* strains, each of which has a single non-essential gene that has been deleted from its genome.

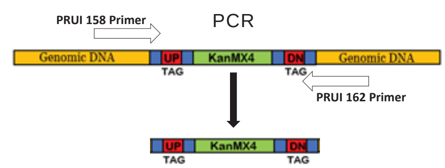


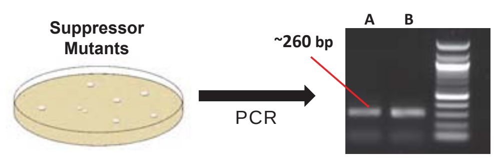
Deletion Collection plate 71-74 transformed with K1-α

These plates show a part of the deletion collection that was transformed with K1-α. As expected, cells grew on dextrose (left), and we had found two *S. cerevisiae* strains—mutants with a single gene deletion that causes resistance to K1-α—were seen growing on galactose (right).



Using primers PRUI-158 and PRUI-162, a PCR reaction was performed on those mutants resistant to K1-α to identify if they contained barcodes. These primers were designed on each side of KanMX4 which would serve as a marker for genes in the whole genome deletion library that have been knocked out. The nonessential gene is replaced by KanMX4 via homologous recombination. As a result, gene knockout could be confirmed on an agarose gel by a band that was ~260 bp in size.





PCR products with visible bands were sent for Sanger Sequencing. With KanMX4 serving as a marker, all single nonessential gene deletions can be identified. This process is used to identify those genes that when knocked out, cause resistance to K1-α or K1-[SS]α.

ACKNOWLEDGEMENTS

This project was supported in part by a SURF award from the UI Office of Undergraduate Research

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FY21 Undergraduate Report for Lewis-Clark State College

Student Name	Advisor	Project	S/Y	Amount Requested Supplies	Amount Requested Salary	Total	Amount Awarded Supplies	Amount Award Salary	Dissemination	Other Outcomes
J. Boozer	L. Latta	Use of Amphioxus as a Model for Regnerative Medicine.	Year	$374	$2,268	$2,642	$374	$1,600	ICUR	
S. Eberly	L. Latta	Effective Antimicrobial agents in Chlorhexidine Gluconate on Multiple Bacterial Species of the Mouth	Year	$0	$1,896	$1,896	$0	$1,600	ICUR	
D. Miller	N. Johnston	Measuring Diffusive Uptake Rates of Diffusive Organic Compounds for use in Passive Sorbent Tube-Type Air Sampling	Year	$2,000	$1,050	$3,050	$0	$1,050	ICUR, INBRE Conference, AGU meeting, manuscript for publication.	
A. Roy	E. Stoffregen	Effect of Y-linked Natural Variation on survival of BLM-Deficient embryos.	Year	$0	$4,200	$4,200	$0	$1,200	ICUR, INBRE Conference.	
T. Coburn	C. Robinson	Effects of Bio-Electro-Magnetic-Energy Regulation (BEMER) on Lactate Threshold with Aerobic Activity.	Year	$2,336	$1,800	$4,136	$2336 (joint award for all 3 students)	$1,200	LCSC Research Symposium, ICUR	
B. Menti	C. Robinson	Effects of Bio-Electro-Magnetic-Energy Regulation (BEMER) on Lactate Threshold with Aerobic Activity.	Year	$2,336	$1,800	$4,136		$1,200	LCSC Research Symposium, ICUR	
C. Smith	C. Robinson	Effects of Bio-Electro-Magnetic-Energy Regulation (BEMER) on Lactate Threshold with Aerobic Activity.	Year	$2,336	$1,800	$4,136		$1,200	LCSC Research Symposium, ICUR	
Rachel Hull	K. Allison	An exploration of nursing students perspectives regarding LGBTQ+ Health Care.	S	$1,097	$1,800	$2,897	$0	$1,260	ICUR	
Carly Jones	C. Robinson	The effectiveness of liquid versus capsule iron supplements absorption and effects on endurance athletes	s	$3,720	$1,200	$4,920	$2,480	$250	ICUR; LCSC research symposium.	
Emily Adams	C. Robinson	The effectiveness of liquid versus capsule iron supplements absorption and effects on endurance athletes	s	shared with Carly	$1,200	$1,200	awarded $2480 jointly with Carly	$250	ICUR; LCSC research symposium.	
Total						$33,213	$2,710	$10,810		

Boozer Abstract

The invertebrate amphioxus obtain the ability to regenerate their posterior tail end after damage or loss. To increase this rate of regeneration, the chemical compound curcumin was added to the experimental tank as it contains anti-microbial, anti-inflammatory, and wound healing properties. For 4 weeks, 6 individuals in the control tank and 6 individuals in the curcumin tank were maintained at proper salinity and temperature, fed every 3 days, and photographed every 7 days to track growth. The results indicated there was no significant difference in growth between control and experimental groups, however trends of a higher mean growth can be seen in the experimental group.

Colburn Abstract

EFFECTS OF BIO-ELECTRO-MAGNETIC-ENERGY REGULATION (BEMER) ON LACTATE THRESHOLD WITH AEROBIC CAPACITY

T.Colburn*, B.Menti, C. Smith, C. Robinson*

ABSTRACT: The Bio-Electro-Magnetic-Energy-Regulation (BEMER) pad is a relatively new piece of technology. Currently, the technology is primarily used in physical vascular therapy, but many studies have been done to expand the scope of the BEMER pad. For example, one study has shown positive effects of the BEMER pad in the reduction of cancer cells during chemotherapy. Other studies have found positive results using the BEMER technology to increase circulation and oxygen saturation levels. PURPOSE: To determine if the BEMER pad is a viable tool to improve aerobic performance in elite athletes, as well as the general population. METHODS: The participants will be randomly assigned between a placebo group and a BEMER pad treatment group. Both groups will lay on the BEMER pad, however the pad will be turned off for the placebo group. All participants will undergo a pre-test and post-test. Both tests will be a sub-maximal $V0_2$max test on the treadmill. The tests will end once the lactate threshold is reached and participants will complete a gradual cool down. Once the pre-test is completed, the participants will be asked to complete ten consecutive days of BEMER treatments or placebo treatments lasting 10 minutes for each session. Following the ten days of treatment post-test will be performed and the lactate threshold will be calculated again. The pre-test and post-test data will then be compared to determine if there is greater positive correlation between the BEMER treatment group and lactate threshold when compared to the placebo group. In addition to lactate threshold, we will be recording blood pressure, heart rate, 0_2 saturation, respiratory exchange ratio (RER), and ventilatory threshold. These variables were then compared between the pre-test and the post-test.

The data for this study is currently being collected and results are pending.

This study is being supported by an Idaho HURC grant and Lewis-Clark State College Division of Movement and Sport Sciences.

The Bio-Electro-Magnetic-Energy-Regulation (BEMER) pad is a relatively new piece of technology. Currently, the technology is primarily used in physical vascular therapy, but many studies have been done to expand the scope of the BEMER pad. For example, one study has shown positive effects of the BEMER pad in the reduction of cancer cells during chemotherapy. Other studies have found positive results using the BEMER technology to increase circulation and oxygen saturation levels.

Eberle Abstract

- The antimicrobial properties of a prescription mouth rinse, Chlorhexidine Gluconate 0.12%, was studied to determine its efficacy in combating the number of microbes in the oral cavity.
- The specialty of oral surgery poses many questions involving microorganisms, namely what can be done to limit them in an environment that is so heavily contaminated.
- Subsequent studies utilized streptococci strains, *S. mutans* and *S. salivarius*.
- Microbial population growth was determined using spectrophotometric readings analyzing dose-dependence and species-dependence.

Miller Abstract

ICUR 2021 Abstract - HERC funded research by Dylan Miller with mentor Dr. Nancy Johnston

Miller, D. D., Bajracharya, A., Dickinson, G. N., Durbin, T. A., McGarry, J. K. P., Moser, E. P., Nuñez, L. A., Pukkila, E. J., Scott, P. S., Sutton, P. J. and Johnston, N. A. C. Analysis of Diffusive Rates for Use with Air Toxic Risk Assessment. Idaho Conference for Undergraduate Reference, July 2021.

Risk to human health due to air toxics exposure can be best assessed using time-weighted averages of various compound concentrations. These average concentrations are delivered by passive sampling techniques, which requires diffusive uptake rates (UTRs) for analysis. The use of these samplers is advantageous as a result of versatility in sampling duration, low costs of operation, and ease of use. Supplementing a current shortage of UTRs for samplers containing Tenax®TA, a parallel active and passive air sampling method was used to determine UTRs for 27 VOCs, including known carcinogens such as BTEX compounds, hydrocarbons, and terpenes. These rates were measured for 24-hour, 7, 14, and 28-day sampling durations to accommodate the wide time range for which passive samplers can be employed. All analysis of samples was completed by thermal desorption-gas chromatography-mass spectrometry. The applicability of the UTRs measured here was demonstrated by retrospective analysis of VOC data from the 2019 NASA/NOAA Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) campaign. This field study examined smoke composition from wildfires in the United States. The concentrations derived from UTRs determined in this study were subsequently used to assess human health risk from exposure to fire emissions measured during FIREX-AQ. Limited fire activity in 2019 led to low exposure to carcinogenic VOCs, but the UTRs determined here are equally applicable to any employment of diffusive sampling.

Stoffregen Abstract

Lack of Blm protein during early embryonic development in Drosophila impacts the lifespan of surviving progeny

Abbey Roy, Brayden Graves, Kyra Lockett, Abygail Marler, Nathan Anderson, Karly Lacey, Leigh Latta, Eric Stoffregen

During the early stages of Drosophila embryogenesis, maternally loaded Blm DNA helicase is essential for proper DNA replication; embryos from Blm mutant females, who fail to provision Blm to their eggs, accumulate DNA damage and most do not survive this early developmental period. Despite this severe maternal effect lethality, a small percentage of embryos do survive in the absence of Blm. However, survivors of this Blm-null embryonic environment may experience sub-lethal DNA damage that poses long-term biological consequences, such as decreased lifespan. We found that flies that developed without Blm had a reduced lifespan compared to those that developed with Blm. Due to the role Blm plays in ensuring proper replication through repetitive DNA sequences, we hypothesize that Y chromosomes containing more repetitive DNA might further reduce lifespan in a Blm deficient background.

Lack of Blm protein during early embryonic development n *Drosophila* impacts the lifespan of surviving progeny

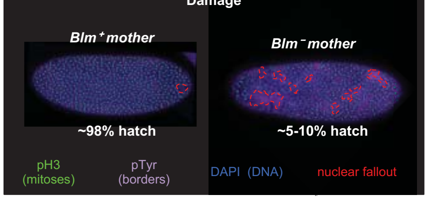
Abbey L. Roy, Brayden M. Graves, Kyra M. Lockett, Abbey J. Marler, Eric P. Stoffregen

LEWIS-CLARK STATE COLLEGE
Division of Natural Sciences and Mathematics

Introduction

- In humans, mutations in BLM DNA helicase cause Bloom Syndrome, an autosomal recessive cancer predisposition syndrome.
- In *Drosophila*, Blm protein provided to eggs by mothers, plays an essential role in ensuring proper DNA replication during early embryogenesis.
- Most progeny from *Blm*-mutant mothers die during embryonic development due to a lack of maternal Blm gene products (Figure 1).
- It is unknown what effects the lack of Blm during early embryogenesis has on flies that survive this Blm-null environment.
- We found that flies that developed without Blm had a reduced lifespan compared to those that developed with Blm. Due to the role Blm plays in ensuring proper replication through repetitive DNA sequences, we hypothesize that Y chromosomes containing more repetitive DNA content might further reduce lifespan in a Blm-deficient background.

Figure 1: Embryos Lacking Blm Incur Widespread DNA Damage

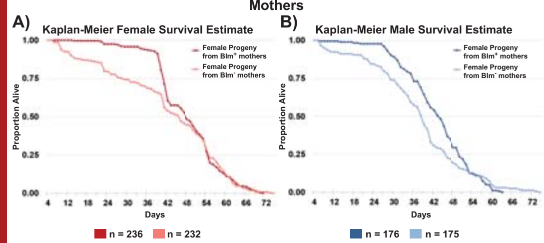


An embryo from a Blm⁺ mother (left) shows one cluster of empty actin cages (dotted red outline), which reveals a region of DNA damage leading to nuclear fallout. An embryo from a Blm- mother (right), who is unable to supply the embryo with functional Blm protein has massive nuclear fallout as indicated by the dotted red outlines.

IdahoINBRE

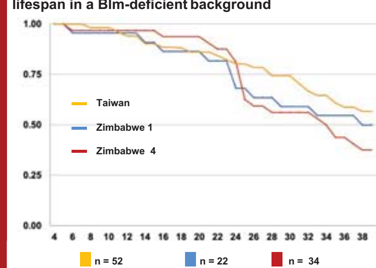
Surviving adult progeny that were **deficient for Blm** DNA helicase during early embryonic stages exhibit a **reduced lifespan**. Y-chromosome variability may exacerbate the reduction in lifespan.

Figure 2: Lifespan Differences Between Progeny from *Blm⁻* versus *Blm⁺* Mothers



Kaplan-Meir plots display the surviving proportion of female (A) and male (B) progeny over time for both *Blm⁻* and *Blm⁺* mothers. Lifespan of progeny from *Blm⁻* mothers was significantly reduced within the first 40 days for females and within the first 50 days for males compared to progeny from *Blm⁺* mothers.

Figure 3: The effect of variable Y chromosomes on lifespan in a Blm-deficient background

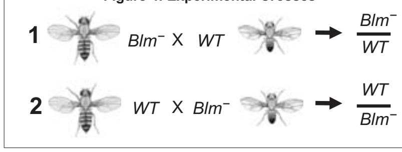


Kaplan-Meir plot displaying the surviving proportion of male progeny from *Blm⁻* mothers. Each line represents a population of male progeny with a different Y chromosome. Initial estimates indicate that Zimbabwe 1 has more Y-linked DNA than Zimbabwe 4 and Taiwan.

Methods

- The crosses shown below (Figure 4) show how we obtain the genetically matched progeny used in the lifespan experiments.
- Progeny from *Blm⁻* and *Blm⁺* mothers were allowed to mate for 3 days post-eclosion. On day 4, the flies were segregated by sex, and deaths were scored daily.

Figure 4: Experimental Crosses



(1): Cross between *Blm* mutant mothers and *wild type* fathers. Resulting progeny do not receive maternally loaded Blm during early cell cycles. However, as they are genotypically heterozygous, Blm will be produced once zygotic transcription begins. **(2)**: Cross between *wild type* mothers and *Blm* mutant fathers. These flies receive maternally loaded Blm, and are also genotypically heterozygous, so they have functional Blm available during the entirety of their development. For Fig. 3, the WT or Blm- fathers have either the Taiwan, Zimbabwe 1, or Zimbabwe 4 Y chromosome.

Results

- Progeny from *Blm⁻* mothers demonstrated significantly reduced lifespan during the first 40-50 days post-eclosion, as compared to progeny from *Blm⁺* mothers (Figure 2).
- Y chromosome variability may influence the reduced lifespan in the *Blm⁻* background (Figure 3), but the experiment has a low number of progeny and is not yet complete.

Discussion

- Our data supports the hypothesis that a lack of maternally loaded Blm during early embryogenesis reduces the lifespan of flies that survive to adulthood.
- There is a trend toward lifespan variability based on Y-chromosome variability that will require further experimentation.

References

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- Han *et al.* Oncotarget (2016).
- Dunkler, D., et al. Journal of Statistical Software (2018).
- R Core Team (2019\. URL https://www.R-project.org/.

Acknowledgements

- The project described was supported by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under Grant #P20GM103408 and with funding from the Higher Education Research Council (HERC).
- *Drosophila* images (Fig.4) courtesy of @lifeofmaro.
- Thank you to Dr. Leigh Latta for help with statistical analysis.

The Utility of Curcumin as a Regenerative Aid in the Invertebrate Amphioxus

Judith Boozer, Leigh C. Latta IV
Lewis-Clark State College, Lewiston, ID

Lewis-Clark STATE COLLEGE

INTRODUCTION

- Regeneration is defined as the formation of new animal or plant tissue. Previous studies have shown vertebrate-like regeneration with the invertebrate amphioxus (Somorjai et. al).

- Curcumin has been used in multiple experiments for its anti-microbial, anti-inflammatory, and wound-healing properties. Some studies have even shown the use of curcumin increases the rate of wound healing in mice (Jagetia et. al).

-I hypothesized the use of curcumin will increase the rate of regeneration in the invertebrate amphioxus

METHODS

- Two 10-gallon saltwater aquariums were set up with enough sand to cover the bottom of the tank. They were maintained at 35 ppt salinity and 21.1ºC.

- 10 mg of Curcumin was solubilized in 10 mL of ethanol and added to one tank to serve as the treatment, while 10 mL of ethanol was added to the second tank as control.

- 6 Amphioxus were housed in each tank and fed 2 mL of liquid phytoplankton every 3 days and kept under natural light-dark conditions.

- To begin the experiment, all 12 individuals were anesthetized in a clove oil mixture made of 0.3 mg clove oil in 800 mL of 35 ppt salt water. The individuals had roughly 1 mm of their tail cut off with a sterile razor blade and were photographed. After tail removal, 6 individuals went into the treatment tank, and 6 individuals went into the control tank.

- Every 7 days the amphioxus were extracted from their tank and photographed.

- After 4 weeks the photographs were analyzed and measured by standardizing the photographs so that each individual was 3 cm from anus to tail end at 60% magnification.

- After that, measurement of new growth was collected, and statistical analysis was done.

ABSTRACT

The invertebrate amphioxus obtain the ability to regenerate their posterior tail end after damage or loss. To increase this rate of regeneration, the chemical compound curcumin was added to the experimental tank as it contains anti-microbial, anti-inflammatory, and wound healing properties. For 4 weeks, 6 individuals in the control tank and 6 individuals in the curcumin tank were maintained at proper salinity and temperature, fed every 3 days, and photographed every 7 days to track growth. The results indicated there was no significant difference in growth between control and experimental groups, however trends of a higher mean growth can be seen in the experimental group.

Figure 1.

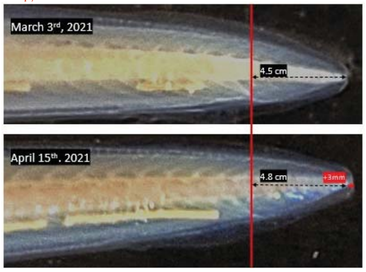

Figure 1. Proof of Regenerative Tail Growth in Amphioxus. Prior to the experiment a test was run to confirm the ability that an amphioxus could regenerate its tail after 1 mm was cut off. This individual was tracked for over a month and after standardizing the photos and lining the individual up at its anus, the individual had regenerated 3mm of its tail during this time frame. The photos were standardized by both being taken at 3.0X as well as blown up to 100% magnification.

Figure 2.

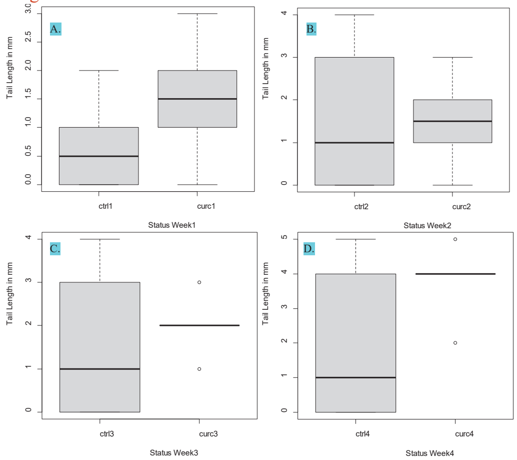

Figure 2. Weekly Comparison of Tail Length Growth Between Curcumin and Control Groups.
2a. Week 1 growth between control and curcumin group. Mean is 0.5 mm for control and 1.5 mm for curcumin.
2b. Week 2 growth between control and curcumin group. Mean is 1 mm for control and 1.5 mm for curcumin.
2c. Week 3 growth between control and curcumin group. Mean is 1 mm for control and 2 mm for curcumin.
2d. Week 4 growth between control and curcumin group. Mean is 1 mm for control and 4 mm for control.

ACKNOWLEDGMENTS

Funding for this project was provided by Idaho State Board of Education Higher Education Research Council Grant and IDeA Networks of Biomedical Research Excellence Grant to J. Boozer

RESULTS

- Wilcoxon rank sum tests showed no significant difference in the amount of regrowth of the posterior end between control and curcumin groups.

- Week 1 ($p = 0.1808$)
- Week 2 ($p = 0.8691$)
- Week 3 ($p = 0.4099$)
- Week 4 ($p = 0.1581$)

DISCUSSION

- Throughout the duration of the experiment, I observed differences in behavior between the control and curcumin groups. The curcumin group practiced more normal behavior each week as they all burrowed and moved rapidly after touch stimulation in contrast to the control group that all stayed on top of the substrate and moved much less after touch stimulation.

- Two of the six amphioxus in the control group degenerated throughout the duration of the experiment and remained at 0 mm of growth each week, seen in Fig 2. Similarly, the mean tail regrowth of the curcumin group remained higher as a trend throughout the 4 weeks.

- The nonsignificant trend of increased amphioxus regeneration in the presence of curcumin suggests additional experiments with larger sample sizes may yield more robust results.

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Effects of Bio-Electro-Magnetic-Energy-Regulation (BEMER) on Ventilatory Threshold with Aerobic Capacity

B. Menti, C. Smith, T. Colburn, & C. Robinson
[1]Movement and Sport Sciences, Lewis-Clark State College, Lewiston, Idaho

Abstract

The Bio-Electro-Magnetic-Energy-Regulation (BEMER) pad is a relatively new piece of technology. Currently, the technology is primarily used in physical vascular therapy, but many studies have been done to expand the scope of the BEMER pad. For example, one study has shown positive effects of the BEMER pad in the reduction of cancer cells during chemotherapy. Other studies have found positive results using the BEMER technology to increase circulation and oxygen saturation levels.

PURPOSE: To determine if the BEMER pad is a viable tool to improve aerobic performance in elite athletes as well as the general population.

METHODS: The participants will be randomly assigned between a placebo group and a BEMER pad treatment group. Both groups will lay on the BEMER pad, however the pad will be turned off for the placebo group. All participants will undergo a pre-test and post-test. Both tests will be a sub-maximal $V0_2$max test on the treadmill. The tests will end once the lactate threshold is reached, and participants will complete a gradual cool down. Once the pre-test is completed, the participants will be asked to complete ten consecutive days of BEMER treatments or placebo treatments lasting 10 minutes for each session. Following the ten days of treatment post-test will be performed and the lactate threshold will be calculated again. The pre-test and post-test data will then be compared to determine if there is greater positive correlation between the BEMER treatment group and lactate threshold when compared to the placebo group. In addition to lactate threshold, blood pressure, heart rate, 0_2 saturation, respiratory exchange ratio (RER), and ventilatory threshold will also be recorded. These variables will also be compared between the pre-test and the post-test. The data for this study is currently being collected and results are pending.

Introduction

Aerobic capacity is one of the greatest indicators of success in aerobic sports. With access to workout facilities limited for the foreseeable future, athletic populations are struggling to maintain previous levels of activity. (Hall, Phillips, Arena, & Laddu, 2020). Athletic populations have been shown to have significantly poorer performance in maximal oxygen uptake, heart rate, blood lactate levels, and ventilatory function after 2-4 weeks (Mujika & Padilla, 2001). With such quick detraining times, it is hard for these populations to maintain previous levels of fitness and more people are sliding into sedentary behaviors. The most common metrics used to measure the fitness levels of aerobically trained individuals are ventilatory and lactate thresholds. The ventilatory threshold (also known as the anaerobic threshold) is the most accurate metric showing the beginning of the accumulation of lactate in the blood, which causes altered oxygen kinetics, metabolic acidosis and hyperventilation (Gaskill, Ruby, Walker, Sanchez, Serfass, Leon, 2001). An alteration of this point could have major implications for an athletic individual's performance. BEMER therapy has proven effective in many other mediums, such as increasing the radio sensitization of tumors in cancer patients (Storch, Dickreuter, Artati, Adamski & Cordes, 2016) and in fatigue levels in patients with multiple sclerosis (Piatowski, Kern & Ziemssen, 2009). Both of these studies show how the BEMER is able to increase microcirculation and oxygen supply in capillaries. However, this modality has been used mostly in clinical settings. The benefits it could have on aerobic capacity, ventilatory thresholds, or in athletic populations have not been properly explored.

The purpose of this study is to investigate if the BEMER pad can be used to help enhance aerobic performance in both athletes and non-athletes. This will be done using the metabolic cart to see if there is a difference in the lactate threshold between a pre-test and post-test. Participants will be randomly placed in one of two groups, a group with BEMER treatments and a placebo. Heart rate, blood pressure, oxidation, ventilation threshold, and respiratory exchange ratio will also be tested.

Results

The preliminary results show very little significance in the BEMER pad being used as a tool to increase ventilatory threshold. There was a slight benefit in the use of the BEMER pad; those that were in the BEMER group showed an improvement from 76% max HR to 78% max HR when they hit their ventilatory threshold. Comparatively, out placebo group went down from 76% max HR to 75% max HR. A paired t-test was also run comparing results of the pre- and post-test ventilatory thresholds. The treatment group (n=5) had a p=0.341 and the placebo group (n=5) had a p=0.439. With the current sample size, this is an insignificant amount and could have happened by chance. Most of the participants at the current time are highly trained aerobic athletes. With a diversification of the population and an increase in participants, results may show a statistically significant change.

The BEMER pad also showed no correlation on the dissipation of blood lactate levels at any of the 3 times collected after the test was done. The accumulation and dissipation of lactate in the blood was similar for both the placebo and BEMER group. With the majority of the participants being highly trained athletes, the BEMER pad did not provide them much aid in the dissipation of lactate throughout the 30-minute testing period.

Methods

Before testing can begin:

- Researchers will recruit participants verbally and explain the process of consent, PARQ (Physical Activity Readiness Questionnaire) and its purpose is to inform the researchers of any potential safety risks that the participants may have. This includes, but is not limited to, Asthma, Cardiovascular Disease, high blood pressure, and Diabetes. , and purpose of their experiment.
- Participants will be required to fill out a PARQ form and consent form to ensure the safety of the participant
- The participant will be informed that they can ask any questions they may have and that they may drop out at any point.
- Participants will have resting cardiovascular assessments collected ; Resting heart rate, resting oxygen saturation rate, resting Blood pressure, resting lactic acid, and calculated exercise heart rate to ensure safety.
- Participants will be assigned to a Bio-Electro-Magnetic Energy regulation pad group and a placebo group. The placebo is the BEMER pad turned off in the same position on the table. How participants will be assigned will be the random assignment function in excel.
- Before pretesting, participants will be required to undergo a pilot treatment of the BEMER pad or placebo to make sure that they will be able to complete the study.
- Researchers will come 30 minutes before any testing to prepare equipment and metabolic cart. This will include keeping track of equipment, calibrating the metabolic cart, cleaning and sanitizing any testing or treatment area, and making sure the BEMER pad is fully functional.

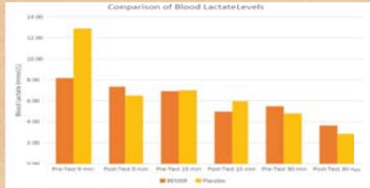
Once all criteria are meet, pre-testing can begin:

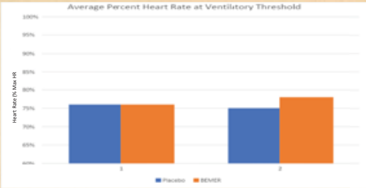
- Participants will be equipped with a metabolic cart and heart rate monitor. These will be consistently monitored during the entire test to ensure the safety of the participant and collect the desired data. Altogether, the cart will keep track of heart rate, oxygen saturation, blood pressure, lactate, ventilatory threshold, and respiratory exchange ratio.
- Begin stage 1 of the pre-test, Increase the % grade and speed (mph) every 3 minutes.

The stages go as follows:

Stage #	Time (Min)	Speed (Mph)	Grade (%)
1	0-3	3	3
2	3-6	4	4
3	6-9	5	5
4	9-12	6	6
5	12-15	6	7
6	15-18	6	8
7	18-21	6	9
8	21-24	6	10
9	24-27	6	11
10	27-30	6	12

- Once the lactate threshold has been crossed (estimated at 75-85% of Maximum heart rate) the test will end, and pre-test data will be collected. This data will be collected on an excel spreadsheet that is only available to the research head and the student researchers.
- The participants will be asked to participate in ten consecutive days of BEMER or placebo treatments. These treatments will be for 10 minutes. Once ten days are done, a post test will be done. This test will follow the same protocol as the pre-test.
- Pre-test data and post-test data will be compared and analyzed using a paired t-test to make a final decision on the hypothesis.





Discussion

The purpose of this study was to determine the effect of Bio-electromagnetic energy regulation(BEMER) therapy on ventilatory threshold (VT) and blood lactate levels during submaximal exercise. This was investigated using individuals meeting the ACSM guidelines of 150 minutes of moderate-to-vigorous exercise per week.

The ventilatory threshold was the main indicator of the accumulation of blood lactate and the switch from aerobic to anaerobic energy systems within this study. Any significant differences within the study were determined running a paired t-test on the pre-treatment results vs. the post-treatment results. For the placebo group, there was no significant difference between the pre- and post-test ventilatory thresholds (p=0.439). In the treatment group, there was also no significant difference between pre- and post-treatment results (p=0.341). Another indicator used to determine the effects of the BEMER was the percentage of the participant's maximal heart rate (HRmax) they had achieved when they for reached their ventilatory threshold. During the pre-test, participants in both the placebo and treatment groups reached their VT at an average of 76% of their HRmax (placebo SD=6%, treatment SD=8%). During the post-test, the participants who received the placebo treatment achieved their VT at an average of 75% of their HRmax (SD=6%). The participants that received treatment on the BEMER reached their VT at 78% HRmax (SD=4%). This was still not a significant difference. These results show that BEMER therapy does not have any significant effect on the ventilatory threshold of athletic individuals. This could have occurred for a multitude of reasons. BEMER therapy may simply be unable to affect VT. The treatments also lasted for 10 consecutive days. This may not have been long enough for proper physiological change to occur. It also may be more effective in other population groups who would be less susceptible to the ceiling effect and have higher capabilities change. BEMER therapy is a new technology and warrants further investigation into its effects on the human body.

Conclusion

The current data that has been collected displays that there is no difference between the placebo and BEMER group. Both groups show similar performance improvements in both ventilatory threshold and blood lactate clearing post exercise. Since no changes were made to the participants daily activities in the 10-day period aerobic capacity increases are most likely a result of test-retest improvement. If given the opportunity for future research, we would look into more of an intervention with the participants besides just BEMER treatment along with extending the amount of time receiving treatment. However, more data is currently being collected and with a larger N our results may change.

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Acknowledgements

Supported by State of Idaho HERC Grant and Lewis-Clark State College Division of Movement and Sport Sciences

Analysis of Diffusive Rates for Use with Air Toxic Risk Assessment

Dylan D. Miller, Aakriti Bajracharya, Gabrielle N. Dickinson, Timbre A. Durbin, John K. P. McGarry, Elijah P. Moser, Laurel A. Nuñez, Elias J. Pukkila, Phillip S. Scott, Parke J. Sutton, and Nancy A. C. Johnston

Physical, Life, Movement, and Sports Science Division , Lewis-Clark State College, Lewiston, ID

Abstract

Risk to human health due to air toxics exposure can be best assessed using time-weighted averages of various compound concentrations. These average concentrations are delivered by passive sampling techniques, which requires diffusive uptake rates (UTRs) for analysis. The use of these samplers is advantageous as a result of versatility in sampling duration, low costs of operation, and ease of use. Supplementing a current shortage of UTRs for samplers containing Tenax®TA, a parallel active and passive air sampling method was used to determine UTRs for 27 VOCs, including known carcinogens such as BTEX compounds, hydrocarbons, and terpenes. These rates were measured for 24-hour, 7, 14, and 28-day sampling durations to accommodate the wide time range for which passive samplers can be employed. All analysis of samples was completed by thermal desorption-gas chromatography-mass spectrometry. The applicability of the UTRs measured here was demonstrated by retrospective analysis of VOC data from the 2019 NASA/NOAA Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) campaign. This field study examined smoke composition from wildfires in the United States. The concentrations derived from UTRs determined in this study were subsequently used to assess human health risk from exposure to fire emissions measured during FIREX-AQ. Limited fire activity in 2019 led to low exposure to carcinogenic VOCs, but the UTRs determined here are equally applicable to any employment of diffusive sampling.

Introduction

- Air toxics exposure is a concerning contributor to carcinogenic risk in humans[1]
- Passive sampling using sorbent tubes offers average concentrations of target compounds[2].
- Passive sampling requires the use of an uptake rate (UTR), the rate at which compounds diffuse into the sampler and onto the sorbent.
- UTRs published in the scientific literature are lacking[3, 4].
- The aim of this study was to measured the UTRs of VOCs at the 24-hour, 7, 14, and 28-day sample durations on Tenax®TA sorbent.

Methods

- A parallel active/passive sampling technique was used to determine 24-hour UTRs.
- UTRs of longer duration were derived from a manipulation of the concentration equation for passive samplers and rates of shorter sample duration.

$$Concentration = \frac{Mass\ Sampled}{UTR\ x\ time}$$

$$UTR = \frac{Mass\ Sampled}{Concentration\ x\ time}$$

- All Samples were analyzed using TD-GC-MS and chromatograms were individually verified for quality.

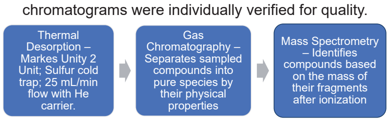
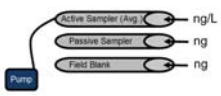
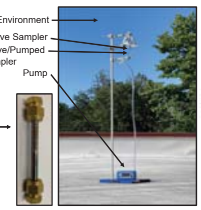
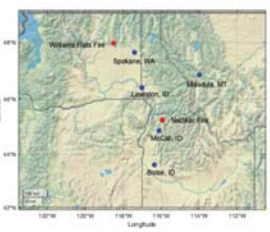


Figure 1. TD-GC-MS components and role in analysis.

Methods (cont.)







Figures 2a-c. 2a (left) Parallel active/passive sampling scheme. 2b (middle) Sorbent tube and sampling apparatus. 2c (right) Long-term sampling map and fire events sampled during the 2019 FIREX-AQ campaign.

Results

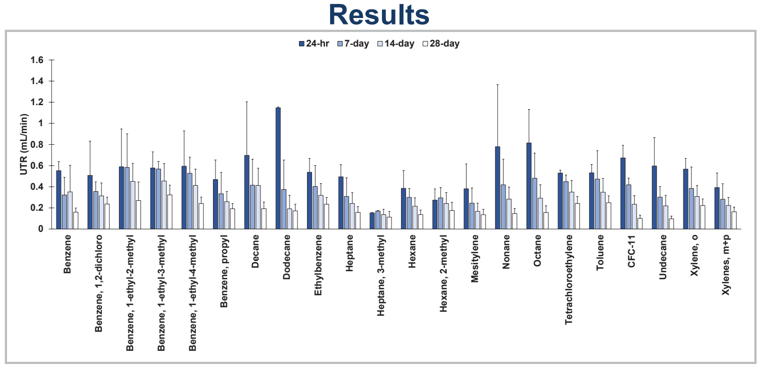


Figure 3. UTRs for 27 VOC applicable for sampling durations of 24 hours, 7, 14, and 28 days.

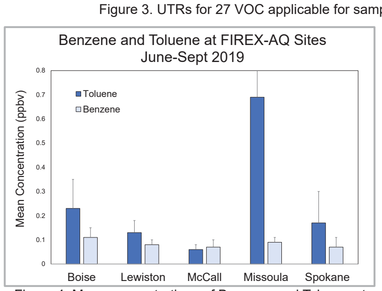


Figure 4. Mean concentrations of Benzene and Toluene at five FIREX-AQ passive sampling sites derived from UTRs determined in this study.

Cancer Risk by Location Due to Benzene	
Location	**Risk**
Boise, ID	1×10^{-6}
Lewiston, ID	0.7×10^{-6}
McCall, ID	0.7×10^{-6}
Missoula, MT	0.6×10^{-6}
Spokane, WA	0.7×10^{-6}

Table 1. Cancer risk due to Benzene at FIREX-AQ sampling sites. Risk is quantified as additional occurrences of cancer.

Discussion

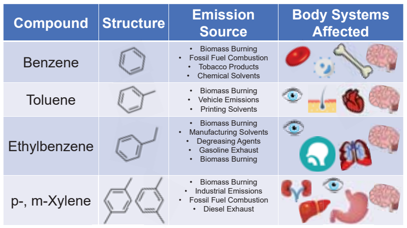


Figure 5. Various VOCs of interest found in wildfire smoke, their structures, sources, and body systems affected.

Conclusions

- Diffusive uptake rates of 27 VOCs on Tenax®TA were acquired for 24-hrs to 28-days.
- 7-day UTR values ranged from 0.17-0.59 mL/min
- Measured UTRs were successfully applied to VOC exposures at FIREX-AQ sites in 2019.
- BTEX compounds ranged from 0.01-0.69 ppbv and were elevated in the late summer.
- Lifetime cancer risk to benzene exposures were 1 x 10^-6 or low risk.
- UTRs can be applied to many passive sampling applications of VOCs.
- Next steps are to compare heath risks from the more active wildfire seasons of 2020 and 2021.

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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.

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Effective Antimicrobial Agents in Chlorhexidine Gluconate 0.12% on Multiple Bacterial Species of the Mouth

LEWIS-CLARK STATE COLLEGE

Sarrah A. Eberley, Leigh C. Latta IV, and Jacob M. Hornby
Division of Natural Sciences and Mathematics, Lewis-Clark State College, Lewiston, ID

Abstract

- The antimicrobial properties of a prescription mouth rinse, Chlorhexidine Gluconate 0.12%, was studied to determine its efficacy in combating the number of microbes in the oral cavity.
- The specialty of oral surgery poses many questions involving microorganisms, namely what can be done to limit them in an environment that is so heavily contaminated.
- Subsequent studies utilized streptococci strains, *S. mutans* and *S. salivarius*.
- Microbial population growth was determined using spectrophotometric readings analyzing dose-dependence and species-dependence.

Introduction

- Microorganisms pose many potential complications in fields of surgery, particularly oral surgery.
- Dose-dependence and species-dependence values were tested using two media types that could readily be mixed as a solid or a liquid broth (Tryptic Soy Agar/Broth and Brain Heart Infusion Agar/Broth).
- The purpose of this research is to expand the literature on oral antimicrobial rinses and share knowledge throughout the dental community to continually limit oral bacterial infections following surgery.

Methods

- Preliminary studies conducted with *S. mutans* and *S. salivarius* grown in multiple media types determined that Tryptic Soy Agar/Broth and Brain Heart Infusion Agar/Broth should be used for the remaining experiments.
- The species were propagated in liquid culture for 18 hours at 200 RPM and 35 degrees Celsius and removed from the shaker table and transferred into sterile 96 well plates according to the desired loading scheme.
- The plates appeared as follows: *S. mutans* in Brain Heart Infusion, *S. salivarius* in Brain Heart Infusion, *S.mutans* in Tryptic Soy Broth, and *S. salivarius* in Tryptic Soy Broth.
- The 96 well plates were placed in the Tecan to measure microbial population growth which was assessed using spectrophotometric methods using absorbance values as proxies for population size.
- Spectrophotometric readings were taken every 900 seconds at 600nm for 350 kinetic cycles.

Methods Cont.

- All data collected using the Tecan was recorded in an Excel spreadsheet for manipulation and analysis using R to estimate the doubling time (DT) and carrying capacity (K), to serve as dependent variables.
- The statistical tests conducted in R consisted of the Shapiro-Wilks test for normality, homogeneity of variances, the Kruskal-Wallis rank sum test, and post hoc tests using the Wilcoxon rank sum test for all pairwise possibilities.

Results

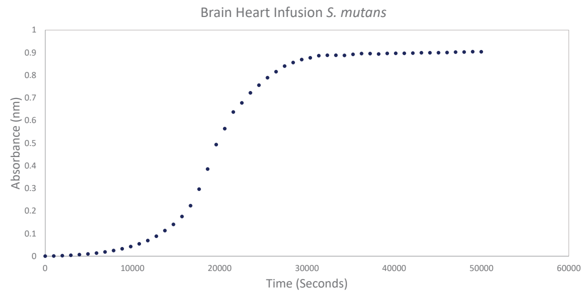

Figure 1. An example of a growth curve created from the data collected during spectrophotometric readings of *S. mutans* in Brain Heart Infusion Broth media.

Table 1. Table 1. Mean and standard error (in parentheses) of doubling time (DT) and carrying capacity (K) for each of two strains of Staphylococcus in two types of media (brain-heart infusion - BHI; tryptic soy broth - TSB) for each dose of Chlorhexidine Gluconate 0.12% (µL Chlorhexidine/200 µL media).

Strain	Media	Dose	DT	K
S. mutans	BHI	0	2290 (57)	0.83 (0.02)
		1	∞ (0)	0 (0)
		2	∞ (0)	0 (0)
		5	∞ (0)	0 (0)
		10	∞ (0)	0 (0)
	TSB	0	1750 (29)	0.52 (0.01)
		1	∞ (0)	0 (0)
		2	∞ (0)	0 (0)
		5	∞ (0)	0 (0)
		10	∞ (0)	0 (0)
S. salivarius	BHI	0	985 (20)	0.47 (0.02)
		1	∞ (0)	0 (0)
		2	∞ (0)	0 (0)
		5	∞ (0)	0 (0)
		10	∞ (0)	0 (0)
	TSB	0	868 (12)	0.33 (0.02)
		1	∞ (0)	0 (0)
		2	∞ (0)	0 (0)
		5	∞ (0)	0 (0)
		10	∞ (0)	0 (0)

Results Cont.

- The Kruskal-Wallis test determined that there was a significant difference in doubling time among Species/Media types at the zero dose (χ^2=50.408; df=3; p-value=6.542e-11). There was also a significant difference in carrying capacity among the Species/Media types at the zero dose in the study (χ^2= 49.827, df = 3, p-value = 8.697e-11).
- Bacterial growth in both strains in both types of media was completely inhibited by Chlorhexidine Gluconate 0.12% at any dosage.
- Inferential statistics could not be performed because the variances of DT and K were zero at every dose other than the zero dose.

Conclusion

- This study determined that there is a significant difference between most media types for bacterial growth among *S. mutans* and *S. salivarius* except there was no difference between *S. salivarius* in Brain Heart Infusion and *S. salivarius* in Tryptic Soy Broth.
- Chlorhexidine Gluconate 0.12% used to treat bacterial species caused a rapid decrease in population numbers and proved that the antimicrobial properties were potent at many dosages.
- In the future I would experiment with lower dosages of Chlorhexidine Gluconate 0.12% and identify the lowest effective dose for bacterial growth inhibition.
- Additionally, I will treat different bacterial species.

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 Judith Boozer.

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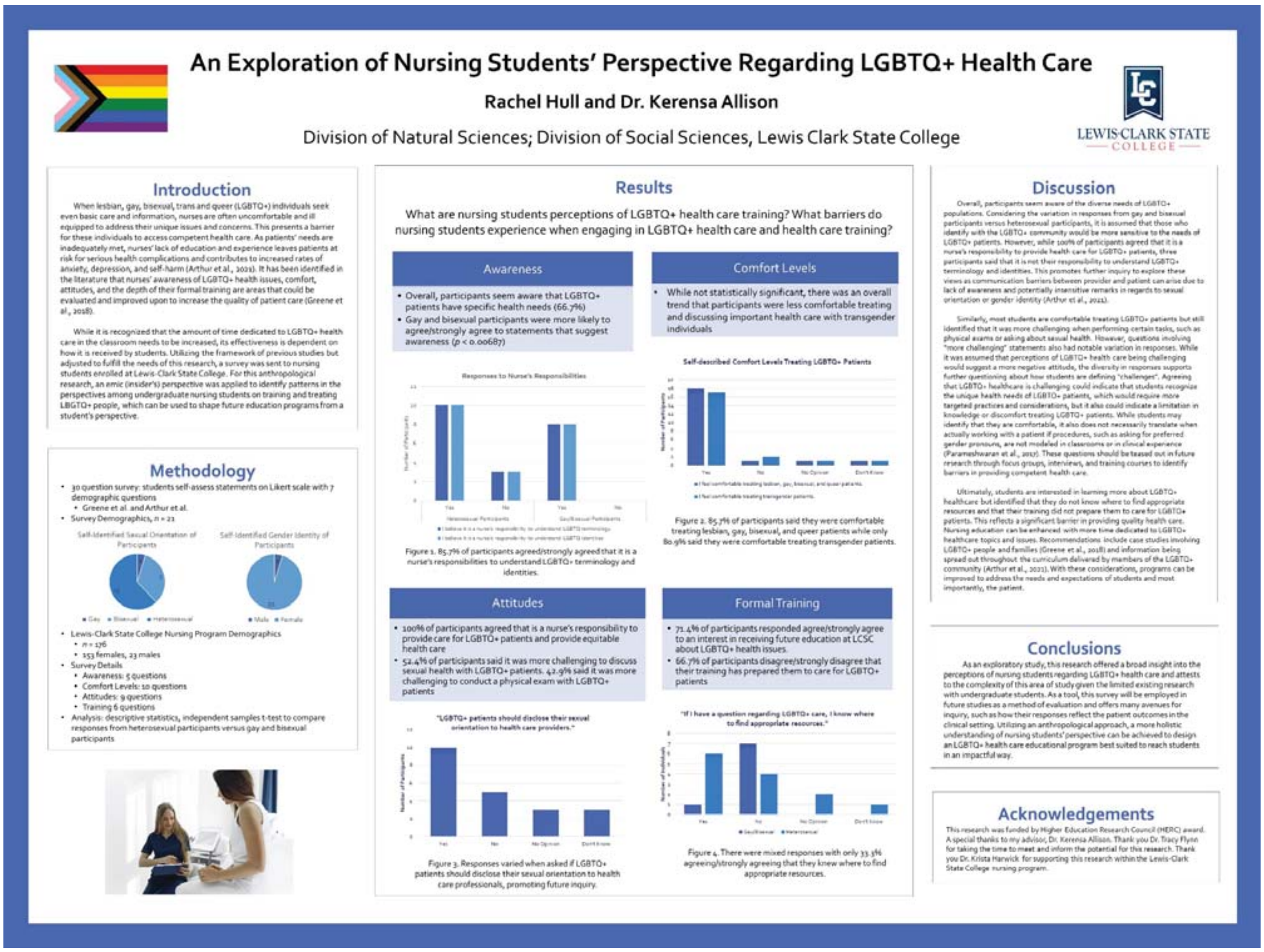

An Exploration of Nursing Students' Perspective Regarding LGBTQ+ Health Care
Rachel Hull and Dr. Kerensa Allison
Division of Natural Sciences; Division of Social Sciences, Lewis Clark State College
LEWIS-CLARK STATE COLLEGE
Introduction
When lesbian, gay, bisexual, trans and queer (LGBTQ+) individuals seek even basic care and information, nurses are often uncomfortable and ill equipped to address their unique issues and concerns. This presents a barrier for these individuals to access competent health care. As patients' needs are inadequately met, nurses' lack of education and experience leaves patients at risk for serious health complications and contributes to increased rates of anxiety, depression, and self-harm (Arthur et al., 2021). It has been identified in the literature that nurses' awareness of LGBTQ+ health issues, comfort, attitudes, and the depth of their formal training are areas that could be evaluated and improved upon to increase the quality of patient care (Greene et al., 2018).
While it is recognized that the amount of time dedicated to LGBTQ+ health care in the classroom needs to be increased, its effectiveness is dependent on how it is received by students. Utilizing the framework of previous studies but adjusted to fulfill the needs of this research, a survey was sent to nursing students enrolled at Lewis-Clark State College. For this anthropological research, an emic (insider's) perspective was applied to identify patterns in the perspectives among undergraduate nursing students on training and treating LBGTQ+ people, which can be used to shape future education programs from a student's perspective.
Methodology
• 30 question survey: students self-assess statements on Likert scale with 7 demographic questions
• Greene et al. and Arthur et al.
• Survey Demographics, n = 21
Self-Identified Sexual Orientation of Participants
Self-Identified Gender Identity of Participants
• Lewis-Clark State College Nursing Program Demographics
• n = 176
• 153 females, 23 males
• Survey Details
• Awareness: 5 questions
• Comfort Levels: 10 questions
• Attitudes: 9 questions
• Training 6 questions
• Analysis: descriptive statistics, independent samples t-test to compare responses from heterosexual participants versus gay and bisexual participants
Results
What are nursing students perceptions of LGBTQ+ health care training? What barriers do nursing students experience when engaging in LGBTQ+ health care and health care training?
Awareness
• Overall, participants seem aware that LGBTQ+ patients have specific health needs (66.7%)
• Gay and bisexual participants were more likely to agree/strongly agree to statements that suggest awareness (p < 0.00687)
Responses to Nurse's Responsibilities
Figure 1. 85.7% of participants agreed/strongly agreed that it is a nurse's responsibilities to understand LGBTQ+ terminology and identities.
Comfort Levels
• While not statistically significant, there was an overall trend that participants were less comfortable treating and discussing important health care with transgender individuals
Self-described Comfort Levels Treating LGBTQ+ Patients
Figure 2. 85.7% of participants said they were comfortable treating lesbian, gay, bisexual, and queer patients while only 80.9% said they were comfortable treating transgender patients.
Attitudes
• 100% of participants agreed that is a nurse's responsibility to provide care for LGBTQ+ patients and provide equitable health care
• 52.4% of participants said it was more challenging to discuss sexual health with LGBTQ+ patients. 42.9% said it was more challenging to conduct a physical exam with LGBTQ+ patients
"LGBTQ+ patients should disclose their sexual orientation to health care providers."
Figure 3. Responses varied when asked if LGBTQ+ patients should disclose their sexual orientation to health care professionals, promoting future inquiry.
Formal Training
• 71.4% of participants responded agree/strongly agree to an interest in receiving future education at LCSC about LGBTQ+ health issues.
• 66.7% of participants disagree/strongly disagree that their training has prepared them to care for LGBTQ+ patients
"If I have a question regarding LGBTQ+ care, I know where to find appropriate resources."
Figure 4. There were mixed responses with only 33.3% agreeing/strongly agreeing that they knew where to find appropriate resources.
Discussion
Overall, participants seem aware of the diverse needs of LGBTQ+ populations. Considering the variation in responses from gay and bisexual participants versus heterosexual participants, it is assumed that those who identify with the LGBTQ+ community would be more sensitive to the needs of LGBTQ+ patients. However, while 100% of participants agreed that it is a nurse's responsibility to provide health care for LGBTQ+ patients, three participants said that it is not their responsibility to understand LGBTQ+ terminology and identities. This promotes further inquiry to explore these views as communication barriers between provider and patient can arise due to lack of awareness and potentially insensitive remarks in regards to sexual orientation or gender identity (Arthur et al., 2021).
Similarly, most students are comfortable treating LGBTQ+ patients but still identified that it was more challenging when performing certain tasks, such as physical exams or asking about sexual health. However, questions involving "more challenging" statements also had notable variation in responses. While it was assumed that perceptions of LGBTQ+ health care being challenging would suggest a more negative attitude, the diversity in responses supports further questioning about how students are defining "challenges". Agreeing that LGBTQ+ healthcare is challenging could indicate that students recognize the unique health needs of LGBTQ+ patients, which would require more targeted practices and considerations, but it also could indicate a limitation in knowledge or discomfort treating LGBTQ+ patients. While students may identify that they are comfortable, it also does not necessarily translate when actually working with a patient if procedures, such as asking for preferred gender pronouns, are not modeled in classrooms or in clinical experience (Parameshwaran et al., 2017). These questions should be teased out in future research through focus groups, interviews, and training courses to identify barriers in providing competent health care.
Ultimately, students are interested in learning more about LGBTQ+ healthcare but identified that they do not know where to find appropriate resources and that their training did not prepare them to care for LGBTQ+ patients. This reflects a significant barrier in providing quality health care. Nursing education can be enhanced with more time dedicated to LGBTQ+ healthcare topics and issues. Recommendations include case studies involving LGBTQ+ people and families (Greene et al., 2018) and information being spread out throughout the curriculum delivered by members of the LGBTQ+ community (Arthur et al., 2021). With these considerations, programs can be improved to address the needs and expectations of students and most importantly, the patient.
Conclusions
As an exploratory study, this research offered a broad insight into the perceptions of nursing students regarding LGBTQ+ health care and attests to the complexity of this area of study given the limited existing research with undergraduate students. As a tool, this survey will be employed in future studies as a method of evaluation and offers many avenues for inquiry, such as how their responses reflect the patient outcomes in the clinical setting. Utilizing an anthropological approach, a more holistic understanding of nursing students' perspective can be achieved to design an LGBTQ+ health care educational program best suited to reach students in an impactful way.
Acknowledgements
This research was funded by Higher Education Research Council (HERC) award. A special thanks to my advisor, Dr. Kerensa Allison. Thank you Dr. Tracy Flynn for taking the time to meet and inform the potential for this research. Thank you Dr. Krista Harwick for supporting this research within the Lewis-Clark State College nursing program.

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

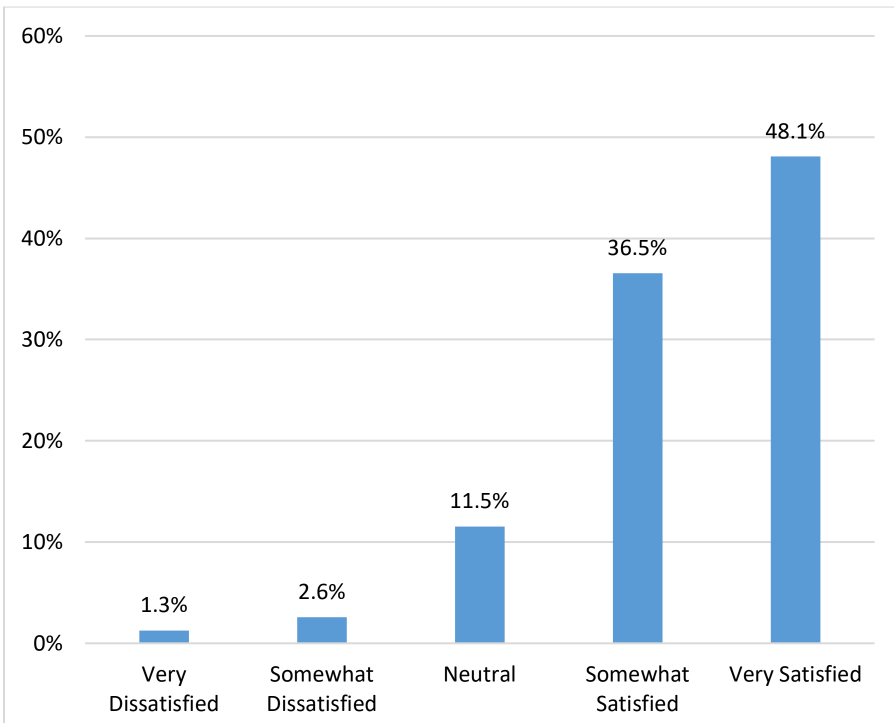
Idaho Conference on Undergraduate Research 2020
Survey Results

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

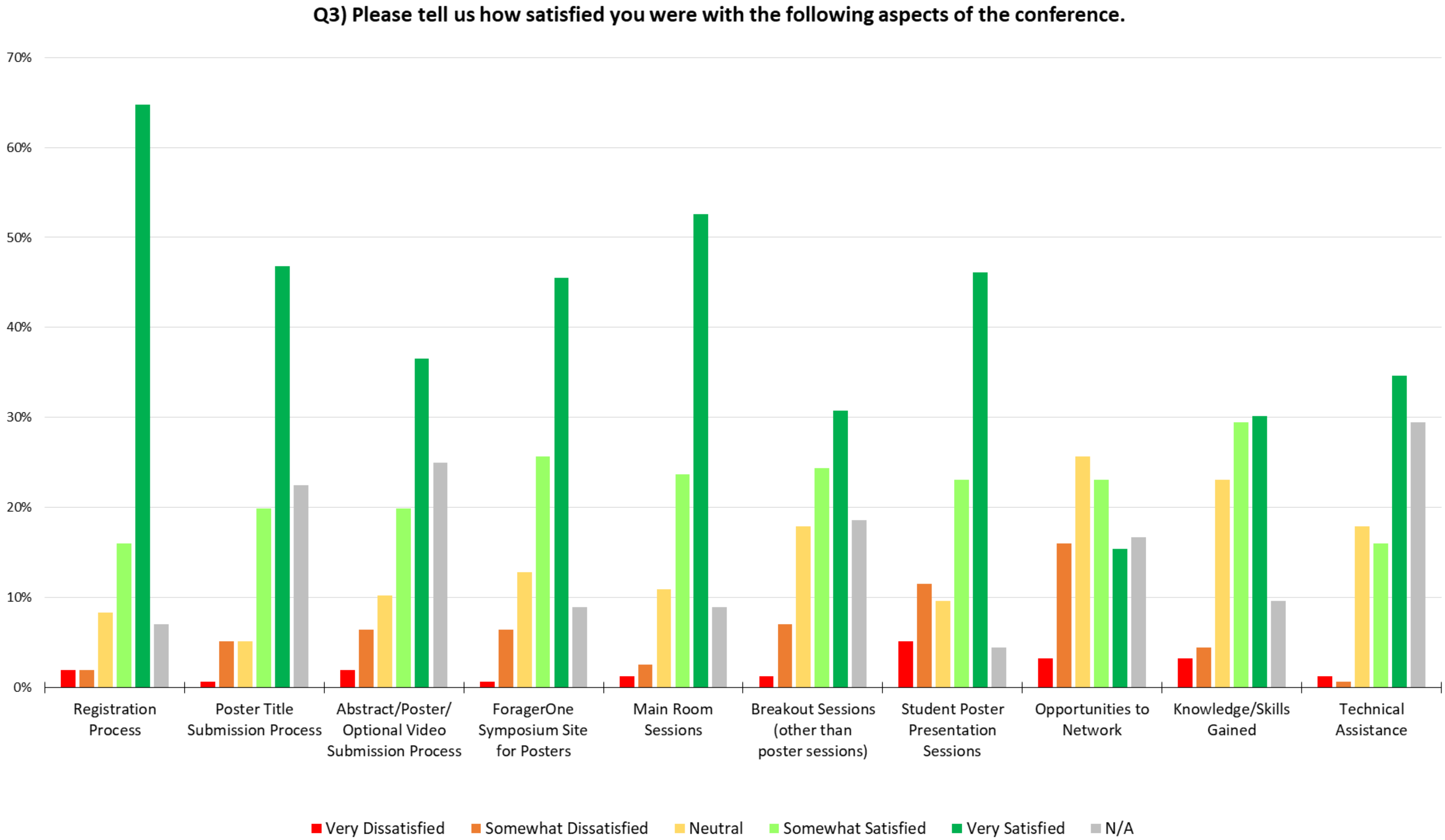
Q2) Please indicate your overall satisfaction with the 2020 Idaho Conference on Undergraduate Research.



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

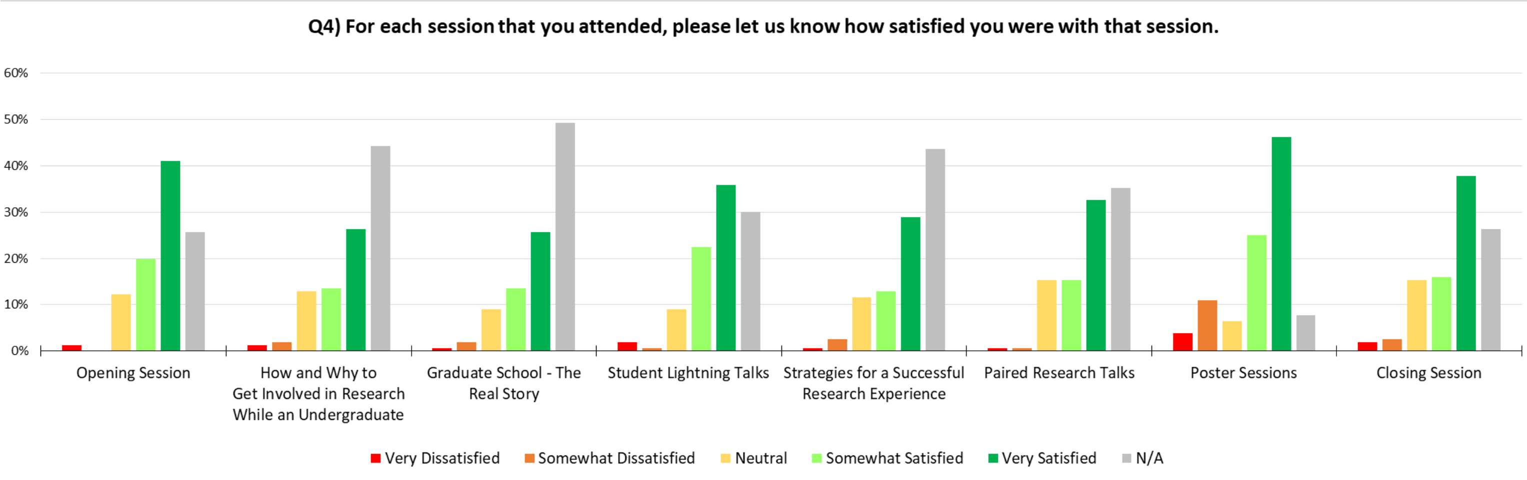
Q3) Please tell us how satisfied you were with the following aspects of the conference.

	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

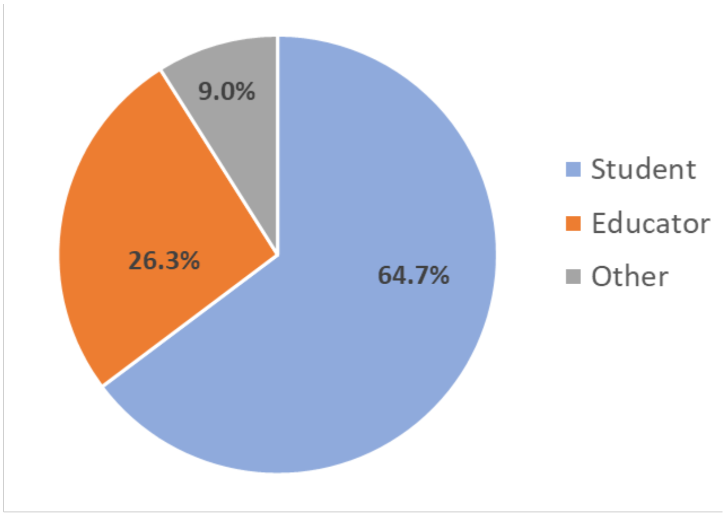

Q3) Please tell us how satisfied you were with the following aspects of the conference.
70%
60%
50%
40%
30%
20%
10%
0%
Registration Process
Poster Title Submission Process
Abstract/Poster/ Optional Video Submission Process
ForagerOne Symposium Site for Posters
Main Room Sessions
Breakout Sessions (other 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.

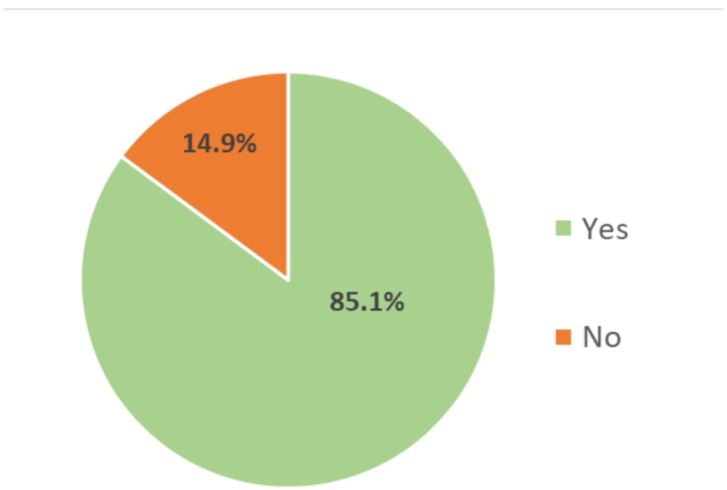


Answer	%	Count
Student	64.7%	101
Educator	26.3%	41
Other	9.0%	14
Total	100.0%	156

Q6) Other roles reported:

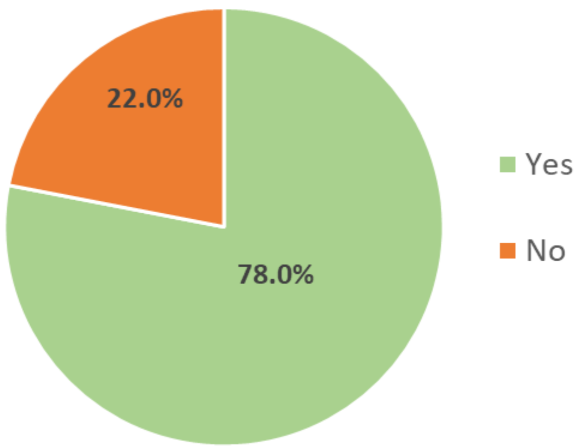
- Administrator
- Staff
- Mentor
- Panelist
- PI
- Program Director

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



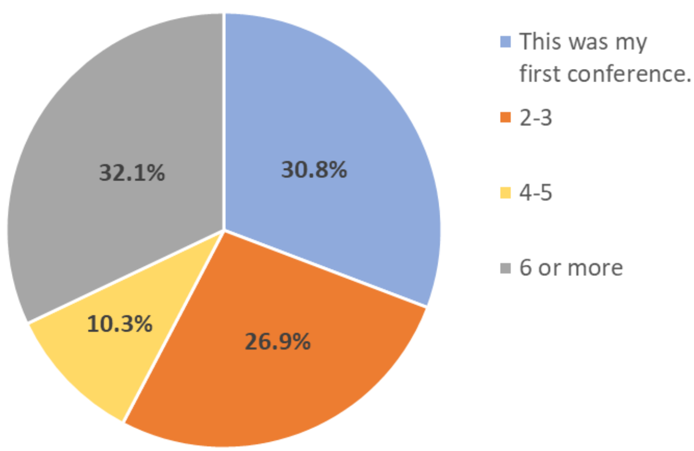
Answer	%	Count
Yes	85.1%	86
No	14.9%	15
Total	100.0%	101

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.)



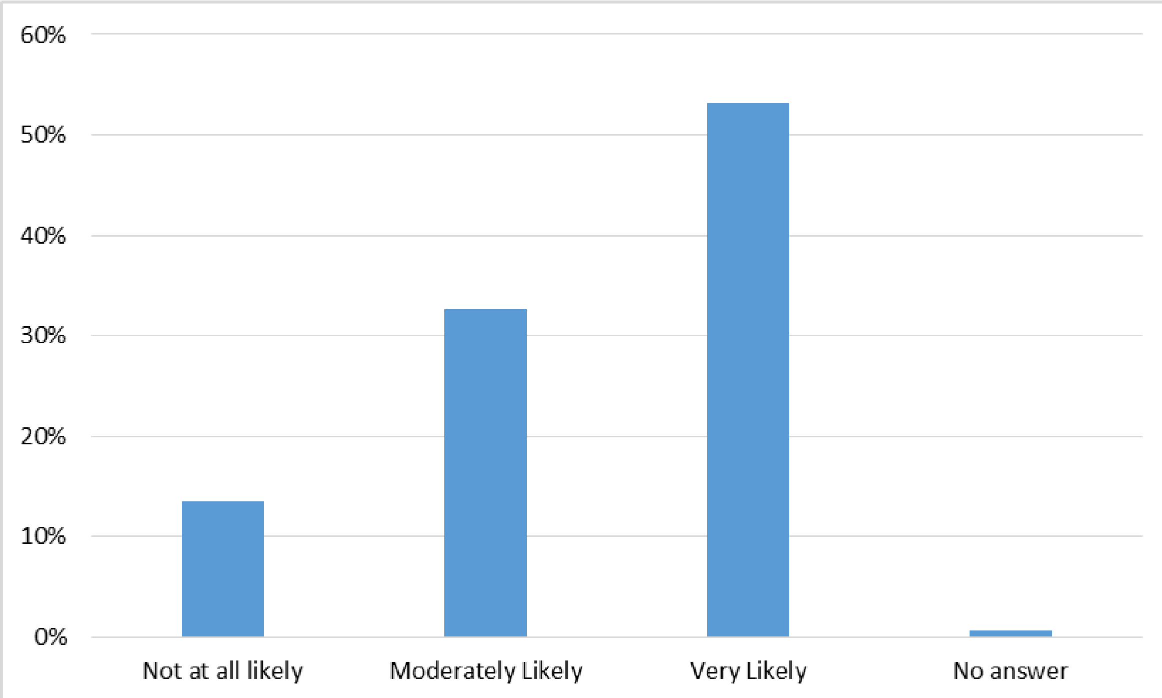
Answer	%	Count
Yes	78.0%	32
No	22.0%	9
Total	100.0%	41

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

Highlights:

- 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*

Strong criticisms:

- 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."*

Changes/Comments by Category (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.

IGEM19-001

HERC/IGEM Project

Yr 3: Final 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: $696,000

Fiscal Period: July 1, 2020 – June 30, 2021

Progress Report Submitted to SBOE: July 8, 2021

Reporting Period: July 1, 2020 – June 30, 2021

Table of Contents

1) Summary of project accomplishments for reporting period:

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 3 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. 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 3, building from Year 1-2 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) 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 focused 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 controls the length of the anaerobic period, with concurrent measurement of the oxidation-reduction (redox) potential. Research suggests that “deep anaerobic” conditions (i.e., longer anerobic periods) can enhance and stabilize EBPR; we utilized real-time redox process monitoring to further evaluate this operational strategy and its impact on operational “success” vs. “failure.” A Civil Engineering MS student completed all these assessments and completed her MS degree and thesis in early June 2021. Results also informed pilot (2021) operations. A publication is expected from this work.
- (Coats) Integrated with ongoing bench-scale EBPR bioreactor operations, another focus is analysis of a full-scale EBPR system to gain new insight into operation of secondary clarifiers related to achieved denitrification (reduction of nitrate to nitrogen gas). Excess nitrate recycled in an EBPR reactor can cause process failure. An MS graduate student defended his thesis June 25, 2021, focused on this topic. A publication is expected from this work.
- (Coats) Complementing EBPR investigations, we are investigating 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/Y3; results are being reviewed to inform 2021 pilot operations, and also to generate a peer-reviewed publication.
- (Coats) 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. Preliminary research generated on this project will contribute to this student ultimately completing his dissertation in fall 2021.

- One of Coats' PhD students conducted intense evaluations of the dairy-based PHA pilot in Y1/Y2, with very successful results. Dr. Coats' student published a peer-reviewed journal manuscript that details the results from these investigations (Guho et al., 2020). The manuscript includes numerous team members, including McDonald's research team. Coats' PHA pilot also was operated spring/summer 2020 (Y2, Y3); a primary focus was to couple Coats' PHA pilot with his EBPR pilot to evaluate broader process integration for enhance waste resource recovery. Utilizing this data coupled with data generated from Coats' EBPR pilot, a peer-reviewed publication was generated (Coats et al., 2021) that focused on interrogating the "sustainability" of integrating the respective processes while also demonstrating proof of concept.
- (Coats) One of Dr. Coats' MS students in Environmental Science completed a comprehensive targeted metabolomics study of a mixed bacterial system synthesizing PHA bioplastics on fermented dairy manure. The MS student will defend her thesis July 1. Subsequent efforts will be made to i) publish the research, and ii) leverage results to further inform the manure-to-plastics process.
- (Feris) Algal cultivars were used throughout year 3 for routine experimental deployment. Experiments focused on cultivation at both bench and pilot scales employing wastewaters and waste nutrient from multiple sources (e.g. currently PHA effluent provided by the Coats lab and struvite provided by 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. Bench scale experiments have elucidated the effects of nutrient deprivation and temperature shock on biomass production when using struvite sourced nutrients (e.g. nitrogen (N) and phosphorus (P)) in the presence and absence of nutrient supplementation. On-going work is measuring effects of these treatments on PUFA production rates. 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*). Results from this work will be drafted into a manuscript as part of a MS thesis (by Mr. Alex Torres) during Fall and Winter of 2021, with a projected submission date in late 2021 or early 2022.

  (Feris and McDonald) We completed our greenhouse/pilot-scale cultivation experiments during Spring 2020 and Summer/Fall 2020 that utilized a mixed-culture approaches for the capture of nutrients from liquid wastewaters (i.e. PHA effluent from the Coats lab system). Produced algal biomass from these experiments have been (a) characterized for carbohydrate and lipid contents, (b) lipid fatty acid profiles, and (c) HTL processed by the McDonald lab in May-June 2021. The HTL aqueous fraction containing nutrients have been collected and analyzed for sugars and organic acids. During the summer of 2021 nutrients captured from the HTL processing of algal biomass will 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 us to accurately 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. A publication is expected from this work.

Greenhouse cultivation results indicate we can generate high and consistent/repeatable levels of algal biomass on PHA reactor effluents and that the growth rates, biomass yields, and nutrient capture rates are repeatable and reliable as well. Our data analysis suggests that our algal community and nutrient capture/biomass production system is resilient to a substantial temporal perturbation in cultivation/incubation. Therefore, providing additional evidence of the stability and reliability of this aspect of our system.

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

- Both Coats' pilot systems (PHA system located at the UI dairy; EBPR system located at the Moscow, Idaho treatment facility) were operational in Y1-Y3. Coats' research team was fully trained on systems operation.
- Completed 2020 operations of Coats' pilot operations. Former efforts continued to focus on collecting data to facilitate ultimate transition to a full scale system; data was used to prepare a journal manuscript (Guho et al., 2020). 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 operational period in summer 2020 (end of Y2; beginning of Y3); data evaluation is ongoing, with the aim to inform 2021 pilot operations that will continue post-grant.
- Coats' pilot scale system at the Moscow treatment facility is operational for May-October 2021. This grant supported efforts to continue operations.
- Pilot scale greenhouse systems were constructed at the Boise State research greenhouse and have been validated for suitability for cultivation of multiple algal strains. In 2019 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. In 2020 we used this centrifuge routinely for the collection of algal biomass associated with our greenhouse cultivation experiments. These experiments have produced significant quantities of algal biomass for testing in our HTL process development (McDonald lab) as described in section (i). Data collection and analysis from the greenhouse/pilot scale experiments have been completed during the second half of year 3. These results will be used 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 2021 in collaboration with the Coats and McDonald labs at UI and as described above for our struvite-based experiments.

iii. Produce prototype products (bioplastic mulch film, biochar, biofuel) for evaluation.

- One PhD student in McDonald's lab has been working on exploring "green" extraction and isolation procedures for producing pure PHA bioplastic generated from pilot plant operations in years 1 and 2. We have trialed the following solvents dimethyl carbonate (DMC), cyclohexanone (CYC), and ethanol in comparison with the standard solvent chloroform. We have also modified an extraction system to accommodate (0.5 kg) batches of biomass for hot extraction. It was shown the DMC was a suitable solvent to extract PHA and can be purified in 1-step rather than a 2-3 step process using chloroform. The new DMC extraction protocols have not had a major influence on PHA properties. We have written a draft manuscript and plan to submit it in July 2021.
- One M.S. student in McDonald's lab has completed her M.S. degree May 2021 and had worked on cross-linking pilot plant extracted and commercial PHA to improve its melt flow properties (rheology) for producing film products. The work shows that cross-linking has improved its melt strength (viscosity) and toughness of the modified PHA. A publication is expected from this work.
- Blends of polylactic acid (PLA) and PHBV (67/33) have been successfully blown into films (Figure 1) and this is a suitable strategy to utilize PHBV in film-based materials. Current and ongoing work will focus on increasing PHBV content by varying process parameters and/or cross-linking PLA-PHBV. This work has been done by McDonald's Ph.D. student. A publication is expected from this work.
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ii. Figure 1. Photo of blown-film being produced of polylactic acid-PHBV blend

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- Greenhouse scale experiments in the Feris lab have been completed and produced suitable quantities of algal biomass. Protein, carbohydrate and lipid content of the algae was determined prior to HTL experiments by the McDonald lab. And on-going analyses are comparing protein extracted/non-extracted algae for HTL. Primary outputs of HTL processing of algal biomass will include biofuel (i.e. biooil), biochar, and aqueous phase nutrients. The aqueous phase nutrients will be used for struvite production and secondary

algal cultivation (as described above).

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 third SAB meeting was convened virtually on December 15, 2020. This meeting focused on providing research updates to our SAB committee members and inquiring with them on where they felt we should focus our efforts over the remainder of year 3. Importantly, a significant component of this conversation was focused on strategies and pathways to commercialization of the technologies we have studied and developed during this project. More work is needed in this area and will likely continue beyond the scope of this project. However, the relationships and advice developed and received by our SAB will be essential to our successful translation from the laboratory to "real-world" deployment.
b. A second SAB meeting was held virtually on December 17th, 2019. This meeting focused on providing research updates to our SAB committee members and inquiring with them on where they felt we should focus our efforts over the remainder of year 2. SAB 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. SAB members renewed their commitments to help the team pursue potential routes for commercialization as opportunities arise. Additionally, the SAB 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 SAB 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.
c. Additionally, our SAB 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.
d. <u>Research plan adjustments in response to our Stakeholder Advisory Board (SAB):</u> SAB 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. The Task A team also intends to build upon the SAB recommendations by contacting our university and regional support networks for business development. One of the Task A team's goals is commercialization of our integrated technology and during the 2nd half of year 3 we will work towards making appropriate contacts to forward this goal.

e. Another recommendation from our December 2019 SAB 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.

f. One of our goals for year 3 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 beyond the scope of this project. We continue to work towards this goal and during year 3, and beyond, we will focus our data collection efforts on system development and scale up as well as communication of research findings with our stakeholder group.

g. 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 since that time we have made significant progress towards our year 2 and year 3 research goals. Travel to and attendance at conferences/meetings that were planned were halted during this period and delivery of presentations impeded.

Goals/Plans for the remainder of Summer 2021 and follow-on research to be completed (Task A):

i: Bench scale

- Due to time limitations we have not completed our proposed experiments where the nutrients captured via HTL processing of algal biomass were to be tested in a secondary stage algae production system for high value commodity production either directly as aqueous nutrients or via production of struvite. However, we will strive to complete this work during the summer/fall of 2021 and use these data to evaluate the highest value use of the algal biomass and captured nutrients. This evaluation will be based on the algae's growth rates, yields, biomass characteristics, and economic potential when grown in the different wastewater nutrient sources.

ii: Pilot scale:

- We will continue to 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.
  - Have produced 300 g quantities of bioplastic material from Coats' pilot scale system for McDonald's ongoing polymer characterization work.
  - Have undertaken blown film trials using commercial and pilot scale produced PHA bioplastics by blending with PLA (Figure 1).

- 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.

<u>iii: Producing prototype products:</u>

- The Feris lab has produced suitable quantities of algal biomass in year 2 and 3 for HTL experiments in 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 of PHA/PLA blends 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.

<u>Accomplishments in Yr 3:</u>

i) Improvements to the water portion of system dynamics model, including updates to correspond to most recent IDWR EPSAM output, and improved user interface to provide decision-support tool for stakeholders

- Evaluated the existing system dynamics 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 to be released by IDWR in 2021
- Evaluated the feedback from IDWR and Surface Water User's Association at the stakeholder meetings in May 2019, Dec 2019, and Oct 2020 and how the ESPAM output could be more useful for stakeholders by incorporating ESPAM-derived behavior into the system dynamics model and creating a user-friendly interface that to allow stakeholders to adjust/understand the impacts of key system variables, thus serving as a decision-support tool for stakeholders
- Incorporated new features that are available in Stella Architect into the system dynamics model and user interface
- Performed an-in-depth review of the theoretical and technical background of each variable applied to the water balance, including the way it was produced by or for the IDWR ESPAM, how the data was accessed in 2008, and how it may change under new versions of ESPAM.
- Developed adaptable and individualized R coding to organize recent versions of the ESPAM data to work with the existing System Dynamics framework. All of this data may change along with changes to ESPAM, including units, size/number of entities, how calculations are performed, and format of the data. Thus, it was necessary for our R coding to be flexible in order to evolve with frequent changes.
- In order to formalize the process for reviewing and adapting the data in the future, R "markdown" files were used to begin development of a "bookdown", which can be used as an instructional guide and reference for future users working with the ESPAM data and system dynamics model.
- The ESPA System Dynamics model was streamlined to increase ease of updating data.
- Verified all units and calculations in the system dynamics model to ensure that they continue to match any formatting changes with the updated ESPAM data.
- Three separate model files were created for additional ease of use, depending on if the user wants to primarily focus on climate issues, is interested in varying the different types of groundwater pumping and recharge, or wants to work as deeply as the surface/groundwater entity scale.
- The newest version of the R bookdown file was completed and published in such a way that it is widely accessible, including researchers and water stakeholders.
- The models now represent the most recent data available from IDWR (Sept. 2018) and the new data in the system dynamics model are now available for stakeholder engagement and scenario planning.
- Improved graphical user interface by making the decision support tool available in the public domain over the internet so that all water interest groups can evaluate various scenarios by incorporating their interest and needs, ultimately enhancing water management decisions in ESPA.
- Updated available water data for Stella Architect using the outcomes from the latest version of ESPAM model
- Incorporated management options into the model, such as water conservation, managed recharge, etc.
- Developed system evaluation criteria associated with new data inputs and potential uses for the expanded and update model, such as system reliability, vulnerability, resilience, etc.

- Notes have been added to the models to reflect changes and improve ease of understanding.
- A manual was written to discuss the functioning of the model files, sources of data, and procedures for update.

ii) Further improvement of systems dynamics model to include linkages between water and energy use in irrigation

- 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 and relationships coded into systems dynamics model in August 2021

Follow-on tasks post grant period:

- The team will continue to work with stakeholders to disseminate the decision support tool to water users and food production/processing entities, as well as seeking external funds to continue to improve it and disseminate it.

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

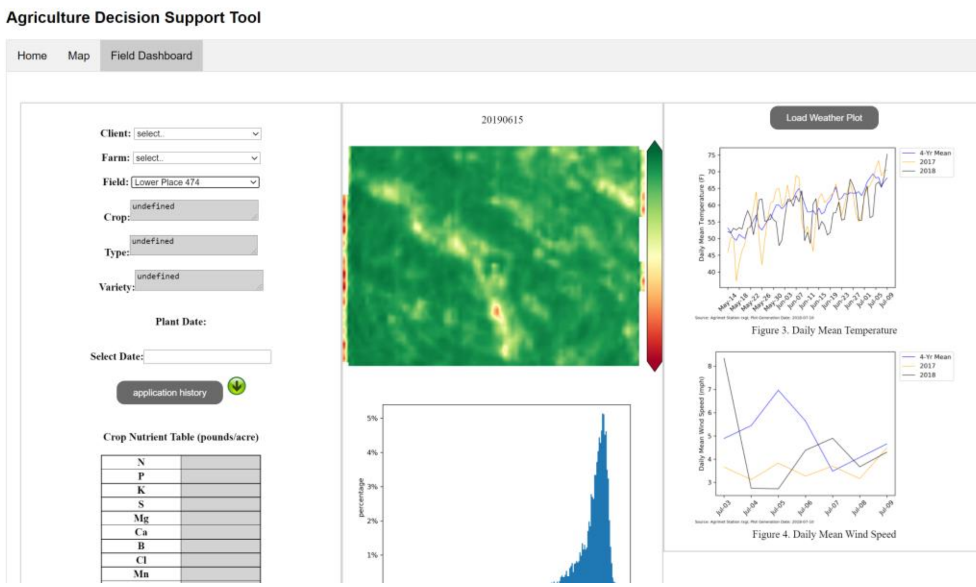
Primary team members: Donna Delparte, (ISU, drone and satellite-based sensing systems) and partners among growers and crop consultants.

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**
    - With our stakeholder input and feedback, our programmer (Di Wu) implemented a decision support online prototype tool for sustainable agriculture decision making: http://avalanche.geology.isu.edu/i2i/progro_hist2.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
    - A key component of the decision support system is to use a historical record of vegetation health over growing seasons going back to 2016 to develop a field prescription map for variable rate nutrient application
    - Stakeholders can browse satellite imagery taken over growing seasons 2016-2020 showing field variation within individual fields online and review prescription recommendations for the coming year

- Stakeholders are utilizing the outputs of the tool to improve ROI, reduce fertilizer inputs and improve precision farming techniques for sustainable agriculture
- Python code to automate nutrient prescription generation is now integrated in to the online tool and producers are adopting new fertilizer prescriptions.
- We have improved the interface to provide a dashboard (see image below) that is useful to growers.



- **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**
  - Hyperspectral camera data collection during the 2019 and 2020 growing seasons supplied a foundation to develop a model for detection of Potato Virus Y (PVY) in potato fields. This spring, our team collected new data from 2021's potato crop and used our model to identify infected plants in the field.
  - PhD student Mike Griffel developed Python code to apply a detection method to identify individual unhealthy plants in a grower's field. This approach leverages machine learning of hyperspectral imagery – thus offering the opportunity to reduce inputs for control and mitigation of disease. We are working with an outside venture capital company to market this technology in partnership with our spin-off company.
  - By individually detecting these plants we can provide coordinate locations for plant removal to existing spraying equipment to target and destroy these plants. By removing these plants, less nutrients are required to mitigate the impact of the virus.
  - Co-I Delparte launched a new Idaho based spin-off company (I2IGeo) to provide growers with technological innovations and decision support to aid their operations, leveraging the research outcomes from this grant.
  - To increase business market potential and kick start I2IGeo LLC, Delparte attended the Idaho I-Corps Ignite Faculty Summer Workshop offered by UI, BSU, ISU and the Center for Advanced Energy Studies.

Plans for the remainder of Summer 2021:

Our team will focus on the final testing and validation of UAS platform and sensor combinations for summer 2021 data collection. The emphasis will be on in-situ PVY detection, nutrient management decision support systems. Dr. Delparte will also continue to work actively toward commercialization of the most promising technologies from this research through her new Idaho company (I2IGeo) based on knowledge and skills developed in the I-Corps Ignite program.

- Additional training/testing with growers on the effectiveness of the satellite-based decision support tool for nutrient application prescriptions
- Commercialization of early season in-situ detection of PVY in potato crops
- Final stakeholder input on preferred delivery methods of time critical data and information related to yield forecasting and best practices for the treatment and removal of infected plants.

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:

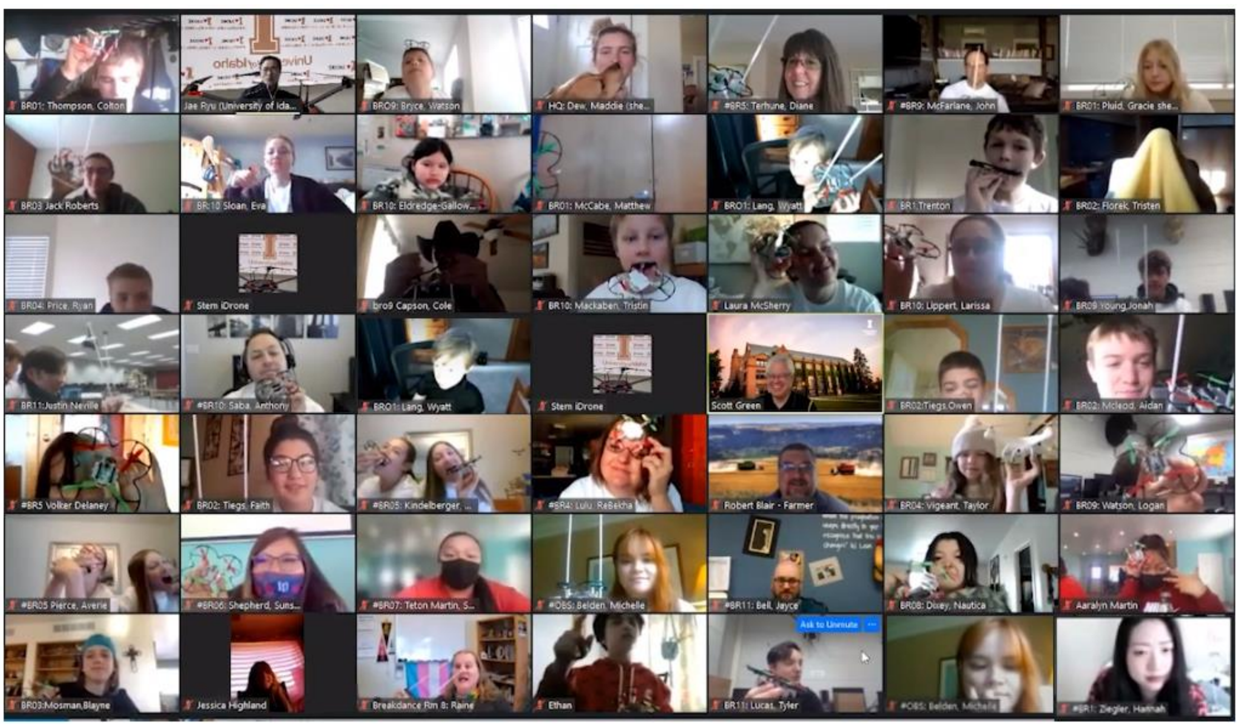
- *Goal 1: Current/near-term workforce development needs*
  - Due to Covid-19 and the cancellation of the meetings for the rural water treatment association, some of the outreach planned for the end of Yr 2 and during Yr 3 for outreach to these professionals via these meetings was difficult to accomplish. However, the team is continuing to engage with our Stakeholder Advisory Board and professional organizations such as Food Northwest and stakeholders such as the IDEQ on needs and opportunities in professional development on pollution control and management. We will continue to identify and implement professional development needs in food, water, energy and waste and interact with stakeholder to identify ways in which the universities can catalyze and facilitate these.
  - In order to better prepare university graduates for careers in integrated management of food production/processing, water and waste streams, as well as maintaining the tri-

institution collaboration in this IGEM grant, the universities plan to develop and maintain an ongoing seminar series in Food-Energy-Water-Waste for faculty, undergrads and undergraduates. The seminar will be joint among the three universities and include coordination with the CAES (Center for Advanced Energy Studies) organization.

- *Goal 2: Longer-term workforce needs*

An important component of meeting longer-term workforce needs throughout all years of our project has been hosting a virtual education program known as "Idaho Drone League(iDrone)" in the Treasure Valley and elsewhere throughout the state. The purpose of these events is to promote STEM pipelines and skills important to the Idaho food industry in the future.

Two Idaho Drone League events took place on October 10, 2020 and April 2-3, 2021 in Year 3. But due to the global pandemic, these events were offered online. Despite the virtual format, the event was very well attended.



For the April 2-3, 2021 event, more than 80 people joined this meeting online, including UI President Green, 12 Zoom breakout session coordinators, 65 registrants, and 10 observers.

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 its entirety once/yr in person (May/June), once/yr via videoconference (Nov/Dec) and have specialized meetings between specific sub-groups of team and advisory board members in between.

Accomplishments this period:

- We held a 3rd meeting of our full Stakeholder Advisory Board (SAB) on Dec 15, 2020. Due to travel restrictions because of the ongoing pandemic, the meeting was held by video conference. 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)
    - Megan Satterwhite, Operations Manager, Idaho Dairyman's Association
    - 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

- As noted on early sections of this report, the Task A team has been engaged in discussions with the Idaho Dairyman's association and the Newtrient LLC on technology transfer, the Task B team is interacting with water users for dissemination of the decision support tool for water/energy planning, and the Task C team was highly engaged with stakeholders in the food production arena on decision support tools.

Plans for follow-on:

- We will hold a SAB meeting in August 2021 to discuss final project accomplishments from Summer 2021 field and research season and discuss plans for follow-on with stakeholders
- Develop a task force that will continue to meet beyond end date of the grant to discuss mechanisms for transfer of applied research from the grant into the private sector. The task force will consist of personnel from the research team, tech transfer and economic development officers from the Office of Research and Economic Development from UI, BSU and ISU, plus stakeholder advisory board members as available.

- 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 to engage in follow-on applied research and mechanism for technology transfer.

2. Summary of budget expenditures to date for Yr 3

A detailed expenditure report for estimated expenses incurred at the UI is provided in Appendix A. Please note that this does not constitute a final report, as some expenses incurred before June 30 are still clearing the system, but this is what we anticipate to be as close to our final numbers as we are able to estimate at this time. The table below summarizes the spending in the major budget categories, relative to the budgeted amounts for Year 3. Please note that the line below for Operating Expenses (OE) includes the amounts originally budgeted for both OE and Participant Costs. This is because the expenses placed under participant costs in the original 2018 budget were judged by the UI accounting personnel to be more appropriately placed under the category of Operating Expenses.

Per grant guidelines, the UI and both subawardees, prior to June 20, the UI and both subawardees carefully projected all spending that would occur by June 30 and returned to SBOE funds that would not be spent by 6/30. The UI and ISU projected that all funds would be expended by June 30, but subawardee Boise State University projected that $6623.60 would not be spent by June 30. The UI sent a check to SBOE in that amount just prior to June 20, 2021. A final and full financial report will be sent to SBOE within the typical timeframe for final grant closeout.

Estimate of Funds Expended (not final)

Category	Budget	Funds Expended	Difference
Salaries/Hourly/Fringe	297756	297378	378
Travel	3337	2520	817
OE	83998	85151	-1153
Participant Support	0	0	0
<$5K Capital	85	85	0
Trustee/Benefits	63410	63452	-42
Sub Contracts	247414	240790	6624
Total	696000	689376	6624

Note: $6623.63 returned to SBOE on 6/20/21

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 Yr 3, 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 (3 whom are from groups underrepresented in STEM), 2 ISU; 2 BSU (both of whom are from groups underrepresented in STEM fields)
Undergrad Students: 7 (5 at UI, 2 at BSU)
Research Scientists: 1 (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 (one PT, one FT); 3 MS student in Environmental Engineering; 4 undergraduate students in Environmental Engineering. 4 women, 5 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 have recruited 2 undergraduate students (1 or 2) for the second half of year 2 and year 3 to assist with laboratory and greenhouse scale experiments.

Task B: Quantifying Water/Energy Linkages

- 1.5 PhD students (1 in Geography, 0.5 in Water Resources) were supported throughout Yr 3. In the last quarter of Yr 3, we sought and received permission to redirect travel funds to support two undergraduates and one additional graduate student as research assistants for this task.

Task C: Technical innovations/sensing systems for reducing water/nutrient use in targeted production systems

- 1 PhD students in Geosciences
- 3 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 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 2021 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 Sept 2021.

- Co-I Erik Coats (and team leader for Task A of this grant) is a Co-I on the recently awarded 5-yr $20M 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.

- Delparte (Lead Task C) received funding to further the PVY testing for the upcoming growing season from the Idaho Specialty Crop Block Grant (Idaho State Department of Agriculture/US Department of Agriculture). Awarded. Field Trials for an Automated Early Season Potato Virus Y (PVY) Detection System. PI- Delparte. Oct 2020 to Oct 2022. $97,803.16

- Delparte (Lead Task C) is working towards commercialization of research supported by this initiative to aid growers in sustainable fertilizer applications and towards a targeted treatment approach for potato virus y.

- All 6 members of the Co-I team are active grant writers and continue to look for new opportunities to “bridge the gap” between academic research and state needs in this arena. One such opportunity we will be evaluating in the future is a new proposed program within the National Science Foundation (NSF) specifically designed to create stronger partnerships between academic institutions and technological needs. The current administration budget proposal for for FY22, the NSF budget includes $865 million for the new program called Technology, Innovation, and Partnerships. We will also aggressively pursue other opportunities within USDA, NSF, EPA, NASA, and other federal agencies.

6. Expenditure reports

The expenditure reports presented in Appendix A details the expenditures at the University of Idaho, as of July 7. As noted above, this is not a final report, as some personnel charges are still clearing the system and a small amount of operational expenses incurred are in the process of being removed.

7. Commercialization Revenue

None to report yet, but the company I2IGeo (Co-I Delparte as Founder) has been formed. Delparte attended the Idaho I-Corps Ignite program in Summer 2021 to learn more about business development and commercializing research.

Publications:

Guho, N.M., D. Pokhrel, M. Abbasi, A.G. McDonald, M. Alfaro, C.K. Brinkman, and E.R. Coats, Pilot-scale production of poly-3-hydroxybutyrate-co-3-hydroxyvalerate from fermented dairy manure: Process performance, polymer characterization, and scale-up implications. Bioresource Technology Reports, 2020. 12: p. 100588.

Bryant, C. and E.R. Coats, Integrating Dairy Manure for Enhanced Resource Recovery at a WRRF: Environmental Life Cycle and Pilot-scale Analyses. Water Environ. Res., 2021.

Coats, E.R., *B. Deyo, *N. Brower, and C.K. Brinkman, Effects of Anaerobic HRT and VFA Loading on the Kinetics and Stoichiometry of Enhanced Biological Phosphorus Removal. Water Environ. Res., 2021.

Appendix A

Detailed Expense Report

Detailed UI Expenditures as of July 7, 2021 and Final Invoices from Subawardees

Please note: This is not a final financial report, because not all expenses have cleared the reporting system. Final financial report will be forthcoming upon grant close-out, including detailed reports from subawardees

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FWRITEM                     University of Idaho
                     Itemized Expenditures by Grant Code
                       From 01-JUL-2020 To 08-JUL-2021

Grant: SG4609 - ISBOE IGEM FY21 Sustain Food Ind-KH         08-Jul-2021 12:11 PM
--------------------------------------------------------------------------------
Salaries
   E4106 Staff
         Brinkman, Cynthia                                              8979.78
             495.02 hours
   E4108 Summer Salary
         Coats, Erik                                                    2350.32
              33.60 hours
         Humes, Karen                                                  21228.48
             288.00 hours
         McDonald, Armando                                             11225.76
             156.00 hours
         Ryu, Jae                                                      19585.32
             334.46 hours
   E4109 IA/GA Salary
         Abbasi, Maryam                                                19869.76
             992.00 hours
         Brower, Nicole                                                17100.00
             912.00 hours
         Deyo, Brent                                                   22800.00
             912.00 hours
         Mellin, Jason                                                  9903.52
             272.00 hours
         Pokhrel, Dikshya                                               7547.40
             420.00 hours
         Smoot, Lindsey                                                18700.00
             992.00 hours
         Thompson, Emily                                               17245.80
             780.00 hours
   E4175 Overtime - Covered by FLSA
         Brinkman, Cynthia                                                45.59
               5.02 hours
                                                                     ----------
                                                                    $ 176581.73

Temporary/Irregular Help
   E4110 Temporary Employee
         Holownia, Sam                                                  2250.00
             125.00 hours
   E4135 Temporary Student
         Alfaro Salmeron, Glenda                                        1500.00
              80.00 hours
```

Black, Edward	5810.75
539.00 hours	
Brower, Nicole	1125.00
60.00 hours	
Buonarati, Nickolas	459.25
41.75 hours	
Crites, Willow	6301.65
576.00 hours	
Cutler, Kylie	270.88
25.00 hours	
Deyo, Brent	2000.00
80.00 hours	
Emerick, Austin	1245.75
116.50 hours	
Guho, Nicholas	8972.98
323.00 hours	
Hurdman, Julie	688.50
38.25 hours	
Neupane, Saurav	10657.64
992.00 hours	
Thompson, Emily	6440.00
280.00 hours	
Walters, Riveraine	10448.00
434.00 hours	
Woodruff, Craig	3625.00
145.00 hours	

	$ 61795.40

Fringe Benefits

E4280 Faculty CFR Benefit Expense	16697.67
E4281 Staff CFR Benefit Expense	3772.59
E4282 Student CFR Fringe Expense	3627.07
E4283 Temporary CFR Benefit Expense	177.75

	$ 24275.08

Travel

E5360 Personal Vehicle - In-State

28-SEP-20	I2149392	Ryu, Jae H.	147.53
20-OCT-20	I2152672	Ryu, Jae H.	190.53
20-OCT-20	I2152672	Ryu, Jae H.	251.98
20-OCT-20	I2152672	Ryu, Jae H.	250.36
20-OCT-20	I2152672	Ryu, Jae H.	251.98
20-OCT-20	I2152672	Ryu, Jae H.	190.53
19-NOV-20	I2156564	Ryu, Jae H.	112.70
20-NOV-20	I2156758	Ryu, Jae H.	150.35
23-JUN-21	I2184245	Ryu, Jae H.	175.19
23-JUN-21	I2184245	Ryu, Jae H.	143.68

E5367 Rental Vehicles - In-State

13-OCT-20	Z1010112	Car Rental Fuel 09142020	26.52
13-OCT-20	Z1010112	Car Rental Fuel 09152020	16.27
13-OCT-20	I2151573	Ryu, Jae H.	87.55

E5396 Lodging & Per Diem ? In State

28-SEP-20	I2149392	Ryu, Jae H.	49.00
13-OCT-20	I2151573	Ryu, Jae H.	26.00
13-OCT-20	I2151573	Ryu, Jae H.	23.00
20-OCT-20	I2152672	Ryu, Jae H.	42.00
20-OCT-20	I2152672	Ryu, Jae H.	49.00
20-OCT-20	I2152672	Ryu, Jae H.	49.00
20-OCT-20	I2152672	Ryu, Jae H.	42.00
20-OCT-20	I2152672	Ryu, Jae H.	49.00
19-NOV-20	I2156564	Ryu, Jae H.	49.00
20-NOV-20	I2156758	Ryu, Jae H.	49.00
23-JUN-21	I2184245	Ryu, Jae H.	49.00
23-JUN-21	I2184245	Ryu, Jae H.	49.00

			$ 2520.17

Operating Expenses

E5020 Postage & Mailing

13-JAN-21	Z1012991	Shipping materials to graduate stud	28.99

E5023 Express Mail

05-JAN-21	Z1012750	RyuJa 893235 USPS Stamps and mailin	15.40
14-JUN-21	Z1018542	Shipping Charges for the Spectromet	112.80
29-JUN-21	Z1019772	McDonald, A: FedEx shipping costs t	508.27
30-JUN-21	I2185662	Ryu, Jae H.	17.99
30-JUN-21	I2185662	Ryu, Jae H.	17.99
30-JUN-21	I2185662	Ryu, Jae H.	350.00
30-JUN-21	I2185662	Ryu, Jae H.	17.99

E5025 Printing & Binding

09-SEP-20	J1275946	Tckt#555840827 iDrone flyr-CALS;bc	150.00

E5070 Conference/Registration Fees

14-DEC-20	Z1012231	RyuJa 701172 Facebook Event registr	10.00
16-DEC-20	Z1012307	AGU Full meeting, advance, non-memb	350.00
16-DEC-20	Z1012307	Student (graduate): Full meeting, A	125.00
17-DEC-20	I2159740	Thompson, Emily	40.00
15-MAR-21	I2169914	Humes, Karen S..	150.00
20-MAY-21	I2178710	Abbasi, Maryam	495.00

E5152 All Other Services

12-AUG-20	I2143936	Idaho STEM Action Center	1250.00

E5177 Program Fees

05-JAN-21	Z1012750	RyuJa 893235 Register@FAA iDrone re	5.00

E5199 Other Professional Service

20-AUG-20	I2144864	Built by Thrive LLC	1450.00
21-SEP-20	I2148357	Built by Thrive LLC	1450.00

E5320 Software/Applications - Individual

14-APR-21	Z1016016	Stella Architect software license	849.00

E5330 Software/Applications - College/Dep			
14-DEC-20	Z1012231	RyuJa 701172 Screencastify Software	29.00
18-DEC-20	Z1012417	RyuJa 622558 Amazon Web Services SB	30.87
E5560 Technology - Supplies			
25-FEB-21	Z1014270	Printer cartridge for lab. Sales ta	121.58
25-FEB-21	Z1014270	Refund for sales tax. Index 820907	-6.88
E5640 R&M Sup - Technology Infrastructure			
23-JUN-21	TC062321	TDX 164787 Switch for Boise Lab 224	327.96
E5710 Tools			
01-MAR-21	Z1014435	A McDonald: laser cutter for resear	389.99
10-MAR-21	Z1014808	A McDonald: Bench circular saw for	126.39
E5720 Educational Supplies			
07-AUG-20	J1274219	JKD/ Phys Mchn Shp Wrk: A.McDonald	373.78
21-SEP-20	J1276372	JKD/ Phys Mchn Shp Wrk: A. McDonald	243.31
E5724 Research Supplies			
09-JUL-20	Z1007362	McDonald- purchased this micromanip	62.00
09-JUL-20	Z1007362	McDonald-purchased some lab supplie	21.71
09-JUL-20	Z1007362	McDonald-purchased these sample hol	160.00
09-JUL-20	Z1007362	McDonald-purchased this replacement	73.32
14-JUL-20	Z1007430	Charge for bulk fasteners for tank	4.19
14-JUL-20	Z1007430	Charge for cylinders, specialty gas	49.50
14-JUL-20	Z1007430	Charge for misc. parts and fittings	221.47
14-JUL-20	Z1007430	Charge for pipette tips, research s	277.84
29-JUL-20	Z1007739	Book: Water in Plain Sight: Hope	15.25
29-JUL-20	Z1007739	Books purchased from Amazon: The C	118.97
29-JUL-20	Z1007739	Books: The Fate of Food: What We'l	33.18
04-AUG-20	Z1007879	McDonald- purchased these glass ext	147.47
04-AUG-20	Z1007879	McDonald- supplies for research	369.58
04-AUG-20	Z1007879	McDonald-purchased 2 replacement pr	196.52
04-AUG-20	Z1007879	McDonald-purchased a small wet/dry	53.97
04-AUG-20	Z1007879	McDonald-purchased these DMA access	116.60
05-AUG-20	Z1007927	Charge for 1000 round bottom test t	373.70
05-AUG-20	Z1007927	Charge for 2 ml vials and caps, 10	360.48
05-AUG-20	Z1007927	Charge for lab tape, research suppl	43.23
05-AUG-20	Z1007927	Charge for nitrogen test kits, rese	109.83
05-AUG-20	Z1007927	Charge for premeasured unit dose re	37.54
05-AUG-20	Z1007927	Charge for reagent, research suppli	738.20
05-AUG-20	Z1007927	Charge for standards for pH testing	59.34
05-AUG-20	Z1007927	Charge for sterile pipettes, resear	61.65
05-AUG-20	Z1007927	Charge for wipes, pipettes for lab	308.47
18-AUG-20	Z1008276	Charge for enzymes to test for glyc	145.55
18-AUG-20	Z1008276	Charge for massive re-stocking of t	3274.96
18-AUG-20	Z1008276	Charge for test kits for nitrogen a	456.42
18-AUG-20	Z1008276	Charge for two new pH probes, resea	541.95
20-AUG-20	I2144934	Ryu, Jae H.	1382.48
01-SEP-20	I2146251	Ryu, Jae H.	534.97
04-SEP-20	Z1008779	Charge for cable for new VFD contro	63.75
04-SEP-20	Z1008779	Charge for cylinders, specialty gas	195.63
04-SEP-20	Z1008779	Charge for medium and large nitrile	342.63

04-SEP-20	Z1008779	Charge for new key pad for Erik Coa	154.50
04-SEP-20	Z1008779	Charge for new sensor caps for diss	442.75
04-SEP-20	Z1008779	Charge for nitrite reagent powder,	149.07
04-SEP-20	Z1008779	Charge for universal pipette tips,	84.63
08-SEP-20	Z1008846	McDonald- item was not as described	-42.40
08-SEP-20	Z1008846	McDonald- purchased disposable glov	92.37
08-SEP-20	Z1008846	McDonald- purchased some gas fittin	26.50
08-SEP-20	Z1008846	McDonald- purchased some high tempe	12.98
08-SEP-20	Z1008846	McDonald- purchased these quick con	41.87
08-SEP-20	Z1008846	McDonald-disposable gloves for rese	104.00
08-SEP-20	Z1008846	McDonald-purchased some gas fitting	42.40
08-SEP-20	Z1008846	McDonald-purchased these hole-saws	8.19
08-SEP-20	Z1008846	McDonald-purchased this glass grind	110.00
22-SEP-20	Z1009345	RyuJa 305625 Amazon Camera mount an	35.98
22-SEP-20	Z1009345	RyuJa 305625 Amazon Monitor mount a	35.39
22-SEP-20	Z1009345	RyuJa 305625 Amazon Power outlet, t	201.73
22-SEP-20	Z1009345	RyuJa 305625 Amazon Printer pick up	12.50
22-SEP-20	Z1009345	RyuJa 305625 Amazon Table mat neede	58.03
22-SEP-20	Z1009345	RyuJa 305625 Amazon UAS development	127.07
22-SEP-20	Z1009345	RyuJa 305625 Amazon Webcam, network	205.32
22-SEP-20	Z1009345	RyuJa 305625 Costco A small monitor	169.59
22-SEP-20	Z1009345	RyuJa 305625 Costco CAMP office sup	83.72
22-SEP-20	Z1009345	RyuJa 305625 Staples Storage boxes	91.12
22-SEP-20	Z1009354	RyuJa 221612 Amazon Data storage an	31.71
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	9.53
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	12.77
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	22.44
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	8.99
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	7.99
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	-80.55
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	203.66
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	19.99
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	73.17
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	65.52
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	35.23
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	122.14
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	10.96
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	244.92
22-SEP-20	Z1009354	RyuJa 221612 Amazon SBOE research p	219.94
22-SEP-20	Z1009354	RyuJa 221612 Tower Hobbies SBOE res	13.76
22-SEP-20	Z1009354	RyuJa 221612 Verizon SBOE research	182.82
24-SEP-20	Z1009447	Charge for cylinders, specialty gas	195.63
24-SEP-20	Z1009447	Charge for liners for Erik Coats' G	174.53
24-SEP-20	Z1009447	Charge for new septa for Erik Coats	78.40
29-SEP-20	I2149458	Oxarc Inc.	80.75
29-SEP-20	I2149453	Oxarc Inc.	68.36
01-OCT-20	J1276792	cfc: ct from 691709 to 691680	8.49
02-OCT-20	I2150083	Oxarc Inc.	80.75
08-OCT-20	I2151006	Ryu, Jae H.	8077.76

09-OCT-20	Z1009984	McDonald- PTFE sheets for research	40.99
09-OCT-20	Z1009984	McDonald- Return of amazon research	-22.60
09-OCT-20	Z1009984	McDonald- items for research	38.34
09-OCT-20	Z1009984	McDonald- purchased this item for r	59.19
09-OCT-20	Z1009984	McDonald- purchased this replacemen	94.34
09-OCT-20	Z1009984	McDonald- sharpening stones for res	22.60
09-OCT-20	Z1009984	McDonald- supplies for research	183.08
09-OCT-20	Z1009984	McDonald-purchased replacement UPS	29.90
09-OCT-20	Z1009984	McDonald-replacement temperature co	20.00
13-OCT-20	I2151582	Ryu, Jae H.	132.32
28-OCT-20	Z1010668	Charge for cylinders, specialty gas	483.22
28-OCT-20	Z1010668	Charge for enzymes for glycogen tes	162.62
28-OCT-20	Z1010668	Charge for metabolites, research su	304.87
28-OCT-20	Z1010668	Charge for metabolites, research su	301.45
28-OCT-20	Z1010668	Charge for metabolites, research su	86.40
28-OCT-20	Z1010668	Charge for vials with screw top cap	360.48
09-NOV-20	Z1011044	McDonald- book for research	13.98
09-NOV-20	Z1011044	McDonald- items purchased for resea	243.61
09-NOV-20	Z1011044	McDonald- items purchased for resea	13.00
09-NOV-20	Z1011044	McDonald- purchased book for resear	7.98
09-NOV-20	Z1011044	McDonald- temperature controller fo	19.74
11-NOV-20	I2155421	Oxarc Inc.	68.36
12-NOV-20	I2155674	Oxarc Inc.	80.75
20-NOV-20	Z1011508	Charge for cylinders, specialty gas	57.00
20-NOV-20	Z1011508	Charge for enzymes for glycogen ana	145.55
20-NOV-20	Z1011508	Charge for metabolites for analysis	453.09
20-NOV-20	Z1011508	Charge for metabolites for analysis	139.41
20-NOV-20	Z1011508	Charge for metabolites for analysis	250.28
20-NOV-20	Z1011508	Charge for new caps for ammonia pro	2634.54
20-NOV-20	Z1011508	Charge for new column for LC/MS to	654.93
03-DEC-20	Z1011818	McDonald- hot blade for research	19.99
03-DEC-20	Z1011818	McDonald- lab supplies for research	38.34
03-DEC-20	Z1011818	McDonald- lab supplies for research	16.00
03-DEC-20	Z1011818	McDonald- lab supplies for research	10.88
03-DEC-20	Z1011818	McDonald- research supplies	194.67
03-DEC-20	Z1011818	McDonald- research supplies	152.87
03-DEC-20	Z1011818	McDonald- steel rulers for the lab	7.98
03-DEC-20	Z1011818	McDonald- supplies for research	321.42
04-DEC-20	I2158036	Oxarc Inc.	80.75
14-DEC-20	Z1012231	RyuJa 701172 Amazon Rubber bands ne	5.18
14-DEC-20	Z1012231	RyuJa 701172 Amazon Weight scale ne	25.02
14-DEC-20	Z1012231	RyuJa 701172 Amazon Wood chips need	27.95
15-DEC-20	Z1012248	Charge for cylinders, specialty gas	195.63
15-DEC-20	Z1012248	Charge for new jugs for wastewater,	39.82
18-DEC-20	Z1012417	RyuJa 622558 Staples Box storage fo	90.91
18-DEC-20	Z1012417	RyuJa 622558 VistaPrint Refund of I	-5.08
18-DEC-20	Z1012417	RyuJa 622558 VistaPrint Refund of I	-3.30
18-DEC-20	Z1012417	RyuJa 622558 VistaPrint Refund of I	-12.46
18-DEC-20	Z1012417	RyuJa 622558 VistaPrint SBOE Stem C	58.30

18-DEC-20	Z1012417	RyuJa 622558 VistaPrint STEM Camp i	89.75
18-DEC-20	Z1012417	RyuJa 622558 Vistaprint Idaho sales	219.64
05-JAN-21	Z1012750	RyuJa 893235 Amazon Certificate cov	7.11
05-JAN-21	Z1012750	RyuJa 893235 Amazon Certificate pap	41.93
06-JAN-21	I2161260	Oxarc Inc.	80.75
13-JAN-21	Z1012991	Chemicals for research purposes.	183.08
13-JAN-21	Z1012991	Chisel for research purposes.	7.99
13-JAN-21	Z1012991	DSC Sample Pan and Pan Style Lid Ki	475.07
13-JAN-21	Z1012991	Electronic balance for research.	293.22
13-JAN-21	Z1012991	Fastener for research purposes	2.60
13-JAN-21	Z1012991	Filters for research purposes	170.95
13-JAN-21	Z1012991	GCMS septa for research purposes	295.02
13-JAN-21	Z1012991	PurpleAir air monitor for research	288.33
13-JAN-21	Z1012991	Switches and outlets for research.	16.85
04-FEB-21	I2165000	Oxarc Inc.	426.22
04-FEB-21	I2165028	Oxarc Inc.	88.80
19-FEB-21	B1847480	Oxarc Inc.	-80.75
19-FEB-21	I2166735	Oxarc Inc.	80.75
25-FEB-21	Z1014270	Oxarc cylinder rental on index 8209	57.00
25-FEB-21	Z1014270	PGO enzyme kit for research. Index	145.55
26-FEB-21	Z1014361	Bearings for pumps. Index 820907 su	76.40
26-FEB-21	Z1014361	Brush to clean glassware. Index 820	7.19
26-FEB-21	Z1014361	Diffuser stones for bioreactors. In	17.97
26-FEB-21	Z1014361	Gasses for my GC/FID. Index 820907	57.00
26-FEB-21	Z1014361	Gene fragment for conducting RT-qPC	100.91
26-FEB-21	Z1014361	Jugs for wastewater. Index 820907 s	60.93
26-FEB-21	Z1014361	Mechanical seals for pumps. Index 8	58.98
26-FEB-21	Z1014361	New pump for lab bioreactors. Index	450.50
26-FEB-21	Z1014361	New pump for lab reactors. Index 82	413.03
26-FEB-21	Z1014361	Test tubes and caps for research. I	547.40
26-FEB-21	Z1014361	Tubing for lab reactors. Index 8209	9.09
26-FEB-21	Z1014361	pH probes for research. Index 82090	673.95
01-MAR-21	Z1014435	A McDonald: Quartz slides for resea	19.28
01-MAR-21	Z1014435	A McDonald: replacement battery for	4.49
09-MAR-21	I2169187	Oxarc Inc.	80.75
10-MAR-21	Z1014808	A McDonald: label maker, USB hub, r	50.24
10-MAR-21	Z1014808	A McDonald: storage containers for	27.98
07-APR-21	I2172827	Humes, Karen S..	31.79
14-APR-21	Z1016039	Caps for DO probes. Index 820907 su	483.95
14-APR-21	Z1016039	Chemicals to inhibit nitrification.	249.21
14-APR-21	Z1016039	DNA fragments for ongoing molecular	110.04
14-APR-21	Z1016039	GC vials and caps for Coats' resear	714.58
14-APR-21	Z1016039	Gas for instruments. Index 820907 s	64.50
14-APR-21	Z1016039	Pump parts for my scale model syste	2628.59
14-APR-21	Z1016039	Wastewater jugs. Index 820907 sueb	40.62
14-APR-21	Z1016039	gene fragments for transcriptomics.	126.63
14-APR-21	I2173614	Oxarc Inc.	80.75
22-APR-21	J1286681	CTMA from 826717 to 820907	369.11
22-APR-21	I2174805	Oxarc Inc.	446.78

29-APR-21	Z1016653	A McDonald: bolts for research proj	6.24
04-MAY-21	J1287367	JKD/ Phys Shp Wrk: AMcDonald	45.00
10-MAY-21	Z1017010	A McDonald: DSC pans for research	708.89
10-MAY-21	Z1017010	A McDonald: Visitorspc Unctd Ansi f	69.95
10-MAY-21	Z1017010	A McDonald: assorted rubber o-rings	7.19
10-MAY-21	Z1017010	A McDonald: lab supplies: wire whee	12.99
10-MAY-21	Z1017010	A McDonald: lab/woodshop supplies f	34.79
10-MAY-21	Z1017010	A McDonald: lab/woodshop supplies f	37.68
10-MAY-21	Z1017010	A McDonald: microscope slides for l	11.95
10-MAY-21	Z1017010	A McDonald: pellet die set for rese	92.05
10-MAY-21	Z1017010	A McDonald: pipe fittings for rese	58.44
10-MAY-21	Z1017010	A McDonald: plug for research equip	3.49
10-MAY-21	Z1017010	A McDonald: quick disconnect compre	34.04
10-MAY-21	Z1017010	A McDonald: replacement v-belt for	6.59
10-MAY-21	I2177451	Oxarc Inc.	71.02
10-MAY-21	I2177459	Oxarc Inc.	88.80
24-MAY-21	J1288566	JKD/ Phys Mchn Shp Wrk: McDonald	105.00
24-MAY-21	J1288569	JKD/ Phys Mchn Shp Wrk: McDonald	138.95
28-MAY-21	Z1017886	Electromagnetic flow meters for my	1619.44
28-MAY-21	Z1017886	New redox probe for research. Index	502.95
28-MAY-21	Z1017886	Nitrate test kits and syringes for	1001.90
28-MAY-21	Z1017886	Nitrate test kits. Index 820907 sue	119.25
28-MAY-21	Z1017886	Phosphorus, ammonia, nitrate test k	2018.55
28-MAY-21	Z1017886	Receipt for Oxarc invoice. Index 82	49.50
02-JUN-21	I2180685	Oxarc Inc.	88.80
14-JUN-21	I2182710	Oxarc Inc.	15.00
22-JUN-21	I2183987	Ryu, Jae H.	1799.00
22-JUN-21	I2183987	Ryu, Jae H.	5000.00
22-JUN-21	I2183987	Ryu, Jae H.	380.22
22-JUN-21	I2183987	Ryu, Jae H.	977.07
24-JUN-21	Z1019058	McDonald, A: Ceramic terminal cover	68.45
28-JUN-21	Z1019296	Gasses for GC/FID. Index 820907 bba	49.50
28-JUN-21	Z1019296	pH buffer solutions for probe calib	139.37
29-JUN-21	Z1019577	Book to be used in completing the g	29.95
29-JUN-21	Z1019577	Book: A systems approach to modelin	49.95
29-JUN-21	Z1019577	Book: System approach to Modeling V	49.95
29-JUN-21	Z1019577	Books and computer accessories to b	124.98
29-JUN-21	Z1019577	Calibration and new optical attachm	2599.00
29-JUN-21	Z1019577	Energy Use in Global food productio	121.88
29-JUN-21	Z1019772	McDonald, A: TA sample holder for r	418.70
29-JUN-21	Z1019772	McDonald, A: TMA standard accessory	371.00
29-JUN-21	Z1019772	McDonald, A: polylactic acid pellet	112.05
29-JUN-21	Z1019772	McDonald, A: replacement PTFE react	84.80
29-JUN-21	Z1019772	McDonald, A: replacement gaskets fr	121.80
29-JUN-21	Z1019772	McDonald, A: small fridge needed fo	139.00
30-JUN-21	F0210814	GRT237742- CALS SOIL/H20	-585.00
30-JUN-21	Z1019899	RyuJa 166416 Amazon Research and ed	159.99
30-JUN-21	Z1019899	RyuJa 166416 Amazon Research and ed	125.16
30-JUN-21	Z1019988	Nitrogen test kits. 768.10 on 82090	768.10

30-JUN-21	I2185662	Ryu, Jae H.	8.99
30-JUN-21	I2185662	Ryu, Jae H.	650.00
30-JUN-21	I2185662	Ryu, Jae H.	864.78
30-JUN-21	I2185662	Ryu, Jae H.	190.94
30-JUN-21	I2185662	Ryu, Jae H.	79.95
30-JUN-21	I2185662	Ryu, Jae H.	1088.00
30-JUN-21	I2185662	Ryu, Jae H.	1218.99
30-JUN-21	I2185662	Ryu, Jae H.	4.99
30-JUN-21	I2185663	Ryu, Jae H.	356.49
30-JUN-21	I2185663	Ryu, Jae H.	309.99
30-JUN-21	I2185663	Ryu, Jae H.	1347.99
30-JUN-21	I2185663	Ryu, Jae H.	90.00
30-JUN-21	I2185663	Ryu, Jae H.	699.95
30-JUN-21	I2185663	Ryu, Jae H.	309.99
06-JUL-21	J1291836	CT/MA from 826703 to 826699	-1347.99
06-JUL-21	J1291836	CT/MA from 826703 to 826699	-309.99
06-JUL-21	Z1020186	Gasses for GC/FID. Index 820907 bba	49.50
06-JUL-21	Z1020186	Gloves for laboratory research work	1543.66
06-JUL-21	Z1020186	New controller for lab operations.	1474.11
06-JUL-21	Z1020186	Nutrients test kits for IGEM resear	1435.65
06-JUL-21	Z1020186	Parts for pumps at my scale model w	1450.03
06-JUL-21	Z1020186	qPCR reagents for ongoing transcrip	2000.54
E5741 Med Lab & Tech Supplies			
13-JUL-20	U0135598	Chemstores/Smoot	73.92
23-JUL-20	U0135673	Chemstores/Crites	2.70
04-AUG-20	I2142886	Oxarc Inc.	80.75
10-AUG-20	U0135767	Chemstores/Abbisa	62.99
10-AUG-20	U0135768	Chemstores/Abbisa	16.95
10-AUG-20	U0135769	Chemstores/Crites	16.95
01-SEP-20	U0135958	Chemstores/Abbasi	13.37
23-SEP-20	U0136136	Chemstores/Abbissa	75.29
23-SEP-20	U0136144	Chemstores/Abbissa	60.52
25-SEP-20	U0136171	Chemstores/Abbissa	58.35
01-OCT-20	J1276988	cfc: ct from 691709 to 691680	19.45
02-OCT-20	U0136231	Chemstores/Abbissa	62.99
06-OCT-20	U0136264	Chemstores/Crites	69.74
15-OCT-20	U0136349	Chemstores/Guho	36.09
20-OCT-20	U0136368	Chemstores/Abbissi	33.91
22-OCT-20	U0120730	Chemstores/Brower	60.90
23-OCT-20	U0121249	Abbasi	50.86
26-OCT-20	U0136387	Chemstores/McDonald	19.21
09-NOV-20	U0136505	Chemstores/Neubane	21.76
24-NOV-20	I2148563	Fisher Scientific Co.	110.72
24-NOV-20	I2148546	Fisher Scientific Co.	88.82
15-JAN-21	U0136853	Chemstores/Smoot	39.87
29-JAN-21	U0137007	Chemstores/Abissa	11.19
29-JAN-21	U0137017	Chemstores/Smoot	29.32
12-FEB-21	U0137139	Chemstoes/McDonald	37.04
22-FEB-21	U0137189	Biostore/Brinkman	195.86

24-MAR-21	U0137411	Chemstores/Peters	87.74
17-MAY-21	U0137815	Chemstores/Abbasi	13.06
07-JUN-21	U0137944	Chemstores/Peters	22.98
10-JUN-21	U0137986	Chemstores/Black	93.39
E5747 Safety Supplies			
10-MAR-21	Z1014808	A McDonald: galvanized safety can f	30.00
E5910 Rent - Machinery & Equip			
01-JUN-21	I2180550	Culligan Water Conditioning	29.95
01-JUL-21	I2185873	Culligan Water Conditioning	29.95

			$ 86662.06

Subawards

ES001 Subaward 1 Expenses			
06-NOV-20	I2154863	Boise State University	24016.80
21-DEC-20	I2160003	Boise State University	5033.24
21-DEC-20	I2160004	Boise State University	7119.96
09-FEB-21	I2165725	Boise State University	5682.39
26-FEB-21	I2167676	Boise State University	4981.14
19-MAR-21	I2170575	Boise State University	14500.61
14-MAY-21	I2178317	Boise State University	11071.18
14-MAY-21	I2178320	Boise State University	15468.67
11-JUN-21	I2182512	Boise State University	28847.79
ES002 Subaward 2 Expenses			
19-MAR-21	I2170470	Idaho State University	59513.70
28-JUN-21	I2184831	Idaho State University	64554.89

			$ 240790.37

Small Equipment (<$5K)

E7951 <5K Office Furniture			
05-AUG-20	Z1007927	Charge for 2 adjustable swivel bar	84.79

			$ 84.79

Tuition Remission and Training

E7140 Tuition and Fees - Grad Assistants			
14-AUG-20	J1274562	G1GB for 171-55579	786.00
14-AUG-20	J1274562	SHI1 for 171-55579	951.00
14-AUG-20	J1274562	T1GB for 171-55579	4152.00
21-AUG-20	J1274874	G1GB for V00664521	786.00
21-AUG-20	J1274874	SHI1 for V00664521	951.00
21-AUG-20	J1274874	T1GB for V00664521	4152.00
21-AUG-20	J1274874	VVSF for V00664521	100.00
02-SEP-20	J1275593	G1HD for 142-24168	43.50
02-SEP-20	J1275593	N1HD for 142-24168	534.50
02-SEP-20	J1275593	SHI1 for 142-24168	475.50
02-SEP-20	J1275593	T1HD for 142-24168	231.00
08-SEP-20	J1275909	G1GA for 151-29182	786.00

08-SEP-20	J1275909	G1GB for 051-04535	786.00
08-SEP-20	J1275909	G1GB for 151-22411	786.00
08-SEP-20	J1275909	T1GA for 151-29182	4152.00
08-SEP-20	J1275909	T1GB for 051-04535	4152.00
08-SEP-20	J1275909	T1GB for 151-22411	4152.00
28-OCT-20	J1278784	G1GB for V00665494	786.00
28-OCT-20	J1278784	SHI1 for V00665494	951.00
28-OCT-20	J1278784	T1GB for V00665494	4152.00
28-OCT-20	J1278784	VVSF for V00665494	100.00
06-JAN-21	J1281486	G2GB for 171-55579	786.00
06-JAN-21	J1281486	SHI2 for 171-55579	951.00
06-JAN-21	J1281486	T2GB for 171-55579	4152.00
08-JAN-21	J1281710	G2GA for 151-29182	786.00
08-JAN-21	J1281710	G2GB for 051-04535	786.00
08-JAN-21	J1281710	G2GB for 151-22411	786.00
08-JAN-21	J1281710	T2GA for 151-29182	4152.00
08-JAN-21	J1281710	T2GB for 051-04535	4152.00
08-JAN-21	J1281710	T2GB for 151-22411	4152.00
14-JAN-21	J1281351	G2GB for V00665494	786.00
14-JAN-21	J1281351	SHI2 for V00665494	951.00
14-JAN-21	J1281351	T2GB for V00665494	4152.00
14-JAN-21	J1281351	VVSF for V00665494	100.00
01-FEB-21	J1282802	G2HD for 142-24168	43.50
01-FEB-21	J1282802	N2HD for 142-24168	534.50
01-FEB-21	J1282802	SHI2 for 142-24168	475.50
01-FEB-21	J1282802	T2HD for 142-24168	231.00
20-MAY-21	J1288392	RSN3 for 151-22411	137.25
20-MAY-21	J1288396	RSN3 for 051-04535	137.25
20-MAY-21	J1288398	G3HA for 151-29182	87.00
20-MAY-21	J1288398	T3HA for 151-29182	462.00
21-MAY-21	J1287827	G3HB for V00665494	87.00
21-MAY-21	J1287827	T3HB for V00665494	462.00
01-JUN-21	J1288997	cfc: ct from 820928 to 820907	137.25

			$ 63451.75

Total Expenses $ 656161.35

FWRITEM University of Idaho
Itemized Expenditures by Grant Code
From 01-JUL-2020 To 08-JUL-2021

Grant: SG4609 - ISBOE IGEM FY21 Sustain Food Ind-KH 08-Jul-2021 12:11 PM

Salaries
E4106 Staff
Brinkman, Cynthia 8979.78
495.02 hours
E4108 Summer Salary

Coats, Erik	2350.32
33.60 hours	
Humes, Karen	21228.48
288.00 hours	
McDonald, Armando	11225.76
156.00 hours	
Ryu, Jae	19585.32
334.46 hours	
E4109 IA/GA Salary	
Abbasi, Maryam	19869.76
992.00 hours	
Brower, Nicole	17100.00
912.00 hours	
Deyo, Brent	22800.00
912.00 hours	
Mellin, Jason	9903.52
272.00 hours	
Pokhrel, Dikshya	7547.40
420.00 hours	
Smoot, Lindsey	18700.00
992.00 hours	
Thompson, Emily	17245.80
780.00 hours	
E4175 Overtime - Covered by FLSA	
Brinkman, Cynthia	45.59
5.02 hours	

	$ 176581.73
Temporary/Irregular Help	
E4110 Temporary Employee	
Holownia, Sam	2250.00
125.00 hours	
E4135 Temporary Student	
Alfaro Salmeron, Glenda	1500.00
80.00 hours	
Black, Edward	5810.75
539.00 hours	
Brower, Nicole	1125.00
60.00 hours	
Buonarati, Nickolas	459.25
41.75 hours	
Crites, Willow	6301.65
576.00 hours	
Cutler, Kylie	270.88
25.00 hours	
Deyo, Brent	2000.00
80.00 hours	
Emerick, Austin	1245.75

116.50 hours	
Guho, Nicholas	8972.98
323.00 hours	
Hurdman, Julie	688.50
38.25 hours	
Neupane, Saurav	10657.64
992.00 hours	
Thompson, Emily	6440.00
280.00 hours	
Walters, Riveraine	10448.00
434.00 hours	
Woodruff, Craig	3625.00
145.00 hours	

	$ 61795.40

Fringe Benefits	
E4280 Faculty CFR Benefit Expense	16697.67
E4281 Staff CFR Benefit Expense	3772.59
E4282 Student CFR Fringe Expense	3627.07
E4283 Temporary CFR Benefit Expense	177.75

	$ 24275.08

Travel	
E5360 Personal Vehicle - In-State	
E5367 Rental Vehicles - In-State	
E5396 Lodging & Per Diem ? In State	

	$ 2520.17

Operating Expenses
E5020 Postage & Mailing
E5023 Express Mail
E5025 Printing & Binding
E5070 Conference/Registration Fees
E5152 All Other Services
E5177 Program Fees
E5199 Other Professional Service
E5320 Software/Applications - Individual
E5330 Software/Applications - College/Dep
E5560 Technology - Supplies
E5640 R&M Sup - Technology Infrastructure
E5710 Tools
E5720 Educational Supplies
E5724 Research Supplies
E5741 Med Lab & Tech Supplies
E5747 Safety Supplies
E5910 Rent - Machinery & Equip

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                                                      ----------
                                                    $  86662.06

 Subawards
    ES001 Subaward 1 Expenses
    ES002 Subaward 2 Expenses
                                                      ----------
                                                    $ 240790.37

 Small Equipment (<$5K)
    E7951 <5K Office Furniture
                                                      ----------
                                                    $     84.79

 Tuition Remission and Training
    E7140 Tuition and Fees - Grad Assistants
                                                      ----------
                                                    $  63451.75

                                                 ---------------
                          Total Expenses         $   656161.35
```

BOISE STATE UNIVERSITY
OFFICE OF SPONSORED PROGRAMS

Final Invoice

105323

Invoice Date	Invoice Amount	Due Date
6/8/2021	$28,847.79	Payment due upon receipt

Bill To
University of Idaho
875 Perimeter Dr

Moscow, ID
83844
US

Attn: Kay Dee Holmes

Sponsor Award Number	Project Title	Department Number	BSU Award Number	Project Number	Invoice Period
SGA609-877862	Sustaining the Competitiveness of the Food Industry in Southern Idaho YR 3	70600	3221007	2000001742	5/1/2021 to 6/30/2021

Category	Budget	Current Expenditures	Cumulative Expenditures	Remaining Budget
Salary	$ 80,963.00	$ 17,691.24	$ 73,798.36	$ 7,164.64
Fringe	$ 10,106.00	$ 2,231.32	$ 11,293.78	$ -1,187.78
Other Expense	$ 13,000.00	$ 8,925.23	$ 12,353.64	$ 646.36
Student Costs	$ 19,276.00	$ 0.00	$ 19,276.00	$ 0.00

Original Budget	Total Current Expenditures	Total Expenditures	Remaining Budget
$ 123,345.00	$ 28,847.79	$ 116,721.78	$ 6,623.22

Total Expenditures:	$ 116,721.78
Less: Revenue Received:	$ 87,873.99
Less: Outstanding Invoices:	$ 0.00
Amount Now Due:	$ 28,847.79

Where required for federal or federal flow-through agreements, by signing this report, I certify to the best of my knowledge and belief that the report is true, complete, and accurate, and the expenditures, disbursements and cash receipts are for the purposes and objectives set forth in the terms and conditions of the Federal award. I am aware that any false, fictitious, or fraudulent information, or the omission of any material fact, may subject me to criminal, civil or administrative penalties for fraud, false statements, false claims or otherwise. (U.S. Code Title 18, Section 1001 and Title 31, Sections 3729-3730 and 3801-3812).

Please direct questions regarding this invoice to Diana Smlatic at postaward@boisestate.edu.

Payment Options

By Mail:

Boise State University
1910 University Drive
Accounts Receivable
Boise, ID 83725-1247

ACH/Wire Payments:

Account Name:	Boise State University
Account Number:	20000011141546
Bank:	JPMorgan Chase
ACH Routing Number:	028000024
Wire Routing Number:	021000021

Please reference invoice number on electronic payments

Idaho State University

ESTIMATED FINAL INVOICE

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

Karen Humes
University of Idaho
875 Perimeter Dr. MS 1026
Moscow, ID 83844-1026
(208)885-7230

Date Prepared: June 10, 2021

Award Number: SG-3587-SB-877869
Invoice No.: **RGEO2R-10**
Reference invoice number on payment.

PERIOD COVERED: **03/01/2021 - 06/30/2021**

DESCRIPTION	BUDGET	**CURRENT EXPENSES**	CUMULATIVE EXPENSES	(Over)/Under BUDGET
Salary & Fringe	$101,310.04	**$52,457.02**	$101,310.04	$0.00
Materials & Supplies	$8,500.00	**$7,764.87**	$8,499.59	$0.41
Travel	$0.00	**$0.00**	$0.00	$0.00
Tuition	$9,925.96	**$0.00**	$9,925.96	$0.00
Travel	$1,833.00	**$1,833.00**	$1,833.00	$0.00
Consultants	$2,500.00	**$2,500.00**	$2,500.00	$0.00
Totals	$124,069.00	$64,554.89	$124,068.59	$0.41

Cumulative Amount Received:	$59,513.70
Billed-Not Received*:	$0.00
Current Expenses:	$64,554.89

Total Due This Period	**$64,554.89**

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 6·11·2021
Lisa Wood, Director Sponsored Programs Accounting

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

Grants and Contract Accounting
921 South 8th Ave., Stop 8046 | Pocatello, ID 83209-8046 | (208) 282-2592 | isu.edu/research

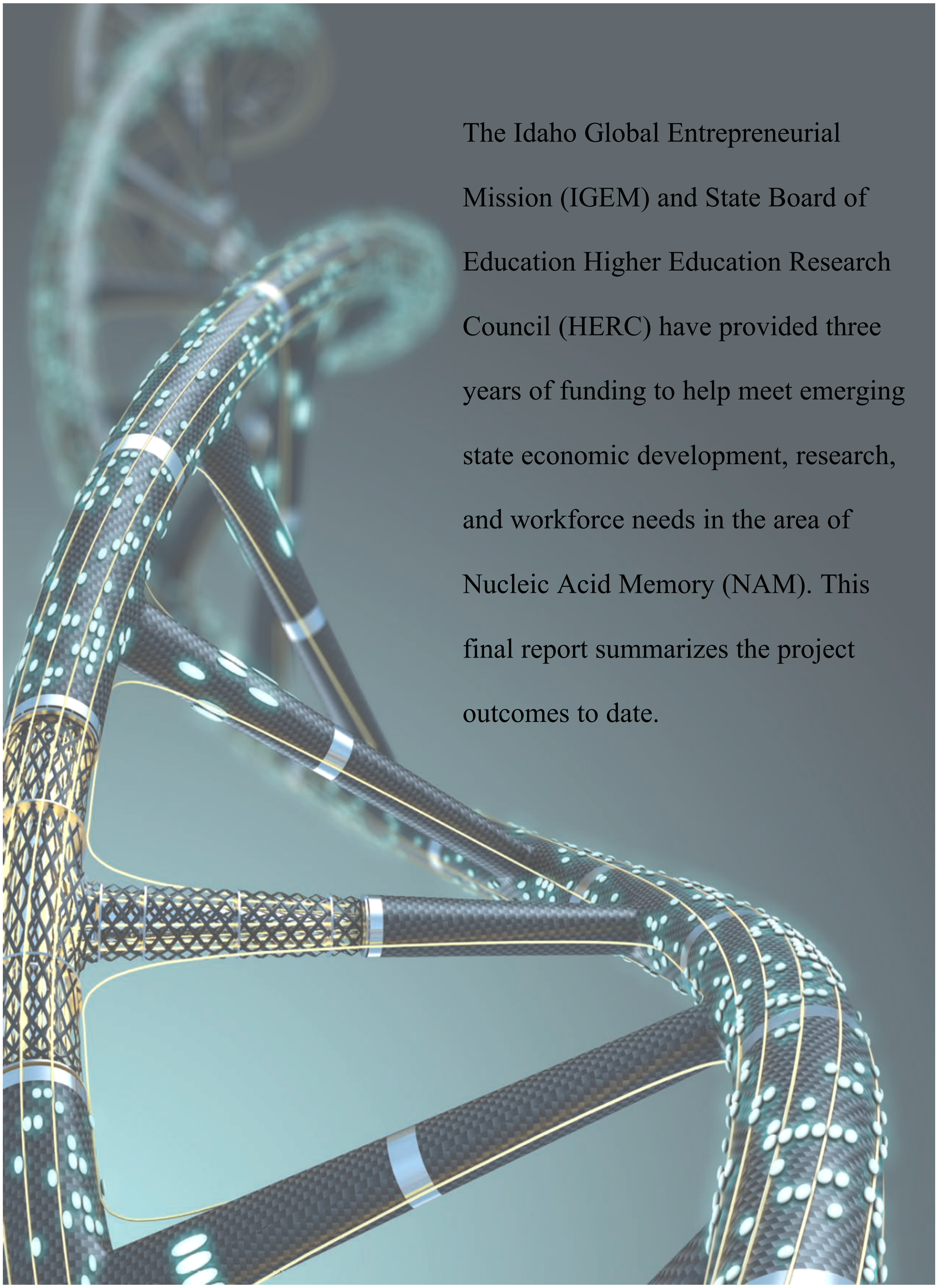
IGEM19-002

BOISE STATE UNIVERSITY

Final Report

IGEM # 19-002: Nucleic Acid Memory

Will Hughes
Chad Watson
Tim Andersen
Eric Hayden
Wan Kuang
George Dickinson
Will Clay
Luca Piantanida
Mike Tobiason



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 final report summarizes the project outcomes to date.

I. Executive Summary

According to our theoretical study with Micron, Harvard, and the Semiconductor Research Corporation[1], 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. With support from IGEM/HERC, our vision was to prototype a digital data storage paradigm by designing, building, and testing non-volatile nucleic acid memory (NAM) technologies that are inspired by DNA circuits and made possible by innovations in DNA nanotechnology. The focal point for this research was to prototype digital nucleic acid memory (dNAM), a storage medium where data is encoded into the physical address of DNA strands within a DNA origami breadboard.

To achieve working implementations of the dNAM prototype, our team prioritized the following objectives: NAM coding (*objective 1*), NAM sequences (*objective 2*), NAM scaffolds (*objective 3*), NAM fabrication (*objective 4*), and NAM reading (*objective 5*). The following deliverables are aligned to the project objectives and have been coded to reflect progress on each. Green, yellow and red mean that the deliverable has respectively been accomplished, has been partially accomplished, and has not been accomplished. The red deliverables have not been accomplished for two important reasons: (1) the seqNAM prototype in *objective 5* was replaced with a new technique called $_{3D}$NAM – which is described below. In addition, selective area immobilization in *objective 4* was unnecessary once our computer algorithms compensated for the orientation of the DNA nanostructures.

Objective	Year	**Original Deliverable** (progress to date)
1	1	An information encoding/decoding algorithm for dNAM
	2	An information encoding/decoding algorithm for seqNAM
2	1	A high-throughput data pipeline for metrics-based optimization of data cells
	2	Sets of optimized codons and words for seqNAM data encoding
	3	Optimized insertion sequences for custom scaffold synthesis
3	1	Create viable phage modules from E.coli
	2	Validate phage genomes for use in DNA origami synthesis
4	1	Process for design and fabrication of DNA origami storage nodes
	2	Protocols for statistical correlated AFM/SRM defect metrology in DNA origami
	3	Protocols for selective area immobilization of DNA origami
5	1	Optical readout of dNAM
	2	Optical readout of seqNAM
	3	3 nm imaging resolution for SRM

2

Summarized here are products created during the award period, including patents, journals, commentaries, news briefs, software packages, select presentations, dissertations, and a company. Items highlighted in blue were accomplished since the last reporting period.

Product	Status	Details
Patent	filed	**NUCLEIC ACID MEMORY (NAM) / DIGITAL NUCLEIC ACID MEMORY (DNAM):** The present application claims priority to the earlier filed U.S. Provisional Application having Serial No. 62/705,995, and hereby incorporates subject matter of the provisional application in its entirety. The invention relates generally to nucleic acid memory (NAM). More specifically, the invention relates to digital Nucleic Acid Memory (dNAM) which use a nucleic acid architecture to create a physical address by providing docking sites for single stranded nucleic acid for information processing. The invention further relates to methods for enhanced data retention and retrieval and systems for use.
Journal	published	Dickinson, G.D., Mortuza, G.M., Clay, W., Piantanida, L., Green, C.M., Watson, C., Hayden, E.J., Andersen, T., Kuang, W., Graugnard, E., Zadegan, R. Hughes, W.L. An alternative approach to nucleic acid memory. *Nature Communications* 12, 2371 (2021).
Journal	published	Green, C.M., Hughes, W.L., Graugnard, E., Kuang, W. Correlative Super-Resolution and Atomic Force Microscopy of DNA Nanostructures and Characterization of Addressable Site Defects. ACS Nano Article ASAP
Journal	submitted	M. Tobiason, B. Yurke, W.L. Hughes, "Generation of DNA Oligonucleotides with Similar Hybridization Rates," **Nucleic Acid Research**, Submitted 2021.
Journal	in preparation	Llewellyn, S., Mortuza, G., Guerrero, J., Suyehira, K., Hughes, W.L., Andersen, T., Zadegan, R. **Algorithms for Digital Data Storage in Nucleic Acid Memory**, Summer 2021 Submission Goal.
Commentary	published	G. Dickinson, L. Piantanida, W.L. Hughes, "DNA 'Lite-Brite' is a promising way to archive data for decades or longer," The Conversation, May 10, 2021. https://theconversation.com/dna-lite-brite-is-a-promising-way-to-archive-data-for-decades-or-longer-157856
Commentary	accepted	L. Piantanida, W.L. Hughes, "A PCR-free approach to random access in DNA," **Nature Materials**, Accepted 2021 (NM21051571A).
News	published	NSF Research News – Researchers advance DNA as a storage material, May 13, 2021. www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=302717&org=NSF&from=news
News	published	Chemical & Engineering News – Method offers new approach to DNA data storage, April 29, 2021. https://cen.acs.org/biological-chemistry/dna/Method-offers-new-approach-DNA/99/i16
Software	open-access	The DeviceProfiler (DevPro) program by Michael Tobiason calculates the fitness of an existing set of DNA oligonucleotides (oligos). https://github.com/MTobiason/Sequence-Analysis
Software	open-access	The SequenceEvolver (SeqEvo) program by Michael Tobiason generates fit sets of DNA oligos. https://github.com/MTobiason/Sequence-Analysis
Software	open-access	The NAM program by Golum Mortuza encodes, decodes, and performs error correction on nucleic acid memory. https://github.com/BoiseState/NAM
Presentation	poster	Amanda Wolf, Sarah E. Kobernat, Luca Piantanida, Eric J. Hayden. DNA origami FRET Ruler for Nucleic Acid Memory. Idaho Conference on Undergraduate Research, virtual, July 21-22, 2021.
Presentation	poster	Benjamin Balzer, Amanda Wolf, Sarah E. Kobernat, Luca Piantanida, Eric J. Hayden. Enhancement of Digital Nucleic Acid Memory by Customizing DNA Origami Scaffolds. Idaho Conference on Undergraduate Research, virtual, July 21-22, 2021.
Presentation	oral	Christopher M. Green, William L. Hughes, Elton Graugnard and Wan Kuang. Correlative DNA-PAINT/AFM Microscopy of DNA Nanostructures and Characterization of Addressable Sites, FNANO 2021: 18th Annual Conference Foundations of Nanoscience, April 12–14, 2021.
Presentation	oral	George D. Dickinson, Golam Md Mortuza, William Clay, Luca Piantanida, Christopher M. Green, Chad Watson, Eric J. Hayden, Tim Andersen, Wan Kuang, Elton Graugnard, Reza Zadegan and William L. Hughes. Digital Nucleic Acid Memory: A New Approach to DNA-based Data Storage, FNANO 2021: 18th Annual Conference Foundations of Nanoscience, April 12–14, 2021.

Presentation	oral	Luca Piantanida. Digital Nucleic Acid Memory, ASU Center of Molecular Design & Biomimetics Annual Symposium, June 6-9, 2021.
Presentation	oral	G.D. Dickinson, G.M. Mortuza, W. Clay, L. Piantanida, C.M. Green, C. Watson, E.J. Hayden, T. Andersen, W. Kuang, E. Graugnard, R. Zadegan, and W.L. Hughes, "Digital Nucleic Acid Memory" *TECHCON*, September 15-17, 2020.
Presentation	poster	Sarah Kobernat, George Dickinson, William Clay, Luca Piantanida, Chad Watson, Tim Andersen, Wan Kuang, William Hughes, and Eric Hayden. "Improving DNA origami through scaffold optimization" *26th International Conference on DNA Computing and Molecular Programing*, September 14–17, 2020.
Presentation	poster	Sarah Kobernat, George Dickinson, William Clay, Luca Piantanida, Chad Watson, Tim Andersen, Wan Kuang, William Hughes, and Eric Hayden. "Improving DNA origami through scaffold optimization" *26th International Conference on DNA Computing and Molecular Programing*, September 14–17, 2020.
Presentation	oral and poster	M. Tobiason, B. Yurke, and W.L. Hughes (2019). Engineering Kinetically Uniform DNA Devices, 2019 TECHCON conference presented by the SRC. Austin, Texas.
Presentation	poster	M. Tobiason, B. Yurke, and W.L. Hughes (2019). Engineering Kinetically Uniform DNA Sequences, 25th *International Conference on DNA Computing and Molecular Programing (DNA25)*. Seattle, Washington.
Presentation	poster	M. Tobiason, B. Yurke, and W.L. Hughes (2019). Engineering Kinetically Reproducible DNA Devices, 16th *Annual Conference on Foundations of Nanoscience: Self*-Assembled *Architectures and Devices (FNANO19)*. Snowbird, UT.
Presentation	poster	M. Tobiason, B. Yurke, and W.L. Hughes (2019). Engineering Kinetically Reproducible DNA Devices, *Semiconductor Research Corporation: Semiconductor Synthetic Biology (SemiSynBio) Annual Review*. College Park, MD.
Presentation	oral and poster	C.M. Green, M. Tobiason, R.M. Zadegan, W.L. Hughes (2019). Nucleic Acid Memory, *Semiconductor Research Corporation: Semiconductor Synthetic Biology (SemiSynBio) Annual Review*, College Park, MD.
Presentation	poster	C.M. Green, G. Dickinson, R.M. Zadegan, W.L. Hughes, E. Graugnard, W. Kuang (2019). Correlative metrology and defect analysis of DNA origami, *Semiconductor Research Corporation: Semiconductor Synthetic Biology (SemiSynBio) Annual Review*, College Park, MD.
Presentation	oral	W. Clay, G. Dickinson, L. Piantanida, C. Watson, W.L. Hughes, W. Kuang, "Real-Time Drift Correction for Super-Resolution Microscopy using Multiple Tracking Markers" *TECHCON*, September 15-17, 2020.
Presentation	oral	Christopher M. Green, William L. Hughes, Elton Graugnard and Wan Kuang. Correlative DNA-PAINT/AFM Microscopy of DNA Nanostructures and Characterization of Addressable Sites, FNANO 2021: 18th Annual Conference Foundations of Nanoscience, April 12–14, 2021.
Dissertation	published	Green, Christopher Michael, Nanoscale Optical and Correlative Microscopies for Quantitative Characterization of DNA Nanostructures (2019). *Boise State University Theses and Dissertations*. 1639.
Dissertation	published	Tobiason, Michael D., In Silico Sequence Optimization for the Reproducible Generation of DNA Structures (2019). *Boise State University Theses and Dissertations*. 1614.
Dissertation	published	Burden, Steven J., The Development of Nucleic Acid Biosensors with Allosteric Fluorescence Signals (2019). *Boise State University Theses and Dissertations*. 1627.
Dissertation	published	Suyehira, Kelsey, "Using DNA For Data Storage: Encoding and Decoding Algorithm Development" (2018). *Boise State University MS Thesis*.10.18122/td/1500/boisestate
Company	launched	Facible is a purpose-driven biodiagnostic technology company focused on a new hospital-grade fast track test that offers speed, accessibility, and accuracy. Steven Burden is the founder and CEO of the company, which includes 25 employees.

Based on the above listed outcomes, the Nucleic Acid Memory (NAM) Institute at Boise State was invited to join the DNA Data Storage Alliance. The alliance is the first and most extensive bridge between industry and academic organizations that are pioneering DNA data storage. Its mission is to "*create and promote an interoperable storage ecosystem based on DNA as a data storage medium*". The alliance will recommend the creation of specifications and standards (e.g., encoding, reliability, retention, file systems) which enable end-users to add interoperable DNA-based storage solutions to their existing storage hierarchies. The founders include Illumina, Twist Biosciences, Western Digital, and Microsoft. Member organizations include but are not limited to: Ansa Biotechnologies, Battelle, Catalog, The Cloude Nobs Foundation, DNA Script, EPFL, ETH Zurich, Imagene, IMEC, Iridia, Kioxia, Molecular Assemblies, PFU, Quantitative Scientific Solutions, Quantum, Seagate, Semicondcutor Research Corporation, Spectra Logic, University of Arizona, University of Washington, Digital Preservation, Oligo Archive, Lost Alamos National Laboratory, Cinémathèque Suisse, 21e8, DNAli, and University of Marburg. This network is critical as Boise State attempts to license the NAM intellectual property and/or the research team spins-off companies in the memory/biotechnology arena.

Supported by this research project, Steven Burden (founder/CEO) and Clementine Gibard Bohachek (co-founder/CSO) spun-off Facible, a biodiognostics company in Boise that has 25 employees and is seeking FDA approval for a novel COVID-19 screening technology. In service to future generations of biotechnology start-ups in Idaho, Facible and the Nucleic Acid Memory Institute are actively exploring the creation of a biotech incubator in Boise.

[1] V. Zhrinov, R. Zadegan, G. Sandu G.M. Church, W.L. Hughes, “Nucleic Acid Memory,” **Nature Materials**, 15, 366-370 (2016). doi.org/10.1038/nmat4594

[2] M. Tobiason, B. Yurke, W.L. Hughes, “Generation of DNA Oligonucleotides with Uniform Structure Formation,” **Nucleic Acid Research**, Submitted 2021.

[3] C.M Green, W.L. Hughes, E. Graugnard, W. Kuang, “Correlative DNA-PAINT/AFM Microscopy for Characterization of Strand Defects in DNA Nanostructures,” **ACS NANO**, Accepted 2021 (nn-2021-01976x).

[4] G.D. Dickinson, G.M. NatureMortuza, W. Clay, L. Piantanida, C.M. Green, C. Watson, E.J. Hayden, T. Andersen, W. Kuang, E. Graugnard, R. Zadegan, and W.L. Hughes; An Alternative Approach to Nucleic Acid Memory, **Nature Communications**, vol 12, number 2371, 2021 (doi.org/10.1038/s41467-021-22277-y).

II. Technical Summary

To realize our vision, we report the successful use of in-silico fitness score optimization to generate DNA sequences for dNAM with similar hybridization rates. Three optimization criteria were utilized: a network fitness score (N) where points are accumulated for inter-oligo secondary structures, an oligo fitness score (O) where points are accumulated for intra-oligo secondary structures, and a class of weighted fitness scores (W) which are linear combinations of N and O. Hybridization rates for both optimized and non-optimized oligo-sets were experimentally characterized and compared. A total of 144 hybridization rates were measured using fluorescent quenching and reported. For a duplex-formation reaction, W-fit oligo-sets were found to exhibit Arrhenius temperature dependence with consistent Arrhenius parameters. However, non-optimized oligo-sets exhibited an Arrhenius temperature dependence with variable Arrhenius parameters for the same duplex-formation rate. Optimization was observed to substantially decrease hybridization-rate variation, with three W-fit oligo-sets exhibiting typical hybridization-rate dispersions of ± 7.7% (duplex-formation) and ± 14% (strand-displacement). For the duplex-formation of both optimized and non-optimized oligo-sets, a very strong linear relationship between the two Arrhenius parameters was observed, indicating that this model may be over parameterized. For comparison, an alternative model describing the experimental data using a single variable parameter was derived. Further analysis of hybridization rates reported in the literature indicated a statistically significant ($p < 0.05$) correlation between decreasing O values and decreasing hybridization-rate dispersion in five separate datasets. This work has been submitted to Nucleic Acids Research[2]. The resulting computer programs created for this study (DevPro / SeqEvo) are freely available for academic use—and can design NAM prototypes with predictable kinetic performance.

To further realize our vision, we developed a metrology technique for analyzing defects in DNA-origami that combined super resolution microscopy (SRM) and atomic force microscopy (AFM); achieving strong correlations between structures visualized with both tools[3]. With the ability to detect single molecules, we resolved data sites with: (**1**) no observed defects in AFM and SRM (74 ± 2%), (**2**) defects observed in AFM only (8 ± 2%), (**3**) defects observed in SRM only (16 ± 1%), and (**4**) defects observed in AFM and SRM (2 ± 1%). In doing so, we observed that unresolved data sites in the SRM images are not strongly correlated with defects seen with AFM, revealing that most site defects do not arise from unicorporated strands but from strands that are present in the structure, and are most likely damaged due to photo-oxidation and UV damage. Our analysis indicates that there is significant room for progress in the design of data sites to overcome strand defects. We believe this method, in conjunction with the software tools above, will extract defect mechanisms and inform new design principles for increasing the yield and fidelity of NAM prototypes.

The culmination of the above listed research was published in Nature Communications[4], where we encoded '*Data is in our DNA\n*' into dNAM. In dNAM, data is encoded by selecting combinations of single-stranded DNA with (1) or without (0) docking-site domains. When self-assembled with scaffold DNA, staple strands form DNA origami breadboards. Information encoded into the breadboards is read by monitoring the binding of fluorescent imager probes using SRM. To enhance data retention, a custom multi-layer error correction scheme that combined fountain and bi-level parity codes was used. Each origami encoded unique data-droplet, index, orientation, and error-correction data. The error-correction algorithms fully recovered the message when individual docking sites, or entire origami, were missing. Our prototype achieved an areal density of 1000 Gbit/cm^2. After accounting for using 2/3 of the bits for indexing and error correction, this resulted in an areal data density of 330 Gbit/cm^2. Although relevant only for reading throughput, for comparison, recent advancements in tape report an areal information density of 31 Gbit/cm^2. Unlike other approaches to DNA data storage, reading dNAM did not require sequencing. As such, the technology offers a novel approach to explore NAM viability.

To improve our data density, we designed, built, and started to optimize a custom SRM system that is capable of 3 nm resolution. Our design is highly rigid with no moving parts and is compatible with the enclosures and vibration isolation tables traditionally used to stabilize scanning probe microscopes. We also replaced seqNAM with 3DNAM. Briefly described, 3DNAM integrates time-correlated SRM and DNA self-assembly to read non-volatile information with sub 5 nm lateral and 1 nm axial resolution. To enable time-correlated imaging measurements, we developed a TCI array in a 180nm semiconductor process provided by a commercial foundry (X-FAB). We also used an industry standard toolset (Cadence) to simulate and verify the design of our imager. X-FAB provided a comprehensive model of the SPAD to enable co-simulation with our design. The photon detection efficiency of our SPAD is around 25%, near the minimum required for our application. We anticipate improving this to 50% in our next revision due to refinements in the fabrication process by X-FAB. We submitted our design for fabrication in January 2021 and received the bare imager die in June 2021. We are in the process of packaging the die for benchtop characterization and then microscope integration. Back of the envelope calculations indicate that 3DNAM could have information densities above 10 Tbit/cm^2 and read speeds over 56 Tbit/day. It also has the potential to be used as a new sequencing technology. Regardless if this can be achieved, the time correlated imager we are creating has potential for commercial development. Single photon detection and precision timing capabilities are only available as bulky and low-throughput devices. Thus, by developing TCI, we are not only providing an enabling technology for 3DNAM, but are also addressing an unmet commercial need for this class of scientific instrumentation.

What follows are select project accomplishments that reinforce the technical summary.

III. Project Accomplishments

Objective 1: NAM Coding

1. Introduction

Objective 1 addresses the development and testing of algorithms for encoding and decoding information stored in NAM prototypes, which are robust to high levels of insertion, deletion, and substitution errors, and, in the case of seqNAM, which avoid biologically deleterious sub-sequences. Both objectives have been met, with encoding/decoding algorithms developed for both seqNAM and dNAM, and validated with in-silico simulations, as well as wet-lab experiments.

2. Deliverables

Objective	Deliverables
1A	An information encoding/decoding algorithm for dNAM (year 1)
1B	An information encoding/decoding algorithm for seqNAM (year 2)

3. Most significant results, outcomes and deliverables.

Deliverable 1A — An information encoding and decoding algorithm for dNAM. Robust dNAM-specific information encoding and decoding algorithms were developed and validated. With dNAM, the presence and absence of individual DNA molecules (staple strands) on a DNA-origami scaffold is used to store bit values. These bit values, *i.e.* the presence/absence of the DNA staple strands at various locations on the origami surface, are read using SRM, which is subject to relatively high read errors due to incomplete staple strand incorporation, defective imager strands, fluorophore bleaching, and background fluorescence. This high error rate necessitated the development of robust information encoding and decoding algorithms, combining multiple levels and strategies of error correction and error handling. Information is encoded using a fountain code, combined with a custom, bi-level, parity-based, and orientation-invariant error detection scheme (***Fig 1***). Fountain codes are an optimal mechanism for transmission of data over extremely noisy and unreliable channels, and work by dividing a data file into small segments, combining these segments via XOR into what are called droplets, and then sending the droplets at random to a receiver. Our algorithm encodes each droplet onto a single origami and adds additional bits of information for error correction to help ensure that individual droplets can be recovered. Together, the error correction and fountain codes increase the probability that the message can be fully recovered while minimizing the number of DNA origami that must be observed.

Through wet lab experiments, as well as through exhaustive simulation we have validated that the combination of the multi-level error correction strategy and fountain codes provide extremely robust storage and recovery of file information for dNAM. This approach took dNAM from an idea to practice.

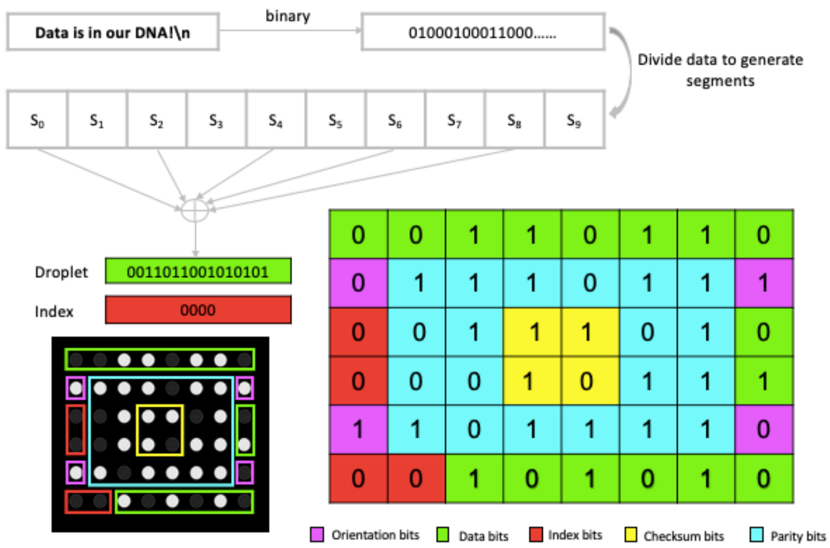


Figure 1. Example of Fountain Code implementation of dNAM digital encoding. The figure illustrates some of the main steps involved in encoding a digital message into dNAM. First a character string is divided into non-overlapping segments. These segments are combined in various patterns via an XOR operation 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. Origami index 0 is depicted from the prototype.

Deliverable 1B — An information encoding and decoding algorithm for seqNAM. When encoding binary data into sequences representing DNA strands, the algorithms should account for biological constraints representing the idiosyncrasies of working with a molecular substance. In response, we developed REDNAM (Robust Encoding and Decoding of Nucleic Acid Memory). REDNAM includes a novel mapping scheme and translation stage which converts hexadecimal data to codons while accounting for four constraints: removing start codons, avoiding repeating nucleotides, excluding longer repeating sequences, and maintaining close to 50% GC content. We have integrated this mapping scheme into the fountain code algorithm to balance information density with error correction and parity data.

The primary innovation of REDNAM is the mapping approach, which is inspired by the codon to protein mapping scheme used in living cells. Uniquely, our codon-base mapping removes biologically active sequences—such as start codons and some known promoter regions—avoids multiple repeats of unique nucleotides, and excludes repeating sequence strings. This promotes more robust encoding and decoding of the information stored in the DNA, as it avoids structural problems that lead to synthesis and sequencing errors, and is also safer from a biological perspective, as our algorithm avoids the occurrence of start and other codons involved in transcription and translation.

As with dNAM, our implementation of REDNAM is used in combination with a fountain code to increase robustness. ***Figure 2*** shows the basic steps in the information encoding/decoding process. The fountain code algorithm is ideal because the mapping scheme is entirely separate from the rest of the encoding and decoding processes. This allows us to easily include our mapping and translation stage, which takes more biological constraints into account.

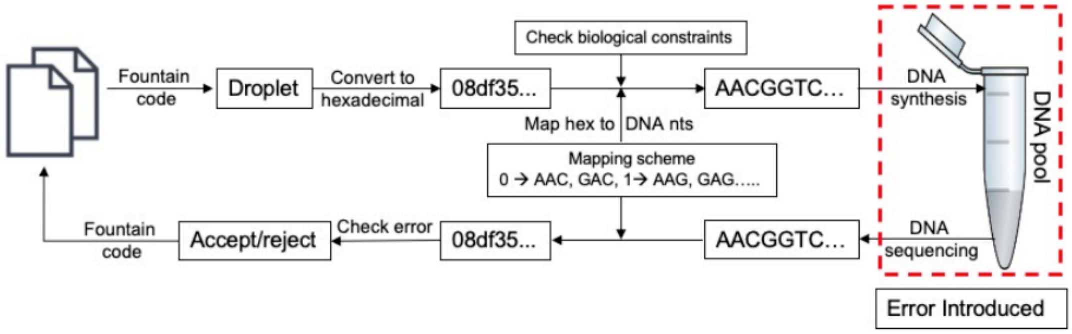


Figure 2. *Overview of the REDNAM DNA based storage system.*

To validate the REDNAM algorithm, we encoded a JPEG file of size 13,170 bytes, resulting in 604 DNA sequences, each 250 nucleotides long. The synthesized sequences were sequenced using the Illumina Miseq platform, producing 78 million reads of sequences, where 5M reads were unique to the pool (***Fig 3***). To check the robustness of our algorithm, we sub-sampled portions of the 78 million reads and tested the decoders ability to recover the original message. For sub-samples greater than 9000 reads, the decoder successfully recovered the file 100% of the time. While this seems like a large number of required samples, it is primarily due to the repetition of the reads in the sub-samples, as some sequences occur much more frequently than others.

To further test the robustness and efficiency of our algorithm, we performed simulations on randomly generated files, testing the encoding and decoding of files ranging from 1 to 49 MB at 1 MB intervals, where each of the encoded files was subjected to varying levels of simulated errors—including insertion, deletion, or mutation of any random nucleotide or even total deletion of any random sequence. In all cases, the decoding algorithm was able to recover missing/corrupted data.

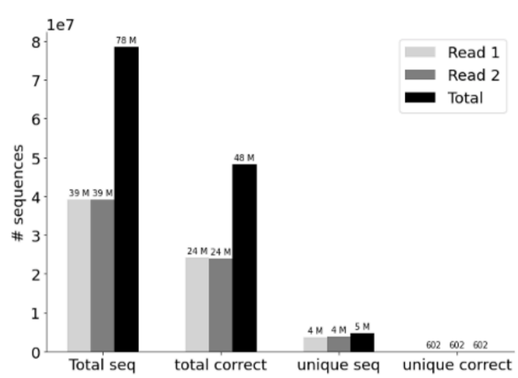


Figure 3. *Sequence frequency distribution among two reads.* In total there were 78 million sequences read where 5 million reads were unique. Out of all the reads, 62% of the reads were correct.

Objective 2: NAM Sequences

1. Introduction

For NAM applications, it is ideal to have uniform hybridization rates. For these purposes, hybridization-rate variation results in inconsistent synthesis or inconsistent kinetics during DNA-PAINT. *Objective 2* focused on improving sequence-performance relationships and improving our ability to generate new sequences for NAM devices. Important outcomes include the creation of: (**1**) three high-performing metrics for *in-silico* sequence optimization, (**2**) one computer program (SeqEvo, which optimizes these metrics), (**3**) one kinetic model describing the temperature-dependence of DNA duplex-formation rates, and (**4**) new sequences for future 2D and 3D-NAM devices. Together these outcomes increase our predictive capacity for engineering NAM systems.

2. Deliverables

Objective	Deliverables
2A	A high-throughput data pipeline for metrics-based optimization of data cell anchor strands (year 1)
2B	Sets of optimized codons and words for seqNAM data encoding (year 2)
2C	Optimized insertion sequences for custom scaffold synthesis (year 3)

3. Most significant results, outcomes and deliverables.

Three fitness scores were developed for quantifying inadvertent hybridization reactions a given oligo-set may undergo: (**1**) a network fitness score (N) – which quantifies inadvertent inter-oligo simple secondary structures; (**2**) an oligo fitness score (O) – which quantifies inadvertent intra-oligo simple secondary structures; and (**3**) a weighted fitness score (W) – which is a linear combination of N and O.

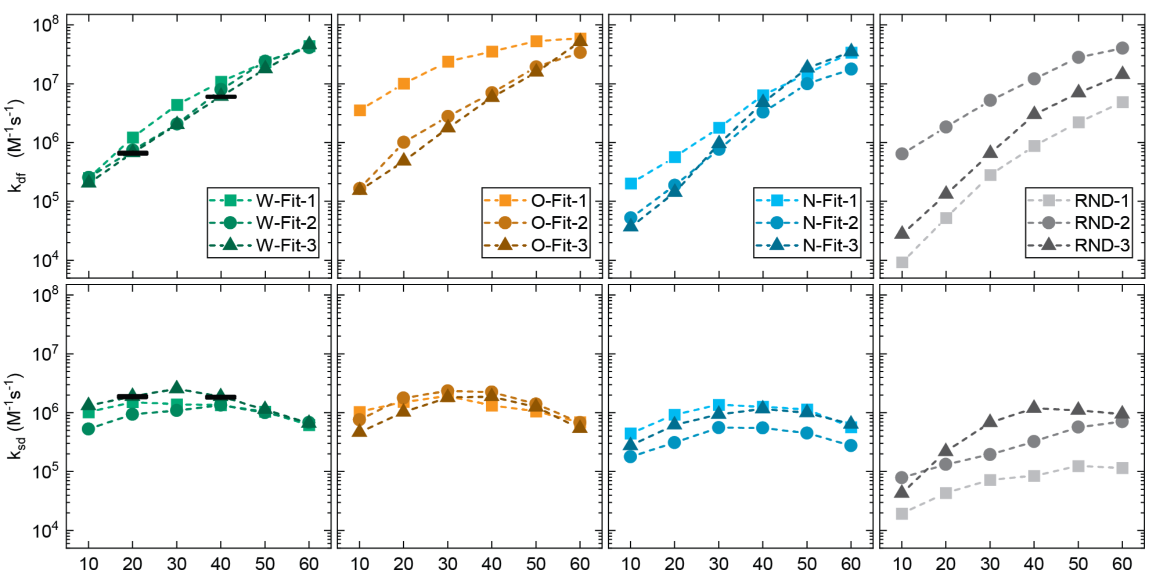


Figure 4. *Hybridization rates were experimentally measured for 12 unique oligo-sets (aka "DNA sequences").* These sets were named according to the method used to generate them (i.e. the W-Fit-1 oligo-set was the first generated using optimization of the W fitness score). Rates were measured for six experimental temperatures, for both a duplex-formation (k_{df}, above) and a strand-displacement reaction (k_{sd}, below).

A model DNA system was used to study the relationship between DNA sequence and hybridization-rates. *In-silico* optimization of the three fitness scores were used to generate novel sets of oligos. In total, twelve oligo-sets (*i.e.*, DNA sequences) were generated and experimentally characterized. 144 hybridization-rate measurements (***Fig 4***) were collected, which enabled the study of hybridization-rate dispersion as a function optimization criteria (***Fig 5***). Optimization of the W-fitness score was observed to result in low hybridization rate dispersions. Typical dispersions of ±7.7% for the duplex-formation reaction and ±14% for the strand-displacement reaction were observed for the oligo-sets.

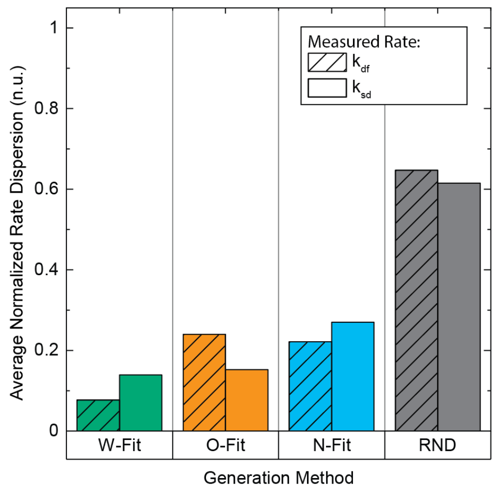


Figure 5. *In-silico optimization of the W fitness score was observed to yield oligo-sets with the most favorable hybridization-rate dispersions.*

Duplex-formation rates were observed to exhibit an Arrhenius temperature dependence (***Fig 6***) with strongly correlated activation energy (E_a) and pre-exponential factor (A). This enabled the derivation of a new kinetic model for the duplex-formation reaction, which reduced the number of sequence-dependent parameters necessary to predict duplex-formation rates from 2 to 1. This new model simplifies the task of predicting *in-silico* hybridization-rates. In addition, the hybridization rates observed for the sampled sequences (***Fig 4***) suggest that this parameter results from inadvertent intra-oligo structures, and that the reaction rates can be accurately predicted *in-silico*.

The SeqEvo code was designed to generate sequences for relatively small networks of interacting DNA oligos. In order to generate oligo-sets large enough for NAM, refactoring of the code was necessary. This process reduced the time to calculate the N, O, or W fitness scores, enabling larger oligo-sets to be generated. By the end of this objective, run-time was sufficiently low to enable the design of an oligo-set containing 8,000 total bases and 517 total oligos. The refactored SeqEvo code was used to generate four new oligo-sets for novel designs (***Table 1***). This included new sequences for a 10x10x10 DNA molecular canvas,[a] which is an attractive substrate for future 2D-NAM and 3D-NAM devices. It is speculated that this structure will have hybridization-rate dispersions similar to those observed in ***Fig 5*** (i.e. conservatively estimated at ± 14%).

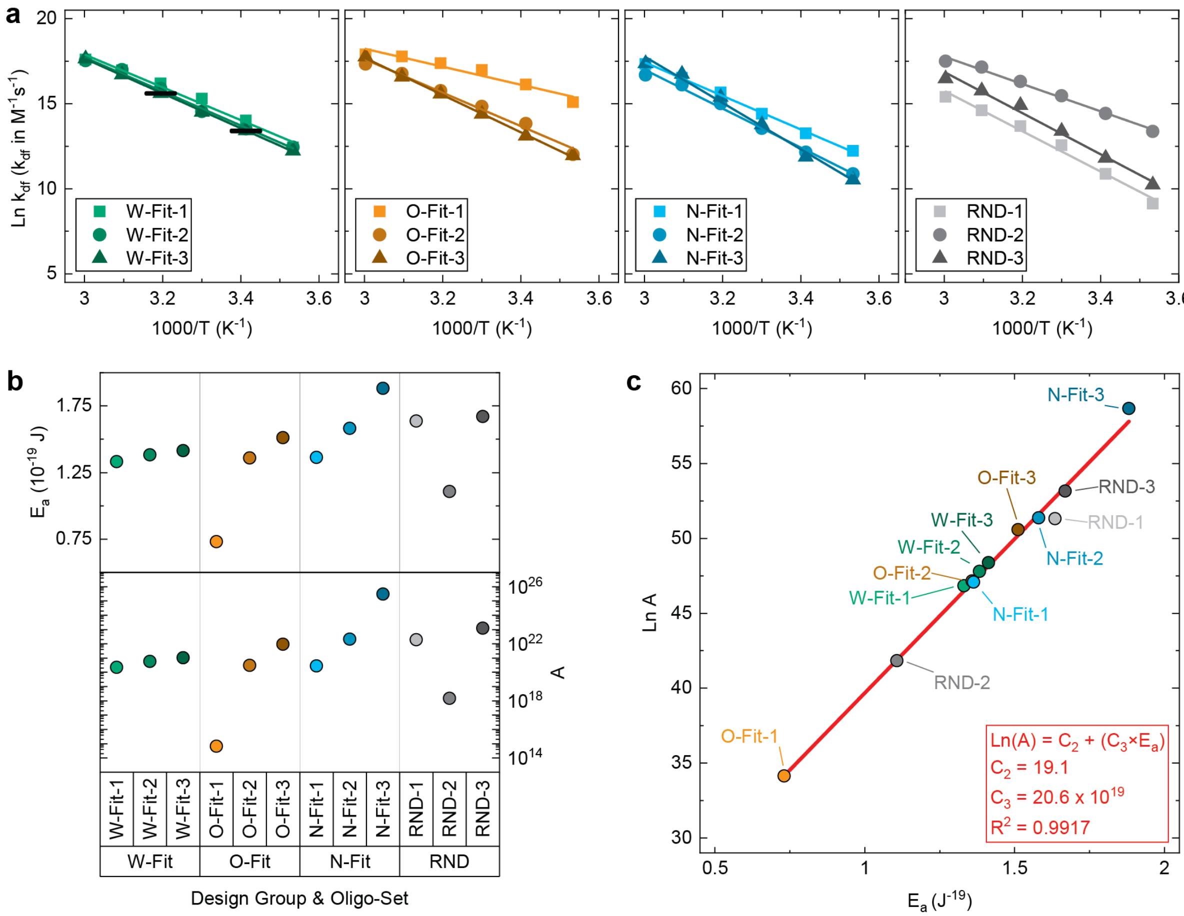


Figure 6. *Duplex formation rates for the twelve oligo-sets were found to exhibit an Arrhenius temperature dependence with strongly correlated values of the activation energy (E_a) and pre-exponential (A).* This enabled the derivation of a new kinetic model for this reaction which reduced the number of variable parameters necessary to predict duplex-formation rates from 2 to 1.

Table 1. *Oligo-sets generated for four designs using SeqEvo.* The source of these designs included: [a] Ke, Y.G., Ong, L.L., Shih, W.M. and Yin, P. (2012) Three-dimensional structures self-assembled from DNA bricks. Science, 338, 1177-1183; [b] Qian, L. and Winfree, E. (2011) Scaling up digital circuit computation with DNA strand displacement cascades. Science, 332, 1196-1201; [c] Kotani, S. and Hughes, W.L. (2017) Multi-Arm Junctions for Dynamic DNA Nanotechnology. J Am Chem Soc, 139, 6363-6368; and [d] Zhang, D.Y., Turberfield, A.J., Yurke, B. and Winfree, E. (2007) Engineering entropy-driven reactions and networks catalyzed by DNA. Science, 318, 1121-1125.

Design	№ Oligos	Oligo-Set	*N*	*O*
10x10x10 Canvas [a]	517	As published	2.22×10^{25}	2.15×10^{8}
		W[10^8] Optimized	1.96×10^{11}	1.94×10^{6}
Four-Input OR Network [b]	45	As published	2.71×10^{22}	8.08×10^{4}
		W[10^4] Optimized	3.13×10^{10}	5.18×10^{4}
Autocatalytic Network [c]	10	As published	1.11×10^{45}	6.35×10^{5}
		W[10^6] Optimized	3.97×10^{7}	9.78×10^{4}
Autocatalytic Network [d]	6	As published	1.32×10^{6}	7.50×10^{4}
		W[10^2] Optimized	4.10×10^{5}	1.51×10^{4}

Objective 3: NAM Scaffolds

1. Introduction

Objective 3 addresses the design, construction and production of single stranded DNA used as scaffolds for the DNA origami that dNAM is built upon. We have produced several ssDNA scaffolds of different sizes in E. coli. We have designed and are building a larger ssDNA scaffold by shuffling together the DNA from these different sized scaffolds. This larger scaffold will be used to synthesize a dNAM node with increased per node data.

2. Deliverables

Objective	Deliverables
3A	Create viable phage modules from E. coli
3B	Validate phage genomes for use in DNA origami synthesis

3. Most significant results, outcomes and deliverables.

Use viable phage modules to build larger scaffolds for improved data density. In our dNAM design, several data sites are used for orientation and error correction. Larger origami could include more data sites used for encoded information. Towards this goal, we have designed a scaffold that can produce a 78x120nm origami, which is 60% larger in area than our previously demonstrated structure. This larger origami can achieve an 8x10 data grid with two extra rows and columns of data compared to our previous 6x8 data grid. Synthesis of this scaffold is underway, as described next.

In our scaffold production approach, E. coli are transformed with phagemids, which are circular DNA plasmids that can produce ssDNA upon subsequent infection with “helper phage”. We developed a strategy to build the DNA phagemid needed to produce the larger scaffold by shuffling together parts of smaller phagemids. Modular phagemid parts are extracted from smaller scaffolds by PCR, and can be combined back together in numerous combinations to meet design requirements. For our design goal of a larger scaffold, three unique 11,054 nt scaffolds were designed using a 10,080 bp phagemid combined with inserts from the smaller phagemids. Distinct 982 bp regions of the 3kb, 5kb, and 8kb phagemids were amplified with PCR primers that add KpnI and BglII cleavage sites. They were then cut with restriction enzymes and pasted into the matching restriction sites in a 10,080 bp phagemid using DNA ligase. These ligated phagemids were transformed into E. coli which will be grown and screened for the desired size. Scaffold production with helper phage when folded into an origami rectangle, the 11kb dNAM contains 8x10 data sites, compared to the original 6x8 dNAM (60x90nm); increasing the operable size by 60%.

Objective 4: NAM Fabrication

1. Introduction

Objective 4 addresses the design, build, and test of NAM prototypes. dNAM was created and while outside the scope of this project, 3D-NAM has been designed and is currently under test. Single-molecule defect analysis was performed by correlating SRM and AFM together; which was enabled by creating cross-compatible substrates.

2. Deliverables

Objective	Deliverables
4A	Process for design and fabrication of DNA origami storage nodes (year 1)
4B	Protocols for statistical correlated AFM/SRM defect metrology in DNA origami (year 2)
4C	Protocols for selective area immobilization of DNA origami (year 3)

3. Most significant results, outcomes and deliverables.

dNAM was successfully designed, built, and tested. Our first prototype included data domains spaced at 10 nm intervals to achieve an areal density of 1000 Gbit/cm^2. After accounting for using 2/3 of the bits for indexing and error correction, this resulted in an areal data density of 330 Gbit/cm^2. Although only comparable for reading throughput, not storage, this is significant because recent advancements in magnetic tape have reported a two-dimensional areal information density up to 31 Gbit/cm[2], though the current commercially available material typically has lower density. Our dNAM prototype is the first and only example of reading and writing DNA without the need for sequencing technology. It is also the only DNA-based memory system that does not require custom sequences to be synthesized to change the encoded and decoded message.

3D-NAM is a newly proposed modification to dNAM that has the potential to provide an order of magnitude higher information density. This technique relies on super resolution microscopy to perform spatial and temporal readout with sub 5 nm lateral and 1 nm axial resolution. While outside of the scope of this project, the DNA nanostructures for 3D-NAM have been designed and are currently being tested. This work, if successful, is significant because it would enable a new way to sequence DNA, at a single-molecule level, without signal amplification.

In Support of dNAM and 3D-NAM, an accessible strategy for high resolution, correlative DNA-based points accumulation for imaging in nanoscale topography (DNA-PAINT) super-resolution and atomic force microscopy (AFM) of DNA nanostructures was created, enabled by a simple and robust method to selectively bind DNA origami to cover glass. Using this correlative microscopy technique, addressable “docking” sites on DNA origami were examined to distinguish between two defect scenarios – structurally incorporated but inactive docking sites, and unincorporated docking sites. In addition to creating a new microscopy technique, the results are significant because over 75% of defective docking sites were incorporated but inactive, suggesting unincorporated strands played a minor role in limiting the availability of addressable sites. The effects of strand purification, UV irradiation, and photooxidation on availability were also explored, providing insight on potential sources of defects and pathways towards improving the fidelity of DNA nanostructures for 2D and 3D-NAM.

To enable the above listed outcomes, cross-compatible SRM and AFM substrates that combined transparency, favorable DNA origami adsorption, low affinity for single-stranded DNA imager strands, and near atomic-level flatness were created via glow discharge. The results were validated by prior observations of DNA origami adsorption to piranha/HF-cleaned, thermally-grown silica, for which it was postulated that pH-dependent adsorption resulted from the deprotonation of silanol groups generated during cleaning. This is significant because DNA origami are typically bound to cover glass by biotin-avidin binding between biotinylated DNA present in the origami and surface-bound, biotinylated proteins (commonly biotinylated bovine serum albumin – BSA-biotin). While the surface proteins passivate the surface to diffusing imager strands during image acquisition, they are too rough to perform high-resolution AFM and/or SRM.

Objective 5: NAM Reading

1. Introduction

Objective 5 addresses NAM readout. The information stored in DNA is read by a super-resolution fluorescent microscopy technique. We achieved optical resolution as small as 5 nanometers to enable high areal density data storage. We also worked with Objectives 2-4 to create an optimized set of sequences that produces the least imaging defects. However, the imaging resolution is insufficient for seqNAM. A change in direction (see *III. Significant Changes in Direction*) was introduced in 2020 to address the resolution with a 3D super-resolution technique.

2. Deliverables

Objective	Deliverables
5A	Optical readout of dNAM (year 1)
5B	Optical readout of seqNAM (year 2)
5C	Sub-nanometer imaging resolution for SRM (year 3)

3. Most significant results, outcomes, and deliverables.

NAM readout with the use of super-resolution imaging of DNA. The result is published recently in Nature Communications[3].

Image drift is one of the limiting factors for single-nanometer resolution super-resolution imaging. Several improvements are made to the real-time active drift correction system. A temperature stabilized single-frequency laser source is utilized to increase the wavelength stability. The position of the slides is determined in all three dimensions by imaging the reference gold nanoparticles with a resolution of 3 nanometers. The resulting resolution as small as 4.5 nanometers is achieved which is important for NAM data density.

An additional pathway to improving resolution is through the elimination of mechanical and optical noise from the microscope system. Commercial optical microscopes have many moving parts that are susceptible to both vibration and drift coming from mechanical and thermal sources. They also have external light leaks, internal stray light, and internal optics that are not needed for DNA-PAINT microscopy. To improve performance, a custom SRM system has been designed. The design eliminates all macroscopic moving parts, is mechanically rigid, and uses a minimal number of components so to minimize mechanical sources of drift and noise. The design is also light-tight and designed to minimize stray light and optical loss internally. Additionally, the system's compact and lightweight design will make it possible to integrate it onto mechanical and thermal isolation systems used for AFM and other forms of high-sensitivity microscopy. A rendering of the mechanical design is shown in ***Figure 7A***.

The prototype design has been constructed and tested on our dNAM samples. An averaged image of a dNAM tile is shown in ***Figure 7B***. The system hasn't been integrated with mechanical or thermal isolation, but does utilize the active drift correction system described above. The system has not been fully optimized in terms of the illumination and experimental conditions but our initial experiment with the system has shown 4.5 nm FWHM resolution. This is superior to our best results of 7.2 nm on the commercial system, and we're optimistic more improvements can be made through optimization.

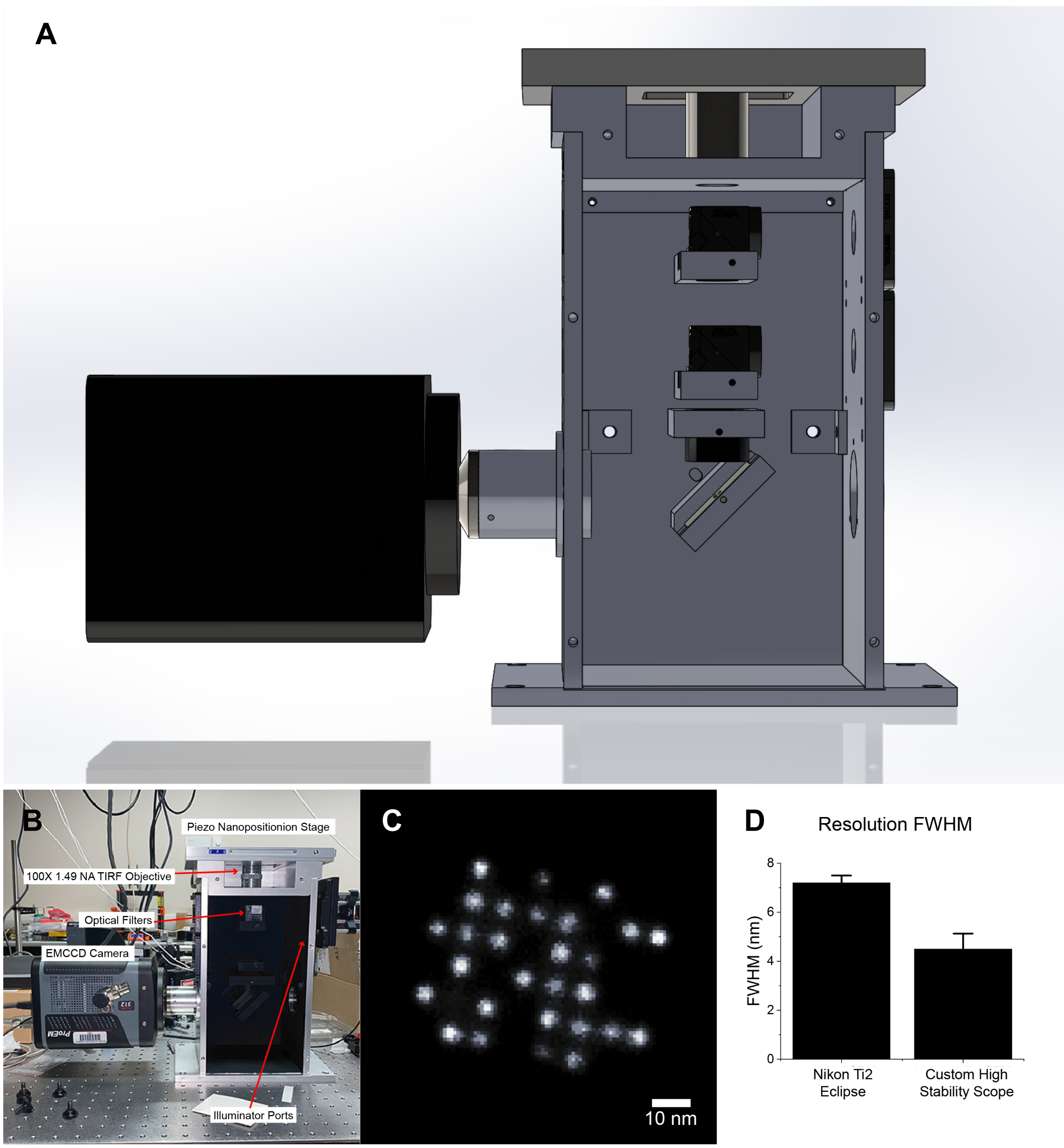


Figure 7. (**A**) CAD rendering of custom microscope design. showing third-party components attached to custom body. (**B**) Fabricated Microscope. (**C**) Super-resolution image of DNAM Tile recorded with custom scope. Showing 4.5 nm FWHM resolution. (**D**) Head-to-head resolution comparison between a highly optimized Nikon SRM system and the new custom SRM system.

IV. Significant Changes in Directions

Objective 1. None to date.

Objective 2. The initial strategy proposed for this objective was to build upon the previously-developed SeqEvo computer program to generate new NAM sequences. Experimental results collected while validating the SeqEvo software created a feedback-loop which changed the course of this research. As a result, further effort than anticipated was spent studying the kinetics of DNA oligo hybridization and developing new methods of in-silico optimization.

Objective 3. While we had originally planned to modify phage directly, the phagemid and helper phage approach was determined to be more modular. In addition, we are able to use numerous phagemids developed by others as modular sources of DNA that can be shuffled together without concern of reproduction effects.

Objective 4. While protocols for immobilization of DNA origami were achieved (described above), selective area protocols proved unnecessary for two algorithmic reasons: (**1**) custom pattern-recognition software was created that distinguished, rotated, and registered NAM structures so that they could be successfully read, and (**2**) custom encoding and decoding algorithms enabled reading NAM structures, with multiple messages, without needing to physically partition the data via typical approaches to random access.

Objective 5. In the project, an increased localization accuracy and enhanced drift correction are achieved. Theoretically, localization accuracy can be continuously improved by increasing photons collection since the imager strands are continuously replenished from solution. In practice, it is observed that the docking sites can become unavailable after 10s of minutes of imaging due possibly to photo damage. It limits how much further the resolution can be reduced. Sub-nanometer imaging resolution may not be achieved with resolution enhancement alone. Instead, $_{3D}$NAM is being explored to achieve an effective nanometer resolution. The data imager strands are designed in a way that imager strands will be attached at multiple distance from the donor fluorophore.

V. Future Directions

Objective 1.

dNAM. We will examine more advanced error correction codes in order to reduce the space devoted to error correction on the origami. We will determine how to utilize the information in the SRM image to guide the decoding algorithm as it corrects errors. i.e. look at how we can prioritize bits in the error correction search based on the information that supports that bit as found in the SRM image. Finally, we are working on developing deep NN based algorithms for reading the SRM image.

seqNAM. We are currently researching how we can improve the encoding algorithm by viewing the encoding process as the search for a shortest path in a weighted graph. The approach we are developing starts by constructing a weighted graph from the local constraint matrix and the information to be encoded, and then proceeds to search for the shortest paths through this weighted graph using a uniform-cost search. We are also interested in how we can incorporate non-local constraints in this process, such as the avoidance of long repeats or palindromic sequences, or other structural issues. To this end, we are exploring using a transformer deep learning model to speed structure problem prediction during the graph search, so that this can be run real-time during the search to provide guidance to the shortest path algorithm.

Objective 2. As a result of this research, it is now possible to generate high-quality DNA sequences for relatively large oligo-sets for NAM-based memory systems, as well as other DNA-based systems. However, it is not yet clear how much this will improve synthesis yields and/or performance of NAM devices. A quantitative study of the performance of the newly generated NAM sequences will be necessary to validate and further improve the sequence generation process.

Objective 3. We will continue to synthesize our 8x10 dNAM using the larger scaffold. In addition, we plan to design larger structures using multiple orthogonal smaller scaffolds stitched together with staple strands.

Objective 4. During this project, three super-resolution microscopes have come online. The first is a commercial-grade SRM system with vibrational and environmental control. The second is a modularly built SRM system that is used to experiment with novel approaches to SRM including but not limited to time-correlated SRM for $_{3D}$NAM. And the third is a state-of-the art custom designed and built SRM system from the frame-up. In the future, the first microscope will be used to test new NAM prototypes in a controlled environment, the second will pilot new SRM techniques, and the third will push the resolution limits of SRM as close to its theoretical limit as possible. Together, they will explore $_{3D}$NAM and eventually a new approach to sequencing DNA.

As an important step in this direction, ***Figure 8*** is a calibration standard created on a dNAM substrate to probe the physical limits of SRM. The top and left images are three- and two-dimensional representations of the substrate, where the red and blue protruding strands are respectively orientation makers and data sites with various lengths. The SRM image in the center and the corresponding photon intensity versus distance plot on the right indicate that we have imaged length 1 through 7 nts in increments of 1 nt. As shown in the intensity plot, when the imager probe was a mini-hairpin structure, the short data sites could be read. In comparison, when the linear probe was used as a control, the data sites could not be read. The ability to image 1 nt with SRM is below the resolution of AFM. Looking to the future, we will validate or debunk our findings through careful design and execution of control studies. If validated, will also explore the imaging mechanism.

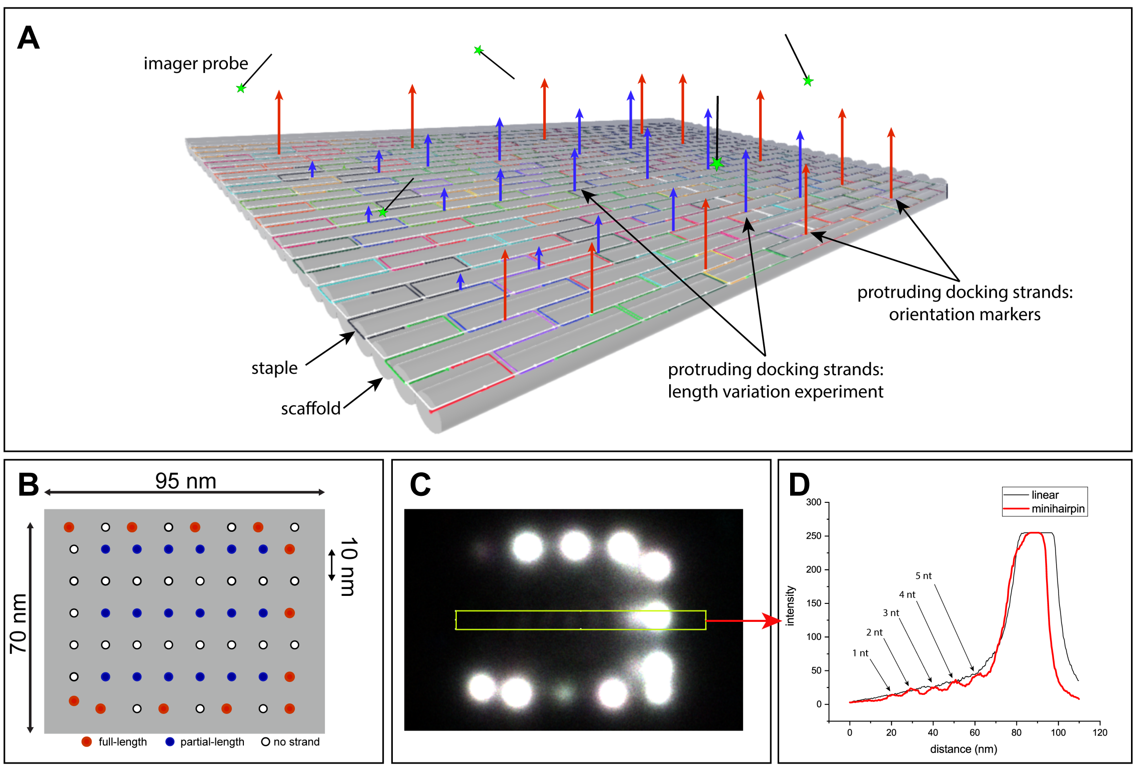


Figure 8. (**A**) Three and (**B**) two-dimensional representation of a dNAM substrate, where the red protruding strands are orientation makers and the blue protruding strands are data sites with various lengths. (**C**) Corresponding SRM image of a dNAm substrate with (**D**) the corresponding intensity versus distance profile.

Objective 5. To enable 3DNAM, we are developing a custom imaging array that combines high resolution, high light sensitivity, and high timing sensitivity. Conventional imagers use a lengthy exposure time to capture an image in a low-light environment, as we have in imaging the fluorescence of 3DNAM. Due to this exposure time, conventional imagers are incapable of extracting fluorescent lifetime. The time correlated imager (TCI) we developed uses single-photon avalanche diodes (SPADs) which have a binary response to a single photon, meaning we can extract the exact moment of a photon's arrival. While there are commercially available SPAD imagers, they are unsuitable for 3DNAM imaging as they only have a single pixel or have poor photon detection efficiency. Fortunately, SPADs can be integrated directly into integrated circuit technology, meaning we can develop our own imager with supporting circuits to extract lifetime information. ***Figure 9A*** shows the cross section of the SPAD structure we used to implement our TCI. ***Figure 9B*** shows a simplified architecture of our first TCI prototype. It is comprised of a 16x16 SPAD array, column-level monostable circuits to stretch SPAD events and then reset the SPAD after photon detection, and shared time-to-digital converters (TDCs) that convert the photon's arrival time with respect to the laser into a digital code. Our TDC has a timing resolution of 62 ps and a selectable range to accommodate up to an 80MHz laser pulse repetition rate (***Figure 9C***). Our next prototype will include lifetime computation on-chip to compress data. We will use a center-of-mass method that directly extracts fluorescent lifetime with low computational overhead and is scalable to larger arrays (***Figure 9E***).

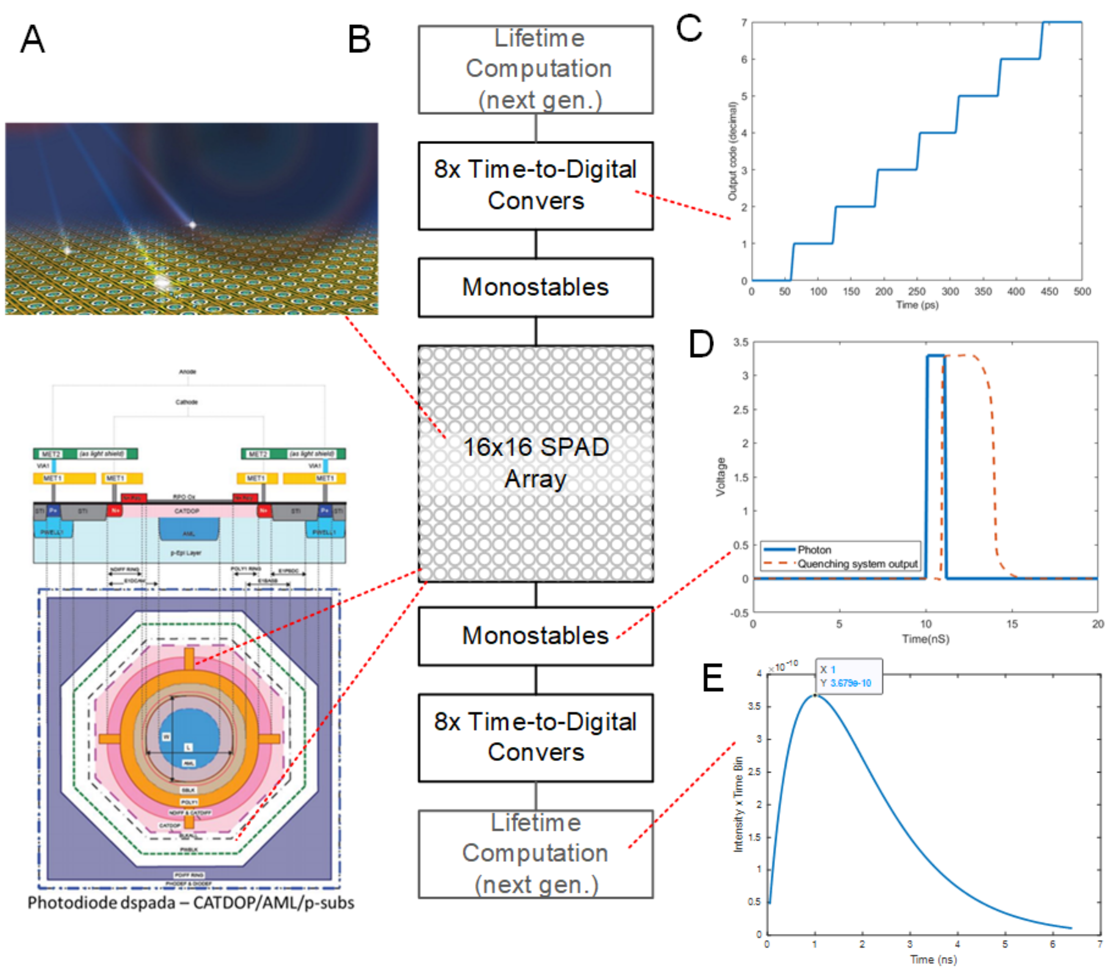


Figure 9*. Time correlated imager (TCI) overview.* (**A**) Cross section and layout view of the implemented SPAD. (**B**) System architecture of the TCI consisting of a 16x16 SPAD array, column-level monostable circuits, time-to-digital converters (TDCs), and on-chip fluorescent lifetime computation. (**C**) Plot of the simulated transfer function (photon arrival time vs. digital output) for the TDCs. (**D**) Plot of simulated photon arrival and corresponding monostable circuit output. (**E**) Time histogram of simulated fluorescent events with a fluorophore lifetime of 1ns. The center-of-mass closely matches the fluorescence lifetime.

VI. Demonstration of Economic Development and Impact

External Networks. As outlined in the Executive summary, the Nucleic Acid Memory (NAM) Institute at Boise State was invited to join the DNA Data Storage Alliance. The alliance is the first and most extensive bridge between industry and academic organizations that are pioneering DNA data storage. Its mission is to "*create and promote an interoperable storage ecosystem based on DNA as a data storage medium*". The alliance will recommend the creation of specifications and standards (e.g., encoding, reliability, retention, file systems) which enable end-users to add interoperable DNA-based storage solutions to their existing storage hierarchies. The founders include Illumina, Twist Biosciences, Western Digital, and Microsoft. Member organizations include but are not limited to: Ansa Biotechnologies, Battelle, Catalog, The Cloude Nobs Foundation, DNA Script, EPFL, ETH Zurich, Imagene, IMEC, Iridia, Kioxia, Molecular Assemblies, PFU, Quantitative Scientific Solutions, Quantum, Seagate, Semicondcutor Research Corporation, Spectra Logic, University of Arizona, University of Washington, Digital Preservation, Oligo Archive, Lost Alamos National Laboratory, Cinémathèque Suisse, 21e8, DNAli, and University of Marburg. This network is critical as Boise State attempts to license the NAM intellectual property and/or the research team spins-off companies in the memory/biotechnology arena.

External Impacts. As outlined in the Executive Summary, Steven Burden (founder/CEO) and Clementine Gibard Bohachek (co-founder/CSO) spun-off Facible, a biodiognostics company in Boise that has 25 employees and is seeking FDA approval for a novel COVID-19 screening technology. In service to future generations of biotechnology start-ups in Idaho, Facible and the Nucleic Acid Memory Institute are actively exploring the creation of a biotech incubator in Boise.

External Funding. Beyond the IGEM/HERC investment, the NAM Institute has secured $1,549,995 in grants from the National Science Foundation and the Semiconductor Research Corporation. According *The Implementation Group* (TIG) -- which is a research development firm specializing in strategic positioning, proposal development, and team science to increase Boise State's competitiveness for external funding – the awarded grants are among the most competitive and prestigious within the Boise State portfolio because we outcompeting MIT, Stanford and many other premier institutions that were positing for SemiSynBio funding. Building on our initial success, the NAM Institute is preparing to submit proposals to the NSF SemiSynBio III proposal opportunity this academic year, as well as the NSF Partnership for Innovation pathway to help the team evaluate if and how it should spin-off a company. To strengthen our proposal, we have designed, built, and started to test a custom SRM with 4.5 nm resolution. We have also designed and fabricated a custom 16×16 time-correlated imaging (TCI) array for super resolution and fluorescence lifetime imaging microscopy (FLIM). Both the microscope and the TCI array are viable scientific instrumentation products that could be licensed or sold.

Future Funding. In support of future funding, the research team has provided thought partnership to IARPA on its proposed Biologically Templated Nanofabrication (IGATA) initiative; including but not limited to sharing technical ideas, suggesting performance metrics for the community to consider, introducing IARPA to leaders in the DNA nanotechnology community, reviewing drafts of their whitepaper (which will translate into an RFP), and offering to support their workshop once the RFP is approved.

In addition, the NSF Germination program aims to foster the development of frameworks, platforms, or environments to enable faculty to form research questions and ideas with potentially transformative outcomes. Based on the success of 2 NSF Germination Awards (# 1745944, 1629659), the PI has been invited to design, test, evaluate, and implement frameworks, platforms and/or environments that enable academics to formulate research questions and ideas that have the potential to address critical societal challenges.

VII. Demonstration of Economic Development and Impact

Demonstration (07/01/2018–07/27/2021)	**Amount**
External Funding	$ 1,549,995
Number of External Grants	3
Private Sector Engagement	~ 20 companies
University Engagement	~ 20 universities
Industrial Alliances Joined	1 (*DNA Data Storage Alliance*)
Federal Agency Engagement	5 agencies (*NSF, SRC, IARPA, DARPA, NIH*)
Industry Involvement	2 companies (*Micron, SRC*)
U.S. Patents Submitted	1
Publicly Available Software Packages	3
Plant Variety Protection Certificates	0
Technology Licenses Signed	0
News Releases	3 articles
Start-up Businesses Started	1 (Facible with 25 employees)
Jobs Created outside of BSU	~ 10

VIII. Numbers of Student, Staff, and Faculty participation

We were fortunate to have a diverse team of perspectives, experiences, and expertise. From the initial ideation phase leading to our proposal, to the research that led to our outcomes, we have embraced team science in addressing the future information storage needs outlined in the SemiSynBio Roadmap. In the following table, we recognize the people that have enabled the research during the project, from our students, staff, and principal investigators.

Contributor	Objective/Support	Experience	Professional Outcome
Steven Burden, PhD student	Objective 3	Biology	Earned his PhD, Co-founder and CEO of Facible
Chris Green, PhD student	Objective 4 and 5	Materials Science	Earned his PhD; NRC postdoctoral fellow
Mike Tobiason, PhD student, postdoctoral researcher	Objective 2 (PhD student), Objective 1, 2, and 5 as postdoctoral researcher)	Materials Science	Postdoctoral researcher for the NAM Institute
Golam Md Mortuza, PhD student	Objective 1	Computer Science	Passed his PhD proposal; intern at Facebook during summer 2021
Reza Zadegan, postdoc	Objective 1 and 4	Materials Science	Tenure-track faculty at NCA&T
Chad Watson, project manager	N/A	Project Management, Research Development	Boise State's Division of Research and Economic Development and the Center for Advanced Energy Studies
Kelsey Suyehira, MS student	Objective 1	Computer Science	Earned MS in Computer Science; Software Development Engineer at Cradlepoint
Elton Graugnard, co-PI	Objective 4	Materials Science, Physics	Transitioned off project to focus on developing atomically-thin semiconducting materials; awarded $126k by the Micron Foundation
Will Hughes, PI	Objectives 1-5	Materials Science	N/A
Wan Kuang, co-PI	Objective 5	Electrical Engineering	N/A
Tim Andersen, co-PI	Objective 1	Computer Science	N/A
Eric Hayden, co-PI	Objective 3, VIP	Biology	N/A
Shoshi Llewellyn, MS student	Objective 1	Computer Science	N/A
Will Clay, postdoctoral researcher	Objective 5	Optical Physics	N/A
Luca Piantinada, postdoctoral researcher	Objective 4, VIP	Bionanotechnology	N/A
George Dickinson, postdoctoral researcher	Objective 1, 4, 5	Biology, Computer Programing, Optical Physics	N/A
Clementine Gibard Bohachek, postdoc	Objective 3, VIP	Biology	Cofounder and CSO of Facible
Ben Johnson, collaborator	Objective 5	Electrical Engineering	N/A
Mehdi Bandali. PhD Student	Objective 5	Electrical Engineering	N/A
Natalya Hallstrom. Lab Man.	Objective 2–4, VIP	Biology	N/A
Sarah Kobernat, PhD student	Objective 3, VIP	Biology	N/A
Jacob Elmore, Julie Ramirez, Levi Orr, Amanda Wolf, Kaelee Ryner, Ben Balzer, Madia Bazso, Baylee Zanone, Ashlyn Trapp, Tia Senger, Hailey Jorgensen, Isaiah Keylor Aidan Poe, Katie Mateo Kelly Mazur, Hannah Hernandez, Gabe Frandsen, Lauren Grillo, Kayla Jonas, Olivia Paulsen, Brendan Yoshino, Hagen Shults, Madison Edwards, Tanner Pollock	A total of 24 students participated in our NAM VIP course over the last three years. These students range from freshman to seniors and span multiple majors: biology, pre-med, health sciences, chemistry, and psychology. The VIP students supported Objective 3.		Ben Balzer and Amanda Wolf selected to be summer undergraduate researchers for the NAM Institute; Ashlyn Trapp selected for an NSF REU on Data-Driven Security.

IX. Dissemination

See the summarized table of disseminated products on page 3 of this report.

X. Summary of Budget Expenditures

The investments from IGEM/HERC were largely infrastructure-centric; bringing the biological, computer, and materials sciences closer together by moving the NAM Institute into the Micron Center for Materials Research. Equipment that supported this project and its team integration included a:

- Custom super-resolution microscope – for pushing the physical limits of SRM
- Commercial super-resolution microscope – for routine NAM characterization
- SRM Environment Chamber – to minimize humidity and temperature effects
- SRM Vibrational Table – to minimize noise from vibrations during SRM
- Autoclave – for sterilizing solutions and equipment
- Shaker incubator – for microbial growth
- Sterile incubator – for growth and maintenance of E. coli strains.
- Gel imager – for validation, quantification and documentation of all Nucleic activities d materials including oligos, plasmids, scaffolds, and origami structures.
- Refrigerator – for storage of temperature sensitive biological material

With a desire to grow our computational capacity, and in anticipation of the long-term effects of the pandemic on our experimental research, our team also invested into a:

- Dell PowerEdge DSS 8440 RTX 8000 GPU node with 8 NVIDIA Quadro RTX 8000 48 GB GPU cards and 384 GB of system memory.

The above node continues to support our research via deep neural models to improve and speed up performance on such tasks as localization of fluorescent markers in SRM imagery, translation of SRM imagery to binary strings, and secondary structure prediction for our NAM encoding algorithms.

For this and more, the faculty, staff, and students would like to extend their greatest appreciation to IGEM/HERC. This project, and its resulting outcomes would not have been possible in the absence of your investment.

IGEM20-001

Idaho State University

Disaster Response Complex

College of Science and Engineering

Department of Civil and Environmental Engineering

IGEM20-001

A Disaster Response Complex for Emergency Responders in Idaho

2nd Year Annual Report

July 1, 2020 – June 30, 2021

June 30, 2021

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

2nd Year Annual Report: July 1, 2020 – June 30, 2021

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 training of emergency responders than the current facilities can support. In 2019, researchers at Idaho State University were awarded funding from the State of Idaho under the 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 (GIS), 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 protocols. 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), 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 (2nd Year)

This is the annual report for the second year of the project. The second-year budget for the project was $271,400, which included a $4,000 budget cut due to the developments with COVID-19. The project personnel would like to thank the State Board of Education for offering a no-cost extension for the first year of the project. This certainly assisted in making more progress during a pandemic. Despite the ongoing global pandemic, the project personnel made substantial progress in the second year toward all three pillars of the DRC as described below.

While still under construction, the DRC started its training on October 31, 2020. Since then 350 individuals including instructors and role players have participated in exercises and trainings offered through the DRC. From these, about 180 were civilian responders (ISU EMT and other programs, ISU Public Safety, Idaho State Police, Pocatello Police, Fire departments, and local search and rescue units) and approximately 170 were military responders, primarily Civil Support Teams from the National Guard representing about 20 states. An additional 150 or more members of the National Guard from across the country are expected to train at the DRC by Fall 2021. ISU is collaborating with INL on the training of the National Guard units. Dozens of civilian responders are also expected to use the DRC for their training in the remaining half of 2021.

Most of the National Guard units are training at a former Armory building in Pocatello. The Armory was originally planned to be excessed by ISU, however, after a proposal by the DRC team, it was assigned to the DRC project to serve as an indoor year-round training facility. The space inside the Armory was cleaned out and new classrooms, offices, and meeting rooms, equipped with all facilities were established. New state-of-the-art training lanes were designed and constructed inside the Armory building. ISU and the state of Idaho have a lot to be proud of for having the National Guard back training in the former Armory building after half a century. The DRC has been expanding its collaboration with local, regional, and national stakeholders. Tours and discussions were held for potential partners from the Federal Bureau of Investigation (FBI), Southeast Idaho Health District, counties, and Local Emergency Planning Committees (LEPCs) in Southeast Idaho and other partners from the public/private industry.

Additional research funds were obtained from ISU and CAES to engage more students and researchers on the DRC project. Students and researchers participated in scholarly activities in disaster response, such as submission of peer-reviewed journals, presentation of the project in the 2021 American Society of Civil Engineers (ASCE) Southern Idaho Section Civil Engineering Conference.

Many tours of the DRC were provided for the stakeholders and potential partners on the project. Several media articles were published to promote and spread the word about the DRC. In line with ISU's branding, logos and white pages for the DRC were created. A website has also been launched (https://isu.edu/cee/research-facilities/drc/). In 2021, the project personnel initiated more marketing/promotion efforts, development work, alumni engagement, and business plans to make the DRC sustainable after the end of the project (e.g. June 2022).

A. Research Pillar

Efforts in the research pillar were primarily focused on the use of robotics, AR, VR, GIS, LiDAR, and Radio-Frequency Identification (RFID). Other research areas such as electronic simulations of markers/surrogates for CBRNE training were also initiated with researchers from INL and ISU. Updates in each area of the research pillar are outlined as follows.

- Robotics:
  - An ISU graduate student has been working on the robotic aspects of the project in collaboration with ISU and INL researchers. The student successfully passed his qualifier exam for a doctorate degree at ISU and is making progress toward his dissertation focused on the use of robotics in disaster response.
- AR/VR:
  - Three to four students from ISU have been working under the supervision of the INL researchers on the AR/VR aspect of the project. The researchers from ISU and INL have been holding regular weekly/biweekly meetings to identify further research opportunities in this area. 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 both private and public entities.
  - ISU partnered with INL researchers and developed 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.
  - In December 2020, Dr. Mashal was awarded $20,000 for research in AR/VR through Idaho State University – Center for Advanced Energy Studies (ISU-CAES) funding. The project aims to develop AR/VR templates (e.g. exercises) for responders from both military and civil sectors. ISU is collaborating with researchers from INL on this project.
  - A new Visualization laboratory was established to assist with AR/VR research at ISU. Funding ($16,000) for the laboratory was provided through ISU-CAES. The new "Visualization Laboratory" is equipped with two pro-grade virtual reality (VR) headsets with eye-tracking; one Vive Cosmo and one Oculus Quest headsets that allow users to visualize information in a 3D immersive virtual environment. Additional equipment includes one Dell Alienware laptop and two Alienware desktops to develop VR environments, an iPad pro with built in Light Detection and Ranging (LiDAR) scanner for augmented reality (AR), four monitors and other accessories, and MS HoloLens 2. Three students from Mechanical Engineering have already started using the Visualization Laboratory for research as part of the DRC project.

- ISU-CAES provided additional $5,000 in 2021 for purchase of equipment such as high-speed camera and other accessories in the visualization laboratory.
- ISU-CAES provided approximately $10,800 to engage ISU students in the DRC project; the students are co-supervised by INL researchers. This funding provided the student's hourly pay to work on the research pillar of the project.

- GIS and LiDAR:
  - The outdoor collapsed structure was surveyed and shot using LiDAR during different construction stages. Results will be used for the AR/VR aspect of the project.
- Radio-Frequency Identification (RFID):
  - A faculty with expertise in Electrical and Computer Engineering at ISU has been collaborating with the project personnel on the use of RFID in civil engineering applications. Although the project focuses on applications of RFID for moving of precast concrete elements, there is potential for using this technology in monitoring the movement of concrete rubble as part of the post-disaster response and monitoring. The researchers at ISU have discussed applications of RFID technology in disaster response with INL and are looking for potential opportunities for funding and collaboration.
- Chemical, Biological, Radiological, Nuclear, and High Yield Explosives (CBRNE) Simulation:
  - Numerous meetings were held between ISU and INL researchers to discuss electronic simulations of CBRNE training. ISU and INL are also exploring collaboration with some private companies that offer such capabilities.
  - In 2021, CAES funded $50,000 for program development for a Radiological Dispersal Device (RDD) Training using electronic simulations. While the principal investigator for the project is an INL employee, majority of the funding (e.g. $43,000) have been allocated to ISU to support a graduate student from health physics to participate in this project. The project has three phases and will continue until May 2022.
- Other Technologies:
  - 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. INL has loaned a unique training resource (e.g. vehicle) for the DRC to ISU. sUAV was used for the preparation of this resource before it was shipped to ISU in early 2021. The training resource has already been used in the training of emergency responders at ISU and is unique in the Pacific Northwest.
- Scholarly Activities:
  - A journal paper titled "A Disaster Response Complex for Training of First Responders in Idaho" was submitted to "Countering WMD Journal" which is published by the United States Army Nuclear and Countering WMD Agency. The journal is currently under review.
  - Another journal paper titled "Virtual and Augmented Reality in Disaster Management: A Literature Review of the Past 10 Years" was submitted to 2021 IEEE International Symposium on Mixed and Augmented Reality (ISMAR). After receiving the peer-reviews, the project personnel have been working to refine the paper and submit it again in a peer-reviewed journal/conference.
  - A 50-minute presentation on "A Disaster Response Complex (DRC) for the training of Emergency Responders in Idaho" was made during the 2021 American Society of Civil

Engineers (ASCE) Southern Idaho Section Civil Engineering Conference. The presentation was selected from many other submissions. Participants received Professional Development Units (PDUs) from the ISU presentation.

- A master's level student has been writing his MS project on the DRC. The MS project will include civil engineering design, construction, as well as the state-of-the-art technologies for disaster response.
- Another master's student has been working toward his thesis in electronic simulation of HazMat in disaster training.

- Outreach and New Collaboration/Partnership:
  - 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 companies.
  - Tours of the DRC were held for dignitaries from the Department of Energy, INL, and ISU.
  - ISU has signed Memos/Master Agreements with public and private firms that are partnering on the DRC project.
  - The DRC participated in discussions for a proposal by ISU's Kasiska Division of Health Sciences (KDHS) to Federal Emergency Management Agency (FEMA).

B. Curriculum and Certification Pillar

- On the curriculum side, the project personnel and INL researchers/instructors have been holding regular weekly meetings to develop new curriculum in disaster response that uses the indoor and outdoor DRC facilities.
- The project personnel are collaborating with ISU's KDHSto develop and offer a unique curriculum focused on earthquake response in the fall of 2021.
- In partnership with Battelle Energy Alliance (BEA) and CAES, Idaho State University offered the Laboratory Operations Supervisor Academy (LOSA) at no cost to 30 participating faculty, staff, and students in August 2020. 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 culture of lab safety. 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.
- ISU, INL, and a non-profit entity pursued funding to develop a pandemic-focused version of LOSA. The training was titled LOSA-COVID-19 and targeted employees of the lab, ISU, and other state entities. Initiatives such as "Train-the-Trainer" were part of this plan. ISU submitted a $428,000 proposal to CAES on the LOSA-COVID-19 initiative. The proposal was not successful.
- ISU has completed a Master Agreement with a private company in Idaho to offer curriculum for the DRC. Thirty-eight courses have been shortlisted and discussed for this initiative.
- The project personnel have had discussions and tours of the outdoor DRC with potential instructors/partners from local fire departments and the private industry to develop curriculum for emergency responders in the military, law enforcement, emergency management, and fire departments.

- The project personnel followed up with ISU's College of Technology's Continuing Education/Workforce Training and private industry to explore the initiative of getting Continuing Education Units (CEUs) for the responders taking curriculum at ISU.
- Dr. Mashal and Dean Snyder presented the DRC project at the ISU Alumni Association Town Hall on January 20, 2021.
- Dr. Mashal made an online presentation during the December 3, 2020 meeting of the Eastern Idaho Fire Chiefs Association and shared information about the DRC. The project personnel reached out to local fire departments to consider collaborating with ISU on the curriculum/certification and training/exercise pillars of the DRC.
- Dr. Mashal and Jared Cantrell (DRC manager) presented to Caribou County Local Emergency Planning Committees (LEPCs) on seismic vulnerability in Southeast Idaho and the DRC project on June 16, 2021.

C. Training and Exercise Pillar

In the second year, despite the COVID-19 and lockdown restriction, the project personnel were able to start the training at the DRC while it has been still under construction. More than 350 individuals including instructors and role players have participated in exercises and trainings offered through the DRC since October 31, 2020. From these individuals, about 180 were civilian responders (ISU EMT and other programs, ISU Public Safety, Idaho State Police, Pocatello Police, Fire departments, and local search and rescue units) and approximately 170 were military responders, primarily Civil Support Teams from the National Guard representing about 20 states.

- Other updates from the second year of the project includes, but not limited to:
    - Purchased and transferred multiple conex boxes and various materials and supplies that will be used for the construction of outdoor and indoor training lanes.
    - Finalized design and drawings for the three basic lanes.
    - Completed construction of a complex subterranean lane (Figure 1).
    - Completed construction of a shoring lane inside a conex box.
    - 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 2).
    - The project personnel worked with ISU's Facilities and were granted the Old Armory Building (Figure 3) for research and academic use. This selection was based on the feedback from INL, Idaho National Guard, and other clients. The Armory building is 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 was re-purposed to be used toward serving the National Guard units again. The building has a high-bay area. It also includes spaces that can be used for offices and classrooms. Together with the outdoor facility, the Armory building provides substantial support for all three pillars of the DRC. The project personnel prepared extensive designs and drawings

for the indoor facility, which houses a mock-city block (Figure 4) for indoor training scenarios. Construction for the main part of the mock-city (e.g. storefront and roadway) have been completed (Figures 5 & 6). Furthermore, several classrooms, offices, meeting rooms were painted and set up to support all three pillars of the DRC (Figure 7).

Figure 1. Completed Subterranean Lane

Figure 2. DRC Open House in Fall 2020

(a) Front View **(b)** Parking Lot on the West Side

Figure 3. Armory Building at ISU

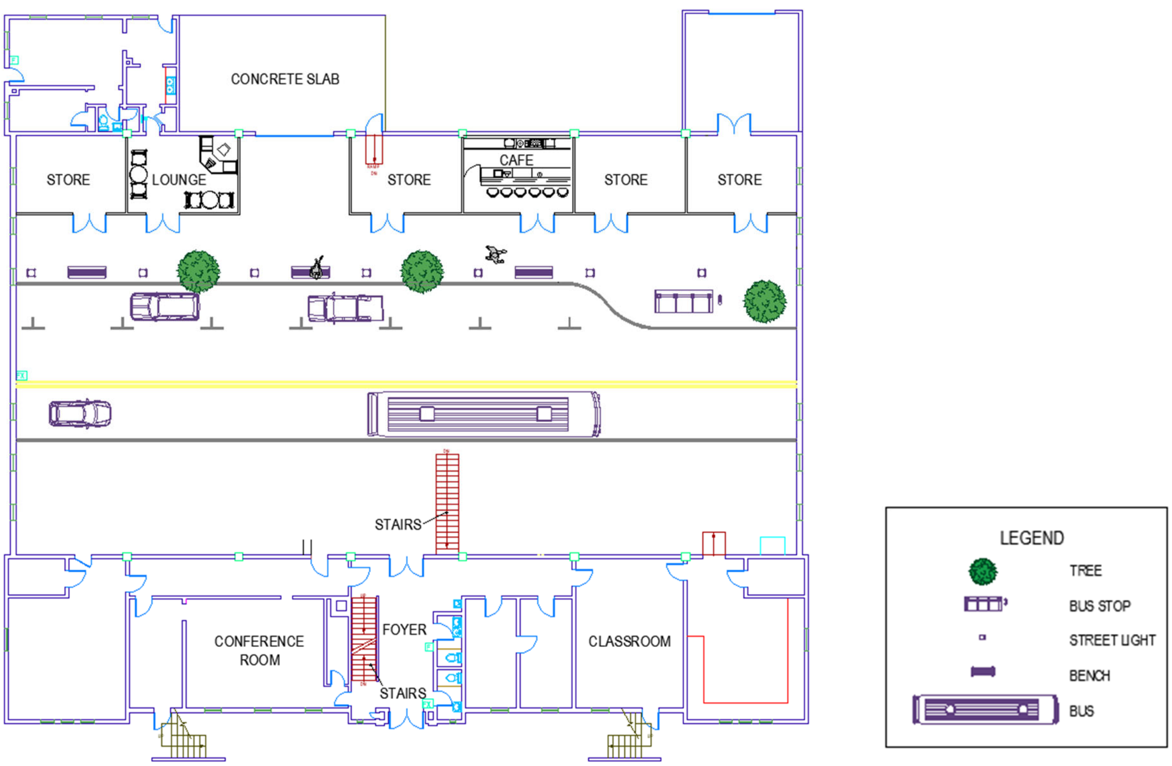


Figure 4. Mock-City Layout at the Armory Building at ISU

Figure 5. Construction of Mock-City Block in the indoor DRC

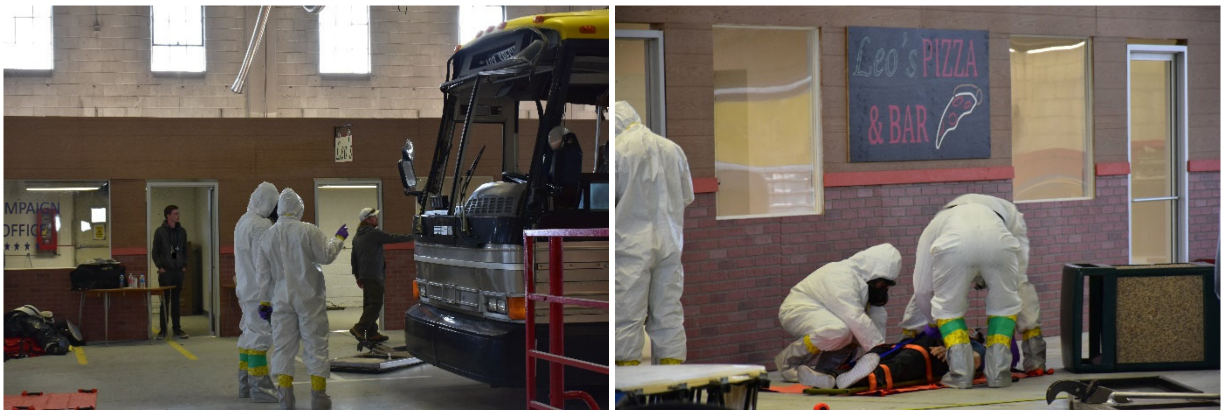


Figure 6. Completed Mock-City Block with National Guard conducting a training in June of 2021

Figure 7. Typical refurbished space in the Armory that serves as a classroom, shown in the photo was a joint exercise by the National Guard and local responders from Idaho

- ISU Research Office as part of the Higher Education Research Council's Research Infrastructure provided $225,000 in funding toward materials and supplies, and building infrastructure in the Department of Civil and Environmental Engineering. A part of this funding (approximately $30,000) was spent toward the construction of the DRC outdoor training campus and installation of a perimeter fence around the site.
- Sample Training Events:
    - In October 2020, twenty students and six instructors in the Idaho State University College of Technology's Emergency Medical Technician program utilized the outdoor DRC for a real-world training. This training was highlighted in the media (Idaho State Journal and ISU website), refer to Appendix 1. Several other training events for the ISU's EMTs were held since October 2020.
    - In November 2020, twenty-five members of the Pocatello Fire Department's Urban Search and Rescue team used the outdoor DRC facility to conduct a special operation exercise that included structural collapse training (Figure 8). The newly constructed subterranean lane was utilized for the training. The event received coverage on Local News 8 as well as Idaho State Journal, refer to Appendix 1. [Devin Christensen, a captain with the fire department who heads the special team, had to travel to Texas A&M University in College Station, Texas, with another member of the department the last time he participated in structural collapse training. "We can train 25 guys here today for the money it takes to send two to a class in Texas," Christensen said].

Figure 8. Training by the Pocatello Fire Department's Urban Search and Rescue team

- On January 16, 2021, a training in the indoor DRC was hosted for the Snake River Search and Rescue Inc. The training included 10 K9 trainers, 12 K9's, 4 student/faculty participants for live finds (Figure 9).

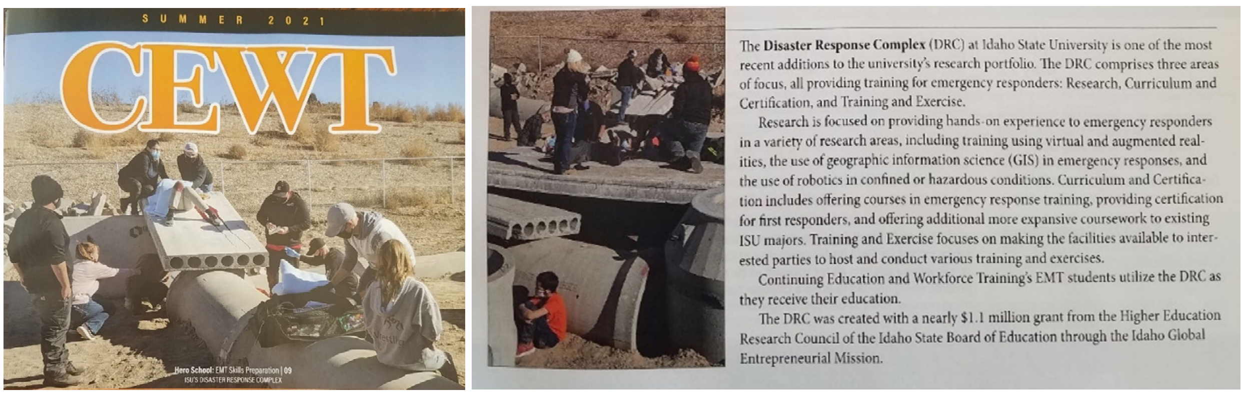
Figure 9. K9s and their handlers training at the indoor DRC

- On February 11, 2021, the Radiological Control Fundamentals Exercise was hosted at the outdoor DRC. This was organized by ISU's College of Technology. ISU Students practiced measuring background radiation levels at the outdoor DRC site; 18 students and 2 instructors participated in the exercise.
- On March 11, 2021, the DRC hosted a "Confined Space" Exercise for the Idaho Falls Fire Department (IFFD) at its outdoor facility. 20 trainees and 4 instructors participated. IFFD practiced confined space maneuvers while practicing use of oxygen and monitoring oxygen levels. The participants also performed tripod extractions and lifts (Figure 10).

Figure 10. Confined Space exercise by the Idaho Falls Fire Department

- On April 3, 2021, ISU's Emergency Medical Technician (EMT) Workshop was held simulating mass casualty response at outdoor DRC site. The training also included landing of an air medical services helicopter at the DRC outdoor site. The event was part of the ISU's Continuing Education and Workforce Training (CEWT). Thirty-six participants including role-players, students, and instructors were part of the workshop (Figure 11). The DRC is collaborating with the CEWT and was featured on the cover page of CEWT's Summer 2021 magazine (Figure 12).

Figure 11. ISU EMT students training at the DRC



The **Disaster Response Complex** (DRC) at Idaho State University is one of the most recent additions to the university's research portfolio. The DRC comprises three areas of focus, all providing training for emergency responders: Research, Curriculum and Certification, and Training and Exercise.

Research is focused on providing hands-on experience to emergency responders in a variety of research areas, including training using virtual and augmented realities, the use of geographic information science (GIS) in emergency responses, and the use of robotics in confined or hazardous conditions. Curriculum and Certification includes offering courses in emergency response training, providing certification for first responders, and offering additional more expansive coursework to existing ISU majors. Training and Exercise focuses on making the facilities available to interested parties to host and conduct various training and exercises.

Continuing Education and Workforce Training's EMT students utilize the DRC as they receive their education.

The DRC was created with a nearly $1.1 million grant from the Higher Education Research Council of the Idaho State Board of Education through the Idaho Global Entrepreneurial Mission.

Figure 12. ISU's CEWT magazine featured the DRC on its front page

- Between April – June 30, 2021, six training events were held for the Civil Support Teams from the National Guard. Some of the training events offered the opportunity for the local responders from the ISU Public Safety, ISU State Police, and other entities to participate in the exercise with the military free of charge. An article highlighting the National Guard training at ISU was published in the media, refer to Appendix 1.

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 developing the templates for a trench rescue and radiological training using AR/VR for civilian and military responders, respectively.
- Exploring funding opportunities in different areas such as AR/VR, instrumentation, and new technologies for disaster response.
- Publishing peer-reviewed papers from the research work.

B. Curriculum and Certification Pillar

- Developing curriculum for the indoor and outdoor DRC in collaboration with INL, KDHS in ISU, and other partners.
- Obtaining input from stakeholders.

C. Training and Exercise Pillar

- Completing construction of the basic training lanes for the outdoor DRC.
- Adding more details to the mock-city for the indoor DRC.
- An estimated 150 members of the National Guard from across the country are expected to train at the DRC by Fall 2021. ISU is collaborating with INL on training of the National Guard units.
- Multiple events have been scheduled at the DRC for local and regional responders. Dozens of civilian responders are expected to use the DRC for their training in the remaining half of 2021.
- ISU will be co-hosting a HazMat Training for the Idaho Office of Emergency Management in the summer of 2021.

D. Promotion, Marketing, Development Work

- The project personnel are working with colleagues at ISU on the following initiatives:
  - Develop marketing details (e.g. brochures)
  - Host outreach efforts
  - Present and attend regional conferences in disaster response
  - Arrange tours for state legislators, members of the U.S. Congress, leadership from the National Guard units, and other stakeholders to the DRC
  - Develop a business plan for the DRC to be sustainable after the end of the IGEM-HERC project in June of 2022

5.0 Expenditure Report

The project expenditure until June 23, 2021 is presented in Table 1. The project spent all its allocated budget of $271,400 for the second year. There was a rollover of $32,947 from FY20 (total of $304,347 for the 2nd year of the project) which has been spent as well. Appendix 3 includes a breakdown of the budget and expenditure report.

Table 1. Summary of Budget Expenditures

Salaries & Fringes already posted June 23, 2021 (faculty, graduate students, research engineer)	$159,424
Travel	$925
Capital Expense	$64,292
Services and Supplies	$52,547
Tuition Remission (graduate student)	$9,926
Salary & Fringes to be posted through June 30, 2021 (faculty, graduate students, research engineer)	$17,233
Total	**$304,347**

6.0 Partnerships

The project personnel have had discussions with the interested individuals and entities listed in Table 2 on this project with one or more pillars of the DRC project. The impact of the partnership with some of the entities named in Table 2 has created opportunities for students and faculty at ISU as well as the collaborators.

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 supervising several students.

Table 2. Entities that have toured/visited/briefed/or collaborated on the DRC project

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 and Rescue, Inc.
14	Argon Electronics
15	Preparedness Innovations
16	Eastern Idaho Fire Chiefs Association
17	Eastern Idaho Safety Consultants
18	Bannock County Emergency Services
20	Caribou County Public Safety and LEPC
21	Idaho State University • College of Technology

  - Nuclear Operations Technology
  - Continuing Education/Workforce Training)
- Kasiska Division of Health Sciences
  - Institute of Emergency Management
  - Department of Community and Public Health
- College of Science and Engineering
  - Department of Mechanical Engineering
  - Department of Computer Science
  - Health Physics
  - Physics
  - Department of Chemistry
  - Electrical and Computer Engineering
  - Environmental Monitoring Laboratory
- Department of Public Safety
- Emergency Management
- GIS Center
- Idaho Accelerator Center

7.0 Economic Impact

Excluding the research and curriculum pillars, and considering only the training & exercise pillar for the DRC, as of June 30, 2021, more than 350 individuals from across the United States have used the DRC for the world-class and unique training. If a regional multiplier[1] model is used to measure the economic impact, and a conservative estimate of $500 per participant who trained at the DRC is used, the regional multipliers for the Southeastern Idaho based on Idaho's Department of Labor's most recent data from June 2021 for "Professional and Management Development Training" would be as follows:

Sales Multiplier = 1.48

Jobs Multiplier = 1.12

Earnings Multiplier = 1.31

Regional Economy Impact (Sales) = 350 x $500 x 1.48 = $259,000

Regional Economy Impact (Jobs) = 350 x $500 x 1.12 = $196,000

Regional Economy Impact (Earnings) = 350 x $500 x 1.31 = $229,250

8.0 Faculty and Student Participation

Through June 30, 2021, 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.

[1]A multiplier model uses an approach to measure how important one industry is to other industries in the region. For instance, a multiplier of 1.5 means that for every dollar spent on that industry, the regional economy will be affected by 1.5 times of the original investment.

Table 3. Participating Researchers

Position	Numbers
Faculty	7 (including the PIs)
Graduate Students	7
Undergraduate Students	10
Researchers	6
Total	**30**

9.0 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 second year of the project.

Table 4. Summary of the Criteria for Measuring Success for Year 2

Criteria	Pillars of the Disaster Response Complex		
	Research	Curriculum & Certification	Training & Exercise
Original Proposal (Jul 2020 – Jun 2021)	1. Detailed design/construction of the Phase II rubble pile, addition of new training lanes. 2. Publication of 3-4 papers. 3. Hiring two additional graduate students.	1. Development of two additional classes in emergency training in collaboration with INL/CAES. 2. Obtaining certification. 3. Offering training courses to 100 students/first responders.	1. Training of 400 DoD CRE customers/Idaho National Guard personnel. 2. Expanded customer base offering CBRN training.
Actual Performance (Jul 2020 – Jun 2021)	1. Detail design and construction of the rubble pile was completed. A city-mock for the indoor DRC has been developed and construction is complete. 2. Logos were created, a website was launched. 3. A journal paper was submitted; another journal paper is currently under revision; a concept paper was prepared by INL researchers. 4. Five graduates and multiple undergraduates were hired to work on the DRC project under the supervision of ISU/INL researchers. 5. One PhD student is currently working on his dissertation on the use of	1. Course description and topics were developed for a class in gamma spectroscopy. Unfortunately, this class will not go through after receiving instructions from the government. 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 part of the curriculum under the DRC. 3. Thirty-eight classes have been shortlisted and discussed between ISU and a private company. Materials for the classes are ready. ISU is planning to work with the collaborators to advertise some of these classes under the DRC in 2021.	1. More than 350 individuals have used the DRC for their training events between October 31st, 2020 – June 30th, 2021. This number included emergency responders from the military (e.g. 170) and civilian (e.g. 180) sectors. 2. 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.

	robotics in disaster response. 6. A master's student is writing his MS Project on the DRC project. 7. Another master's student is working toward his thesis on the use of electronic simulations for HazMat in disaster training.	4. ISU is collaborating with KDHS on an earthquake-response curriculum and training that will be hosted at the DRC in the fall of 2021. 5. The project personnel are actively looking for certification and continuing education unit opportunities for the classes offered through the DRC.	

10.0 Future Plans

Multiple training and exercise events at the DRC are planned for 2021. In addition, work is on-going to develop the curriculum and certification, and the research pillars. 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 put limitations on hosting training events in Pocatello and at ISU between February 2020 – May 2021. Several planned training events for 2020 had to be canceled. DRC will need more than three years from the start of the project in August 2019 to become self-sustaining. Additional funding and opportunities are actively being explored to make the DRC a long-term resource for the training of emergency responders from Idaho and the region.

Future improvements and renovations of the Armory building such as: adding new training lanes in the indoor/outdoor facility, partnerships with the private and public industry, hiring new researchers and students to work on different pillars of the project, training more emergency responders, arranging tours for potential partners and stakeholders, and spreading the word about the DRC in Idaho and the Pacific Northwest. Funding opportunities are actively being pursued to further develop the facilities for project continuation and expansion.

11.0 Commercialization Revenue

Nothing to report for the period July 2020 – June 2021. The Project has potential for developing intellectual property.

Appendix 1. Media Articles

Idaho State EMT program partners with the Disaster Response Complex for 'real-world' training

Article Link (ISU): https://www.isu.edu/news/2020-fall/idaho-state-emt-program-partners-with-the-disaster-response-complex-for-real-world-training.html

Article Link (Idaho State Journal): https://www.idahostatejournal.com/community/isu-s-emt-program-partners-with-the-disaster-response-complex-for-training/article_335920c3-04c2-5f15-b8c8-26de999f3acd.html

By Miriam Dance, COSE Director of Public Relations | November 5, 2020

POCATELLO – Twenty students and six instructors in the Idaho State University College of Technology's Emergency Medical Technician program received real-world emergency response training at the new ISU Disaster Response Complex, which is run by the Department of Civil and Environmental Engineering.

Training scenarios were constructed to simulate emergency situations. The simulated scenario training is a typical component of the EMT program, which is part of the College of Technology's Continuing Education and Workforce Training programs. However, conducting the training at the Disaster Response Complex allowed for the development of new mass casualty and individual injury incidents of an industrial nature that were not possible before, including extractions from buildings that may have collapsed or dark tunnels that may have flooded. "We were thrilled to be able to conduct training at the new DRC facility," said RaeLyn Price, health programs coordinator for Continuing Education and Workforce Training. "The training exercise on Saturday went as well as anyone could ever expect. Students and instructors all enjoyed the experience."

During the Halloween Day training, trainees worked together to assess the situation and then determine how to enter the scene to safely assist and treat injured individuals. Once rescued, trainees prepared the injured for transport to appropriate medical facilities. Each training scenario required the students to work as a team to safely rescue the mock victims.

To set the stage for the emergency scenarios, victims were dressed in full moulage, which involves creating realistic-looking mock injuries on volunteer 'victims.' Using moulage created a new element for the trainees since they hadn't yet experienced anything as true to life while in the course. One challenge participants faced was getting past the realistic appearance of victims and using the skills they learned in the course to address the situation.

"It was awesome to watch the students seriously take on their roles and work together to provide appropriate treatments and rescue," Price said. "We look forward to utilizing the DRC for more training opportunities in the future."

The Idaho State Disaster Response Complex is a unique facility recently added to the university's research portfolio. It was created with a nearly $1.1 million grant from the Higher Education Research Council of the Idaho State Board of Education through the Idaho Global Entrepreneurial Mission.

"The DRC is a unique facility in the Northwestern United States," said Mustafa Mashal, associate professor in the Department of Civil and Environmental Engineering and Principal Investigator for the Disaster Response Complex project. "We have capabilities to simulate various scenarios for training emergency responders. There are numerous collaborators, faculty, and students working on the DRC project. The ultimate goal of the project is to save lives during an emergency scenario, through efficient and effective responses."

The DRC has three focus areas: research, curriculum and certification, and training and exercise. The training and exercise focus area encourages local and regional emergency responders to use the DRC for real-world simulations of natural and man-made disasters. Search-and-rescue scenarios can be structured in several ways using precast concrete elements to create situations that require navigating training lanes such as collapsed structures, confined spaces, and vehicle rescue.

"From the perspective of an educational institution, the project benefits our students through a wide variety of learning and research processes," Mashal said. "From a community perspective, this project benefits Idahoans and beyond by helping ensure the emergency responders have an exceptional facility to conduct training and exercise events."

The DRC outdoor facility is still under construction and more training lanes are planned to be added in the upcoming months. The EMT program is the first group to use the DRC's outdoor facility.

"We welcome emergency responders from our community, region, and nation to use the DRC for their training and exercise events," Mashal said. "The doors of the DRC are open for anyone who wants to explore collaboration with ISU on disaster response. The DRC is a long-term resource for our emergency responders and we are very glad to have this facility here in Pocatello."

To learn more about the DRC, please visit https://www.isu.edu/cee/research-facilities/drc/.

Local first responders train at ISU's new Disaster Response Complex

Article Link (Local News 8): https://localnews8.com/isu/2020/11/17/local-first-responders-train-at-isus-new-disaster-response-complex/

By Emma Iannacone

POCATELLO, Idaho (KIFI/KIDK) - Local first responders trained at Idaho State University's new Disaster Response Complex on Tuesday.

Members of the Pocatello Fire Department's search and rescue team spent hours in a simulated building collapse, trying to rescue a mannequin. In light of the many recent earthquakes in our area, PFD felt it was a good time to brush up on their rescue skills.

The training is one of the first of its kind at the Disaster Response Complex. The Complex was created with a nearly $1.1 million grant from the Higher Education Research Council of the Idaho State Board of Education.

ISU's Department of Civil and Environmental Engineering associate professor Mustafa Mashal was the principal investigator for the project.

"When we started this project, we noticed there is no facility of this kind in the Northwestern United States," Mashal said.

Mashal's team successfully applied for a grant in 2019, opening the door to create a curriculum in emergency response at ISU.

The structural collapse training is the second to take place at the Disaster Response Center near Alvin Ricken Road in Pocatello.

"We're just really excited to have the facility ISU has provided here. We normally would have to go out of town, as far as Texas, to get a facility like this," said Captain Devin Christensen, with PFD.

The Disaster Response Complex offers more than just training for our first responders. It also offers technological research opportunities for ISU students and faculty.

Engineering students were tasked with creating the simulated building collapse.

"It’s kind of a real-life exercise,” said Bruce Savage, department chair of Civil and Environmental Engineering. "They get to evaluate the different forces and different scenarios the training teams want to partake in, and then evaluate what’s going to make this safe but still allow them a realistic opportunity to test their skills."

The Disaster Response Complex is available to first responders all over the region. New scenarios will be created by engineering students.

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'Saving lives': Pocatello firefighters practice rescuing victims from collapsed structures at new ISU facility

Article Link (Idaho State Journal): https://www.idahostatejournal.com/news/local/saving-lives-pocatello-firefighters-practice-rescuing-victims-from-collapsed-structures-at-new-isu-facility/article_c5924635-e7cd-5f79-9703-21df08dff407.html

By JOHN O'CONNELL/IDAHO STATE JOURNAL

POCATELLO — One group of Pocatello firefighters cut through structural steel with a blowtorch Tuesday morning while others sawed into a slab of concrete, making certain no debris would fall on the dummy trapped below.

Members of the Pocatello Fire Department's Urban Search and Rescue team practice rescuing trapped victims from collapsed concrete structures at a new research and training facility opened by Idaho State University

Members of the department's Urban Search and Rescue team got to simulate tactics to rescue survivors from a collapsed concrete structure at Idaho State University's new Disaster Response Complex.

The facility, located east of campus in a spacious, fenced area above the Idaho Accelerator Center, is unique in the Pacific Northwest. It's primary purpose is university research, but it should also provide an invaluable training and certification resource for several ISU departments, local and regional emergency responders and even soldiers with the Idaho National Guard.

Devin Christensen, a captain with the fire department who heads the special team, had to travel to Texas A&M University in College Station, Texas, with another member of the department the last time he participated in structural collapse training. He anticipates the team will now train locally at least twice per year, at a considerable savings to local taxpayers.

“We can train 25 guys here today for the money it takes to send two to a class in Texas,” Christensen said.

The training grounds include several concrete culverts arranged in a winding tunnel, piles of debris and steel supports and concrete slabs that can be cut during rescue training and replaced afterwards.

Christensen explained the training could prepare his team to rescue victims trapped under a collapsed highway bridge, or covered beneath rubble after a bombing or an earthquake.

“I think the main thing is it’s a great opportunity to work with ISU and to bring departments from the region together,” Christensen said.

ISU engineering students designed the facility. It was funded with a $1.1 million grant from the Higher Education Research Council of the Idaho State Board of Education through the Idaho Global Entrepreneurial Mission.

Mustafa Mashal is an associate professor in the Department of Environmental Engineering and the principal investigator for the Disaster Response Complex project. He said additional lanes at the facility will include an area to simulate vehicle rescues and a structure that simulates roof collapses.

ISU engineering students are designing the facilities. Mashal said they’re also using the facility to test robotic and virtual reality technology they’re developing for use in rescues. Some students, for example, are writing a Ph.D. dissertation on adding capabilities to a rescue robot enabling it to navigate through confined spaces. The new collapsed structure facility will enable them to conduct a full-scale validation of those capabilities, he said.

Mashal said the facility will also be useful in develop curriculum and obtaining certifications.

Mashal witnessed the need for such research and training during the aftermath of the 2011 earthquake while in Christchurch, New Zealand.

“Saving lives is the ultimate goal of this project,” Mashal said.

Jared Cantrell, project manager of the Disaster Response Complex, said ISU’s College of Technology recently used the facility to conduct mass casualty training for future emergency medical technicians. He said the university’s GIS program is also interested in using the facility.

Cantrell expects the facility will be self-sustaining with funding from users throughout the community who take advantage of training opportunities.

He hopes to conduct one to two small trainings per week and a couple of larger trainings per month at the facility, with the goal of keeping the cost to users as affordable as possible.

“We’re trying to make this as open and available as possible to serve the community,” Cantrell said.

Idaho State University Disaster Response Complex Hosts Training Events for Emergency Responders

Article Link (ISU website): https://isu.edu/news/2021-spring/idaho-state-university-disaster-response-complex-hosts-training-events-for-emergency-responders.html

April 20, 2021

Taking COVID-19 pandemic challenges in stride, the Idaho State University Disaster Response Center (DRC) is preparing to host multiple training events in the coming months to assist with the readiness and skill development of emergency responders.

The DRC is currently working with local, regional, and state entities to host training events at its facilities on ISU campus in Pocatello.

Training scenarios for emergency responders include subterranean, breaching, and HAZMAT response. One of the emergency responder communities that the DRC will be hosting includes the Civil Support Teams (CSTs). CSTs are part of the United States National Guard which supports civil authorities during domestic natural or human-made disasters that may result in catastrophic loss of life or property. There are 57 federally sustained but state-controlled CSTs throughout the United States and its territories that are on standby for emergencies 24 hours a day, year-round. The Idaho National Guard's CST is based in Boise and consists of 22 soldiers and airmen.

Local first responders, like firefighters and law enforcement agencies, are also able to utilize the DRC training facilities to practice efficient and effective responses to natural and human-made disaster situations.

“This training facility will not only better lives, but it will save lives,” President Kevin Satterlee said. “The complex simulates real-world training exercises for first responders. It is unique for our region, and the knowledge gained will be used to address disaster and emergency situations that may impact our state, our region, and our entire nation.”

The DRC is a unique training facility in the Northwestern United States. Training events hosted at the DRC simulate real-world emergency and search-and-rescue scenarios and have the potential to improve and maintain life-saving skills used by responders during disaster remediation. Training scenarios can be customized and structured in several ways. For instance, precast concrete elements are used to create situations that require navigating training lanes that simulate collapsed structures, confined spaces and vehicle rescues.

The principal investigator on the DRC project is ISU’s Associate Professor Mustafa Mashal, the co-principal investigator is Professor and Chair Bruce Savage, both from the Department of Civil and Environmental Engineering.

“The DRC’s ultimate goal is saving lives when a catastrophe hits. As a citizen of the United States, I am truly honored that our DRC project supports the community of emergency responders in various ways,” Mashal said.

While construction on the core DRC facilities is complete, projects to expand facility capabilities are planned to continue this year. As the DRC broadens its offerings, customizable training can focus on issues beyond cleaning up the aftermath of disasters to the protection of national security.

The DRC opened for training events in 2020 and has already hosted more than 100 first responders. The DRC kicked off 2021 by hosting a K-9 training event for the Snake River Search, Inc. in January. Ten K-9 trainers, 12 K-9’s, and four ISU students and faculty participated in the exercise.

“It is also exciting to see how far we have come with the DRC project,” Mashal said. “In August of 2019, we started this project from nothing. Today we have a nearly 3-acre outdoor facility that has already started hosting training events for the emergency responders, and has created opportunities for numerous engineering students at ISU to work in different areas of the project, including research, design, construction, curriculum, and training events. The credit for the DRC goes to our hard-working engineering students at ISU who despite all the odds imposed by the global pandemic have done a fantastic job.”

Recently the DRC hosted a training for the Idaho Falls Fire Department where 20 trainees and four instructors participated in a confined space exercise.

The DRC has also been an advantageous resource for ISU students, faculty, and staff who have utilized the DRC for practical training on several occasions. One such example is ISU’s College of Technology’s Emergency Medical Technician program that has been utilizing DRC to provide hands-on and realistic training to the participants.

The DRC has three focus areas: research, curriculum and certification, and training and exercise. The training and exercise focus area encourages local and regional emergency responders to use the DRC for real-world simulations of natural and man-made disasters. The development of the DRC was made possible by funding from the Idaho State Board of Education under the Higher Education Research Council – Idaho Global Entrepreneurial Mission (HERC-IGEM). 18 engineering students from ISU have been working on different pillars of the DRC. The facility is managed by ISU's Department of Civil and Environmental Engineering.

To learn more about the DRC, please visit https://www.isu.edu/cee/research-facilities/drc/.

Appendix 2: Sample Student Activities

Dates	Daniel Garz	Katie Hogarth	Uma Shankar Medasetti
July, 2020		DRC precast inventory Conex lane 1 drawings White page development Jouranl completion	Finalize purchases for Viz lab Setup lab in ERC Tested/setup lab equipment
August, 2020	Open House Cityscape roof design Journal summaries	Open House Began conex lane fabrication Began 3D conex drawing Finalize journal	Open House Funding proposals
September, 2020	Presidents visit GIS drone flight	Presidents visit Conex lane fabrication	Presidents visit Develop concept paper
October, 2020	Armory layout Finalize cityscape layout	Finished conex lane fabrication reloacted conex and other materials to DRC	Develop concept paper
November, 2020	Construction staking for conex tower Cityscape framing	Continue conex drawings	Finalize concept paper
December, 2020	Cityscape framing Walls, sheeting, drywall	Place conex footings Transfer materials	
	Writing MS project on the DRC		
January, 2021		Research for Taping and Mudding Taping and Mudding of indoor DRC Volunteer for Dog training	Journal work with Shisir
February, 2021			3MT Event Prep Argon Meeting Alineware Backpack/Hololens work
March, 2021		Aid in set up for Idaho Falls Fire Department	AR/VR Development Branch Review Paper

April, 2021		Set-up and assisted with INL Event Selection of images and framing for armory	Digital Forum Terrorism meeting
May, 2021		Hang Framed photos for armory Begin Signage and Furnishing of Indoor DRC	Review Paper Oculus Quest work
June, 2021	Preparing for MS project defense		

Dates	Mahesh Acharya	Mahesh Mahat
July, 2020	Outdoor DRC rubble pile construction	Outdoor DRC rubble pile construction
August, 2020	Open House	Open House Inventory of incoming materials for DRC Footings construciton
September, 2020	Presidents visit	Presidents visit Continue inventory Footings construction Clean and empty armory
October, 2020		Finish footing construction Clean armory
November, 2020	Set lane for PFD training	Set lane for PFD training Cityscape framing
December, 2020	Cityscape framing Walls, sheeting, drywall	Cityscape framing Walls, sheeting, drywall
January, 2021	Planning for Trench Design for Outdoor Facility Weeley Meetings	Mudding the drywall gaps Painting the indoor facilities
February, 2021	College of Tech. tour of DRC Indoor and Outdoor Facility Trench Design Literature	Painting the indoor facilities
March, 2021	Dr. Karen tour of DRC Indoor and Outdoor Facility Trench Design Calculations	Painting the indoor facilities

		Removing the old furnitures from armory offices
April, 2021	Continue work on detailing and design of trench	Setting up new furnitures
	Help on training of the first responders at the facility	Wood panel installation in the interior facilities
		Training at Stephan's
		Blinds installation
May, 2021	Drawings and details of the trench	Lights installation
	Work to obtain quotes from precast yards	Window frame/ pixie glass/ wall baseboard installation
		Bench installation for classroom/ Batching for hollowcore
June, 2021		Painting the classroom

Dates	Samantha Kerr	Rachel Brownell
July, 2020	Indoor drawing development Outdoor DRC rubble pile construction	White page development Garage structure drawings Material lists
August, 2020	Open House Continue indoor development	Open House Journal summaries for writing Assit with conex lane fabrication
September, 2020	Presidents visit Begin trench deveopment Determine materials for indoor cityscape Determine final cityscape layout Create cut sheets for construction	Presidents visit Conex lane fabrication DRC materials inventory Review journal Began handling DRC website DRC tower drawing
October, 2020	Develop budget and pricing of materials Search for cheap options for cityscape Finalize drawings and cutsheets for cityscape	Finish conex lane fabrication CMS website training Continue website work
November, 2020	Lead indoor cityscape framing Continue searching for materials	Website maintenance
December, 2020	Cityscape framing Continue searching for materials	Website maintenance
	Left Project	Left Project
January, 2021		
February, 2021		
March, 2021		

Dates	Zachary Free
July, 2020	Setup lab and equipment Test equipment
August, 2020	Open House Funding proposals
September, 2020	Presidents visit Develop concept paper
October, 2020	Develop concept paper
November, 2020	Finalize concept paper
December, 2020	
January, 2021	
February, 2021	VR Discussion with INL Began work on Radiological Response training in VR with Uma Shankar and Jack Dunkar VR environment set-up (Stephens Performing Arts Center as setting) Weekly meeting for PAC Training
March, 2021	

April, 2021	Participated in the Rad-response training at Holt Arena Character controls in VR environment
May, 2021	
June, 2021	

Dates	Jack Dunker
July, 2020	
August, 2020	
September, 2020	
October, 2020	
November, 2020	
December, 2020	
January, 2021	Joined Project
February, 2021	Setup demo project. Joined Project VR project Meeting
	Researched translation of c++ function for Unreal to C# for Unity. DRC meeting VR project Meeting
	Setup repository for project. DRC meeting VR project Meeting
	Setup initual instance of Stevens Performing Arts Center in engine. DRC meeting VR project Meeting
March, 2021	Setup landscape actor in Unity VR project Meeting
	Added concrete and asphalt materials to landscape. Cleaned up excess assets. DRC meeting VR project Meeting
	Increased landscape resolution. Started on player avatar. DRC meeting VR project Meeting

	Setup basic movement controls for avatar. DRC meeting VR project Meeting
April, 2021	VR project Meeting DRC Meeting
	Started translating c++ code from demo project to c# for radiation simulation. VR project Meeting
	Setup user interface readout to display dose rate. DRC Meeting VR project Meeting
	Disaster Response roleplay. Connected user interface to radiation simulation VR project Meeting
May, 2021	VR project Meeting DRC Meeting
	Started translating c++ code from demo project to c# for radiation simulation. VR project Meeting
	Setup user interface readout to display dose rate. DRC Meeting VR project Meeting
	Disaster Response roleplay. Connected user interface to radiation simulation VR project Meeting
June, 2021	Fixing and updating environment to be more accurate to Stevens PAC area. VR project Meeting

Appendix 3: Expenditure Report

Data_Description				Accounted Budget	Year-to-Date													Encumbrances	Reservations	Total by ROWS
Fiscal_Month (As of June 29, 2021)				Temporary Budget	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Subtotal	YTD	YTD	
				Amount	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	Value
AHRC48_APPR IGEM Response Complex for Eme	Labor			0.00																
		610_Salaries		0.00	(2,153.85)	(5,384.62)	(5,384.62)	(8,076.93)	(5,384.62)	(5,115.39)	(5,071.64)	(6,265.73)	(6,318.71)	(9,483.12)	(5,763.36)	(5,303.86)	(69,706.45)	0.00	0.00	(69,706.45)
		620_Irregular Help		0.00	(429.84)	(7,583.31)	(6,749.49)	(3,908.13)	(2,481.63)	(2,323.11)	(4,095.50)	(2,551.96)	(2,473.86)	(3,715.03)	(9,831.92)	(17,560.66)	(63,704.44)	(0.00)	0.00	(63,704.44)
		630_Fringe Benefits		0.00	(125.68)	(2,126.31)	(2,322.52)	(2,935.62)	(1,928.71)	(1,859.76)	(1,940.25)	(2,254.47)	(2,272.23)	(3,410.15)	(2,258.77)	(2,577.88)	(26,012.35)	(0.00)	0.00	(26,012.35)
	Direct Expenditures																			
		700_Travel		0.00	0.00	0.00	(924.69)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(924.69)	0.00	0.00	(924.69)
		720_Services		304,347.00																304,347.00
			722_General Services		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(14.50)	(35.50)	(50.00)	0.00	0.00	(50.00)
			724_Professional Services	0.00	0.00	(540.50)	(165.28)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(1,153.46)	(163.84)	(2,023.08)	0.00	0.00	(2,023.08)
			727_Administrative Services	0.00	0.00	0.00	(1,509.00)	(1,864.70)	(250.00)	0.00	(23.45)	0.00	(129.00)	(164.60)	0.00	0.00	(3,940.75)	0.00	0.00	(3,940.75)
			728_Computer/Tech Services	0.00	0.00	(88.88)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(88.88)	0.00	0.00	(88.88)
			729_Repair and Maintenance Services	0.00	0.00	(839.68)	0.00	0.00	(109.99)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(949.67)	0.00	0.00	(949.67)
			741_Rentals and Operating Leases	0.00	0.00	0.00	0.00	(466.20)	0.00	(132.50)	0.00	0.00	(93.50)	0.00	(535.20)	(4,668.50)	(5,895.90)	0.00	0.00	(5,895.90)
		730_Supplies																		
			731_Administrative Supplies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(480.46)	(2,198.95)	(2,431.73)	(5,271.69)	(10,382.83)	0.00	0.00	(10,382.83)
			732_Fuel and Lubricants	0.00	0.00	(46.16)	0.00	(23.24)	(57.20)	(54.88)	(51.74)	(58.77)	(55.02)	(84.42)	0.00	(145.16)	(576.59)	0.00	0.00	(576.59)
			733_Computer Supplies	0.00	0.00	(125.96)	(64.98)	(131.87)	(55.07)	0.00	0.00	(69.98)	0.00	0.00	(341.96)	0.00	(789.82)	0.00	0.00	(789.82)
			734_Repair and Maintenance Supplies	0.00	(560.95)	0.00	(2.95)	(24.38)	(2,034.84)	32.00	0.00	(172.00)	(43.07)	(289.88)	(31.94)	(56.82)	(3,184.83)	0.00	0.00	(3,184.83)
			736_Institutional/Specific Use	0.00	(537.94)	(1,461.61)	(517.60)	(1,135.64)	(1,374.77)	(5,438.77)	(575.51)	(2,216.16)	(7,075.29)	(1,271.93)	(6,861.32)	(884.61)	(29,351.15)	0.00	0.00	(29,351.15)
		800_Capital Expense																		
			820_Buildings and Improvements	0.00	0.00	0.00	(10,000.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(5,267.42)	0.00	(15,267.42)	0.00	0.00	(15,267.42)
			830_Computer Equipment	0.00	0.00	(7,545.25)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(7,545.25)	0.00	0.00	(7,545.25)
			835_Educational Materials and Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(1,996.00)	0.00	0.00	0.00	(1,996.00)	0.00	0.00	(1,996.00)
			840_Motorized Equipment	0.00	0.00	0.00	0.00	0.00	(3,659.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(3,659.00)	0.00	0.00	(3,659.00)
			840C_> $5K Motorized Equipment	0.00	0.00	0.00	0.00	0.00	(15,045.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(15,045.00)	0.00	0.00	(15,045.00)
			845_Office Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(7,461.12)	(989.97)	(7,037.14)	(15,488.23)	0.00	(0.00)	(15,488.23)
			850_Specific Use Equipment	0.00	0.00	0.00	0.00	0.00	(1,762.75)	0.00	0.00	(2,012.94)	(1,515.77)	0.00	0.00	0.00	(5,291.46)	0.00	0.00	(5,291.46)
		870_Educational and Training Assistance																		
			871_Educational and Training Assistance	0.00	0.00	(4,962.98)	0.00	0.00	0.00	0.00	(4,962.98)	0.00	0.00	0.00	0.00	0.00	(9,925.96)	0.00	0.00	(9,925.96)
	Subtotal																			
Total by COLUMNS				304,347.00	(3,808.26)	(30,705.26)	(27,641.13)	(18,566.71)	(34,143.58)	(14,892.41)	(16,721.07)	(15,602.01)	(22,452.91)	(28,079.20)	(35,481.55)	(43,705.66)	(291,799.75)	(0.00)	(0.00)	12,547.25

Note: All project budget for the second year ($304,347) will be spent by June 30, 2021. There are some expenses that have not been posted in this spreadsheet.

IGEM20-002

ISBOE HERC-IGEM
Cellulosic 3D Printing of Modular Building Assemblies

SECOND YEAR REPORT
FISCAL PERIOD – JULY 1, 2020 - JUNE 30, 2021

SUMMARY OF PROGRESS
June 30, 2021

Prepared for:
HERC-IGEM – Idaho State Board of Education
Dr. TJ Bliss

Authors:
Ken Baker, M. Arch – PI
Dr. Armando McDonald – Co-PI
Dr. Michael Maughn – Investigator
Dr. Tao Xing – Investigator
Dr. Ralph Budwig – Investigator
Dr. Damon Woods - Investigator

Report Number: 4 – June 30, 2021

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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.

Tasks for Year 2:

1) Identify private industry investors and solicit financial commitment from industry partners
2) Build a small-scale printer and print a two foot by two-foot by eight-inch wall section
3) Program a computer model for running printer.
4) Perform heat transfer and structural tests on a wall section.

Summary for Year 2:

Significant discovery was made on each of the four tasks identified as Year 2 deliverables. We do not as yet have private industry support for the project as we are, 1) working toward a provisional patent that would allow our disclosure of the resins and process for creating our product and, 2) we are in process of building a new business model under a program developed through the Boise State University Venture College and funded through NSF. Our acceptance in the I-Corps Ignite program is providing a structured business development process that we plan to fully implement over year three of the grant.

U of I Engineering has designed and built a first prototype printer and we have successfully printed single-layer prints. Our refined goal for year three is to print in layers.

Our resin and curing process has successfully produced a hardboard product that looks to be competitive with other hardboards on the market. Unlike current market products, our hardboard has no toxic resins, looks to be highly moisture and fire resistant (testing begins in October 2021), sequesters carbon at a high rate (currently being documented) and, prints and is able to cure without added heat energy.

We have built a guarded hot plate for thermal testing our material and panel sections when complete.

This has been an excellent discovery process for faculty and students. Engineering graduate student, Conal Thie has completed his master's thesis, focusing on the flow characteristics of wood fibers and our resin and extrusion process. Environmental Science doctoral student, Berlinda Orji is documenting the flow and curing process of the mix as part of her dissertation.

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

Second Year Report

Year 2, reporting Dr. McDonald staffing: 1 Ph.D. student in Environmental Science. 1 woman. Salary expenditures and student tuition in the McDonald lab have focused on supporting the research efforts of one Ph.D. 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 2.

The second-year research focused on the use of a selected adhesive amongst the options available for wood composite production due to its ease of use and less squeeze out during extrusion. Continuous capillary extrusion using this wood and adhesive blend were performed using the INSTRON capillary rheometer at high shear rates to determine compressive pressure and viscosity values. Frequency sweeps of the wet blends was done using the purchased DHR2 rheometer between two 25 mm parallel plates, to attain viscosity values at lower shear rates as seen in Figure 1. Dynamic rheology temperature ramps (30°C - 200°C) on wet samples helped in understanding the curing reactions of different wood-adhesive blends.

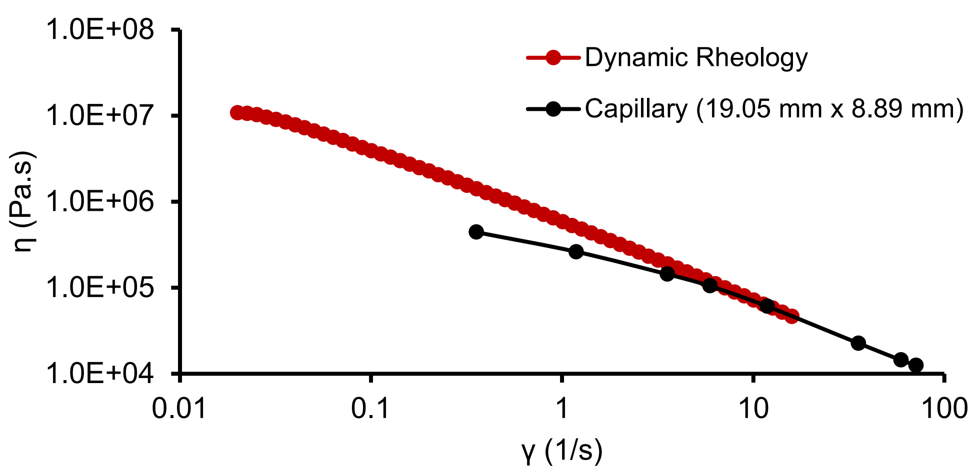


Figure 1: Dynamic viscosity and capillary viscosity from low to high shear rates

A larger capillary setup in Figure 2a, with large dies was machined for bigger sample load with thicker extrudate diameter. With the understanding of the vertical capillary rheology setup, a horizontal extruder setup was coupled together for extrusion and printing purposes. An industrial food processor was also purchased for mixing larger volumes of wood-adhesive samples (Figure 2b). Wet wood-adhesive blends were also pressed in 1-inch and 3-inch molds for characterization. Obtained extruded and pressed samples were cured at different temperatures (60°C - 105°C) and further characterized.

Figure 2: a) Large Capillary rheology setup and, b) Industrial food processor.

The use of carbon dioxide (CO_2) for curing was employed to understand its effect in improving the mechanical and thermal properties of the cured samples produced, whilst reducing environmental issues and improving sustainability. The adhesive used was exposed to 99% of pure CO_2 at different time intervals (0.5 to 20 min) to observe gelation crosslinking reactions before further curing of wood-adhesive blends. Adhesive showed effective gelation and cross linking. Post curing was attained in the oven at different temperatures (60°C - 105°C). Curing of the wet wood adhesive blends with CO_2 was done using a pressure vessel (Figure 3) and in a controlled temperature environment. For the controlled temperature environment, samples pressurized under CO_2 were placed in a water bath at 60 °C for specific times. Wet wood-adhesive blends were cured thermally in the absence and presence of CO_2 with further characterization. Physical and chemical changes were observed with the presence of CO_2 in the cured wood-adhesive blend.

a). Before curing

b) After curing at 105°C

c) After CO_2 (60 psi and 60 °C) and thermal curing

Figure 3: Pressure vessel used for CO_2 curing

Wet and cured extruded slabs from horizontal extruder setup are presently characterized to obtain their properties. Surface chemistry changes were observed with the addition of the adhesive to wood, presence of CO_2, and after curing using the FTIR analysis. Thermal degradation properties of the cured samples which was done using TGA, improved in the presence of CO_2. bending tests, dynamic mechanical analysis (DMA) for mechanical tests, dynamic rheology for flow properties and water soak tests.

Current and future studies involve the improvement of CO_2 curing techniques, use of different additives, catalysts, pressure and temperature modifications for curing, for improvements in properties of the 3D printed cured composite blends.

Build a prototype printer.

Prepared by: Michael R. Maughan, Ph.D, PE and Tao Xing, Ph.D PE

Year-End Update Report, IGEM, June 2021 – University of Idaho Mechanical Engineering

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 researchers in the UI College of Natural Resources (CNR). The goal is to make bespoke small-scale composite structural building panels. UI ME is also responsible for thermal modeling and optimization of the 3D printed composite building panels.

In 2021 the Mechanical Engineering team has continued to make progress on the development and implementation of the system. We have refined the previously identified extrusion technique to eliminate defects on the surface known as shark-skin. This defect is caused by friction and shear gradient within the flowing mixture. In addition to improving extrudate quality, we have identified a suitable hose and attachment method to convey the wood product from the extruder barrel to the nozzle. A nozzle system has been developed with geometry acceptable to print prototype panels. Fig. 4 shows a prototyping progression of the nozzle.

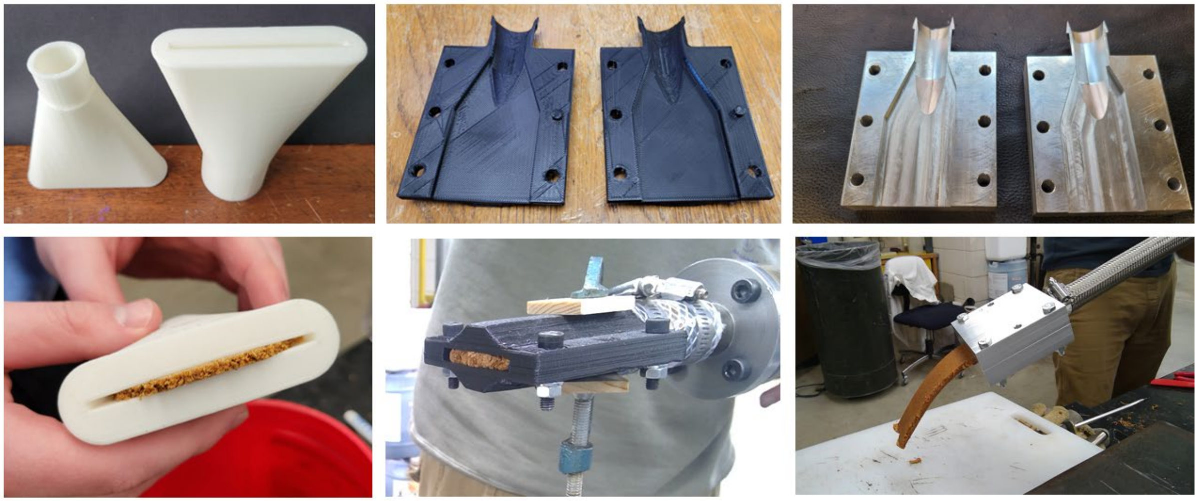


Figure 4. Progression of printer nozzle design.

Continuous flow extruder – We have added a 1hp motor to the extruder. This is necessary to overcome the high pressures required to move and form the composite mixture. Adapting the motor require machining a custom adapter and alignment blocks to support the motor. The machine is now capable of higher output and operates effectively. We have used this machine and a round nozzle to make cylindrical samples which were used to test strength and modulus. We have identified a curing method that achieves properties equal to or exceeding those of particle board. Preliminary moisture and fire testing have been conducted.

Direct extrusion frame and simulation – Using the direct extrusion frame and prior computational model, the simulation has been refined and is being incorporated into a student's Master of Science Thesis. The team has identified a state-of-the-art Discrete Element Modeling (DEM) based simulation software that is fully integrated with ANSYS multiphysics, which will be used to improve the simulation accuracy.

Modular 3D-printer frame – Since December 2020, we have completed the primary wiring and motion gantry. The computer numerical control components of the printer have been installed and the printer has functional motion control. Figure 5 shows the printer with the extruder. In testing with the extrudate, we have learned that adhesive and pressure are required to make the layers bond, so our next task is to incorporate an adhesive spraying system and pressure panel that can be used to maintain adhesion during the first stages of curing. The system utilizes stepper motors for position control. The target layer geometry is wide and thin, which enables a large surface area to promote interlayer adhesion.

Figure 5. 3D printer with extruder system.

Graduate research assistants – UI ME has been staffed with two graduate research assistants (GRA) since December 2020. GRA1 has focused on the deposition process and performance modeling of the material. The GRA2 has wired and finished the printer frame and developed the extrusion nozzle.

Develop guarded hot plate for thermal testing

Prepared by: Damon Woods, Ph.D, P.E., Ralph Budwig, Ph.D, P.E.

Staff: William (Bob) Basham

Graduate Students: Tais Mitchell and Conal Thie

Over the last year, we pursued two separate methods to characterize the thermal properties of the 3D-printed wood composite. Initially, we used a transient probe from East 30 sensors to measure the thermal conductivity of the samples. The transient probe is useful for measuring small samples produced by the rheology press. We used the thermal conductivity results to develop a numerical model and estimate the insulation properties of a full wall assembly made from these materials. We ran further simulations to estimate the potential energy savings for residents compared to other wall types. We used DOE's scout energy analysis tool to estimate the potential market penetration and total energy savings.

Figure 6. Thermal Testing Using a Transient Probe Method.

Once we collected preliminary results with the probe, we worked on a secondary method to measure more thermal properties in accordance with building code requirements. This secondary testing method will provide details on how the layering effects of the 3D printed process impact the thermal properties of the material (Fig. 6). To meet this goal, we have designed and fabricated a thermal testing apparatus in accordance with the ASTM Standard C177 (Fig. 7). In addition to complying with the ASTM standard, the apparatus was designed as a modular assembly for ease of manufacturing. Renderings and photos of the device are shown below. It consists of an aluminum frame to hold the materials, heating plates and sensors controlled by an Arduino board, and a water refrigeration system.

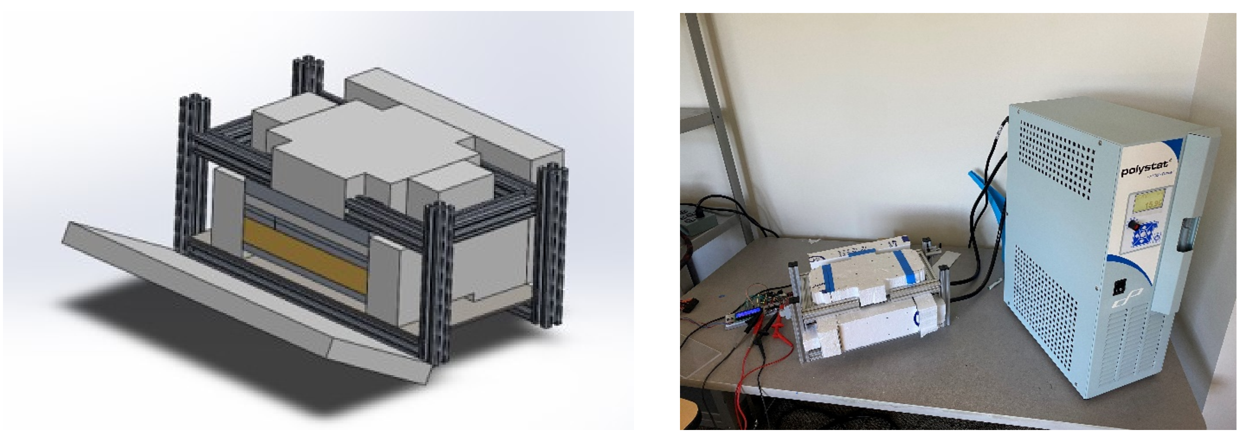


Figure 7. Rendering of 2nd Apparatus (Left) and calibration testing of Apparatus (Right).

The apparatus shown above (Fig. 7) is currently undergoing verification experience with a standard reference material to ensure reliability and compliance towards the standard. We are planning further refinements to make the device computer automated during the test and process the recorded data. The device will characterize the thermal properties of the printed material so that we can optimize the panel materials and configuration.

In addition to the thermal testing, the team also worked to develop a life cycle assessment analysis comparing the environmental impacts of the preliminary wall assembly to other wall envelops in residential and light commercial buildings. The scope of the analysis focused on quantifying the embodied energy of a typical 8-foot by 8-foot wall section in each stage of its life. This includes the material, manufacturing process, building energy usage, and end of life stages. We worked to quantify other Eco indicators including acidification, global warming potential, and Ozone depletion. We learned from the study that the stage responsible for the largest environmental impact is that of the building energy usage phase. Based on our estimates, the 3D printed wood-waste wall showed the some of the lowest energy impacts of any wall assemblies that we studied.

Constructability Analysis

R. Casey Cline, Boise State University, Department of Construction Management
Kirsten A. Davis, Boise State University, Department of Construction Management
J. Ty Morrison, Boise State University, Department of Construction Management

The Boise State University Construction Management (BSU CM) research team has focused on three areas supporting the research efforts: assisting in developing the business case, developing a construction sequencing model, and continuing with the constructability reviews.

Assisting with business case development:

The UI team has been developing the business case for the 3D printed panels. The BSU CM team has been providing assistance in reviewing this work and adding to it based on our areas of expertise in the construction industry.

Discussions have been held with the Idaho Associated General Contractors (AGC) about the progress of the 3D printing project. (Note: The AGC provided a letter of support during the grant application process). The main takeaway at this time is that approaching contractors to participate in testing of the 3D product will be easier, and more likely to be successful, once a product is available.

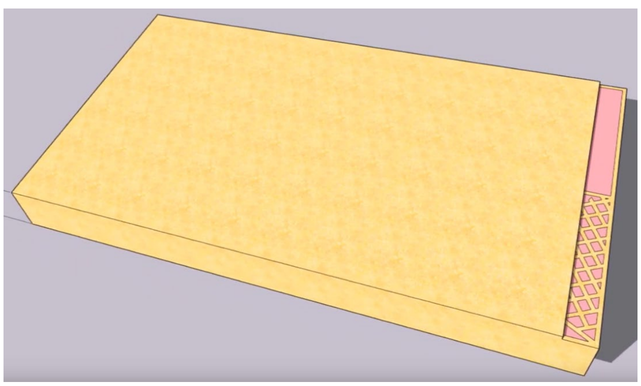
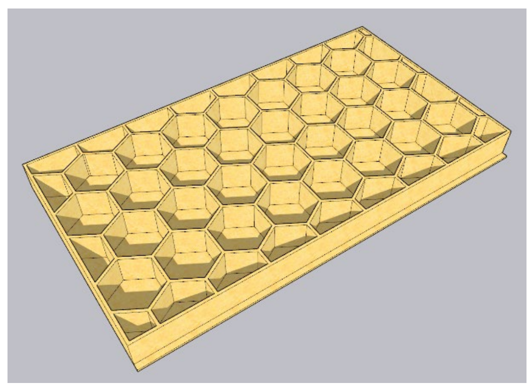
There have been preliminary discussions with the Idaho Forest Products Commission (IFPC) and other building related companies about the concepts and products this work is creating and they are interested in learning more once the details of the panels are more fully developed.

The BSU CM team has also been evaluating the best market (residential, light commercial, etc.) for panels like this based on constructability, using the current and projected panel and material info from the UI teams. For either market, the adoption and use of a 3D printed panels in construction will depend on cost, schedule, and availability of skilled labor. The intent is to have a process where the panels are manufactured in a local factory setting, or possibly fabricated on site.

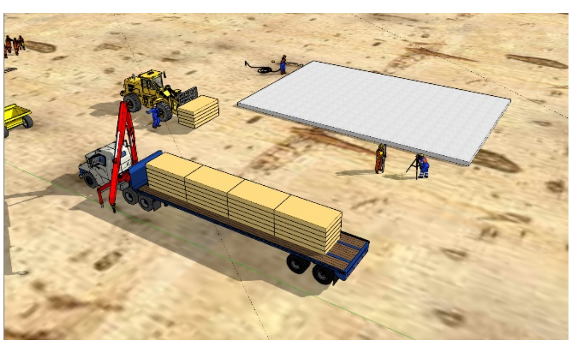
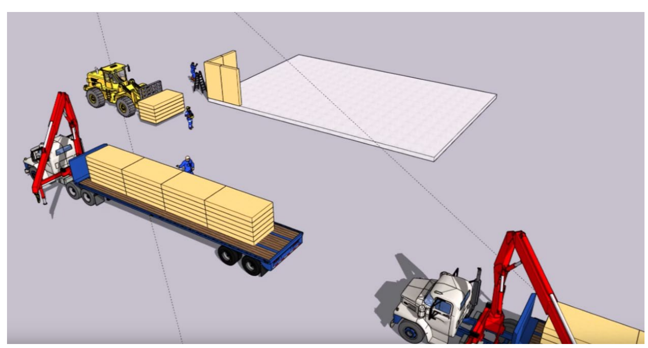
Developing construction sequencing model:

Using 3D modelling and video editing software, models and a video have been developed to begin determining the panel configurations and ideal construction sequencing of panels. This work includes a simulation of full-size panel printing, proposed panel shapes, and a possible construction sequence. Several iterations of the panel configuration have been explored, reflecting the initial fabrication and tests of extrudent. Final refinement of the ideal panel shape and structure is dependent on completion of the extrusion manufacturing process and related properties testing. The modelling and sequencing will continue to evolve and improve as more details about the panel fabrication processes from the UI teams become available. Limitations in the panel fabrication process may affect delivery and erection requirements, causing changes to the final panel shapes and construction sequencing. Several screen shots included below depict examples of the refinement of conceptual design ideas.

Also, as mentioned above, the BSU CM team has identified the possibility of panels for use in residential and light commercial applications which will require adaptation of the basic panel concept (configuration and sequencing) to better facilitate implementation in these two distinct arenas of construction markets.

Examples of possible panel makeup with interior honeycombing revealed

Beginning of possible construction sequence

Continuing constructability review:

The constructability review has continued to evolve as the details of the panel materials have been developed by the UI teams. The BSU CM team has provided troubleshooting on the project and has developed priorities for the wood fiber material and panel development, based on constructability aspects. These priorities include items such as:

- water resistance,
- dimensional stability,
- durability,
- ability to modify panels at job site with common tools such as saws, drills, routers, etc. with minimal damage to panels,
- suitability of panel for paint, adhesives, sealants to stick to panel with minimal prep,
- size and texture of finished panels, and
- ability to embed metal and/or plastic items during 3D printing process to facilitate transportation, connections, utilities located in or attached to panels, and finishes applied to panels.

Future Plans:

We are looking forward to experimenting with small sections of full-thickness panels to help ensure that the panels will meet our constructability priorities. Samples of 3D printed material will also allow us to determine how panels can be connected together to create a wall or other part of a structure, as well as whether those connections actually work. Aspects such as durability of the panels and suitability for finishes will also be explored over the next year.

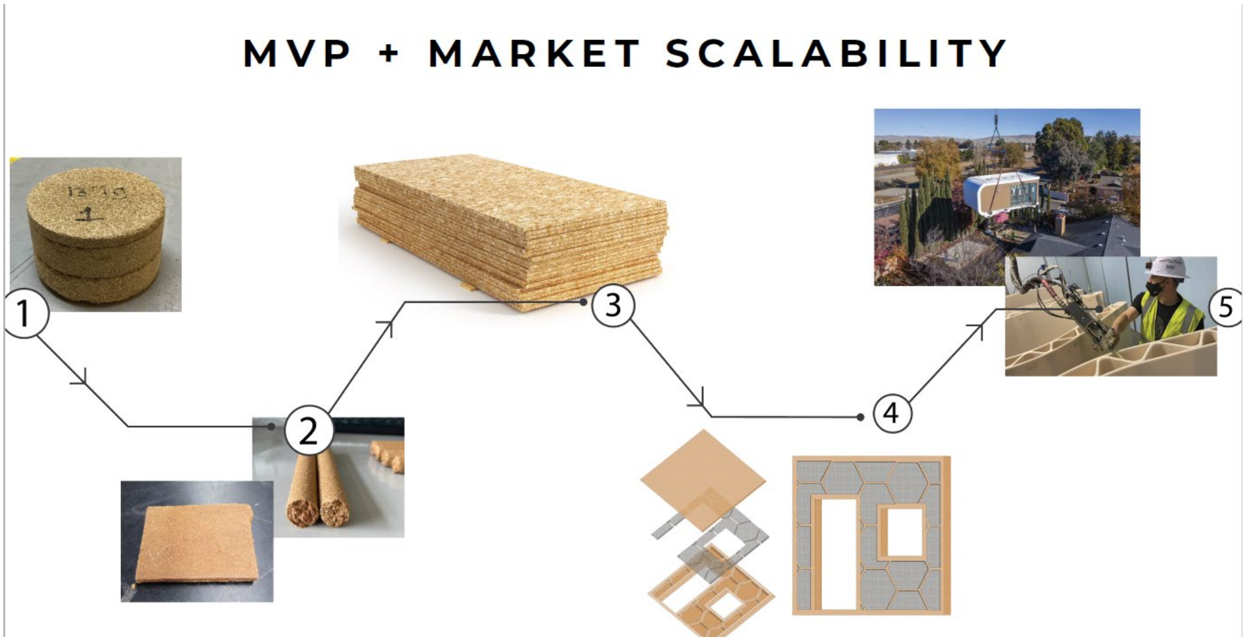
The construction process and sequencing will be updated to reflect improvements made by the UI teams.

3. Summary of Budget Expenditures

Salaries:	$152,528.40
Temp Help	$18,090.00
Fringe	$ 30,993.12
Travel	$ 00
Operating	$ 28,549.67
Small Equip	$ 844.95
Capital Equip	$9991.11
BSU Sub	$28,908.15
Tuition	$46594.00
TOTAL	**$316,499.4**

4. Demonstration of economic development/impact

- Patents, copyrights
    - We are actively working on a provisional patent for the cold-setting process.
- Technology licenses signed
    - None at this time
- Private sector engagement
    - PI Ken Baker and masters' student Kelsey Ramsey were selected by the I-Corps Ignite committee to participate in a four-week three-university class on lean startup business development. We are engaged in moving our product to date forward and finding private funding and a new business case. A large aspect of this class is identifying private sector clients and performing client interviews. These will take place beginning this summer.
- Jobs created
    - None outside the universities at this time.
- External funding
    - We submitted on an NSF Track 2 grant proposal (Michael Maughan PI) and were notified on June 29 that it will be funded. Under this proposal we will expand our current research to other bio-based materials for our panel prints and explore the architectural resiliency expressions of materials in design applications .
    - We have submitted a DOE BENEFIT grant proposal (Ken Baker PI) and are awaiting confirmation of award. This proposal would work toward development of the scale up panel manufacturing process and, solicit a manufacturing partner.
    - We have submitted an ARPA-E concept paper to DOE (Armando McDonald PI) to develop products from our cold-setting mix of wood, sodium silicate and carbon dioxide. We are waiting to receive a go ahead for a full proposal.
- Other pertinent information
    - Although we do not yet have a printed panel, we do have a minimum viable product in the form of a hardboard that we believe will be competitive with current products. The goal under this grant is to get to image #4 below. We are currently approaching #3.



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 were five Research Associates working on the grant in year two.

6. Description of Future Plans for Project Continuation or Expansion

Four key outcomes were expected in year 2 of the three-year grant:

1. The print mix for cold setting print will be identified. Completed.
2. The printer specifications and printer will be further defined as a product that could scale up for manufacturing large-scale panels. Completed
3. Business/industry partners will be engaged and private investment will be solicited. We are currently reworking our business plan under the I-Corps Ignite program.
4. The thermal characteristics of printed panels will be assessed. Ongoing as new prints are developed.

7. Commercialization Revenue

None to date.

SUBJECT

Postsecondary Student Experience Survey Report

REFERENCE

December 2021	The Board discussed initial findings from this survey during the Work Session.

APPLICABLE STATUE, RULE, OR POLICY

Section 33-138, Idaho Code

BACKGROUND/DISCUSSION

During the 2021 Idaho legislative session, allegations were made that some students at Idaho's public postsecondary institutions are being treated negatively because of their personal beliefs and viewpoints. To determine if there is merit to these serious allegations, the Office of the State Board of Education conducted a research study in November 2021 that included a survey of the more than 54,000 students at Idaho's eight public institutions.

The survey included questions that asked students if they feel valued, respected, and like they belong at their institutions. It also asked students if they have experienced pressure to affirm or accept beliefs they find offensive, or if they have been shamed or bullied for sharing their personal viewpoints and perspectives. Students who indicated any degree of pressure or shaming/bullying were given an opportunity to identify, generally, from whom they experienced this treatment (faculty, other students, administrators, etc.). Students were also given an opportunity to provide demographic information, including age, gender, ethnicity, class status (freshman, sophomore, etc.), and political ideology. All questions on the survey were optional to allow maximum freedom and discretion in providing responses.

8,989 students completed the survey, for a total overall response rate of 16.4%. College of Southern Idaho had the lowest response rate (8.9%) and Idaho State University had the highest response rate (24%). All responses to the survey were completely anonymized to protect student privacy. The Board office did not collect data about which students responded or did not respond, nor can the office connect any specific response to any specific student.

The preliminary results of this survey were presented to the Board on December 15, 2021. The Board directed staff to develop a full report of the results. Staff have created an interactive dashboard, with explanatory language, and full datasets made available to the public. Data have been aggregated or masked to ensure student privacy and confidentiality where cell sizes were smaller than five (5) students. The dashboard can be accessed at
https://dashboard.boardofed.idaho.gov/StudentExperienceSurvey.html

IMPACT

The Board may want to use the data from this survey to inform how to respond to allegations of bias on Idaho's postsecondary campuses. The data could also help inform future Board policies that protect freedom of expression and encourage diversity of thought at Idaho's public postsecondary institutions. The information could also help institutions develop awareness and implement strategies to improve the campus experience for all students.

ATTACHMENTS

Attachment 1 – Postsecondary Student Experience Survey Questions and Consent Language

BOARD STAFF COMMENTS AND RECOMMENDATIONS

Board staff, particularly the Chief Academic Officer and the Chief Research Officer, worked closely with Board members and institutional research officers to develop a survey protocol that minimized disruption on campus. While the Board office worked with the institutions to develop the protocol for administering the survey, the data analysis and interpretation was conducted solely by Board staff. The use of a national Institutional Review Board (IRB) for human subjects research, rather than one of the institutions' IRBs, provided an additional layer of independence.

This report was presented to the Council on Academic Affairs and Programs and to then to the Instruction, Research, and Student Affairs Committee of the Board on February 3, 2022.

BOARD ACTION

This item is for informational purposes only.

SURVEY INSTRUMENT with CONSENT

This survey is being administered by the Idaho State Board of Education as part of study to better understand how students perceive their higher education experiences.

Taking this survey is completely voluntary. There are no negative consequences if you choose not to participate. If you start the survey, you can always change your mind and stop at any time.

No personally identifiable information will be preserved by the State Board, including your name or email address. Your responses to this survey will not be connected with your personally identifiable information. You will not be identified in any report or publication of the data collected through this study. You will be asked to voluntarily provide high level demographic data like your age, gender and ethnicity. Any demographic categories with fewer than 5 individuals will be suppressed in publications and in the case of public records requests, as an added level of identity protection.

For questions about this survey and study you may send an email to board@osbe.idaho.gov with the subject line: Campus Climate Survey.

Your participation in this study is completely voluntary, and you can withdraw at any time by closing your browser window. **By clicking the NEXT button, you are indicating your informed consent to participate in this research study.**

SURVEY ITEMS

1. What is your age?
    a. Drop down menu with ages in years

[Go-to end of survey if “17” or below]

2. Which institution do you primarily attend? (Select the institution where you are currently taking most of your credits)
    a. Boise State University
    b. College of Eastern Idaho
    c. College of Southern Idaho
    d. College of Western Idaho
    e. Idaho State University
    f. Lewis-Clark State College

g. North Idaho College
h. University of Idaho
i. Other

[If "Other" go to end of survey]

3. What is your current class status?
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
    e. Graduate Student
    f. I don't know or prefer not to answer

4. Are you Hispanic or Latino?
    a. I am Hispanic or Latino
    b. I am NOT Hispanic or Latino
    c. I don't know or prefer not to answer

[If "Hispanic or Latino" Go to #6]

5. What is your race or ethnicity? (Select all that apply)
    a. American Indian or Alaska Native
    b. Asian
    c. Black or African American
    d. Native Hawaiian or other Pacific Islander
    e. White
    f. I don't know or prefer not to answer

6. What is your gender?
    a. Female
    b. Male
    c. Other
    d. I prefer not to answer

7. To what extent do you feel you belong at your college or university?
    a. Not at all
    b. Somewhat
    c. Quite a bit
    d. Very much
    e. I don't know or prefer not to answer

8. To what extent do you feel valued at your college or university?

   a. Not at all
   b. Somewhat
   c. Quite a bit
   d. Very much
   e. I don't know or prefer not to answer

9. To what extent do you feel you are treated with respect at your college or university?
   a. Not at all
   b. Somewhat
   c. Quite a bit
   d. Very much
   e. I don't know or prefer not to answer

10. While attending your college or university, how often have you felt pressured to accept or affirm beliefs you found offensive?
    a. Never or very rarely
    b. Occasionally
    c. Often
    d. Very frequently
    e. I don't know or prefer not to answer

[If "Very rarely or never" go to #12]

11. Who would you say has pressured you to accept or affirm beliefs you found offensive? (Select all that apply)
    a. Professors or instructors (faculty)
    b. Other students or peers
    c. Administrators
    d. Other employees of the college or university
    e. I don't know or prefer not to answer

12. While attending your college or university, how often have you experienced shaming or bullying from others when you have shared your personal beliefs or viewpoints?
    a. Never or very rarely
    b. Occasionally
    c. Often
    d. Very frequently
    e. I don't know or prefer not to answer

[If "Very rarely or never" go to #15]

13. Who would you say has bullied or shamed you for sharing your personal beliefs or viewpoints? (Select all that apply)
    a. Professors or instructors (faculty)

b. Other students or peers
c. Administrators
d. Other employees of the college or university
e. I don't know or prefer not to answer

14. How safe have you felt to express your personal beliefs with others at your college or university without fear of negative consequences?
    a. Not at all safe
    b. Somewhat safe
    c. Mostly safe
    d. Very safe
    e. I don't know or prefer not to answer

15. How familiar are you with safeguards and policies at your college or university that protect your rights regarding freedom of expression?
    a. Not at all familiar
    b. Somewhat familiar
    c. Mostly familiar
    d. Very familiar
    e. I prefer not to answer.

16. To what extent do you agree or disagree with the following statement: "It is important to participate in courses and activities at my college or university that are designed specifically to enhance my understanding of others' beliefs and viewpoints?"
    a. Strongly disagree
    b. Somewhat disagree
    c. Somewhat agree
    d. Strongly agree
    e. I don't know or prefer not to answer

17. How would you characterize your political views?
    a. Far left
    b. Left
    c. Center
    d. Right
    e. Far right
    f. Other
    g. I don't know or prefer not to answer