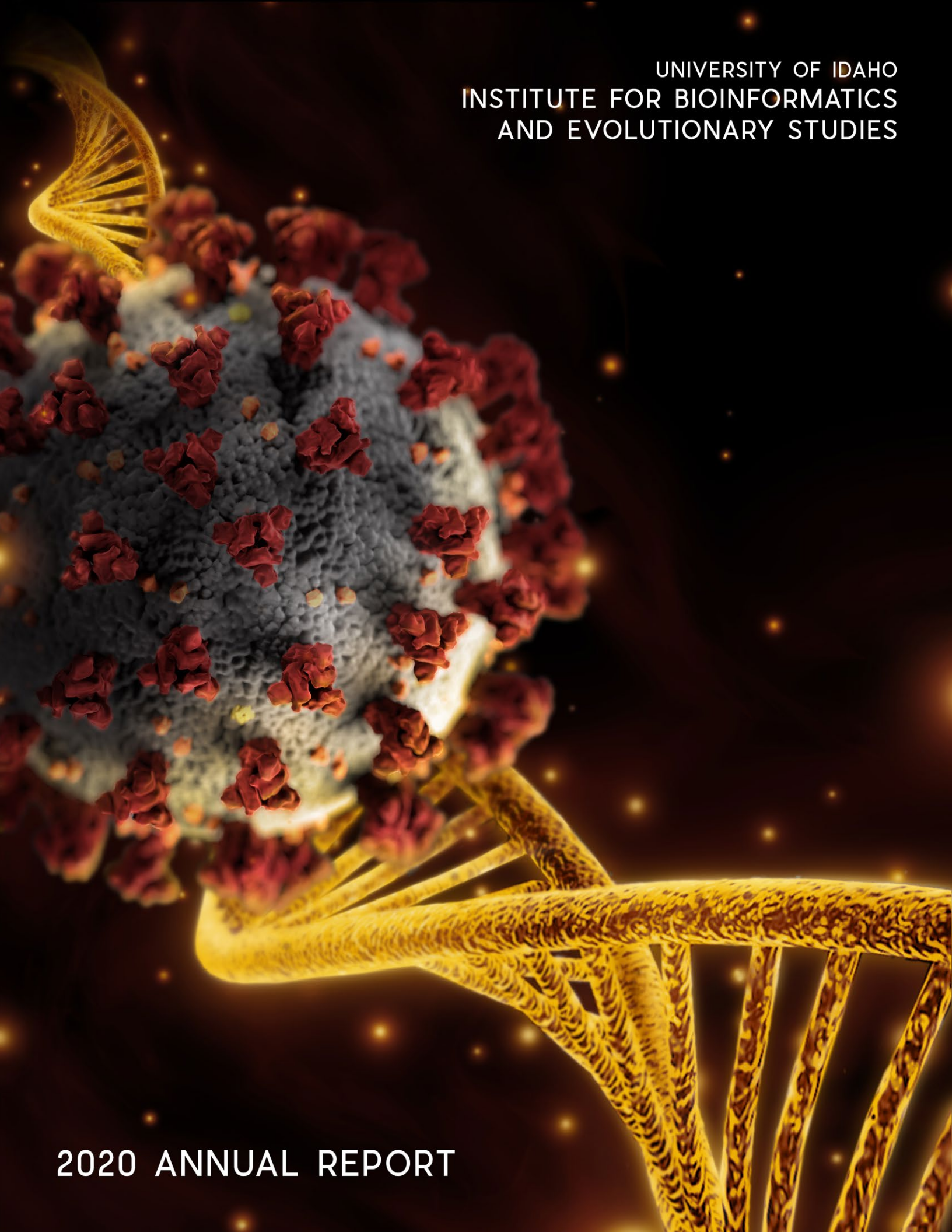


UNIVERSITY OF IDAHO
INSTITUTE FOR BIOINFORMATICS
AND EVOLUTIONARY STUDIES



2020 ANNUAL REPORT

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EXECUTIVE SUMMARY

The Institute for Bioinformatics and Evolutionary Studies (IBEST) is a level III Research Institute at the University of Idaho. IBEST's mission is to empower researchers to understand and apply the evolutionary process. IBEST also provisions and administers critical University infrastructure related to genomics, research computing, and data science.

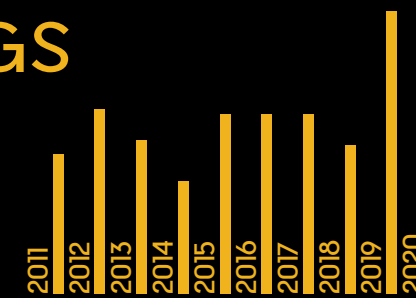
IBEST is a vibrant home for interdisciplinary research, with student, postdoc, and faculty participants from 9 colleges, and 28 departments and academic units, and 7 centers and Institutes at the University of Idaho. These participants engage with IBEST in numerous ways including proposal support, grants management, and usage of genomics, bioinformatics, computational, and data science infrastructure.

IBEST participants contribute significantly to the University of Idaho's Strategic Plan goals. In FY20, 14 faculty submitted a total of 24 proposals through IBEST, requesting a total of ~\$16.7 million. Of these requests, ~\$9.6 million has been awarded and ~\$5.3 million remains pending. Total FY20 research expenditures from extramural grants were \$2.3 million, and total research expenditures were \$3.3 million.

Faculty participating in IBEST report 100 publications in 2020 along with 82 conference presentations and 71 invited research presentations or keynote addresses. These faculty also represent a significant impact on the University of Idaho's training mission, mentoring 133 undergraduates, 145 graduate students, and 48 postdoctoral scholars.

DISSEMINATION OF RESEARCH FINDINGS

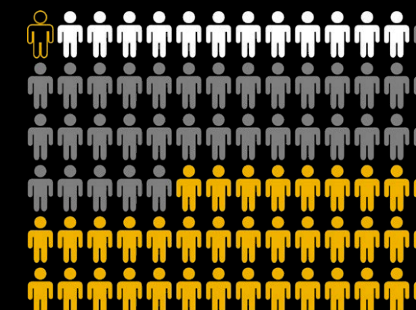
2 INVENTION DISCLOSURES
 71 INVITED SEMINARS & KEYNOTES
 82 CONFERENCE PRESENTATIONS
 100 PUBLICATIONS
 32,451 CITATIONS SINCE 2011



1,027 PUBLICATIONS IN THE PAST DECADE

TRAINEES

5 DOCTORAL RESEARCH STAFF
 48 POSTDOCTORAL RESEARCHERS
 133 GRADUATE STUDENTS
 145 UNDERGRADUATE RESEARCHERS



GRANT ACTIVITY

14 FACULTY SUBMITTING PROPOSALS
 24 PROPOSALS SUBMITTED
 \$3.3M IN RESEARCH EXPENDITURES
 \$9.6M RESEARCH FUNDS AWARDED
 \$16.7M RESEARCH FUNDS REQUESTED



OF REQUESTED FUNDS WERE AWARDED

QUICK METRICS



LETTER FROM THE DIRECTOR

Last year, I argued in my annual letter that IBEST plays a central role in building research capacity at the University of Idaho. This research capacity, represented by instrumentation and the personnel required to staff it, is critical in helping the University achieve its strategic research goals. The year 2020 has taught us that research infrastructure is also critically important because it facilitates adaptiveness and responsiveness to crises – such as the effective response to a global pandemic.

COVID 19 emerged as an international crisis early in 2020, though many academics at the U of I and across the globe were sounding the alarm before then. By February, the terrifying toll of this virus was becoming clear, and governments were beginning to act – shutting down massive sectors of our economy in order to limit the spread of the virus. There were no winning cards to play – as massive unemployment and economic agony was being balanced against an increasingly horrifying death toll. The initial shutdowns appeared to slow the spread at regional levels, and states began opening their economies.

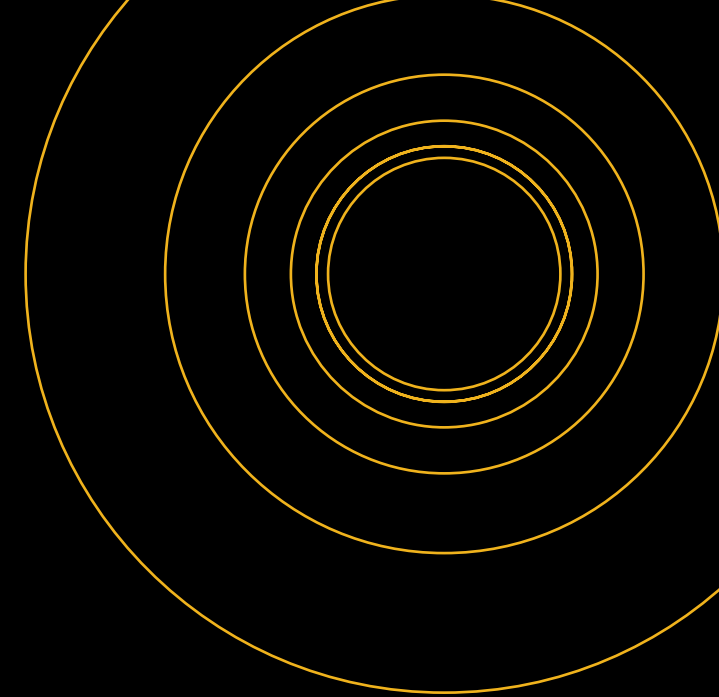
The University of Idaho decided that the value of face-to-face education to our students warranted reopening the University for the Fall 2020 semester. In order to reopen safely however, high throughput COVID 19 testing was a painfully clear necessity. President Green approached IBEST early in 2020, asking whether the research infrastructure and personnel in IBEST's Genomics Resources Core could be redeployed toward testing.

What unfolded since then was remarkable. Led by the IBEST Genomics Resources Core, a team of people identified an appropriate testing strategy, secured the necessary equipment, and stood up a fully functional CLIA certified testing lab in partnership with Gritman hospital. This effort represented the University of Idaho at its best. Several faculty, including Dr. Lisette Waits, Dr. Larry Forney, Dr. Brian Small, and Dr. Matt Powell loaned important (and expensive) equipment to the effort. Others, including Dr. Ken Cain, Dr. Paul Rowley, Dr. Eric Coates, and Dr. Lisette Waits allowed their highly trained staff to become certified technicians in the lab in order to process samples. Staff in the Office of Research and Economic Development and the President's Office worked together to navigate myriad issues related to biosafety, finances, staffing, and legal agreements. We also worked with officials from the State of Idaho to secure testing reagents from the federal stockpile.

While the ride was bumpy at times, we now have a fully functional high throughput COVID testing lab that can process more than 1,000 patient samples in a single day. As of November 2020, the lab had processed more than 20,000 tests – the samples drawn from students, staff, and patients from our local community. This effort has played a central role in keeping the University safely open during the Fall semester, and has saved the U of I millions of dollars.

I cannot overstate how proud I am of the faculty, students, and staff that made this testing effort happen. It is important that we all remember that these dedicated individuals and the highly technical equipment they rely upon, are not here by accident. A comprehensive testing effort like this would simply be impossible without a thriving research community and robust infrastructure.

I cannot predict what 2021 will bring. Cyborg penguins may invade South America. Fungal aliens from beyond Neptune may infiltrate our government. An uprising of Karens in the Midwest may secede from the United States. No matter what comes our way though, I am confident we are ready to adapt and conquer any new challenge.



MISSION

IBEST empowers researchers to understand and apply the evolutionary process.

VISION

IBEST aspires to be a globally recognized center of excellence in evolutionary science that facilitates high impact research in evolutionary science; helps the U of I attract and retain world-class faculty, staff, and students; and provisions cutting edge research infrastructure for genomics, bioinformatics, and computation.

THE CENTRALITY OF EVOLUTION TO THE UNIVERSITY OF IDAHO'S LAND GRANT MISSION

Many components of the University of Idaho's Land Grant mission rely on understanding and applying the evolutionary process. Understanding evolution is essential to improving human well-being because evolutionary processes drive critical health challenges such as emerging infectious diseases, antimicrobial resistance, and even the origin and treatment of diseases such as cancer, mental illness, and obesity. Evolutionary mechanisms also drive agricultural challenges such as the emergence of pesticide resistance, the effects of invasive species, and artificial selection for desirable traits in cultured plants and animals. Understanding evolution also helps us protect our natural heritage by informing conservation policy and providing insight into adaptation to changing environments. Less obviously, computers can use evolution to solve complicated problems and to design both software and hardware. Evolutionary computation is at the heart of the revolution in Artificial Intelligence. Evolutionary models have even proven important in understanding the diversity of languages and cultures.

IBEST PROVIDES AN INTERDISCIPLINARY, COLLEGIATE, AND INCLUSIVE ENVIRONMENT DEFINED BY A SHARED COMMITMENT TO UNDERSTANDING AND APPLYING THE EVOLUTIONARY PROCESS.

MAXIMIZING RESEARCH IMPACT

Our goal at IBEST is to maximize the RESEARCH IMPACT of participating faculty. This impact can take many forms, ranging from applied solutions to specific problems to basic research that illuminates the processes that govern the world around us. Our focus on research impact draws primarily upon the review criteria for major research funding agencies. For example:

THE NATIONAL SCIENCE FOUNDATION¹ ASKS REVIEWERS TO DETERMINE THE POTENTIAL FOR THE PROPOSED RESEARCH TO:

- Advance knowledge and understanding within its own field or across different fields (Intellectual Merit)
- Benefit society or advance desired societal outcomes (Broader Impacts)

SIMILARLY, THE NATIONAL INSTITUTES OF HEALTH SIGNIFICANCE² SCORE CONSIDERS:

- Does the project address an important problem or a critical barrier to progress in the field?
- Is there a strong scientific premise for the project?
- How will the project improve scientific knowledge, technical capability, and/or clinical practice?
- How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?

The realized or potential impact of a research program can be difficult to describe and quantify. Impact can occur on a continuum from very basic to very applied and it may not truly be known or appreciated until many years after the work is completed. At IBEST, we try to consider impact broadly and inclusively.

¹ <https://www.nsf.gov/pubs/policydocs/pappguide/>
² https://grants.nih.gov/grants/peer/guidelines_general/impact_significance.pdf

HOW CAN RESEARCH HAVE IMPACT?

GENERATIVE Broadly applicable, generates new ideas
BRILLIANT Thoughtful, creative, and visionary
EXPLANATORY Provides valuable understanding
USE-INSPIRED Motivated and informed by societal issues
ENGAGED Carried out in partnership with society
PRACTICAL Carried out in partnership with society

HIGH IMPACT RESEARCH INFLUENCES HOW PEOPLE THINK ABOUT THE WORLD

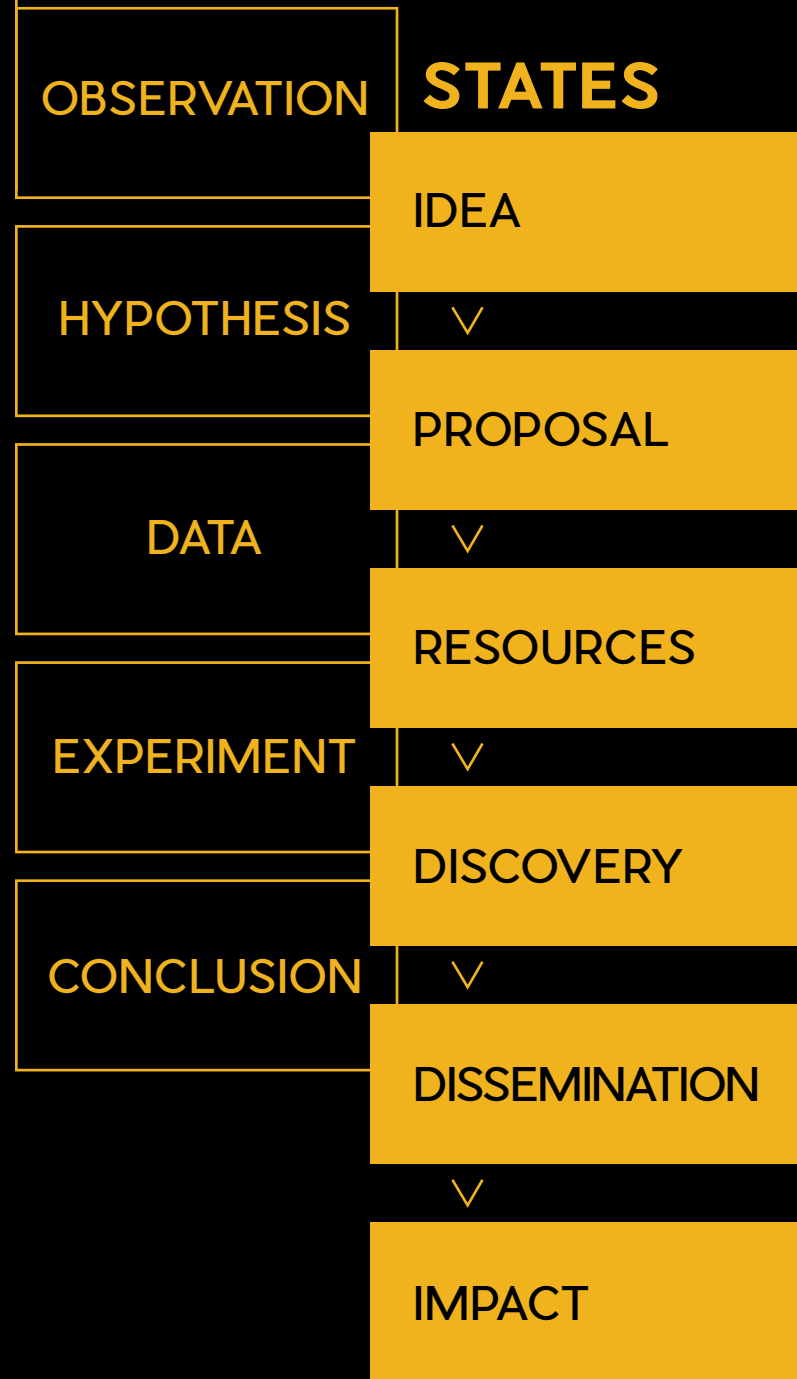
CATALYZING THE RESEARCH PROCESS

THE IBEST LOGIC MODEL To best understand how to maximize the research impact of participating faculty, IBEST has developed a logic model for the research process. This model is important because it guides how we invest our limited resources and helps us measure whether we are achieving our goals. In this logic model, we break the research process into a series of states, beginning with a nascent idea and culminating with the scholar's intended or potential impact. These states are common milestones through which a research project can typically traverse and mirror the steps in the scientific method.

Most research begins as an IDEA. Over time, the researcher refines the idea until it can be formalized as a hypothesis within a research PROPOSAL. These proposals are often framed as requests for RESOURCES, which usually come in the form of funding. Research resources, however, are merely the means to an end. The resources are spent on personnel, supplies, and equipment to collect and DISCOVER data, which is then synthesized and DISSEMINATED to the research community. The most typical state at this stage of the model is a publication in a peer-reviewed journal. Ultimately, though, the point of the research is its intended IMPACT, whether it be solving a problem or broadening our understanding.

This model of the research process is admittedly an oversimplification. However, by envisioning the research process in this way, we can identify investments that increase the rate at which faculty can move their research forward, transitioning between the states described above. We refer to these investments as FORCE MULTIPLIERS.

SCIENTIFIC METHOD



RESEARCH FORCE MULTIPLIERS

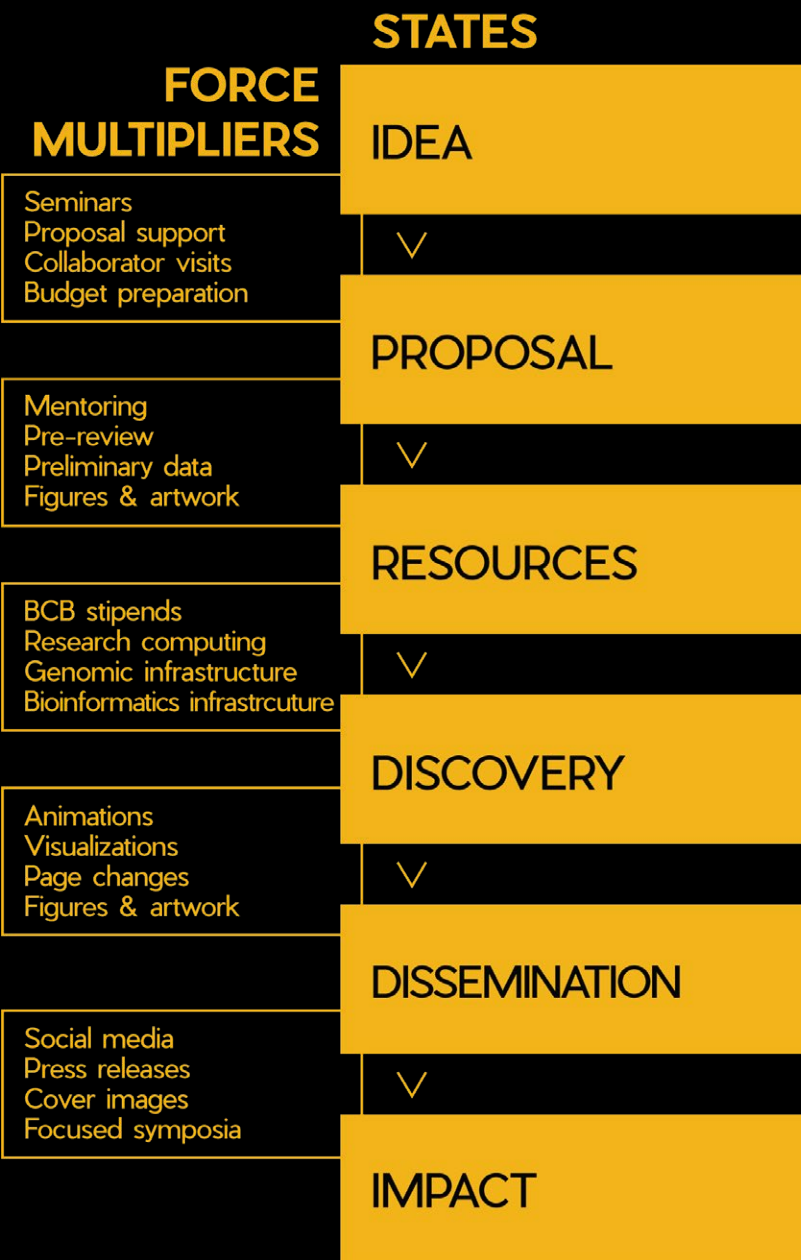
“A capability that, when added to and employed by a combat force, significantly increases the combat potential of that force and thus enhances the probability of successful mission accomplishment.”

– US DEPARTMENT OF DEFENSE

The force multiplier concept originated in military history, which describes a force multiplier as anything that increases the effectiveness of a fighting force. Examples include unique tactics, specialized equipment, or training. In the business world, force multipliers allow an organization or individual to accomplish more with the same amount of effort.

At IBEST, most force multipliers are designed to save faculty time by allowing them to focus on the conception and execution of their research, rather than activities for which they were not formally trained.

Other IBEST force multipliers provide specialized expertise or equipment that allow researchers to do things they normally couldn't or conduct their research much more rapidly. These IBEST functions are commonly housed within our three service centers, the Genomics Resources Core, the Computational Resources Core, and the Northwest Knowledge Network. Examples of these types of force multipliers include next-generation sequencing technology, bioinformatics analysis, research computing infrastructure, and data services.



FORMALIZING RESEARCH IDEAS

At this stage of the research process, IBEST invests in activities that help researchers refine ideas, find collaborators, and articulate their research clearly in proposals. Common strategies at this step involve connecting researchers with each other and protecting faculty time to work on articulating their science. Examples of these activities include funding collaborator visits, our joint seminar series with IMCI and the Bioinformatics and Computational Biology (BCB) graduate program, workshops, and many different forms of proposal development support.

COLLABORATOR VISITS IBEST has funded the travel costs to send faculty to visit collaborators or bring collaborators to the University of Idaho. These visits typically focus on the development of a publication or grant proposal. Support of this type is distributed at the discretion of the IBEST Director.

IBEST SEMINARS IBEST collaborates with IMCI and BCB to offer a seminar series of visiting speakers each semester. Speakers are nationally and internationally recognized scientists and are selected and hosted by the students in the BCB graduate program.

PROPOSAL SUPPORT One of IBEST's main tactics at this stage is to maximize the time that faculty spend writing about their science and minimize the time the faculty spend on paperwork. IBEST administrative staff support faculty in all phases of proposal development, including RFA review, proposal initiation, budget development, document management (such as current and pending support, biosketches), sub-award coordination, VERAS, Grants.gov, Research.gov and FastLane support, and coordination with the Office of Sponsored Programs and Office of Research and Faculty Development. These services are restricted to proposals that will be submitted through IBEST.

Thibault Stalder (left) explains his research to Justin Pickard at IBEST's 2019 Sketch Your Science event.

GETTING PROPOSALS FUNDED

Proposal review at most funding agencies is extremely competitive. At IBEST, we try to do everything we can to increase the probability that proposals are funded. Many factors affect the competitiveness of a proposal, and the needs of principal investigators at this stage vary considerably. In addition to protecting faculty time, we offer support for proposal pre-review, faculty development, art and graphic design, and teaching release. Other strategies at this stage are related to the generation of supporting data and new methods, typically in collaboration with one or more of our scientific service centers.

PRELIMINARY DATA GENERATION IBEST has offered a variety of mechanisms that support the collection of preliminary data for grant proposals. The two most common are Technology Access Grants (TAGS), which fund the use of our core facilities or Pilot Grants, which fund personnel and supplies. The BEACON Center for the Study of Evolution in Action has also funded many faculty with seed grants intended to collect preliminary data.

TEACHING RELEASE IBEST can support teaching buyouts for faculty working on large programmatic proposals that will be submitted through the institute.

PROPOSAL PRE-REVIEW IBEST funds stipends to reviewers to pre-review some proposals before their submission. We reserve this process for new investigators or large programmatic proposals.

FACULTY DEVELOPMENT AND MENTORING IBEST offers workshops that build faculty skill sets. Recent examples include “Business for Scientists,” in which faculty learn the fundamental concepts of pitching ideas, business models, and team management skills. We have also partnered with the College of Science, the ORED Research and Faculty Development Team, and IMCI to offer faculty development workshops related to proposal development.

ART AND GRAPHIC DESIGN IBEST staff can support the development of high-quality figures and artwork for publications and grant proposals.

METHODS DEVELOPMENT The staff in the GRC, CRC, and NKN routinely help faculty develop new research methods and write relevant pieces of methods sections for both proposals and manuscripts.

SEAMLESS GRANTS MANAGEMENT

Maximizing research impact means helping researchers make the most out of every grant dollar. IBEST invests in the people and infrastructure that are required to execute highly technical and cutting-edge research in genomics, bioinformatics, mathematical modeling, geospatial mapping, and data science.

GRANTS SERVICES IBEST provides fiscal management of resources by overseeing all post-award grant functions such as early budget setups; advance funding requests; sub-award initiation and monitoring; sponsor pre-approvals for no-cost extensions, re-budgets, expenditure reviews, and compliance; budget transfers; payroll cost transfers; comprehensive financial reports and project closeouts. Administrative staff also collaborate with the grants managers of various sponsoring agencies to determine appropriate actions on matters regarding modifications to contracts, re-budgeting, funding carry-forward, time extensions, and other contractual terms. Working one on one with faculty researchers, IBEST staff proactively manage grant budgets by providing accurate projections and fiscal advice and assuring compliance with university, state, and federal guidelines.

BCB FELLOWSHIPS IBEST has funded many BCB fellowships, which allow graduate students to work full time on funded research projects.

CRC INFRASTRUCTURE Fully described on pages 31-34, the CRC provides a variety of research computing infrastructure.

GRC INFRASTRUCTURE Fully described on pages 35-38, the GRC provides next-generation sequencing and bioinformatics support.

NKN INFRASTRUCTURE Fully described on pages 39-42, the NKN provides a variety of services and infrastructure related to data management, web hosting, and app development.





TELLING THE RESEARCH STORY

IBEST helps researchers to effectively and broadly communicate their work. This includes publications, findable, accessible, interoperable, and reusable (FAIR) data repositories, and support for image production, visualization, and animations for print, web, and other digital media.

VISUALIZATIONS IBEST staff are available to collaborate with faculty on complex data visualizations, which can be deployed in print or online. [Online visualizations](#) can be interactive and can draw on dynamic data sets. IBEST staff are available to collaborate with faculty on complex data visualizations, both in print and online. Online visualizations can be interactive and can draw on dynamic data sets. For example, the [Lassa virus dashboard](#) was created by BCB PhD candidate Tanner Varrelman and NKN to visualize the spatial and temporal distribution of Lassa virus across West Africa. Interactive maps allow the user to view the spatial location of virus samples from humans and rodents as well as associated meta data for a specified date range.

ANIMATIONS IBEST has supported the development of animated visualizations, interactive displays, and virtual reality demonstrations that can be used for data exploration or outreach activities. One of these animations was created for Scott Nuismer to demonstrate the power of [self-disseminating vaccines](#).

PHOTOGRAPHY AND VIDEO IBEST staff are available for [photography](#) and video production to support the dissemination of faculty and student research.

INFLUENCE AND EXCELLENCE

IBEST works with investigators to promote their research and ensure their work is consumed broadly and recognized for its excellence. To do this, our staff help with press releases, and write articles for web and print that are published in Departmental, College, and University media. We also host symposia and other events in which faculty and students share their work.

PRESS RELEASES IBEST administrative staff coordinate with faculty and U of I Communications and Marketing to publicize important research discoveries. This includes writing of articles and production of visual collateral.

SOCIAL MEDIA IBEST publicizes events and research discoveries through social media channels.

SYMPOSIA IBEST organizes regional symposia on topics related to our research mission. These symposia typically feature distinguished keynote speakers, poster sessions, and platform presentations.



IBEST STAFF

ADMIN



BARRIE ROBISON
IBEST Director

NKN



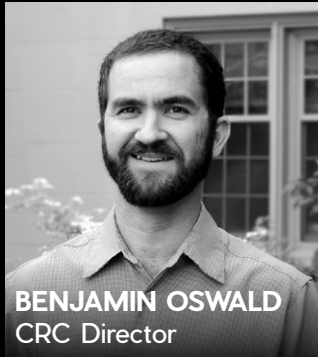
LUKE SHENEMAN
NKN Director

GRC

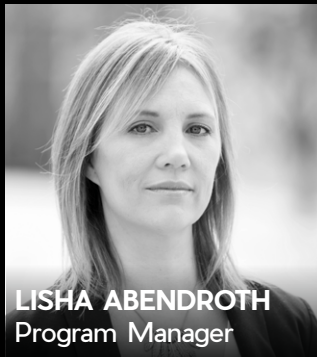


DAN NEW
Laboratory Services Manager

CRC



BENJAMIN OSWALD
CRC Director



LISHA ABENDROTH
Program Manager



JENNIFER HINDS
Research Applications Architect



MATT FAGNAN
Laboratory Coordinator



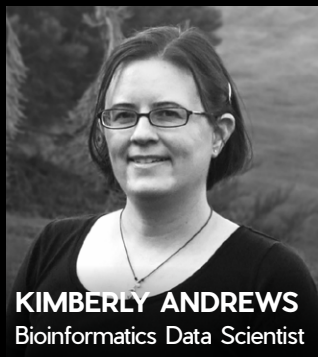
JAMES O'DELL
Systems Administrator



MOLLYANN JONES
Grants Services Manager



GINA WILSON
Web Developer



KIMBERLY ANDREWS
Bioinformatics Data Scientist



KATY RIENDEAU
Design/Marketing Coordinator



ANDREW CHILD
Data Manager

ADMINISTRATION The administrative core of IBEST performs research support functions for faculty and is a crucial point of interaction between IBEST faculty and other administrative units on campus. Research grant proposals may be submitted through IBEST if they pertain to evolutionary science or rely on IBEST infrastructure. Administrative staff assist the PI in proposal development, including budgets, collection and organization of required documents, figures, covers, and layout. Once a grant is awarded, IBEST staff oversee purchases, travel, and other research expenditures. The IBEST staff also coordinate all post award actions such as re-budgeting requests and no cost time extensions between the PI and the Office of Sponsored Programs. The Administration Core also supports the management of large program grants such as COBRE, NSF Science and Technology Centers, or NSF EPSCOR Track II awards.

COMPUTATIONAL RESOURCES CORE The Computational Resources Core (CRC) provides computing services, data storage and consultation for the research community at the University of Idaho. We provide a testbed for the development and evaluation of novel approaches for data analysis and modeling, at a reasonable cost. The CRC contains an advanced mix of high-performance computing clusters, powerful servers, and reliable data storage components. We staff personnel with the knowledge and technical skills required to compress years of analysis into days. See pages 31-34 for a more detailed description of the CRC.

IBEST STEERING COMMITTEE The IBEST Steering committee represents the colleges that most rely on IBEST infrastructure and activities. The Steering Committee advises IBEST on investments and keeps the Institute current regarding emerging infrastructure needs and opportunities.

- MAREK BOROWIEC** College of Agricultural and Life Sciences
- TARA HUDIBURG** College of Natural Resources
- MICHAEL OVERTON** College of Letters, Arts, and Social Sciences
- TERENCE SOULE** College of Engineering
- EVA TOP** College of Science

GENOMICS RESOURCES CORE The Genomics Resources Core (GRC) is the only comprehensive facility on the University of Idaho campus that houses all the equipment and personnel necessary to aid researchers in every aspect of high-throughput genomics research. It provides the molecular expertise and equipment needed for the most high-throughput sequencing studies and develops partnerships with other service facilities around the U.S. when additional capacity or specialized equipment are warranted. See pages 35-38 for a more detailed description of the GRC.

NORTHWEST KNOWLEDGE NETWORK Northwest Knowledge Network (NKN) provides research data management and computing support for researchers and their collaborators. We are structured to provide researchers with the establishment, storage and curation of quality data and metadata, and access to high-performance computing, tools, modeling, and visualization. We also cultivate connections to relevant national and international data repositories. NKN's support keeps researchers on the cutting edge of science and enhances competitiveness for external research grants. The data and metadata developed in research projects and curated by NKN is a valuable, long-term asset for a public land-grant university and provides a foundation upon which to develop new research. See pages 39-42 for a more detailed description of NKN.

PARTICIPATION IN IBEST

PRINCIPAL INVESTIGATORS

Faculty who are the most integrated with IBEST are those who submit grant proposals through the institute, and/or for whom IBEST administers their budgets. To be submitted through IBEST, the research proposal must meet one of the following criteria: be aligned with IBEST's intellectual focus on evolutionary science; or makes use of IBEST infrastructure, including the CRC, GRC, NKN, and other research support functions.

ONESMO BALEMBA Biological Sciences, CoS

TONIA DOUSAY Curriculum and Instruction, CEHHS

LARRY FORNEY Biological Sciences, CoS

JAMES FOSTER Biological Sciences, CoS

LUKE HARMON Biological Sciences, CoS

PAUL HOHENLOHE Biological Sciences, CoS

TARA HUDIBURG Forest, Rangeland and Fire Sciences, CNR

ADAM JONES Biological Sciences, CoS

MARSHALL MA Computer Science, CoE

CHRIS MARX Biological Sciences, CoS

DIANA MITCHELL Biological Sciences, CoS

SCOTT NUISMER Biological Sciences, CoS

BENJAMIN OSWALD IBEST, ORED

MICHAEL OVERTON Political Science, CLASS

CHRISTINE PARENT Biological Sciences, CoS

BEN RIDENHOUR Mathematics, CoS

BARRIE ROBISON Biological Sciences, CoS

PAUL ROWLEY Biological Sciences, CoS

LUKE SHENEMAN IBEST, ORED

TERENCE SOULE Computer Science, CoE

DEBORAH STENKAMP Biological Sciences, CoS

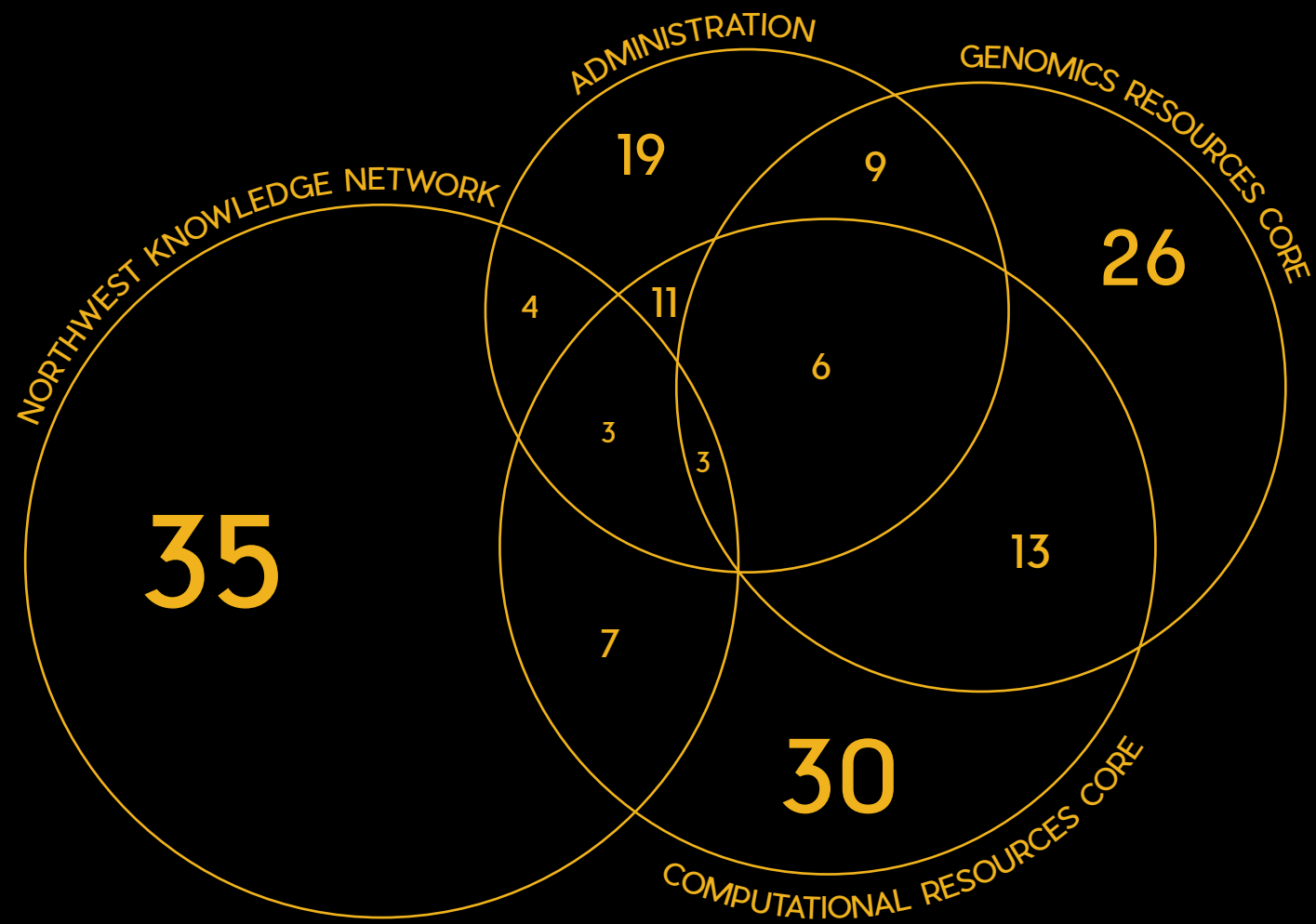
JACK SULLIVAN Biological Sciences, CoS

DAVID TANK Biological Sciences, CoS

EVA TOP Biological Sciences, CoS

CORE FACILITY USERS

The IBEST Core facilities support the research of faculty from 9 different colleges, 28 academic departments, and 7 centers and institutes. The types of services and infrastructure provided by the IBEST cores are described more fully in their respective sections of this report.

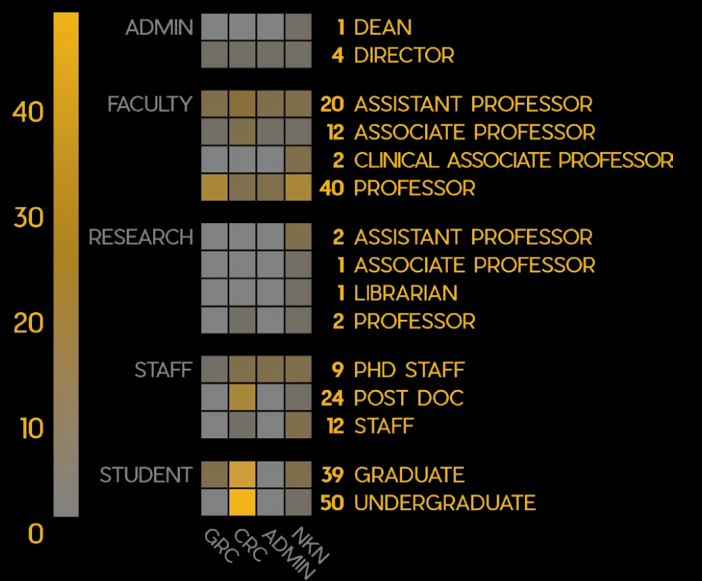


IBEST supports the research of 83 faculty from across campus. This figure shows how these faculty engage with IBEST's various functions.

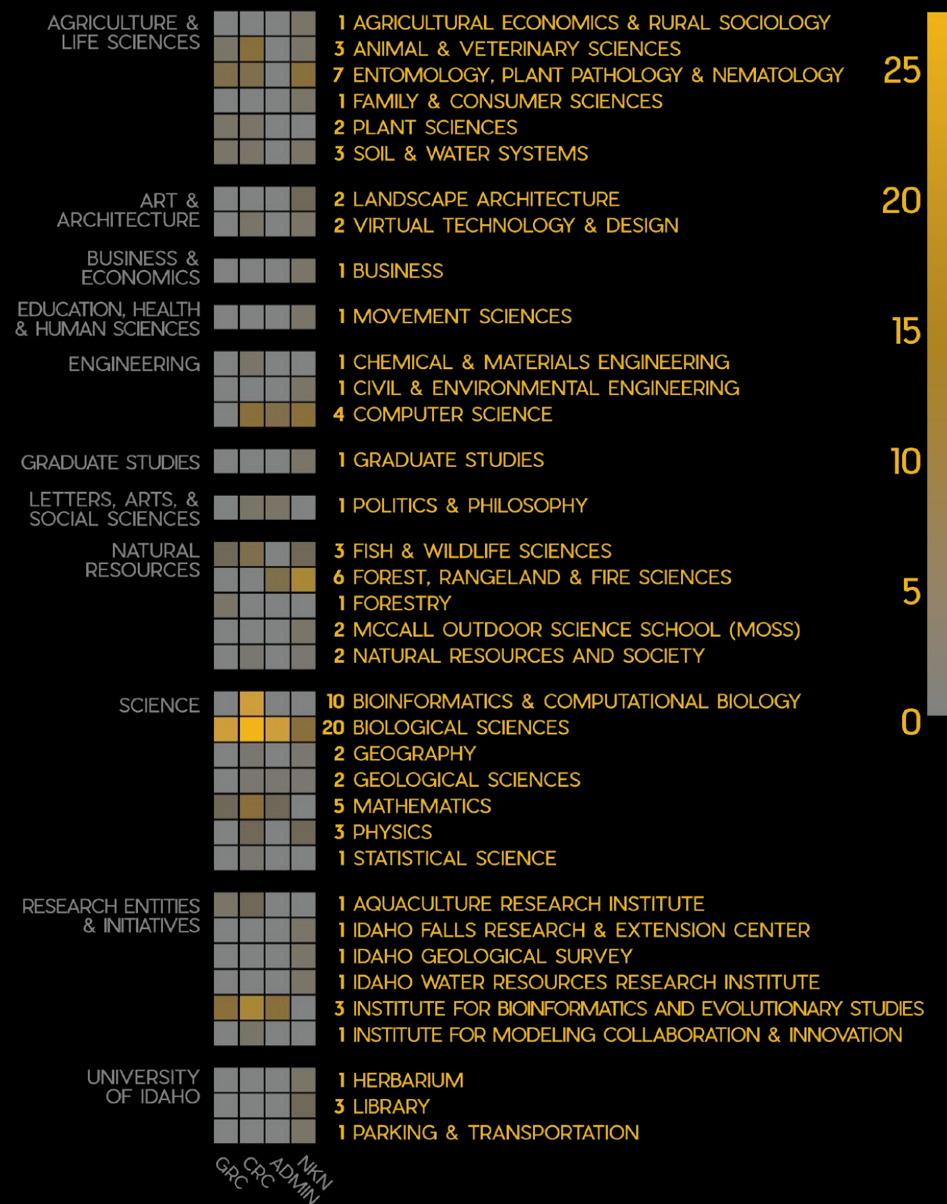
BY COLLEGE



BY CAREER



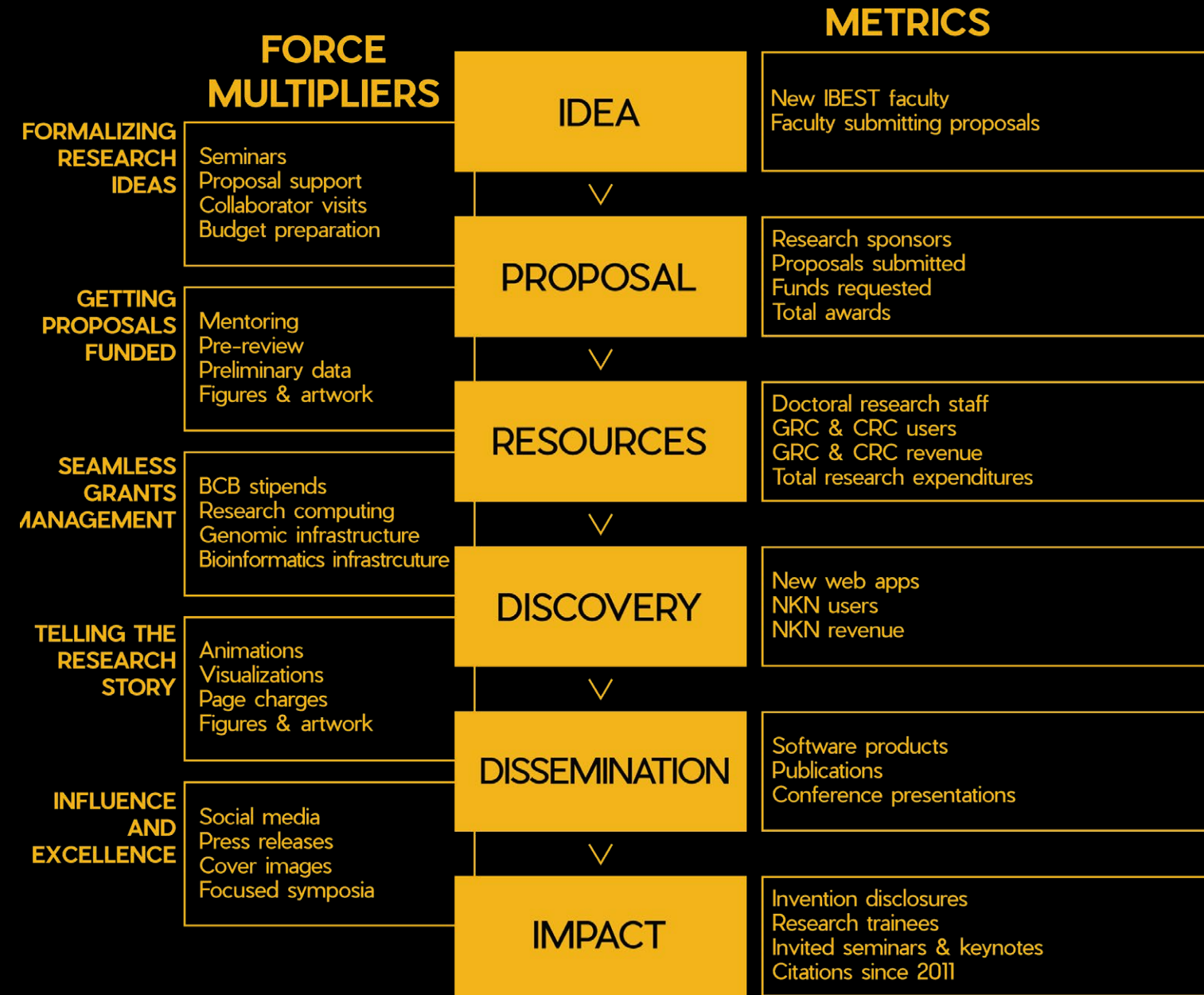
BY DEPARTMENT



These heat maps describe how IBEST faculty, postdocs, and students are distributed across U of I's academic units and career stage.

2020 ACCOMPLISHMENTS AND PERFORMANCE METRICS

LOGIC MODEL Each of the states in our model of the research process is associated with METRICS, which are variables that can be quantified and used to measure our progress toward our goals. Here, we define these metrics, describe our process for collection and measurement, and report them for Fiscal Year 2020. In some cases, our metrics do not align well with a fiscal year reporting window (publications in a calendar year are an obvious example). For these metrics, we report a rolling window to provide context for the 2020 partial calendar year.



IBEST plays an important role in helping researchers generate and refine their research ideas. We invest in activities such as IBEST lunch and our seminar series precisely because they help faculty discuss their research, identify future collaborators, and get critical feedback. As a Tier III Institute, IBEST seeks to have a campus-wide impact, and activities that help researchers generate and refine their ideas are important in growing participation in IBEST across campus. Ideas are critically important, but they also defy metrics and quantification. However, research activity at this stage does scale with participation. We therefore track two metrics, the total number of faculty submitting proposals through IBEST and the number of faculty doing so for the first time.

NUMBER OF FACULTY SUBMITTING PROPOSALS THROUGH IBEST

While participation can be measured at any number of IBEST events (lunches, seminars, symposia, workshops), the number of faculty submitting proposals most closely aligns with the University of Idaho’s goal of increasing research expenditures and achieving Carnegie R1 status. This year, 14 faculty submitted proposals through IBEST.

NEW FACULTY SUBMITTING PROPOSALS THROUGH IBEST

IBEST seeks to broaden interdisciplinary research in evolutionary science. An important metric in this regard is the number of new investigators that submitted proposals through IBEST. In FY20, 3 new faculty chose to work with IBEST to submit proposals: Tara Hudiburg (Forest, Rangeland, & Fire Sciences, CNR), Marshall Ma (Computer Science, CoE), and Adam Jones (Biological Sciences, CoS).

IN FY20, 14 FACULTY SUBMITTED PROPOSALS THROUGH IBEST AND 3 OF THESE DID SO FOR THE FIRST TIME

Proposal submissions are a critical metric for IBEST because they are related to the U of I’s strategic plan and our goal of achieving Carnegie R1 status. At IBEST we track the number of submissions, the amount of funds they request, and the number of different research sponsors.

Balemba, Onesmo	COS, Bio	Diabetic Complications Consortium	DiaComp	\$99,367	Awarded
Forney, Larry	COS, Bio	NIH	Structure, immunity and microbiome	\$83,133	Pending
Harmon, Luke	COS, Bio	NSF	Using natural replicates to understand convergence and macroevolution	\$800,252	Declined
Harmon, Luke	COS, Bio	NSF	Integrating biogeography to understand hummingbird pollination network	\$292,487	Declined
Hohnelohe, Paul	COS, Bio	NIFA/USDA	Predicting Range Expansion in <i>Diorhabda</i>	\$118,975	Awarded
Hudiburg, Tara	CNR, Fire	DoE	Mechanisms driving the coupling and decoupling of methane oxidation in soil	\$350,939	Pending
Hudiburg, Tara	CNR, Fire	DoE	Variation in nitrogen allocation and response to changing climate	\$755,142	Pending
Jones, Adam	COS, Bio	NSF	RoL: Evo-devo of male pregnancy	\$586,223	Awarded
Jones, Adam	COS, Bio	NSF	DEB: Genomics of Sexual Selection in Pipefishes and Seahorses	\$1,028,242	Awarded
Ma, Marshall	COE Comp Sci	NSF	R1I Track-2 FEC: Improve Prediction of Tick-Borne Disease Patterns & Dynamics	\$5,830,709	Awarded
Mitchell, Diana	COS, Bio	NIH	Macrophage Determinants of Retinal Regeneration	\$1,804,695	Declined
Mitchell, Diana	COS, Bio	NIH	Macrophage Determinants of Retinal Regeneration	\$1,804,695	Awarded
Nuismer, Scott	COS, Bio	DTRA	Emerging Virus Flyways - Enhancing high-consequence zoonotic patho	\$297,402	Declined
Nuismer, Scott	COS, Bio	NSF	EAGER: Preventing SARS-CoV-3: Feasibility of a transmissible vaccine	\$56,420	Awarded
Nuismer, Scott	COS, Bio	NSF	Quantifying the strength and form of interactions among pathogen strains	\$535,645	Pending
Oswald, Benji	IBEST	ORED	EIS: Modernization of high performance research computation infrastructure	\$4,000	Awarded
Overton, Michael	CLASS PolySci	NSF	Smarter Cities: The Effects of Data Literacy on Local Government Innovation	\$369,074	Declined
Parent, Christine	COS, Bio	NSF	REU supplement request, DEB	\$17,900	Awarded
Parent, Christine	COS, Bio	NSF	RAHSS Supplement Request DEB	\$6,049	Awarded
Robison, Barrie	IBEST, Bio	ID Wheat Commission	Effects of the cereal seed microbiome on amylase activity and falling numbers	\$39,728	Awarded
Robison, Barrie	IBEST, Bio	NIH	EvoHealth: A program to improve pathways to STEM careers in Idaho	\$1,303,909	Declined
Soule, Terry	COE Comp Sci	NSF	Salmon Run	\$210,904	Declined
Soule, Terry	COE Comp Sci	DARPA	DARPA: Gamebreaker	\$249,490	Declined
Soule, Terry	COE Comp Sci	Idaho SGC	ISGC HEP_The Great Filter	\$25,000	Pending

10 RESEARCH SPONSORS | 24 PROPOSALS SUBMITTED
\$16,677,980 REQUESTED | \$9,592,308 AWARDED

2019

2020

2021

2022

2023

2024

\$75K BARRIE ROBISON IDAHO SBE

\$40K BARRIE ROBISON IDAHO WHEAT COMMISSION

\$74K EVA TOP IDFG

\$15K PAUL ROWLEY NSF BEACON

\$32K PAUL ROWLEY NSF BEACON

\$24K CHRISTINE PARENT NSF BEACON

\$90K ADAM JONES NSF BEACON

\$18K EVA TOP NSF BEACON

\$14K ERIC BRUGER NSF BEACON

\$1K CHRISTINE PARENT SOCIETY FOR THE STUDY OF EVOLUTION

\$130K JAMES FOSTER NSF BEACON ADMINISTRATION

\$4K BENJI OSWALD ORED

\$56K SCOTT NUISMER NSF

\$18K CHRISTINE PARENT NSF

\$6K CHRISTINE PARENT NSF

\$99K ONESMO BALEMBA DIACOMP

\$119K PAUL HOHENLOHE NIFA/USDA

\$586K ADAM JONES NSF

\$1.03M ADAM JONES NSF

\$5.8M MARSHALL MA NSF

\$1.8M DIANA MITCHELL NIH

\$19K CHRISTINE PARENT NSF

\$242K MICHAEL OVERTON HUD

\$191K EVA TOP NIH

\$36K DAVE TANK NSF

\$600K TERRY SOULE NSF

\$250K SCOTT NUISMER DTRA

\$211K TERRY SOULE NSF

\$2.5M SCOTT NUISMER NSF

\$1.3M BARRIE ROBISON NIH

\$654K LARRY FORNEY NIH

\$83K LARRY FORNEY NIH

\$500K CHRISTINE PARENT NSF

AWARDED

SUBMITTED

IBEST ACTIVE & PENDING GRANTS TIMELINE

This figure shows research grants submitted and awarded through IBEST that were active in FY20. Also shown are some of the grant proposals submitted in FY21 that have not yet been awarded.

At this stage, we quantify the research activity of IBEST using metrics that measure either research expenditures, numbers of research personnel, or usage of infrastructure. In some cases, IBEST contributes directly to priority metrics that are used by the University of Idaho to measure progress in our 10-year Strategic Plan; these metrics are indicated with a gold ribbon. 🏆

NEW AWARDS We track both the number of new awards that will be administered by IBEST each fiscal year and their total dollar amount. Awards for this year amounted to \$9,388,964.

RESEARCH EXPENDITURES This metric, which is a priority metric for the University Strategic Plan, measures the dollars spent from sponsored grants and other activities related to research. In FY20, IBEST research expenditures amounted to \$3,294,812.



NUMBER OF DOCTORAL RESEARCH STAFF This metric is also used in the University Strategic Plan and is part of the calculation for R1 status. IBEST was the administrative home to 5 doctoral research staff in FY20.



COMPUTATIONAL RESOURCES CORE USERS AND REVENUE Usage of IBEST's research computing capabilities is important to track because it helps us predict future demand on existing resources, and guide investments accordingly. Revenue by core facilities represents research activity that flows through IBEST and is related to institutional research expenditures. The CRC had 146 users and generated \$82,180 in revenue this year.

GENOMICS RESOURCES CORE USERS AND REVENUE These metrics tell us the breadth of our impact and tracking revenue helps us move towards a sustainable business model. The GRC had 27 users and generated \$222,539 in revenue in FY20.

IBEST PIs RECEIVED 11 NEW AWARDS IN FY20, TOTALING \$9,388,964 IN FY20, IBEST RESEARCH EXPENDITURES AMOUNTED TO \$3,294,812

The process of discovery and data generation are difficult to quantify. However, modern science is often associated with Big Data, which falls under the purview of the Northwest Knowledge Network (NKN). We therefore track data repositories and other metrics associated with NKN.

NORTHWEST KNOWLEDGE NETWORK USERS AND REVENUE Either through grants or our service center, NKN partners with diverse research teams to help them acquire, store, manage, and disseminate data as invaluable public research outputs. NKN leverages their growing data collection by developing interactive tools that help scientists and stakeholders discover, access, visualize, and analyze these data. NKN had 60 users and generated \$103,627 in revenue this year.

WEB APPLICATIONS NKN developed, launched, or redesigned 12 new interactive, data-driven, research-oriented web/mobile applications in FY20 including [RangeSAT](#), [MOSS Adventure Learning](#), COVID Modeling, Crop [Variety Testing Database](#), VROOM, 2020 [Northwest Climate Conference](#), [Data Science Competition](#) website, [Research Computing](#) website, [Rinker Rock Creek Ranch](#) database, and more.

MOODLE ONLINE COURSES As we have all seen this year, online learning is a valuable tool for educators, students, and workers alike. The open-source learning management system Moodle is just one of these tools that NKN utilizes. After starting out with only 200 users, the online courses now have 5,300 regular users. Moodle has proven to be such a successful tool that The Office of Wildland Fire has developed its own national version. Gina Wilson, NKN's primary course manager, has presented at a number of Wildland Fire meetings to engage stakeholders about the use and functions of the online learning systems she administers.

NKN'S MOODLE USERS INCREASED TO 5,300 IN FY20 THIS YEAR, NKN DEVELOPED 12 NEW WEB AND MOBILE APPS

DISSEMINATION

To help track the dissemination data of faculty participating in IBEST, we have partnered with Dr. Jeremy Kenyon with the University of Idaho Library. The U of I Library houses the VIVO database, which monitors publication indices and aggregate citations and other useful metadata.

PUBLICATIONS Publications are the most important metric of scientific dissemination. Reporting publications on a fiscal year basis is not particularly sensible, so we report a constantly updating set beginning with IBEST's formation as an Institute in 2011. Publications by year are shown in the table below.

CONFERENCE PRESENTATIONS We track submitted conference presentations (poster or talk). These are self-reported in aggregate by faculty, and typically do not include student presentations. 82 conference presentations were reported this year.

SOFTWARE PRODUCTS Many IBEST researchers are associated with computational disciplines. Thus, we track the deployment of software products. This year, NKN extended its expertise to launch VROOM, a mobile app developed for U of I Parking and Transportation Services to incentivize staff, students, and faculty to use alternative methods of transportation to commute to campus.

YEAR	IBEST PUBLICATIONS	TOTAL CITATIONS
2011	83	5,855
2012	110	10,263
2013	91	4,616
2014	67	2,719
2015	107	2,956
2016	107	2,539
2017	106	1,736
2018	88	911
2019	168	744
2020	100	112
TOTALS	1,027	32,451

IN FY20, TOTAL CITATIONS INCREASED BY 5,746

Research impact can be difficult to quantify. In fact, some research might not fully realize its impact until decades after publication. We can estimate impact using a variety of accepted but flawed metrics. These include citations, prestigious invitations to speak at conferences and institutions, and outcomes related to training.

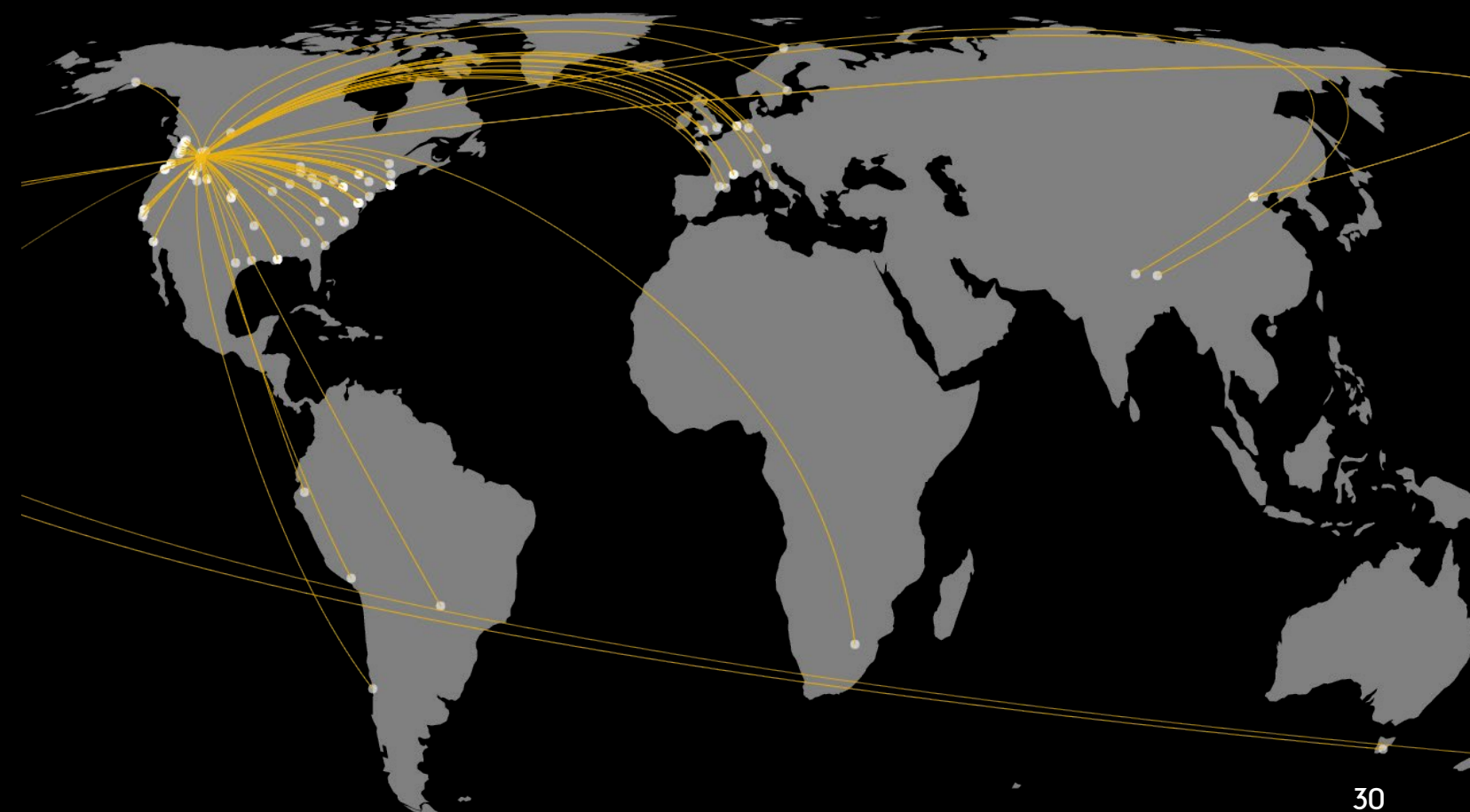
TRAINING IMPACTS This metric is a priority metric for the University 10-year Strategic Plan. Faculty who participate in IBEST report mentoring the following number of trainees in FY20:



- 48 POSTDOCTORAL RESEARCHERS
- 133 GRADUATE STUDENTS
- 145 UNDERGRADUATE RESEARCHERS

CITATIONS Working with the U of I Library, we have used the web of science database to quantify the total number of citations of publications that faculty self-report as associated with IBEST. We include only works published since 2011, the year IBEST became an Institute. This obviously omits the many publications associated with the COBRE grant that initiated IBEST. As of 2020, the 1,027 publications had been cited 32,451 times, an increase of 5,746 in the past year.

INVITED PRESENTATIONS An indication that researchers are considered thought leaders in their disciplines is invitations to speak at conferences, department seminars, or deliver keynote or other prestigious addresses. IBEST faculty report delivering 71 such presentations in FY20. The locations of the activities are represented on the map below.



IMPACT

COMPUTATIONAL RESOURCES CORE



MISSION AND VISION The mission of the Computational Resources Core (CRC) is to provide state of the art computing and data management services to our customers. Our vision is to remain technologically current in hardware, software, and services while partnering with customers to help them perform and disseminate their research in a fiscally sustainable way. Our guiding principles are to maximize the reliability, availability, and effectiveness of our services while minimizing administrative costs.

1,305,358 TOTAL CPU-HOURS USED THIS YEAR ON THE CLUSTER.

A 370% INCREASE OVER LAST YEAR.

THE EQUIVALENT OF 149 YEARS OF COMPUTING ON A SINGLE DESKTOP MACHINE.

INFRASTRUCTURE

HIGH PERFORMANCE COMPUTING The CRC has one main computer cluster for research and genomic data analyses. We have continued to add computational capacity, the main cluster now provides 2528 processor cores (up from 2080 last year) and over 13 terabytes of system memory. This year we have continued to see increased demand for GPU enabled computational infrastructure to be used for machine learning and neural network simulation. Two of the new compute nodes make modern GPU accelerated computing accessible to all our users. Cluster nodes are connected with 40Gb/s QDR Infiniband connections, providing fast, low latency data transmission for increased performance of HPC applications. We also have twelve 'standalone' servers (over 600 total cores and over 5 terabytes total system memory) for applications that require large amounts of memory on a single system but do not take advantage of the parallel cluster resources. Three of our most powerful servers in this group contain 256 times the system memory of a standard desktop (1TB or 1024GB) and are used primarily for sequence assembly of next-generation sequencing data. One of these standalone servers provides the sequence processing for the Genomic Resources Core's (GRC) new PacBio Sequel II high-throughput sequencer that was purchased in FY20.

DATA STORAGE The CRC maintains two tiers of primary storage. The first tier is comprised of fast but more expensive disk arrays, which we have expanded to 260TB. The second tier uses the Ceph open source software and has 40 servers and over 2.5 PB of hard drives. The Ceph system provides greater performance and has better self-balancing and healing properties. Additionally, we have more than 300TB disk available for data archiving and backup storage within the McClure data center. We backup regularly to servers located in the U of I Library datacenter. In addition, the core provides in-house developed solutions to maintain data integrity and restoration.

SERVICES

USER ACCOUNTS Most users select either a 'Standard' or 'Satellite' user account – which allows *carte blanche* access to specific CRC compute resources. The 'Standard' account allows for greater data storage and access to the most powerful standalone servers. We strongly feel that billing by compute time used or by unit of data stored (as cloud providers do) stifles research activity as any compute missteps become quite costly. We also offer more limited free accounts on our older compute hardware. These free accounts can still access our full software stack and are a good place for undergraduates to jump into HPC. New this year, we have started to provide HPC services to Reed College with an umbrella agreement. This new service provides simplified billing and user-management for primarily undergraduate institutions, and a new revenue stream for the CRC.

CRC EDUCATION Productive and useful interactions with our major users and project groups are a high priority for us. We regularly present updates and short workshops at weekly IBEST Lunch meetings of IBEST faculty, staff and students. These informal interactions allow us to receive and give advice, gauge customer satisfaction, and brainstorm possible future directions for strategic planning.

We offer education and training services for current and potential core users and their students. Our online documentation provides instruction on typical and advanced step-by-step workflows, how to access our systems, how to run jobs on the clusters and process the results, and how to use bioinformatics software. We also offer regular workshops on topics such as:

- Linux Command Line Basics
- HPC Cluster Computing
- Tensorflow & Machine Learning

SOFTWARE We can provide a high level of support for custom software installations due to extensive use configuration management systems. We have over 400 software modules currently installed, whereas many cores provide only limited support for software installation, which makes it difficult to replicate prior work or to test new user-developed software. This mechanism is uniform across over 120 systems, so the learning curve for users is very shallow. This mechanism also makes it possible for us to install and test new software without disrupting system availability.

SUSTAINABILITY The sustainability of the CRC over the long term will require that we maintain self-generated revenue and regain institutional financial support. User fees alone cannot maintain centers such as the CRC given their high capitalization and maintenance costs. Our goal is to support the UI research community at a minimum of expense to the end users, recovering maintenance expenses with self-generated revenue and relying on future grant funding and F&A returns to continue to replace aging hardware. To avoid costly maintenance contracts with hardware and software vendors, we rely primarily on open-source software and on commodity hardware with warranties included at the time of purchase.

RESEARCH ENABLED BY THE CRC The CRC supports research in a variety of disciplines across the University of Idaho campus and beyond. In FY2020 we supported 70 users across 20 departments.

Research subjects are quite diverse, some examples:

- Metagenomics
- Biomolecular Modeling
- Phylogenetics
- Cancer Genetics
- Dynamical Behaviors of Physical Systems
- Geodynamic Modeling
- Climatology
- Epidemiology

MAIN CLUSTER
2528 PROCESSOR CORES.
13+ TB OF SYSTEM MEMORY.

CLUSTER NODES
40GB/S QDR INFINIBAND CONNECTIONS.
FAST, LOW LATENCY DATA TRANSMISSION
FOR INCREASED PERFORMANCE OF HPC
APPLICATIONS.

STANDALONE SERVERS
12 SERVERS (600+ CORES & 5+TB OF
SYSTEM MEMORY).
300+TB DISK AVAILABLE FOR DATA
ARCHIVING AND BACKUP STORAGE.

“THE LINUX PHILOSOPHY IS ‘LAUGH IN THE FACE OF DANGER’. OOPS, WRONG ONE. ‘DO IT YOURSELF’. THAT’S IT.” - LINUS TORVALDS

“THERE ARE ONLY TWO INDUSTRIES THAT REFER TO THEIR CUSTOMERS AS ‘USERS’.” - EDWARD TUFTE

GENOMICS RESOURCES CORE

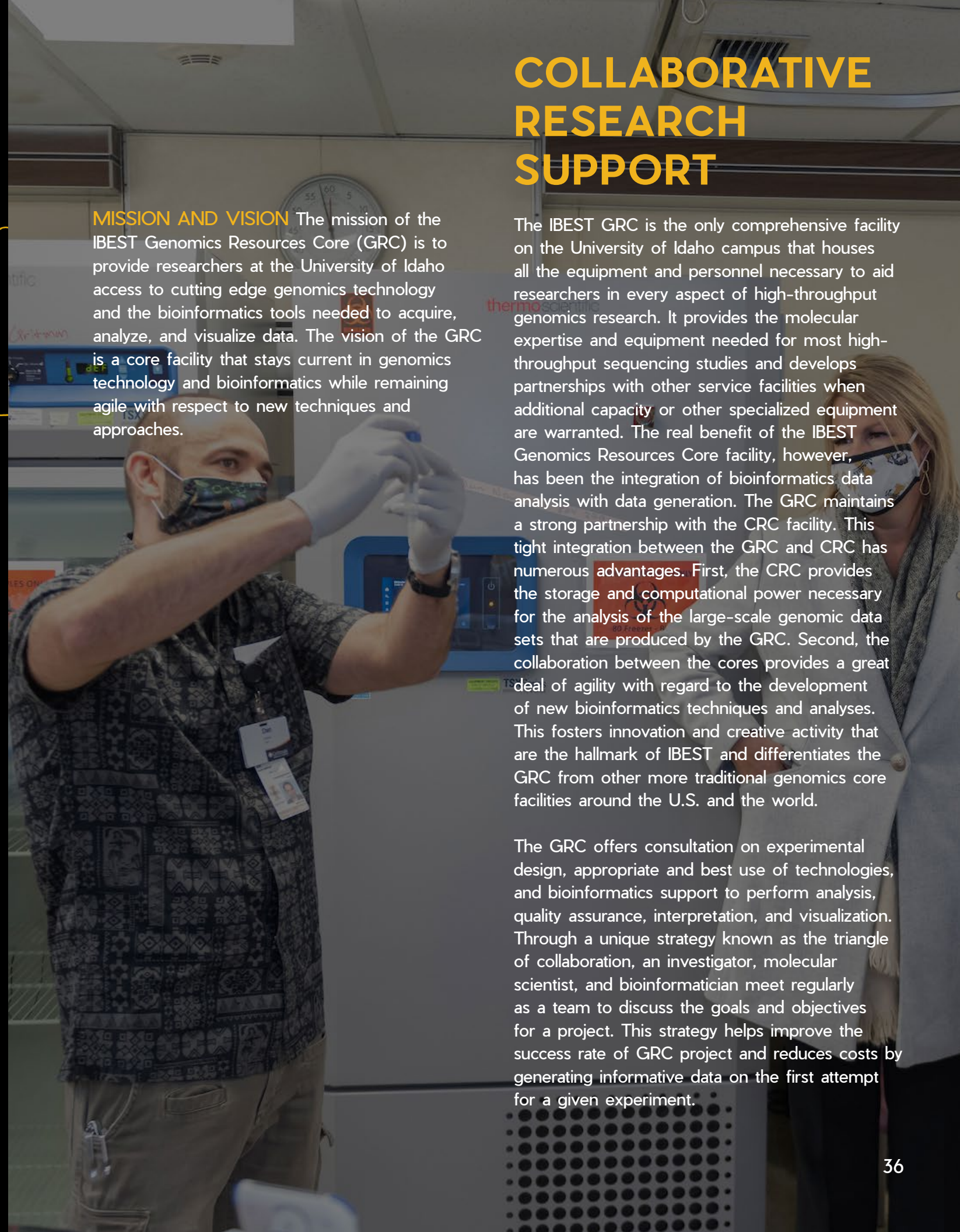


MISSION AND VISION The mission of the IBEST Genomics Resources Core (GRC) is to provide researchers at the University of Idaho access to cutting edge genomics technology and the bioinformatics tools needed to acquire, analyze, and visualize data. The vision of the GRC is a core facility that stays current in genomics technology and bioinformatics while remaining agile with respect to new techniques and approaches.

COLLABORATIVE RESEARCH SUPPORT

The IBEST GRC is the only comprehensive facility on the University of Idaho campus that houses all the equipment and personnel necessary to aid researchers in every aspect of high-throughput genomics research. It provides the molecular expertise and equipment needed for most high-throughput sequencing studies and develops partnerships with other service facilities when additional capacity or other specialized equipment are warranted. The real benefit of the IBEST Genomics Resources Core facility, however, has been the integration of bioinformatics data analysis with data generation. The GRC maintains a strong partnership with the CRC facility. This tight integration between the GRC and CRC has numerous advantages. First, the CRC provides the storage and computational power necessary for the analysis of the large-scale genomic data sets that are produced by the GRC. Second, the collaboration between the cores provides a great deal of agility with regard to the development of new bioinformatics techniques and analyses. This fosters innovation and creative activity that are the hallmark of IBEST and differentiates the GRC from other more traditional genomics core facilities around the U.S. and the world.

The GRC offers consultation on experimental design, appropriate and best use of technologies, and bioinformatics support to perform analysis, quality assurance, interpretation, and visualization. Through a unique strategy known as the triangle of collaboration, an investigator, molecular scientist, and bioinformatician meet regularly as a team to discuss the goals and objectives for a project. This strategy helps improve the success rate of GRC project and reduces costs by generating informative data on the first attempt for a given experiment.



GRC SERVICES

BIOINFORMATICS AND DATA ANALYSIS

Bioinformatics data analysis is often the most challenging aspect of any experiment. The GRC offers bioinformatics services through staff bioinformaticians and can perform a full range of analysis tasks to address questions in areas like population genomics, microbial community dynamics, differential gene expression, functional and comparative genomics, and systems biology. GRC bioinformaticians begin with raw output from genomics equipment and proceed through quality assurance, data processing and analysis, data interpretation, and visualization. Analyses are conducted using pipelines in the public domain or those developed by core staff members.

CORE PERSONNEL HAVE DEVELOPED ANALYTICAL TECHNIQUES AND PIPELINES FOR MICROBIAL COMMUNITY ANALYSIS, GENOME ASSEMBLY, TRANSCRIPTOME ASSEMBLY, POPULATION VARIANT ANALYSIS, PHYLOGENETIC ANALYSIS, SNP/INDEL DETECTION, AND RNA-SEQ ANALYSIS. THESE PIPELINES TRANSFORM AND MANIPULATE RAW DATA INTO A FORM AND FORMAT THAT CAN BE MINED BY INVESTIGATORS.

The GRC bioinformaticians seek feedback from investigators after preliminary data analysis so adjustments in output content, form, and format can be made. Data are then re-analyzed or additional analyses are performed until the project's goals are met, figures are generated, and summary tables are provided to the investigators in a form that is useful to them. The core staff provides investigators with detailed knowledge of the laboratory protocols and bioinformatics methods used so they can be included in reports and publications as needed. As a result, core staff members are often included as co-authors on publications because of their significant intellectual contributions to research projects.

PROJECT CONSULTATION Core facility staff consult with investigators to discuss project aims, expectations, experimental design, appropriate and best use of technology, sample quantity and quality issues, and data analysis needs. During consultation, a project timeline is formed, expected costs are discussed, deliverables are identified, and a user agreement is reviewed. Having these discussions early in a project provides an opportunity for core personnel to offer their expertise, advice, and assistance to enhance the proposed project and sidestep potential problems. This service is especially important to researchers developing grant proposals, where a detailed quote and sophisticated understanding of the protocols and analysis are likely to increase chances for funding and ensure accurate budgeting.

PROJECT MANAGEMENT The GRC offers genomics project management to customers by integrating services in all three phases of genomics research: project planning and consultation, genomic data generation, and bioinformatics data analysis. In contrast, most core facilities around the country focus on data generation, leaving investigators to struggle with immense data sets. Our integrated approach is unusual, and a key component to our continued success.

GENOMICS DATA GENERATION The GRC operates and maintains equipment that allows high throughput sample preparation, quality assurance, and generation of high throughput DNA/RNA sequence data. When projects require technologies that are not present in the facility, the GRC facilitates access to technology through collaboration with other regional facilities. For example, when investigators require the additional capacity provided by the Illumina HiSeq platform, the GRC staff prepares Illumina libraries that are sent to other institutions for sequencing, and the data are then sent back to the GRC for processing and analysis. The fact that the sequencing was done off-site is seamless and causes no additional work for the investigator.

RESEARCH ENABLED BY THE GRC

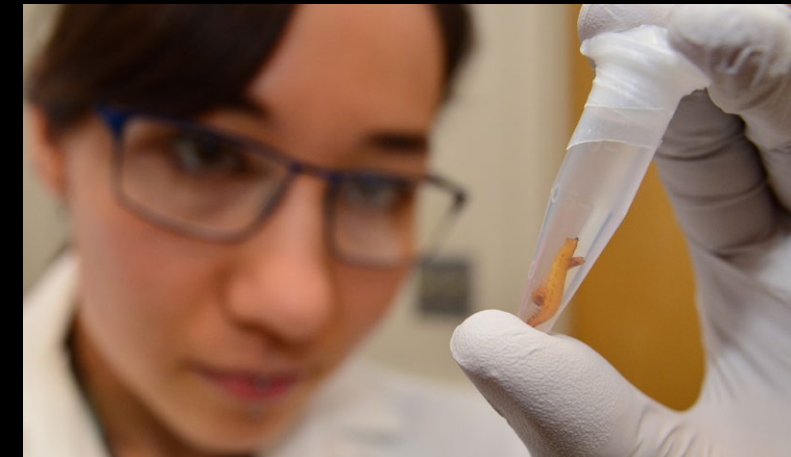
COVID TESTING LAB One of the advantages of having a comprehensive genomics facility was made clear during the COVID 19 pandemic. The GRC housed both the equipment and technical experts necessary to create a fully functional high throughput COVID testing lab in collaboration with Gritman Medical Center. Additional equipment for this lab came directly from the GRC, Hagerman Fish Culture Experiment Station, and the College of Natural Resources. Further, because the GRC collaborates broadly with the molecular biologists across campus, we were able to identify, organize and recruit part time staff for this project by working with students, technicians, and postdocs from 4 different colleges (Science, Agriculture and Life Sciences, Natural Resources, and Engineering). These individuals put in long hours to perform thousands of COVID 19 tests for the University and our local community.

MANAGING AN IDAHO PEST The GRC collaborated with researchers from multiple institutions and organizations, including the University of Idaho and the Idaho Wheat Commission, to investigate the population genomics and phylogenetics of wireworm, an important agricultural pest species for Idaho farmers. The GRC generated and analyzed genomic data from hundreds of wireworms and identified six highly divergent groups distributed across the Pacific Northwest. This information will help guide [effective management strategies](#), as each divergent wireworm group may respond differently to control measures¹.

¹ Andrews, K.R., Gerritsen, A., Rashed, A. et al. Wireworm (Coleoptera: Elateridae) genomic analysis reveals putative cryptic species, population structure, and adaptation to pest control. *Commun Biol* 3, 489 (2020). <https://doi.org/10.1038/s42003-020-01169-9>

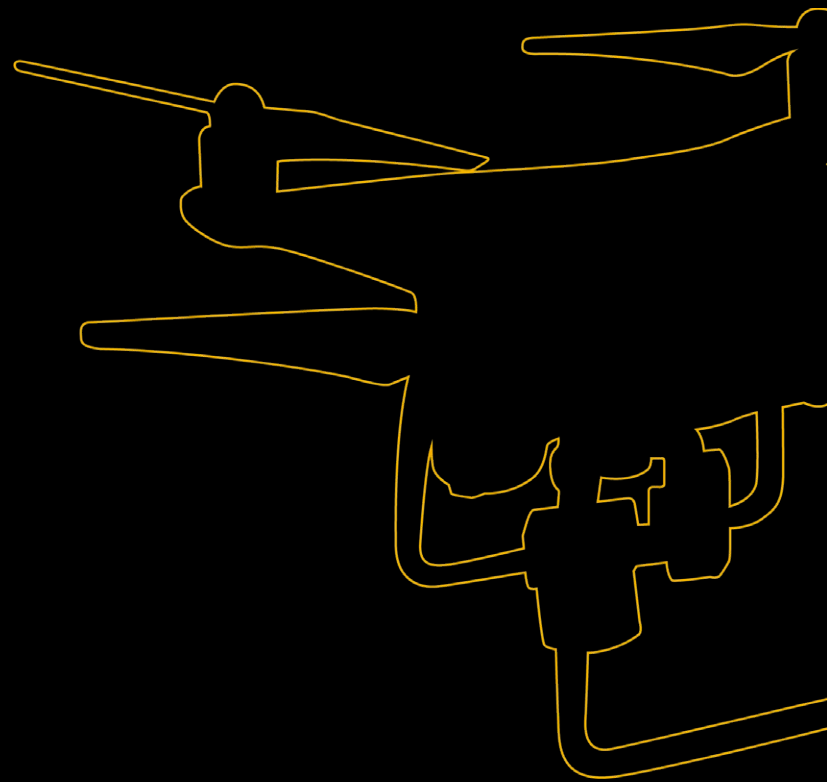


Idaho's Governor and Board of Education President visiting the COVID-19 testing lab



Alida Gerritsen inspecting wireworms

NORTHWEST KNOWLEDGE NETWORK



MISSION AND VISION Northwest Knowledge Network's (NKN) mission is to accelerate the transformation of research data into knowledge by making transdisciplinary research data more findable, accessible, interoperable and re-usable by supporting full end-to-end Data Lifecycle Management. Our vision is to accelerate the pace of scientific discovery by becoming a leading interactive Data Observatory, enabling seamless access to vast, interoperable, and transdisciplinary research data.

INFRASTRUCTURE

NKN maintains infrastructure in two datacenters in Idaho: one at the U of I Library in Moscow and another at the Idaho National Laboratory (INL) in Idaho Falls. These two facilities are connected at 10 gigabit-per-second (Gbps) speeds through the Idaho Regional Optical Network. Each server cluster consists of a small number of enterprise-grade servers that are directly interconnected over a local dedicated 10Gbps managed switch. All NKN servers utilize a dedicated, multi-path, high-performance storage fabric populated with NetApp FAS 2554 storage arrays. In total, NKN manages more than a petabyte of storage between U of I and INL that can be easily expanded to several PB without additional investments in auxiliary cyberinfrastructure.

Both server clusters are configured in a flexible, highly virtualized environment using the commercial VMWare vSphere/ESXi hypervisor that allows for dynamic resource provisioning and allocation, monitoring, and remote administration. Research data is replicated between clusters for the purposes of redundancy, disaster recovery, and load balancing. NKN virtual machines can also take advantage of a separate high-performance Science DMZ network, providing unfettered access to NKN's large data collections.

NKN currently manages over 100 virtual machines (VMs) for a variety of purposes, installed with Red Hat Enterprise Linux 6/7, CentOS 7, or Windows Server 2008/2012 operating systems. The core NKN services provided by these virtual servers include project-specific web applications, multiple ESRI ArcGIS geospatial servers, file sharing servers, dedicated data transfer nodes (DTNs), the [NKN data sharing portal](#), private cloud storage, metadata harvesting, web servers, database servers, THREDDS/OPeNDAP, and various development and testing servers.

NKN is actively engaged with national and international scientific data management initiatives such as DataONE, CUAHSI, EarthCube, and ESIP. NKN operates a member node in the DataONE federation, connecting our data observatory to data repositories across the globe. Through our involvement, data published at NKN can be automatically replicated to other DataONE member nodes, increasing the exposure, resiliency, accessibility, and discoverability of these data. NKN contributes datasets and over 5TB of storage capacity to the growing DataONE network.

In addition, NKN provisions and hosts dedicated virtual machine servers to research projects in order to extend delegated, controlled access to our compute and storage infrastructure. In many cases, this allows research projects to manage their virtual server environments to meet their project needs without having to purchase and manage their own physical hardware.

All NKN server, network, and storage infrastructure is administered by dedicated NKN systems administrators that work in collaboration with the IBEST CRC, U of I Information Technology Services (ITS), INL, and IRON technical personnel. New NSF-funded network infrastructure upgrades ensure that NKN servers and data can be accessed at 10 Gbps network speeds to provide virtual server access to any location with similar network capabilities.

PROJECTS AND ACTIVITIES

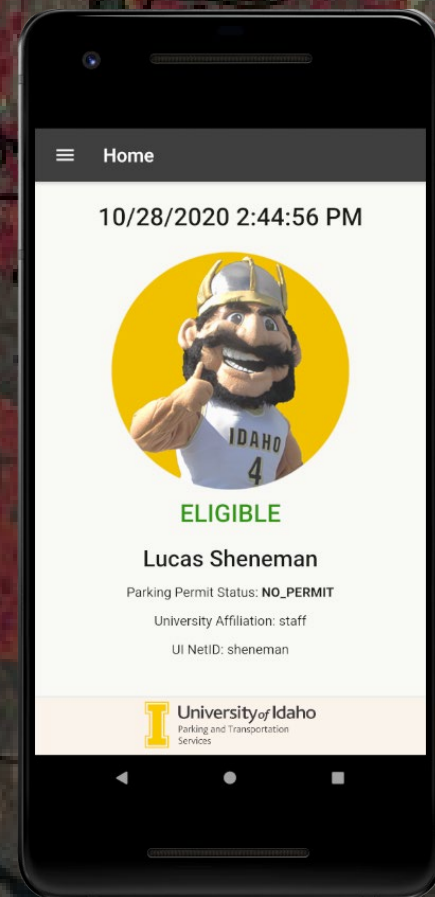
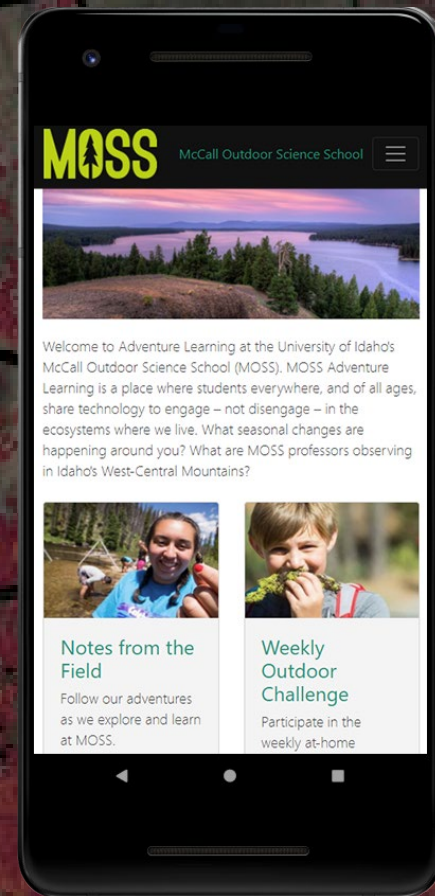
While there were considerable challenges in 2020 due to university budget constraints and the COVID-19 pandemic, the IBEST Northwest Knowledge Network (NKN) team helped meet these challenges in notable ways.

COVID-19 MODELING AND VISUALIZATION

NKN staff have been involved with important COVID-19 modeling and data visualization efforts in collaboration with the Institute for Modeling, Collaboration and Innovation (IMCI). This team effort with IMCI has helped researchers and U of I leadership better understand and respond to the dynamics and risks from COVID-19 in our region. NKN hosts and co-developed the Idaho Pandemic Modeling website.

ONLINE LEARNING Restrictions stemming from the pandemic completely disrupted the normal outdoor classroom experience at the [McCall Outdoor Science School](#) (MOSS). Early in 2020, MOSS engaged the NKN web development team to substantially re-tool the MOSS Adventure Learning website in order to provide a compelling online outdoor classroom experience for students throughout Idaho who could not attend MOSS in person.

As much of the U.S. was under some form of COVID-19 work restriction during portions of 2020, the use and demand for online courses surged dramatically. Many of the educational courses used by the wildland fire management and research community shifted to an online format in 2020. NKN either hosts or administers significant portions of the online wildland fire courses used in all 50 states. Web developer Gina Wilson responded by shifting her entire effort to meet the acute demand for these important online educational resources.



RESEARCH COMPUTING COORDINATION In 2020, NKN continued to help facilitate research computing coordination at the University of Idaho and across the state. NKN lead the development of the [U of I Research Computing website](#) that serves as a central catalog of institutional research computing resources.

NKN worked closely with research computing colleagues at Boise State University and Idaho State University on a pilot project to deploy shared data storage infrastructure within the Collaborative Computing Center (C3) at the Idaho National Laboratory. All three universities effectively extended their campus networks into the C3 facility in Idaho Falls and physically and securely connected them to a single NKN data storage system. This is the first known situation where all three of Idaho's research institutions are physically connected in such a direct way. Preliminary performance testing is underway, with the expectation that this shared storage system will facilitate direct sharing of research data between ISU, BSU, and U of I for the statewide NSF EPSCoR GEM3 project.

DATA DRIVEN TOOLS In FY20, Jennifer Hinds from NKN worked with U of I researchers Drs. Vincent Jansen, Jason Karl, Roger Lew, and Crystal Kolden to design and deploy [RangeSAT](#), an interactive graphical web application that incorporates satellite remote sensing and gridded meteorological data to better understand the impact of grazing patterns on specific cattle pastures. Jennifer developed the responsive and interactive geospatial mapping components and graphing tools. This important project is hosted at NKN, was funded from the USDA and The Natural Conservancy.

MOBILE APPLICATION DEVELOPMENT In FY20, NKN extended its capability and in-house expertise to design, build and launch interactive research-oriented mobile applications for both the Apple iOS and Google Android mobile platforms. In addition to prior citizen science mobile apps developed in FY19, NKN successfully completed and deployed VROOM, a mobile app developed for the U of I Parking and Transportation

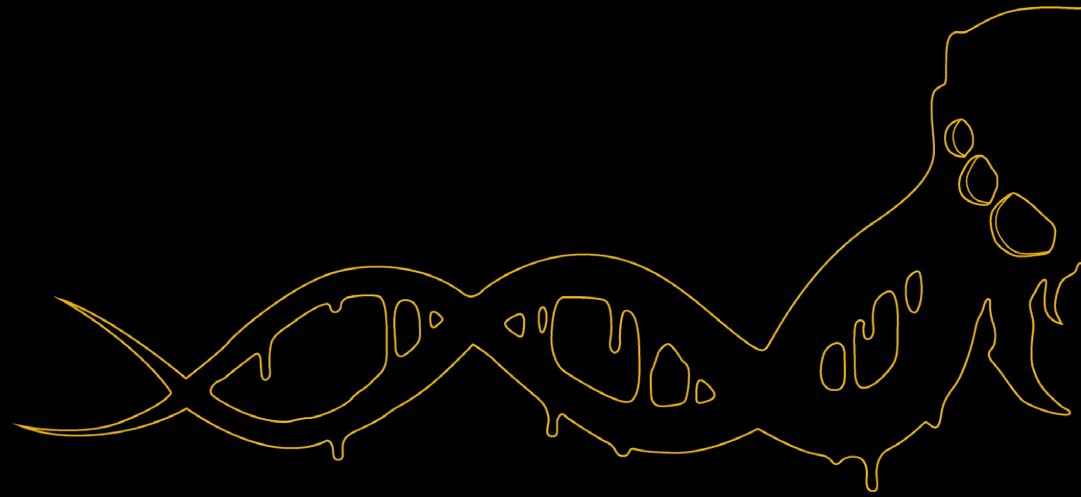
Services (PTS) unit to incentivize U of I staff, students, and faculty to use alternative methods of transportation to commute to campus. The app has both a mobile interface component and a backend database and API endpoint which are hosted at NKN. VROOM has been published on both the Apple App and Google Play stores. NOTE: Due to concerns around launching the app during COVID-19 restrictions, the app is temporarily unavailable for download and use.

HIGHLIGHTING UNDERGRADUATE RESEARCH NKN developed and launched the [Idaho Spotlight on Undergraduate Research Experiences](#) (ISURE) web application.

ISURE is a collaboration with Drs. Holly Wichman, Jim Bull, and Mark Nielsen along with the U of I Office of Undergraduate Research. The project allows undergraduate researchers at the U of I to autonomously login using their U of I credentials and provide detail and visualizations that show off their impressive research using an interactive content management system (CMS). The site has been exceptionally well-received and used by dozens of undergraduates as a way to promote and increase exposure to their work. It is also a valuable recruiting tool, demonstrating to would-be Vandals the caliber of undergraduate research occurring at the U of I. The site, hosted by NKN, is actively promoted by the U of I Office of Undergraduate Research.

RINKER ROCK CREEK RANCH DATABASE Rock Creek Ranch (RCR) near Hailey, Idaho provides a unique opportunity to establish a long-term monitoring program that can be used to support current and future research objectives and provide long-term information regarding rangeland challenges and opportunities in the Northern Basin and Range and Snake River Plain ecoregions. NKN worked with Dr. Tracey Johnson to deploy a data-driven web interface for managing and sharing Water and Forage monitoring data for the U of I's Rinker Rock Creek Ranch.

POLYMORPHIC GAMES



MISSION AND VISION [Polymorphic Games](#) is an experimental video game development studio. Our studio employs interdisciplinary teams of undergraduate students to create compelling and fun video games that are based on scientific models.



PUBLISHED GAMES

DARWIN'S DEMONS Polymorphic Games' first project was a space shooter game inspired by Space Invaders. In Darwin's Demons, the player battles an evolving population of aliens. The aliens' traits are encoded by a digital genome and the fittest enemies reproduce to create the next generation. Over time, the population of enemies adapts to the player's strategy. Players can choose from a wide range of ships and secondary equipment, which increases player interest and serves to drive evolution along different trajectories. [Darwin's Demons was released for sale](#) on Valve's Steam platform on February 13, 2017 (the Monday after Darwin Day). Darwin's Demons was the first commercially released video game to fully feature evolving enemies. We have used Darwin's Demons in middle school classrooms to teach hypothesis testing, and students in Biology 315 (Genetics Lab) have used the game to test hypotheses about quantitative and evolutionary genetics.

PROJECT HASTUR Polymorphic Games' second commercial release was an [evolutionary tower defense game](#). Project Hastur features fully realized 3D game environments and enemies. Game enemies are encoded by a digital genome, and mutations of this genome can produce a startling array of phenotypes. In Project Hastur, the player can play through a campaign that features 14 unique maps that unlock a series of defensive capabilities. The game features its own story, a wide variety of upgrade choices, and many fun Easter eggs about evolution. For Project Hastur, our student developers created a method for evolutionary procedural generation of game enemies. All of the creatures in the game have the same architecture of their digital genomes. These genomes are converted in the Unity Engine to different morphologies, behaviors, colors, and other game traits. This technique evolves original game content as the game progresses rather than relying on preprogrammed scripts—an innovative programming approach developed by our studio.

STEM EDUCATION We were motivated to create Polymorphic Games by the idea that evolution makes a game better – more compelling and more fun – because the game adapts to the player. This approach represents a positive combination of STEM engagement and informal learning.

Project Hastur and Darwin's Demons both feature **EXPERIMENT MODE**, in which the evolutionary parameters can be altered. This feature has numerous benefits – it allows exploration of the evolutionary system on which the game is built and allows the player to autonomously test cause and effect as they adjust parameters.

UNDERGRADUATE TRAINING Polymorphic Games employs a unique development approach, in which undergraduates from a wide range of disciplines (including Computer Science, Virtual Technology and Design, Biology, English, Theater, Education, Business, and Music) collaborate to create video games that incorporate evolution as a core game mechanic.

VISUALIZATIONS AND SCIENTIFIC COLLABORATION Using game engine technology to conduct experimental biology. In collaboration with Dr. Adam Jones and his student [Bernadette Johnson](#), our studio created an animated digital representation of a killifish. The Jones lab used this to test for female color preference¹.

Demonstrating the power of transmissible vaccines. In collaboration with Dr. Scott Nuismer, Polymorphic Games created an [animated and interactive visualization](#) that demonstrates the potential for transmissible vaccines prevent zoonotic disease.

¹ Johnson, B.D., Fox, A., Wright, L.R., Carney, G.E., Robison, B.D., Jones, A.G. *Nothobranchius furzeri* as an emerging model for mate choice: female choice revealed by animations. *Behaviour* 158, 1 (2020). <https://doi.org/10.1163/1568539X-bja10052>

ACTIVE PROJECTS

THE BIOLOGY OF TICK-BORNE DISEASE Polymorphic Games is collaborating on a large new grant that will study Tick Borne Diseases. The grant, led by Dr. Marshall Ma from the Department of Computer Science, involves collaborators from the U of I, Dartmouth University, and the University of Nevada Reno. Polymorphic Games will develop games and visualizations that help with education and outreach regarding the biology of vector borne disease.

EVOLVY BUGS This new version of Darwin's Demons will bring evolutionary procedural content generation into the world of mobile gaming. As with our previous games, Darwin's Demons Mobile will use the evolutionary models to evolve original game content as the game progresses rather than relying on pre-programmed content. EvolvY Bugs is a more whimsical take on the space shooter genre, but make no mistake, it is built upon published models of quantitative trait evolution and sexual selection. Kristen Martinet, a BCB PhD student studying under Dr. Luke Harmon, is using EvolvY Bugs to study sexual selection and the evolution of female choice.



2020 NEWS HIGHLIGHTS

A NEW VISION FOR VARIETY TESTING JUNE 16, 2020

If you're like me, you don't often stop to think about where your food comes from or the effort it takes to get it onto your dinner plate. For many of us, agriculture is a parallel world to the one we live in. It's a massive industry that goes unnoticed, even if we pass by grain storage facilities on our daily commute.

Three University of Idaho experts are working to convey the importance of this unseen world with a seemingly innocuous project—a database to store crop variety testing information. This database will become a key tool for both growers making planting decisions and researchers who need detailed agricultural information.

The team has been met with an array of challenges. Preparing data for the site is laborious and requires a substantial amount of knowledge. Maintaining communication and collaboration between disciplines is essential. Finding a common denominator for the data is key. Dr. Jennifer Hinds says, "It's a struggle to design a structure that can be robust but forces everyone to play into it in a consistent fashion. You need to have constant communication so you can design a database that's going to be the best for users." But through all these challenges, the hardest part might be just [getting people to listen](#).

BACTERIAL EVOLUTION IN BIOFILM MAY 11, 2020

In the midst of a global health crisis, the researchers in Dr. Eva Top's lab are studying another crisis that may be just as serious. There are projections that by 2050, there could be more people dying from antibiotic resistant bacteria than from cancer.

This issue is not a new one. Though antibiotics have saved millions of lives, as soon as we began using them, bacteria began to adapt and develop resistance. Additionally, the pipeline of new antibiotics is running dry, and the more we use antibiotics, the more bacteria become resistant to them.

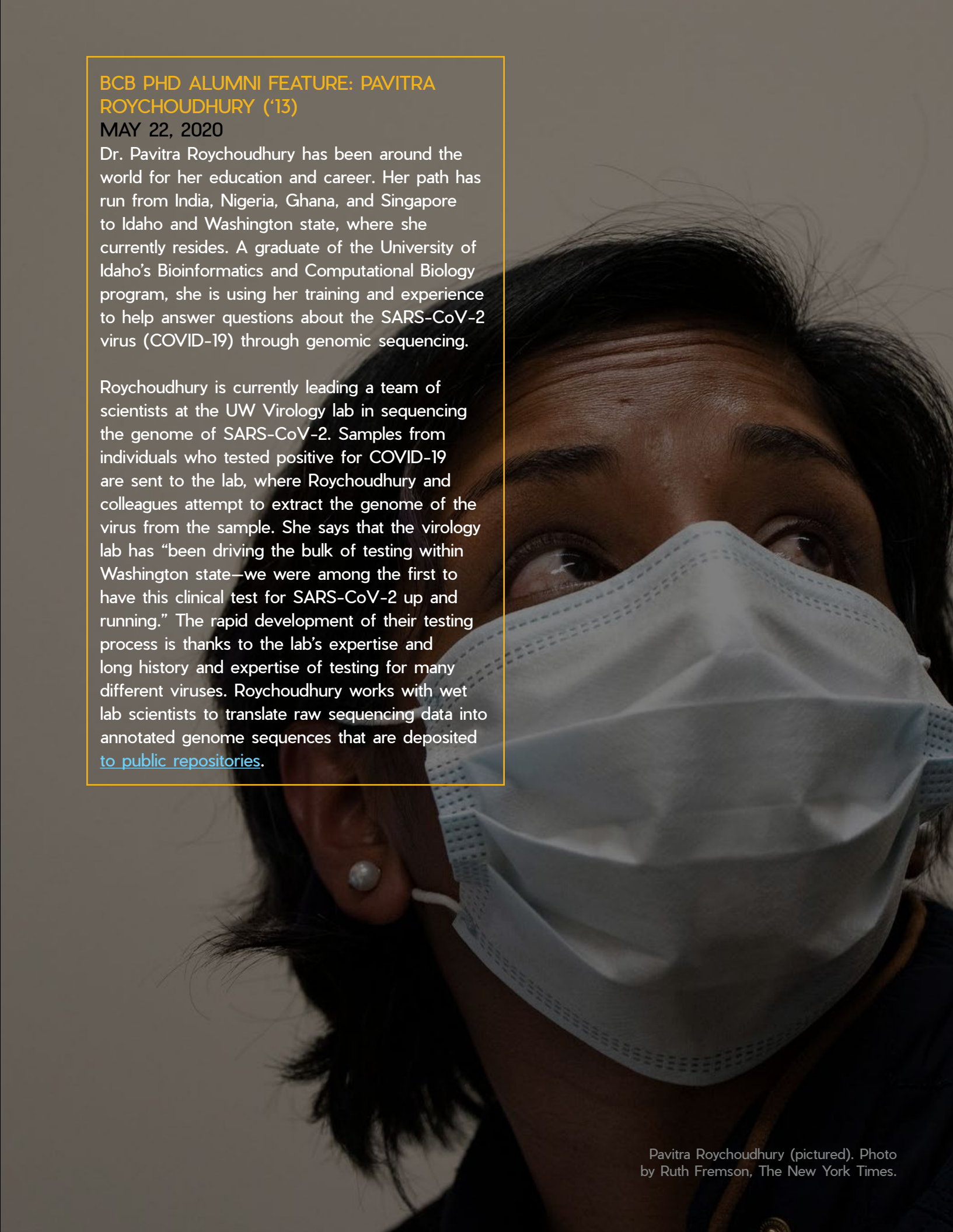
Trying to find a solution, the Top lab members, including Research Support Scientist Dr. Thibault Stalder, specialize in the study of multi-drug resistant plasmids in bacteria. Stalder was the lead author on a paper published in *Molecular Biology and Evolution* on February 6 that questions how the evolution of plasmids and bacteria is affected when grown in biofilm. Plasmids are mobile genetic elements contained in bacteria; they can carry genes that confer resistance to antibiotics and are a main driver of the [current antibiotic resistance crisis](#).

BCB PHD ALUMNI FEATURE: PAVITRA ROYCHOUDHURY ('13)

MAY 22, 2020

Dr. Pavitra Roychoudhury has been around the world for her education and career. Her path has run from India, Nigeria, Ghana, and Singapore to Idaho and Washington state, where she currently resides. A graduate of the University of Idaho's Bioinformatics and Computational Biology program, she is using her training and experience to help answer questions about the SARS-CoV-2 virus (COVID-19) through genomic sequencing.

Roychoudhury is currently leading a team of scientists at the UW Virology lab in sequencing the genome of SARS-CoV-2. Samples from individuals who tested positive for COVID-19 are sent to the lab, where Roychoudhury and colleagues attempt to extract the genome of the virus from the sample. She says that the virology lab has "been driving the bulk of testing within Washington state—we were among the first to have this clinical test for SARS-CoV-2 up and running." The rapid development of their testing process is thanks to the lab's expertise and long history and expertise of testing for many different viruses. Roychoudhury works with wet lab scientists to translate raw sequencing data into annotated genome sequences that are deposited [to public repositories](#).



DOMESTIC SHEEP SWABBED FOR MOVI BACTERIA

OCTOBER 22, 2019

Wrestling sheep on a cold morning in order to swab their noses may sound strange, but what researchers learn from these swabs could help protect the sheep in the long run.

Dr. Kim Andrews from the GRC took nasal swabs from over 75 young sheep on October 17, with the help of the University of Idaho Sheep Center team and Dr. Thibault Stalder from Dr. Eva Top's lab. These samples will soon be tested for *Mycoplasma ovipneumoniae* (Movi). This is the beginning of a study that aims to eventually aid in the creation of a vaccine to protect sheep against the Movi bacteria.

Movi is a respiratory pathogen that affects domestic sheep and goats, as well as bighorn sheep and mountain goats. It can cause primary atypical pneumonia and make infected animals more susceptible to secondary pneumonia. Andrews is part of a study being conducted on the Movi bacteria, investigating how it affects domestic and bighorn sheep. This trip to the U of I Sheep Center was to gather some of the preliminary data for the study. Next, the collected samples will be tested for [different strains of Movi](#).



U of I Sheep Center staff preparing to help swab the noses of sheep.

BCB PHD ALUMNI FEATURE: KENETTA NUNN ('20) FEBRUARY 3, 2020

When she started her path on higher education, Dr. Kenetta Nunn wanted to go to medical school. She got her bachelor's degree in biology from Duke University, going the pre-med route, but after working in two different jobs, she realized that research appealed to her more than medical school did.

Nunn's work is centered around the link between estrogen and the vaginal community. She discovered during her master's work that HIV could be trapped in vaginal mucus in some women but was freely moving in others, meaning that viruses would either quickly enter human cells and infect them, or move more slowly, reducing the risk of infection. "We noticed that there are differences in the composition of the vaginal microbiome between those women that could trap viruses and versus those that could not." She is now trying to decipher the relationship between these two facts. She wants to know more about the differences in women's vaginal microbiome, what drives those differences, how they relate to estrogen levels, and what all this means for women's risk for disease.

One of Nunn's accomplishments during her time at the U of I was the "B in your V" study she led from design and completion. She affirmed, "It's a lot of work for a grad student, but it's something I really enjoy. I also enjoy talking to people, so interacting with the women that participated in the study was a lot of fun, and [an escape from the lab](#)."

GETTING THE TIMING RIGHT NOVEMBER 21, 2019

Undergraduate researcher Courtney Schreiner just had her first lead authored paper published in the British Ecological Society's Journal of Applied Ecology no small feat for an undergraduate student. Dr. Scott Nuismer and Dr. Andrew Basinski, a postdoc researcher in Nuismer's lab, co-authored the paper as well. Schreiner, a mathematics major, has been with Nuismer's lab since her freshman year at U of I, and is looking to pursue a doctoral degree once she graduates.

Schreiner's paper entails her research on the timing of vaccinations for wildlife populations. As she found, vaccine timing does matter, and it is most effective at the end of a population's breeding season. The results were determined through the analysis of mathematical models and computer simulations, which are the focus of Schreiner's research. Many infectious diseases in humans and domesticated animals come from wildlife populations, hence the importance of [studies like these](#).

SATELLITES ON THE HOMESTEAD DECEMBER 2, 2019

Ranchers have used farming tools for hundreds of years to manage their land, but now they're using a more unconventional tool—satellites. The RangeSAT project is a collection of user-based web tools for ranchers & land managers that aims to improve land management practices for grazing. It uses vegetation information from satellite imagery to help farmers sustainably graze their livestock.

This project embodies collaboration between researchers, ranchers, and organizations in many fields. Northwest Knowledge Network's Research Application Architect Dr. Jenifer Hinds is taking on the creation of the web tools along with Dr. Roger Lew from the Virtual Technology and Design Program in the College of Art & Architecture. Drs. Vincent Jansen, Jason Karl, and Crystal Kolden represent the College of Natural Resources Department of Forest, Rangeland and Fire Sciences, and are involved in researching and gathering data. The Nature Conservancy (TNC) is also a partner of this project, dedicated to helping ranchers make [sustainable grazing decisions](#).

MOODLE: NKN'S ONLINE LEARNING MANAGEMENT MARCH 30, 2020

As we have all seen the past few weeks, online learning can be a valuable tool for educators, students, and workers alike. The open source learning management system Moodle is just one of these tools that U of I's Northwest Knowledge Network (NKN) utilizes.

In 2012, before she came to work as web developer for NKN, Gina Wilson was working on a grant with Dr. Eva Strand in the Department of Fire Sciences, College of Natural Resources. The grant's main focus was technology transfer of wildland fire scientific knowledge, which involved helping develop decision support tools and providing science application services to the interagency wildland fire community. It also included the delivery and maintenance of online training course for this community which includes the US Forest Service, the Bureau of Land Management, and the National Parks Service. The commercial online platforms that the departments used for training at the time charged by the user—and with around 1,000 users for each course, this was a very costly option. In looking at open source alternatives, Wilson and her colleagues found Moodle. She says, "at the time, I wasn't working for NKN, but NKN was providing server support for the project that I was on. We transferred everything over from the proprietary software, put our courses on the Moodle LMS, hosted on NKN servers, and were able to start using courses and registering students within a very short time. It has continued to grow from there." NKN now manages Moodle courses, but this project is something that Gina brought with her [when she joined NKN](#).

BCB PHD ALUMNI STORY: HANNAH MARX ('16)
MARCH 9, 2020

In the summer of 2005, Dr. Hannah Marx worked as a waitress in the Sawtooth Mountains of central Idaho. She loved hiking in her time off and says, "I was fascinated with the plants I was absorbing." When she returned to the University of Washington for her second year of college, she took a plant identification course to learn more about the plants she saw. "From there, I fell in love with botany. I got increasingly interested in central Idaho, which is where I ended up doing all my fieldwork when I came to the University of Idaho."

Even while attending school at UW, Marx quickly formed a connection to Idaho. She was taught by professor Richard Olmstead, who at the time was Dave Tank's PhD advisor. Marx says she and Tank "barely overlapped; he left for a postdoc just as I was starting to do undergraduate research with Dr. Olmstead." But after deciding to pursue graduate research, she connected with Tank again, and joined his lab at the University of Idaho. "I came to Idaho to work with Dave, and because of the location. It was close to the Sawtooths, where I wanted to eventually return to do my research, because that was the area that [inspired me in the first place](#)."



Hannah Marx on a collecting trip in the Sawtooth Mountains

