

NDSU

OFFICE OF
RESEARCH AND CREATIVE ACTIVITY

NORTH DAKOTA INTERIM HIGHER EDUCATION COMMITTEE
RESEARCH HIGHLIGHTS

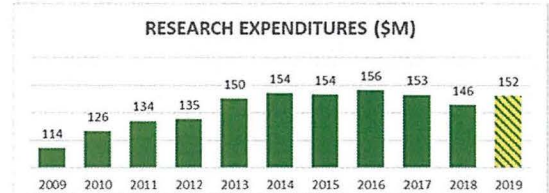
FEBRUARY 20, 2020

NSF HIGHER EDUCATION RESEARCH & DEVELOPMENT HERD SURVEY

The National Science Foundation Higher Education Research and Development (HERD) Survey collects information on R&D expenditures by field of research. Research expenditures are the money spent on creative work undertaken to increase the stock of knowledge and the use of this knowledge to devise new applications.



NDSU has grown in research expenditures since 2009, increasing 33% over the past decade from \$114 million to \$152 million*.



*2019 amount submitted but not verified

FY 2018 Total Research Expenditures: \$145,669,000

FY 2018 NSF HERD Survey Rankings for NDSU

- 138 among 646 institutions overall
- 94 among 408 public institutions
- 110 among 632 non-medical school R&D Expenditures

NDSU ranks in the top 100 in the following fields of research

- Agricultural Sciences
- Business Management and Business
- Communications
- Computer Sciences
- Natural Resources and Conservation Science
- Political Science and Government
- Social Sciences
- Sociology, Demography, and Population Studies
- Visual and Performing Arts

NDSU ranks for federally-financed expenditures

- Department of Agriculture 39
- National Science Foundation 133
- Department of Energy 153
- Department of Health and Human Services 194
- Department of Defense 224
- National Aeronautics and Space Administration 277

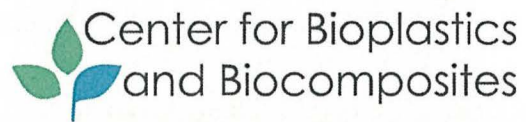
MATERIALS

With a holistic approach, NDSU is creating coatings and new materials, developing new products from the biowaste of other processes, adding selectable biodegradability, and exploring new uses for North Dakota commodities. This research results in a smaller carbon footprint while it diversifies the economy. Many of these discoveries have already been commercialized and are in productive use by industry.

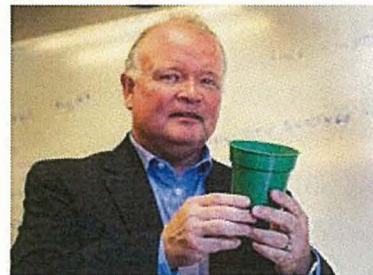
NDSU's integrated materials laboratories facilitate the rapid discovery of biologically-active coatings and materials that can withstand harsh conditions such as marine salt, biofilm infection, barnacles, desert heat, and extreme cold to limit the environmental damage to which they are applied.

NDSU is one of only six universities in the U.S. that offers programs in coatings and polymeric materials and it provides the only academic research program in North America solely focused on organic polymer coatings. The program actively pursues collaborations with other academic institutions, national laboratories, and corporations.

THE CENTER FOR BIOPLASTICS AND BIOCUMPOSITES (CB²) is a National Science Foundation Industry & University Cooperative Research Center (I/UCRC) that focuses on developing high-value biobased products from agricultural and forestry feedstocks.



CB² sites are located at NDSU, Iowa State University, Washington State University, and the University of Georgia. NDSU was selected as the lead site based upon the institution's long history of sustainable materials research and the strength of industry partnerships. Both Iowa State and WSU are in a unique position to successfully develop and operate a bioplastics center. Iowa State is an established leader in the area of biobased products and WSU has a strong history of research and inventions in natural fiber polymer composites. By bringing together their expertise, the center will be able to successfully transfer their ideas, results and technology to the U.S. plastics industry.



CB² Director David Grewell, PhD

Current CB² Industry Members

Companies and organizations interested in bioplastics and biocomposites are invited to join CB² to leverage research and development efforts through the center's projects, receiving access to technologies developed by the center and having access to scientists and undergraduate and graduate students for future employment. Industry members pay a membership fee.



Faculty from all four CB² University sites are encouraged to submit proposals annually and the Industry Advisory Board submits seed concepts which faculty use as the starting point for their research proposals. The faculty's research proposals are designed to address a seed concept and should be focused on helping the industry as a whole rather than a certain specific industry partner.

CB² Projects Recently Awarded at NDSU

- \$44,800 for "Investigating Root Cause and Reduce Fogging Behavior of Natural Fiber Filled Thermoplastics" Ali Amiri, Chad Ulven (Mechanical)
- \$32,013 for "Moisture Sensitivity of PLA/PBS Blends During Ultrasonic and FDM Welding" David Grewell, Lokesh Narayanan (IME)
- \$58,463 for "Plant Oil Based Latex Adhesives" Andriy Voronov, Ghasideh Pourhashem (Coatings and Polymeric Materials)

ELINOR COATINGS, LLC was co-founded by NDSU professor Dante Battocchi, PhD, who studies galvanic corrosion and specialty coatings. Battocchi started with the goal of providing greener, safer, and better protection. Elinor Coatings produces anticorrosion coatings and metal protection solutions for the Department of Defense and private industry. The company specializes in studying galvanic corrosion and surface protection of non-ferrous metals, such as aluminum, magnesium, bronze and multi-metal substrates.



Elinor Coatings engineers solutions for the various poisons, toxins and carcinogens currently used in alloys and has developed products to protect aluminum and bronze assets in addition to waterfront equipment from invasive species like zebra mussels.

Elinor Coatings recently received a \$3.2 million Air Force subcontract to support the development of protective coatings for the nation's aircraft. U.S. Senator John Hoeven secured funding in the Fiscal Year 2019 budget to support the research, and he connected Elinor Coatings with Air Force officials at the University of Dayton Research Institute and the Air Force Research Lab at Wright Patterson Air Force Base.

"ELINOR COATINGS' TECHNOLOGY SHOWED CLEAR BENEFITS FOR THE NATION'S MILITARY VESSELS, AMONG ITS MANY OTHER APPLICATIONS. THAT'S WHY WE WORKED TO CONNECT THEM WITH THE AIR FORCE AND SECURE A CONTRACT THAT WILL SERVE AS A MAJOR SUPPORT IN THE COMPANY'S FUTURE GROWTH."

U.S. SENATOR JOHN HOEVEN



DEPARTMENT OF DEFENSE PROJECTS underway at NDSU include corrosion and anti-fouling studies and bioplastic products development. These have been historically strong areas for NDSU research and feature specialists from the departments of Coatings and Polymeric Materials, Engineering, and Chemistry.



ANTI-CORROSION: INTEGRATED CORROSION TESTING SYSTEM

NDSU's current research tests several coating systems to maximize performance. Industry partner Pittsburgh Plate Glass (PPG Industries) prepares samples for evaluation according to military and industry standards and NDSU performs performance testing and materials research to provide technical data and technology improvements.

Future research directions into improved powder coating systems for military and industrial use are planned. With corrosion performance improvements to improve corrosion performance, as measured by salt spray, will be targeted.



Corrosion on a Navy ship, National Geographic

ANTI-CORROSION: MULTI-SUBSTRATE PAINT ADHESION IMPROVEMENT

When military assets undergo maintenance in an industrial depot, coating systems are brought back up to specification. Many military topcoats are not sufficiently flexible to pass standard adhesion tests when applied to flexible materials because they were not designed to adhere to adhesives and sealants. Improvements in adhesion and flexibility are needed to permit several coatings to work with joined flexible substrates.



NDSU engineers state of the art industrial coatings for application to flexible substrates, composites, and adhesive joints. Changes to industrial, dual-use (military-civilian), and military coatings will improve adhesion to the materials from the baseline.

BIOFOULING: RELEASE COATINGS

This project is a continuation of a long standing research collaboration with the U.S. Navy to design and develop low toxicity marine coatings for combating biofouling on naval ships and other seafaring vessels. A primary emphasis of this program is the acquisition and custom development of robotic tools and automated laboratory equipment to accelerate research and discovery of new low toxicity marine

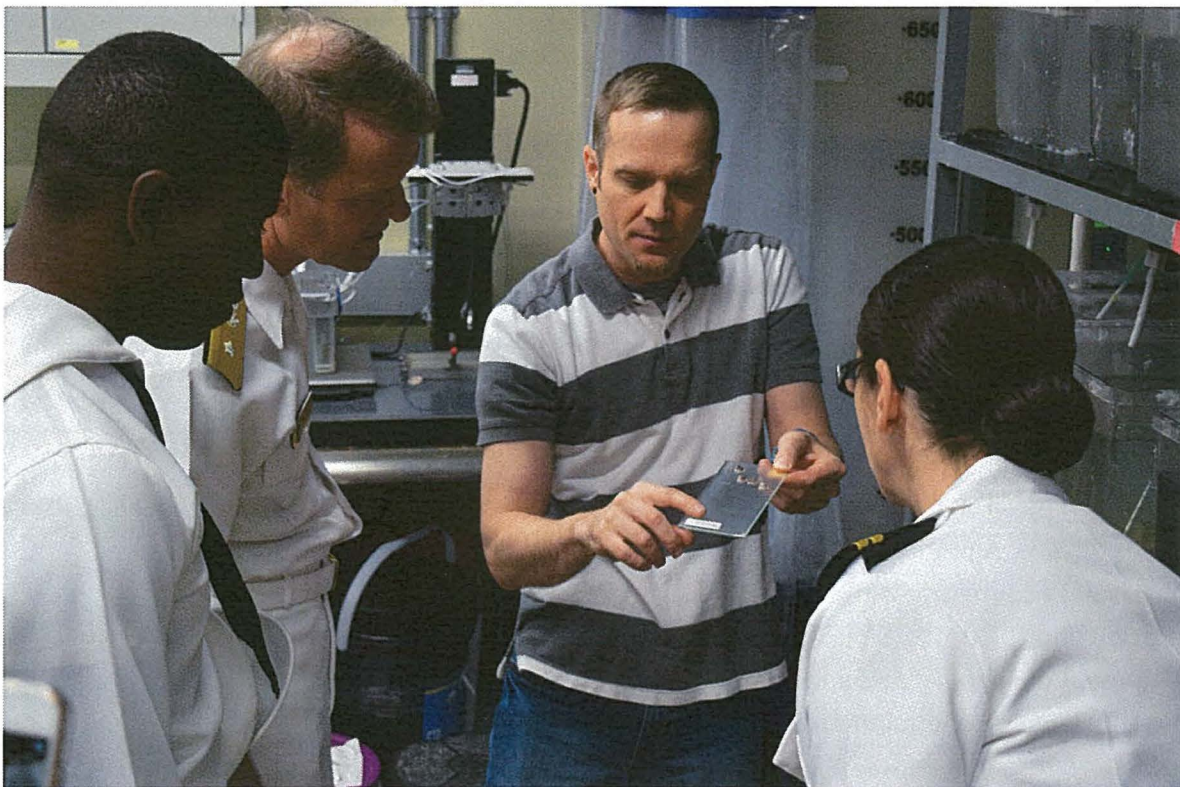


"Barnacle busting: Research targets ship biofouling" Phys.org

coatings using a combinatorial, high-throughput screening approach traditionally leveraged by the pharmaceutical industry for drug discovery; including the development of rapid biological screening assays (e.g. bacteria, microalgae, barnacles and mussels). The current defense grants procured from the Office of Naval Research through competitive grant proposals support the utilization of these in-house biological screening assays to assess the efficacy of new low toxicity marine coating technologies developed at NDSU, at other domestic academic institutions (e.g. Harvard, MIT, U of Florida, U of Houston and Texas A&M), and in the private sector (e.g. Adaptive Surface Technologies, Boston, MA).

GRAY WATER FOULING RESEARCH

This project being carried out in the Bioactive Materials Research Lab (BMRL) is focused on the development of materials and strategies to prevent biofouling on water filtration membranes for the U.S. Army and is a joint effort between NDSU and our private sector partner, PPG Industries, Inc. NDSU conducts testing of new membrane technologies developed by PPG using a laboratory-scale filtration system to simulate reverse osmosis and gray-water fouling conditions on flat membrane sheets. Promising technologies from lab-scale testing models in the BMRL are selected for advanced studies using a pilot scale, spiral round filtration system housed in the Department of Civil and Environmental Engineering at NDSU.



NDSU Senior Research Specialist Shane Staflien shows BMRL research to US Navy Rear Admiral Price

POLYMERS AND COMPOSITES: HIGH PERFORMANCE BIO-BASED POLYMER MATERIAL SYSTEMS

As the military strives for lighter weight, stronger/stiffer, more impact resistant, and higher temperature performing components to ensure soldier safety and greatest performance, high performance polymers and composites have been a primary focus. Recognizing the need for more sustainable paths to creating new and innovative high performance polymers, the Army has specifically outlined “Green Material and Processes” research in their 2015-2035 Science and Technology Campaign Plans.

Bio-based resins, manufactured from agricultural-based products, are notable for their high functionality, vast processing routes, and lower volatile emissions. Such materials are attractive from an ecological, agricultural, and social perspective because of their renewability and positive rural economic impact. However, in markets such as coatings, adhesives and composites, the performance requirements for the materials are demanding and cannot be compromised simply for the sake of using “green” alternatives. This is especially true in the area of structural materials. Resins from North Dakota canola to soybean oil are highly renewable and with recent advancements can result in durable products with long service life.



Items created from bio-based polymer materials

AGRICULTURAL TECHNOLOGY

Agriculture and agricultural engineering remain important aspects of the value that NDSU brings to the state. Today, this tradition is enhanced by the complementary disciplines of biology, computer science, microbiology, coatings and polymers, and materials development, providing new perspectives on the old problem of how to feed our ever-growing world safely, efficiently, and sustainably.

Agricultural technology and precision agriculture are emerging opportunities to increase production revenue through optimized interventions. For example, new areas of research in agri biome technology harness the microbes in the soil to naturally and effectively increase crop density and yield, supporting pest and disease resistance, while sensors in the soil and UAS aerial data inform decisions about timely field treatments.

NDSU is well placed to capitalize on the region's cluster of substantial expertise in high-tech agriculture and commitment to telecommunication infrastructure. John Deere and Appareo Systems, neighbors in the NDSU Research and Technology Park, lead the world in electronics development for agriculture. Innovation developer, Emerging Prairie, has announced plans to develop a fully autonomous farm that will spur new approaches to deal with the "dull, dirty, or dangerous" jobs and workforce deficiencies in agriculture. Finally, both government and industry leaders have expressed their commitment to gigabit speed telecommunication across the state that will allow the connectivity required for information to become decisions.

In support of the emerging field of precision agriculture, NDSU is proud to announce a new undergraduate major. This major will help future students become the professionals needed by the state to continue development of the agricultural revenues and providing excellent jobs for North Dakota students to remain in agriculture. In addition, North Dakota Extension and the Research Extension Centers across the state continue to be invaluable resources to deliver practical education in new technologies for agriculture.

NDSU AGRICULTURAL AFFAIRS includes all three missions reflected in the Land-Grant tradition: teaching, research and extension. As such, it includes

- NDSU College of Agriculture, Food Systems, and Natural Resources
- North Dakota Agricultural Experiment Station
- NDSU Extension
- Northern Crops Institute

Within the last fiscal year, the following crop varieties were released to the Ag market:

- ND Gardener (winter rye)
- ND Dickey (soybean)
- ND Dawn (yellow pea)
- ND Crown (chick pea)
- ND Twilight (black bean)
- ND Heart (conventional oat)
- ND Froberg (hard red spring wheat)

PRECISION AGRICULTURE AT NDSU

Over the last decade, NDSU has grown the Agricultural and Biosystems Engineering Department (ABEN) into a unique program that is housed in both the College of Engineering and the College of Agriculture, Food Systems, and Natural Resources. The program merges the knowledge of biological systems and engineering technologies to solve the complex problems facing our planet. Graduates are highly skilled in developing innovative approaches to solving problems affecting all types of living systems and the department’s goal is to produce professional engineers with commitments to the well-being of humans, animals, plants and ecosystems.

Recently NDSU has made an exciting addition to ABEN programing with the new Precision Agriculture major. The \$4.3 million project is funded by the U.S. Department of Agriculture. NDSU will conduct precision agriculture research, including UAS research and crop management technology on precision weed management and genetic environment and management.



“Brave new world of drones, ag data,” Agweek

Students learn the principles and applications of data mapping, GIS, GPS, sensors, drones, data acquisition and management and use these skills to conduct research, such as the machine identification of weeds. AI-driven autonomous weed control systems will allow our future

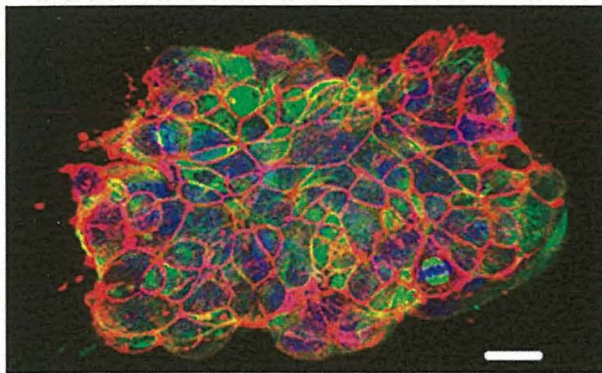
agriculture producers to target even pernicious weeds with selective and precise application of herbicides with the intention of reducing both runoff and cost. The Precision Agriculture major is exactly the type of approach that helps prepare students to innovate and create solutions that support the economies of our communities and the stewardship of our land.



BIOMEDICAL SCIENCE

Using research expertise across disciplines and working with local research and healthcare partners, NDSU has demonstrated a growing presence in biomedical research.

As a timely response to the opioid crisis in the state, NDSU is using its statewide network of pharmaceutical care providers to provide education to fight opioid addiction. ONE Rx trains pharmacy professionals to recognize warning signs to reduce or prevent opioid abuse and addiction. In a separate but complementary discovery, NDSU researchers are engineering synthetic spider silk fibers that can be infused with proteins to deliver antibiotics or other medicines, such as opioids. The nature of the silk bubbles allows the metered micro-release of medicine, with unnecessary excess harmlessly passing out of the body, significantly reducing over-dosing that can lead to addiction.



Drawing upon their expertise in engineering, NDSU researchers have created cancer testbeds made of nanocomposite clay scaffolds that reproduce the 3D environment of a tumor, proving drug effectiveness before it's given to a patient. NDSU researchers are the first in the world to develop and test metastasized pancreatic and breast cancer tumors in this method and have partnered with six prestigious national universities as well as Sanford Health-Fargo to further develop this innovation.

Aldevron, a company that was founded as a NDSU student startup 20 years ago, has just opened a new \$300-million 70,000-sq. ft. production facility for the biological drugs needed for this important clinical research. Aldevron currently employs nearly 200 scientists and staff in its Fargo facility with the intention to increase this number substantially in the next three years. In addition, new research in telemedicine and wellness programs will be needed to provide ND's aging population with appropriate healthcare options that build and maintain communities. With the recently-announced plans to offer a new undergraduate major in Health Sciences, students and researchers will have additional opportunities to serve citizens across the state.



NDSU RESEARCH AND TECH PARK

The NDSU Research & Technology Park is dedicated to enhancing the investments in NDSU by the citizens of North Dakota. Through partnerships with international, national, and regional reputable organizations as well as technology companies and the research community at NDSU, we help develop technology-focused businesses that diversify the economic base of North Dakota.

The NDSU Research & Technology Park also focuses on developing facilities and research centers that are essential to cutting-edge research, operating the NDSU Startup Incubator, which offers space, facilities, and services to entrepreneurs and businesses with technology-driven products or services.

Innovation Challenge for Students

- Increase Entrepreneurship at NDSU / region
- Well-received from business and academic communities
- 44 teams / 150 students in 2019

Innovate ND – Commerce

- Department of Commerce program
- 4 centers (Fargo, GF, Jamestown, Bismarck)
- 4 phases, (40K / 10K) Max of 27 months
- 40+ startups in Fargo program (100+ total)

Incubator Building & Park Grounds

- Balance of anchor tenants & start-ups
 - 22 startups / 3 anchor clients
 - Mixture of software, services providers, and research based companies
 - Linking with opportunities (business & finance)
- Innovation Studio Update
 - Ongoing work with NDSU Faculty, Staff, Students, and the community
- Founders Meeting / Lunch & Learns
 - Speakers / ideas
- Strong relationship with NDSU and the State of ND is key



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North Dakotans Support Funding University Research

A statewide, scientific poll commissioned by the Valley Prosperity Partnership In 2018 shows that North Dakotans support university research

Research to Diversify Economy

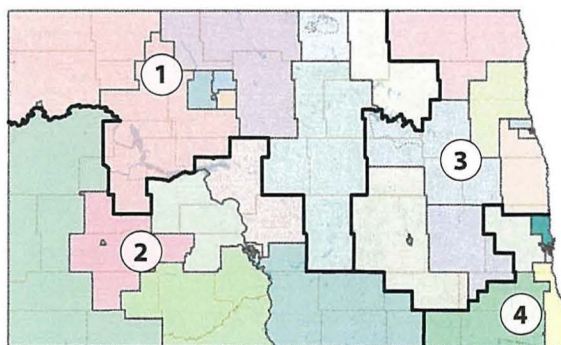
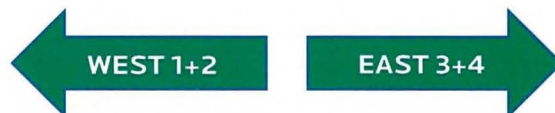
79% of respondents agreed that the state of North Dakota should invest research dollars in new industries in addition to agriculture and energy in order to diversify the economy

- ⇒ 80% in the East
- ⇒ 78% in the West

Emerging Technologies Research

77% of respondents agreed that NDSU and UND can aid in the diversification of the economy through research of emerging technologies

- ⇒ 83% in the East
- ⇒ 78% in the West



Business and higher education leaders, joined by economic development partners, working together to advocate for and achieve common strategic economic development goals.

Business Coalition Supports Expanded University Research Funding to Diversify North Dakota's Economy

Research is the single best investment that North Dakota can make to strengthen and diversify our economy for a more vibrant and prosperous future. A broad coalition of businesses and business groups believe that the University of North Dakota (UND) and North Dakota State University (NDSU) are important economic drivers, whose research sustains our competitive advantages in agriculture and energy and leads to innovations that translate into new economic opportunities, a more skilled workforce, and higher-paying jobs for North Dakotans.

A solid and predictable base of funding is required to ensure that North Dakota's research institutions attract and leverage transformational research opportunities to generate diversified economic growth. These kinds of investments are especially important for developing opportunities associated with key technology sectors with high potential in North Dakota, including value-added agriculture and energy, autonomous and unmanned vehicles, health care, and advanced computing/big data.

As private-sector leaders, we support using Legacy Fund earnings and/or other state funding for universities to perform collaborative research with technology and business innovators, compete for federal and corporate research dollars, and proactively build expertise and capacity in high potential research clusters. Research will diversify our economy and has the strong potential to broaden our state's economic reach for a generation.

AE2S
Alerus Financial
Altru Health
American Crystal Sugar
Appareo Systems
Blue Cross Blue Shield
Border States Electric
Bremer Bank
Cass County Electric Cooperative
Choice Financial
Construction Engineers
Eide Bailly
Ellingson Companies
Forum Communications Company
Gate City Bank
Happy Harry's Bottle Shops
Intelligent Ag
JLG Architects
Midco

Nodak Electric Cooperative
Praxis Strategy Group
RD Offutt Company
Roer's Development
Sanford Health
Xcel Energy
WCCO Belting

Economic Development Association of
North Dakota (EDND)
Grand Forks Region EDC
Great Plains Chapter – Association of
Unmanned Vehicle Systems International
Greater Fargo-Moorhead EDC
North Dakota Petroleum Council
Valley Prosperity Partnership