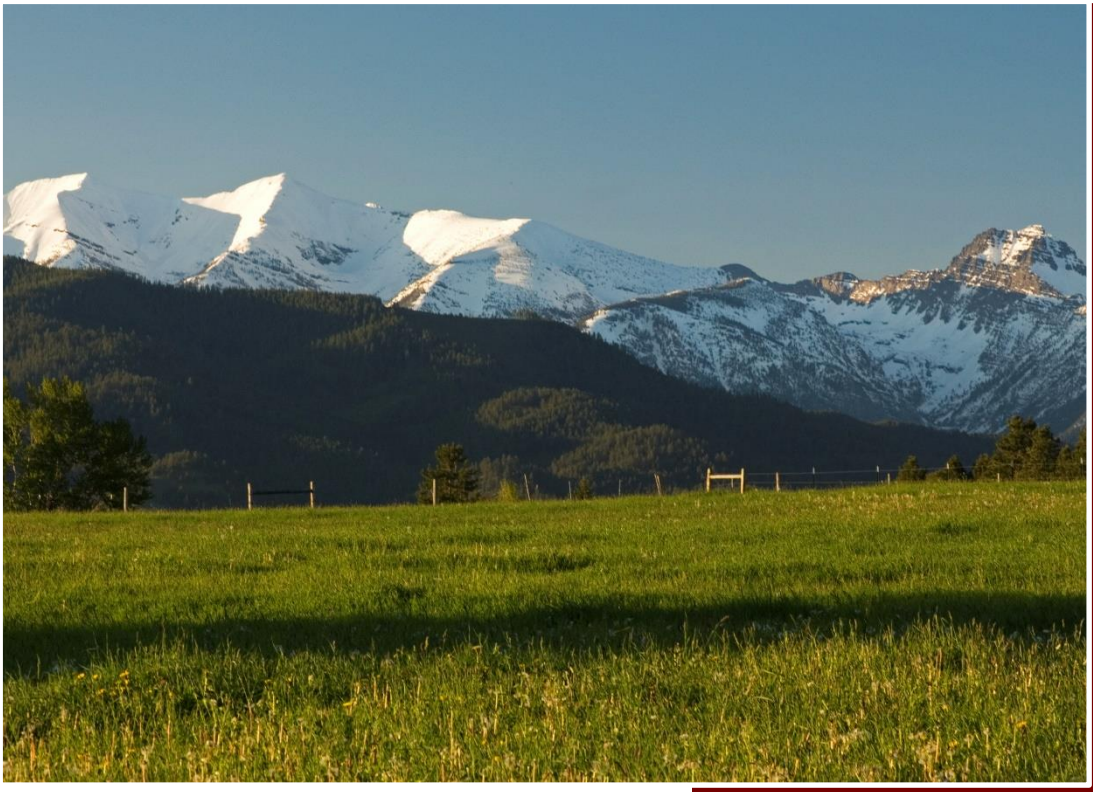
2015

Montana's Science & Technology Plan



Montana University System

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Leading the way forward

Research conducted by the Montana University System is a key driver of economic development in the state of Montana. Scientific research conducted in Montana has the potential to solve today's problems in rural health, agriculture, nutrition, materials science, energy and computational/engineering science. Research also prepares the next generation of students to innovate and create jobs in all sectors. The Science and Technology Plan for 2015 focuses on specific areas of research with significant potential for success in spurring economic development by attracting Federal, State and private investment and spurring the creation of small businesses in Montana.

Five Major Areas of Focus:

1. HEALTH & BIOMEDICINE
2. AGRICULTURE & NATURAL RESOURCES
3. ENERGY AND THE ENERGY/FOOD/WATER NEXUS
4. MATERIALS & MANUFACTURING
5. COMPUTATION & INFORMATION SCIENCES

Education and training in science, technology, engineering & mathematics (STEM) stands as our most important tool for ensuring prosperity across Montana.

In today's world, attracting research dollars for economic development is a highly competitive process. Faculty in the Montana University System (MUS) have proven to be successful in this complex process of winning grant and contract awards from the leading federal funding agencies in the United States with a combined $180 million dollars awarded in FY2014. Montana's future prosperity depends on expanding the investment strategies for research while translating these results to increased economic potential across the state.

Students, well prepared for college and careers in Science, Technology, Engineering and Mathematics (STEM fields), are a vital key to our success. New graduates of the MUS will shape our future through innovation and invention, and are key to maintaining Montana's economic competitiveness. The need for high-quality science education with a focus on critical thinking is more essential now than ever before.

Montana Science Serving Montana Citizens is intended as a statewide science and technology plan for higher education and related enterprises in Montana. This plan will identify priority areas for the MUS and the state of Montana to allocate resources stimulating a research enterprise that has potential to grow, flourish and return benefits to our families, communities and businesses. The plan builds on excellent research already underway and also outlines new directions as Montana looks to its future.

Main Street Montana Project

Governor Steve Bullock initiated the Main Street Montana Project (MSMP) to create a dynamic private-public partnership to build and implement a business plan for Montana by Montanans. The MSMP plan was released in early April 2014 and leverages Montana's unique strengths, tackles challenges that may have slowed growth in the past, and dares Montanans to reach higher and with a clearer focus than ever before.

Technology and innovation drive new job growth and education vitally important to emerging industries. Partnerships between our universities and business communities that are able to move ideas to market already exist. These successful partnerships can serve as models for other Montana communities.

The MSMP plan identified five Pillars to build a successful private-public partnership – two of which are directly related to this Science & Technology Plan and represent challenges to the MUS and the Science & Technology community in Montana.

PILLAR 1: TRAIN AND EDUCATE TOMORROW'S WORKFORCE TODAY

PILLAR 5: NURTURE EMERGING INDUSTRIES AND ENCOURAGE INNOVATION

Using the pillars as a frame of reference, twelve Key Industry Networks (KINs) were formed. The KINs are tasked with identifying the priorities that are most essential to the success of the businesses within their sector. Eight of the twelve KINs that are directly related to this Science & Technology Plan for 2015, include: *Energy and Utilities, Food and Agriculture, Health and Wellness, Innovation and Technology, Interconnectivity and Telecommunications, Manufacturing, Natural Resources, and Small Business.*

Health and Biomedicine

Health and biomedical research is a major focus within the MUS, aiming to improve health care for Montanans. Strong outreach and research programs have been developed to address health care disparities in our rural state, while world class biomedical research carried out on MUS campuses is linked with translational research implemented in partnership with Montana's hospitals.

Montana researchers investigate new ways to prevent, detect, and cure a variety of human maladies, including emerging infectious diseases, respiratory illnesses, stroke, cancer, cardiovascular disease, brain injury, mental illness, and others. It is critical that Montana continues to invest in health sciences and biomedical research in broad areas.

Key research initiatives envisioned include the following objectives:

- Advancing research into the most effective means of providing health care to Montana's rural population
- Developing new techniques to improve nutrition, health, employment and participation in community life for people with disabilities living in rural settings
- Researching new avenues for addressing mental illness
- Identifying risk factors for suicide across the state with an emphasis on rural areas
- Exploring new and emerging biotechnologies
- Partnering with Montana hospitals and biomedical researchers to develop new treatments and technologies

Agriculture and Natural Resources

Northern Seed collaborates with scientists and plant breeders in the MUS, sponsors research and licenses technologies from the College of Agriculture at Montana State University.

Montana is in the enviable position of having one of the most pristine environments in the world, along with extraordinary agricultural productivity. With growing world population and economy, we are witnessing a significant increase in demand for sustainable, high-quality food supplies. The MUS Science and Technology Plan recognizes our need for research to increase agricultural productivity and to tailor environmentally sound and safe extraction technologies for mineral, energy, and water resources in Montana. A challenge will be to expand the associated economic benefits, while preserving the environment for the enjoyment of current and future generations of Montanans and visitors.

Key research initiatives include:

Crops, Pests and Diseases

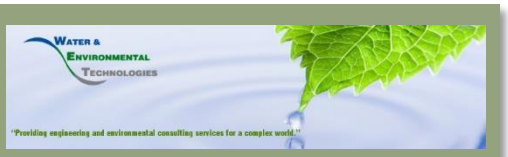
- Breeding plants for greater crop yields and increased resistance to drought, disease and pests
- Researching the use of alternative crops for diversification and to mitigate risk due to climate variability
- Researching marketing and distribution that capitalizes on the premium of Montana quality crops
- Researching bark beetle infestations and impacts on Montana's forest resources

Fire, Water and Minerals

- Researching the role of fire in natural resource management
- Exploring and evaluating mineral resources
- Developing deployable field sensors for resource management and land reclamation
- Creating environmentally sound, safe and economically viable tailored resource development strategies
- Researching groundwater and surface water quality, chemistry, and geothermal resources

Energy and the Energy/Food/Water Nexus

Decades of unprecedented growth in population and a corresponding global economic expansion have created a demand for new energy production and more efficient and environmentally sustainable energy use. Energy research programs include the goals of improving the efficiency of using carbon-based resources as well as identifying and optimizing new sources of energy. It is also important to recognize the importance of the energy/food/water nexus and understanding of the underlying dynamics, processes, and interactions between these three systems. Researchers use integrated analysis and modeling to develop analytical methods that provide critical information on global and region energy, water and food resources. In addition, MUS researchers investigate advanced materials to optimize energy capture and efficiency and continually improve food (livestock and plant) production with consideration of energy and water usage.



In a research partnership with Montana Tech, the Butte firm, Water & Environmental Technologies (WET) developed an innovative on-site wastewater treatment technology now being marketed statewide by a spinoff company, SepticNET. Founded in 2000 by MTech alumni, WET is now a multi-million dollar engineering firm with 35+ employees, offices in Butte, Anaconda, and Great Falls, and projects all over the western US.

The nexus between energy/food/water is a key driver of socioeconomic status and challenges in both urban and rural areas in Montana. Basic and applied research that bridges the hydrological, environmental, ecological, geochemical, energy, agricultural, and engineering sciences is essential. MUS researchers incorporate research advancing technologies that allow remote sensing and continual assessment of energy/food/water resources and interactions.

We can guide effective stewardship of state energy resources, focusing on environmentally acceptable development of, and reliable, cost-effective distribution and use of Montana's energy resources, including petroleum, coal, natural gas, solar, biomass, energy dedicated crops, geothermal, wind and water. Research to enhance oil recovery from existing wells in the Williston Basin Bakken, proppant research for increased efficiency of oil and gas recovery and production through hydraulic fracturing are important strategies.

Key research initiatives include:

- Environmentally acceptable deep well stimulation
- Clean coal technologies for power plant retrofits
- Carbon sequestration and innovative ideas to reduce the carbon footprint
- Smart grid technologies for transporting electricity reliably
- Energy storage and efficiency, the key enablers for solar and wind
- Renewables – wind, solar, biomass, biofuels, advanced fuels
- Research to enable restoration of damaged ecosystems
- Policy and regulation advances to foster environmentally acceptable, sustainable energy development
- Development of solid oxide fuels cells
- Modelling of economically sustainable feedstock for alternative fuels and bio based materials.

Materials Science & Manufacturing

Rivertop Renewables was started based on technology developed by a UM Professor, Dr. Donald Kiely, that could replace environmentally disastrous phosphates in detergents. Today, the company with $30M in venture capital funding remains as the cornerstone of the UM Business Incubator with 40+ high-paying jobs.

The new collaborative Materials Science PhD program involving MSU, MTech and UM has accelerated interest from potential sponsors in materials and manufacturing within and outside of Montana. Because of the expertise base and the economic potential for Montana, this new program focuses on research on biomaterials, energy materials, electronic and optical materials and materials processing including extractive metallurgy. Current nanoscale and microscale polymer fabrication research is focused on chemical sensing, targeted drug delivery, functionalized devices, and optical polarization. The design and characterization of nanotechnology materials and devices is of great interest industrially, for national security, and for economic competitiveness. Intellectual property, spin-off or relocated companies, and high-paying jobs flow from materials science, engineering and manufacturing research.

Key Research Initiatives:

- Advancing research into minerals, metals, alloys, glasses, slags, ceramics, polymers, biomaterials, thin films, nanomaterials and composites
- Researching alternative construction materials that require less energy for manufacture, use recycled materials and have greater corrosion resistance
- Enhancing materials to create longer-lasting and less expensive fuel cells
- Discovering and developing *new* materials with greater strength, reduced weight, reduced cost, corrosion resistance, catalytic traits, resistance to temperature extremes for use in biomedicine, aerospace or in combustion engines
- Engineering optical materials, components and systems for applications in imaging for biomedicine to precision agriculture applications
- Researching optical materials for high-bandwidth computation and data processing
- Advancing joining methods, processing, and additive manufacturing technologies

Computational & Information Sciences

Research computing is no longer a rapidly growing area in higher education. All areas of development potential for Montana agriculture and natural resources, energy, health care, computing, manufacturing and materials sciences depend on substantial research computing capability.

We are establishing a network, the Montana Cloud, to provide necessary infrastructure for the Montana University System, creating an economic advantage for Montana, while concurrently enhancing the cumulative capabilities of the campuses.

Key Research Initiatives:

- Mining large datasets that exist in health care, manufacturing, agriculture, equipment maintenance for higher safety, better management and cost savings
- Developing simple, inexpensive methods for detecting an attack on a computer network
- Modeling weather, hydrology, and vegetation for management in agriculture, forestry, fire management, and human health
- Anchoring a cooperative statewide network of computing capability and associated services
- Digitizing Montana's resources and history
- Exploiting 3D visualization and high-performance computing capabilities to support research and commerce in Montana
- Modeling of biofuel combustion in industrial engines for emission reduction and improving work place air quality.

Technology Transfer & Economic Development

Business Incubators The spirit of innovation and entrepreneurship in the MUS is emerging across all disciplines and spilling out into communities across Montana. Both MSU and UM have business incubators that facilitate launch of start-up and early-stage companies, provide space to incubate start-up and early-stage companies, provide essentials that include a variety of administrative and facilities services, and provide flexibility in tenant improvements and lease terms. Other MUS campuses must be empowered, funded, and enabled to provide similar services in their communities.

Through their business incubators, MSU and UM provide a suite of services to Montana entrepreneurs and businesses by hosting many support programs aimed at facilitating job and company creation in Montana. Outreach efforts provide faculty, staff, students, and alumni in the MUS with many touch-points along their path to success. An incoming freshman can visit the Blackstone LaunchPad offices at MUS campuses and gain insight into launching a business idea around a passion of skiing or the culinary arts. Businesses looking to expand product and service offerings globally can tap into resources that include those dedicated to providing assistance with government contracts (through Procurement and Technical Assistance Program (PTAC) programs, Techlink, or Montana Manufacturing Extension Center (MMEC). In total, the MUS innovation and entrepreneurship programs actively engage with hundreds of businesses and entrepreneurs, with greater than 95% being Montana based.

The ***Technology Transfer Office in the Office of Research and Economic Development at MSU*** has issued more than 250 active licenses, approximately one third of these are shared with Montana companies, including licenses of new wheat varieties that add more than half a billion dollars annually to the Montana economy, and numerous photonics and biomedical technologies. In the past 15 years MSU Technology Transfer Office has facilitated more than 50 startups based on university technology, adding hundreds of high-paying jobs to the Montana economy. These companies also provide internships to our students and employment for our MUS alumni through collaborative research with MSU through SBIR's, STTR's and other grant and contract opportunities. MSU Research has also launched a pilot in-house Gap Fund to assist with funding of early-stage, applied projects to reduce the risk of technology transfer to the private sector.

The ***Technology Transfer Office in the Office of Research and Creativity at UM*** has captured more than 100 new inventions/ideas in the past five years, with nearly 80% still in some form of active assessment or advancement. Comparatively speaking, the University recorded 93 total inventions from the period of 1980 to 2008. Examples on UM inventions include a physiological strain monitor with the potential to reduce human heat related illnesses and death, a portable aquatic cervical traction device for improved treatment of pathological neck injuries, a new topical ointment for treating dermatitis without traditional treatment side effects, novel silica composites with an increased efficiency at removing arsenic from surface water sources, and many, many others.

Workforce Development

Building the talent pool for our state and the companies already here and for those to come requires the development and adoption of benchmarked standards. *Updated science learning standards* prepare students to enter the workforce with enhanced communication, problem-solving and critical thinking skills by encouraging students to understand concepts and content and not just memorize them. There is also a strong need to provide students hands-on training and experiential learning.

Over the past 20 years, there has been a 26% increase in the demand for highly skilled workers proficient in STEM and STEM workers account for over 50% of the nation's sustained economic growth.

The other key to success are students who are well prepared for college and careers in science and STEM fields are vital for shaping our future through innovation and invention, and they are key to maintaining our economic competitiveness. The need for high-quality science education, beginning at the very earliest grades, is more essential now than ever with a focus on critical thinking.

The Montana Photonics Industry Alliance, MPIA is a hub for Montana's optics and photonics companies, entrepreneurs, laboratories, and universities that will aid in commercializing, nurturing, and sustaining organizations that create photonics-related jobs and associated economic opportunities in the state of Montana. This industry has grown out of the efforts of faculty, staff and students of the MUS. MPIA includes approximately 30 companies in optics/photonics in the Gallatin Valley area alone, employing approximately 500 people around the nucleus of the MSU OpTec and Spectrum Laboratories.

Supporting Components

- **Program development**: University-based research and graduate education are inseparable, and states with vibrant and productive research activity also have thriving masters and doctoral programs. The doctoral degree is a research-based degree, and all graduate students are a mainstay of research productivity in science and technology. A concerted effort to recruit, retain, and graduate the most talented graduate students from the state, region, nation, and world will pay off in research productivity and in long term, economic development – as many of these students – wherever they originated will want to pursue their careers in Montana. At the same time, strategic growth of graduate programming through expanded and new graduate programs will be required to capitalize fully in the five theme areas identified in this plan.
- **Computational Science and Information technology** and quantitative modeling infrastructure and research are seen as fundamental in all five core research areas. Advanced networking, large-scale computationally intensive modeling and visualization are seen as fundamental to all five of the major research areas. The infrastructure needed to support leading research should focus on

computation power, connectivity, software and programming expertise, as well as development of modeling tools, algorithms and new statistical, quantitative and computational methods.

- **Partnerships and collaborations –** Public entities (e.g., national laboratories or other research universities), and private, and non-profit organizations perform or support of Montana's research efforts. Partnerships and collaborations within the MUS, with other Montana entities, and beyond our boundaries will leverage and expand the research results and associated benefits to maximize value and return on investment.
- **Technology transfer** allows the MUS to move ideas from the laboratory to the private sector. Many excellent examples of such transfer already exist, but considerable room for growth is evident. The MUS research infrastructure not only should facilitate tech transfer, but it also should encourage researchers to proactively seek opportunities for moving ideas to the marketplace and for employing people in a high- technology economy.
- **Social Sciences** is a necessary component in the research arena as policies and practices increasingly are drawn from scientific discovery. The scientific research community needs to make a concerted effort to engage social science colleagues in cooperative research and in the identification of areas of where research is needed to meet human needs.
- **Ethical conduct** is integral to quality research. Researchers and their students and support staff will engage in formal ethics education opportunities. Additionally, researchers will be honest and transparent regarding any potential conflicts of interest.
- **Communication** will be a high priority for researchers and their students, and they will focus on high quality scientific writing and developing the ability to communicate complex subjects clearly for multiple audiences. Contemporary researchers must communicate effectively not only with other researchers, but also with policy-makers, investors, and the general public. An emphasis will be placed on helping scientists understand the expectations of the public and helping the public understand the implication of scientific discovery.

Strategies for Success

1. **Develop a communication strategy for Montana "Science & Technology" to include**:

    a. Bringing the excitement of discovery to middle school and high school age students across the state through a guest lecture program by faculty researchers
    b. Bringing the excitement and impact of MUS research to communities without MUS campuses.
    c. Supporting the continued development of an online course, "Journalistic Tools for Scientists," to promote regular communications with the greater Montana public
    d. Hold annual tech transfer and research conference in Montana to communicate to Montana business and political leaders the opportunities, potential returns, and economic impacts of investment in MUS research
    e. Strengthen and expand MUS research partnerships with Montana businesses, in part by providing support of innovative campus efforts to commercialize research efforts (tech transfer) with Montana partners;

2. **Encourage an entrepreneurial climate in graduate education by:**
    a. Implementing business school entrepreneurial outreach programs for scientists and engineers
    b. Establishing regular forums on tech transfer in Montana to communicate the economic value of research investment in the state
    c. Connecting graduate students with research and innovation needs of Montana firms
    d. Establish a fund for endowed research scholarships (maybe targeting upper level undergraduate students and graduate students) where private contributions could be matched at some percentage by state funds

3. **Establish a permanent funding mechanism for:**
    a. Establish priorities and funding mechanisms to recruit and retain nationally competitive faculty and researchers in order to grow the research and development capacity of the state
    b. Funding endowed research scholarships for undergraduate and graduate students
    c. Matching requirements for federal dollars