Montana Science Serving Montana Citizens

Montana University System
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socially responsible science and technology in higher education and related enterprises

Five major research areas are the core focus of this *Plan*:

- Energy Sciences and Engineering
- Health and Biomedical Sciences
- Agricultural Science
- Environmental and Ecosystem Science
- Materials Science and Engineering

Faculty, staff, and students in the Montana University System (MUS) are engaged in science and technology research and graduate education that help build Montana's economic future. The MUS research enterprise also builds partnerships with communities, businesses, and other educational entities to help align science education and research with pressing social and economic challenges. The science and technology research community takes seriously its role in preparing future scientists and teachers and in contributing to science literacy for Montana citizens.

Montana research has national and local significance, numerous and important practical applications, and demonstrated potential for commercialization. Despite a relatively small population base, Montana is rapidly gaining recognition as an emerging national leader in transforming basic science into marketable technologies and products and in using scientific research to solve regional and global problems in environmental, energy, and other fields.

"Wind Farm at Judith Gap"
photo by Stephen Hunts

A major strength of the MUS research enterprise is the highly successful integration of research programs across disciplines, departments and colleges. Creating and sustaining truly interdisciplinary efforts has been a major factor in substantially increasing research activity and in enhancing the recognition of our research programs on an international scale. Montana's future will depend on investment in research to develop products, technologies, and businesses that are resistant to economic fluctuation and to try new approaches, such as renewable energy and sustainable agricultural, to improve our quality of life.

Research programs in the MUS contribute to economic development in Montana by:

- Serving as the largest research and development enterprise for our state with total research expenditures in excess of $170 million and close to 90% of that amount arising from successful competition for federal grants from numerous agencies;
- Preparing graduates who have experienced the complete integration of learning and discovery, have had access to state-of-the-art equipment (most purchased by research grants), and are ready to enter the knowledge economy and to work for technology-based companies;
- Offering numerous business assistance programs including the Montana Manufacturing Education Center, TechLink, and others that provide hands-on assistance to manufacturers and other high-tech businesses;
- Supporting technology transfer through licensing of discoveries for commercial applications that lead to new Montana technology-based companies whose employees earn significantly more than the statewide average annual salary, attracting new companies to Montana because of the workforce and supportive technology climate provided by the Montana University System.

"the convergence of global warming, global flattening and global crowding is the most important dynamic shaping our world today."

[1] *Friedman, T. Hot, Flat and Crowded. 2008*

Montana Science Serving Montana Citizens is intended as a statewide science and technology plan for higher education and related enterprises in Montana. The *Plan* will help identify priorities for the MUS and the State of Montana in the allocation of resources to a research enterprise that has great potential to grow and flourish. The *Plan* is based on research already underway and also outlines new directions for research as Montana looks to its future.

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- Agricultural Science
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UM researcher Mark Hebblewhite uses ground telemetry to track wildlife in Canada's Banff National Park

Regarding these five major research areas, multiple studies have concluded that the convergence of global warming, global economic and social integration, and population pressure is the most important dynamic shaping our world today. The term the "Energy-Climate Era" has been used to describe the historical epoch caused by this convergence.[1] On a national and international scale, we need a huge investment in research and development to solve the problems facing the world today.

Energy Sciences and Engineering

Decades of unprecedented growth in population and an apparently insatiable demand for energy has created a demand for new energy production that far exceeds supply, resulting in record high energy costs. Although these demands have waned with the current economic decline, it is virtually guaranteed that economic recovery will re-establish huge demands for energy. Critical 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.

Perry Miller in a field of camelina
Photo by Kelly Gorham, MSU News Services

"Decades of unprecedented growth in population and an almost insatiable demand for energy has created a demand for new energy production that far exceeds supply..."

Key research initiatives envisioned include the following objectives:

Reducing the environmental impact of burning fossil fuels

- Understand the interactions and implications of storing CO2 underground, including fluid flow models, mineral interactions, bio-containment, detection and monitoring, and catalytic recycling of burned carbon;
- Restore and remediate environmental damage caused by fossil fuels extraction and burning, including climate change and related policy implications;
- Convert coal to chemical and fuel stocks through direct microbial action.

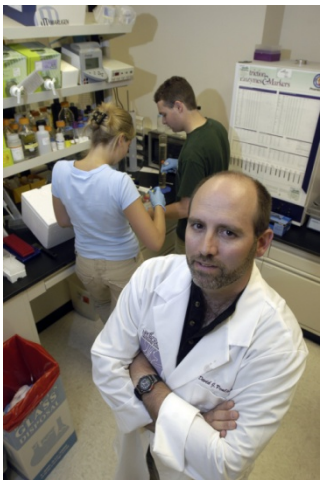
New Energy Initiatives

- Enhance **fuel cell and battery performance and affordability** through the identification of new materials that can operate at high temperature, are less susceptible to poisoning, demonstrate greater fuel flexibility, and do not require expensive precious metal catalysts. Improved batteries in next generation vehicles will require new materials, better diagnostic instrumentation, and increased range. Fuel cell practicality will require reliable hydrogen sources, better catalysts, and realistic storage and delivery mechanisms.
- Foster **wind power** as a significant contributor to energy needs by focusing research on development of more efficient turbine blades and the effective use of small scale (e.g. single family) use.
- Focus **Bio-fuels Research** on improving oil production and quality from crops and non-crop sources (including algae and other microbes) through plant biotechnology, increasing the efficiency of refining bio-fuels and converting biomass into bio-fuel, and optimizing the operation and longevity of engines that run on bio-fuels.
- Expand the use and diversity of alternative sources of bio-fuels, including algae and cellulosic ethanol from non-crop species.

Health and Biomedical Sciences

Health and biomedical research within MUS is focused on improving health care for Montanans. Strong outreach and research programs are addressing health care disparities in our rural state while world class biomedical research carried out on Montana's campuses is linked with translational research implemented in partnership with Montana's hospitals.

Montana researchers work to find new ways to prevent, detect, and cure a variety of human maladies such as emerging infectious diseases, respiratory illnesses, stroke, cancer, cardiovascular disease, prion disease (mad cow), and others. It is critical that Montana continues to invest in health sciences and biomedical research in broad areas, including:



Molecular Biologist Dave Poulsen studies gene therapy in his research lab at The University of Montana

- ***Neuroscience*** - fundamental and translational research involving chemistry, biochemistry, pharmacology, toxicology, and molecular biology to advance our understanding of protein structure and function in the central nervous system, particularly as related to signal transduction, transport, development and pathogenesis;
- ***Cardiovascular function*** - fundamental and translational research into pulmonary and cardiovascular diseases, immune and autoimmune disorders, developmental defects, neurodegenerative diseases, genetic susceptibility, heart failure and vascular disease, and the impacts that environmental factors have in causing or exacerbating these conditions;
- ***Infectious Disease*** - research on resistance of infectious organisms, development of new treatments to combat infectious diseases, development of improved vaccines and therapeutic agents to combat infectious diseases in humans and livestock;
- ***New Medicines, new therapeutic agents and new diagnostic agents*** - synthesis of new molecules with applicability to health care, discovery and characterization of naturally occurring medicinal agents, understanding of drug efficacy and interactions, detection and monitoring of medicinal agents in physiological and environmental systems;
- ***Health Disparity and Health Care Delivery*** – research to understand health conditions that affect various populations disproportionately, focusing especially on health care for rural, indigenous, and lower socioeconomic populations in Montana.

Business Week.com on *October 16, 2008 recognized Montana State University as one of "10 lesser-known schools making their mark in tech development."*

Agricultural Science

With population increases and climate changes, we are witnessing a significant increase in demand for sustainable, high-quality food supplies. An additional significant factor is the increase of biotic stresses that degrade food supplies, such as pathogens and insects. The MUS S&T *Plan* recognizes a need to substantially enhance and expand Montana's efforts to increase agricultural productivity.

Key research initiatives envisioned include the following objectives:

- Plant breeding and molecular biology approaches for increasing quality and yields of crop plants, especially cereal crops that are the staple of the world's food supply;
- Biotechnology approaches including genetic modification for enhancing stress resistance to both biotic and abiotic stresses;
- Expanded use of molecular tools including biochemistry, molecular biology, plant and animal genomics/proteomics with goals to improve productivity, quality, and resistance to climate variations and pathogens;
- Expanded use of advanced sensing technology to enhance productivity;
- Improved understanding of biophysical, ecological and cultural factors influencing carbon cycling to identify improved cropping systems that balance energy and food production;
- Plant breeding to develop native grass strains resistant to invasive weeds.

UM Fire Intelligence Module team members Carl Hartung and Saxon Holbrook set up a computerized network of weather sensors near a Montana Wildfire

Environmental and Ecosystem Science

Montana is in a unique position of having one of the most pristine environments in the nation while exhibiting significant signs of environmental stress from our history of dependence on an extractive economy. This provides both the opportunity and the responsibility to conduct leading research on our own and similar environments around the world. The challenge will be to capitalize on what the environment has to offer while preserving for generations to come the lifestyle that has become a standard of Montana living.

Key research initiatives envisioned include the following objectives:

- ***Monitoring of ecosystems*** – to detect, understand, and predict changes that may be occurring on local, regional, or global scales. Analyzing how climate changes impact temperature, rainfall, and other environmental factors is important for future predictability of water availability, risk of wildfires or floods, food production potential, and overall biodiversity impacts. Large scale monitoring and modeling of Montana's watersheds.
- ***Sensor development and deployment*** - on an ecosystem scale for detection of climatic changes and impacts, thereby positioning the MUS to be a lead domain in National Ecological Observatory Network (NEON), assuming the National Science foundation (NSF) funds the proposed NEON program in 2010 and beyond. [This will allow Montana to be a major player in the deployment of sensors, including remote sensing, that will allow for real time observation of ecosystem changes on a national network scale.]
- ***Understanding and remediating disturbed systems*** – important in Montana to support efforts to restore critical areas of the state.
- ***Integrative studies on ecosystem levels of the behavior and response of organisms*** - to natural and human-induced influence, including the understanding and management of Montana's wildlife resources.

Materials Science and Engineering

There is a rapidly expanding need for new materials that provide a foundation for solving multiple difficult problems that confront our society, such as lighter weight and yet stronger materials that could lead to cheaper and safer transportation, improved materials for the electronics and optics industries, new catalysts for industrial processes, and enhanced materials to address health related issues. It is important to note that the focus on optoelectronics research at MSU has been a major factor in the growth of the optoelectronics private sector, which has increased from two companies in 1990 to more than two dozen today.

The MUS S&T *Plan* seeks to expand our efforts in materials science/engineering and nanotechnology. This area has great potential for technology transfer and for directly contributing to economic development in the near term through licensing technologies to existing companies as well as starting up new companies similar to our recent successes with the optoelectronics and optical materials industry. Discoveries made through materials and nanotechnology research will contribute to solving many of the problems outlined in the previous areas of the *Plan*.

Key research initiatives envisioned include the following objectives:

- Improving optical materials through research in physics and electrical and computer engineering;
- Enhancing materials for fuel cell membranes to prevent degradation of the membranes and prolonging life, thus reducing fuel cell cost;
- Using biologically inspired approaches to nanofabrication to produce new materials, including nano-materials with applications in medicine, electronics and catalysis.
- Designing and developing new composite materials for applications in the mining industry and in metal ion remediation of industrial and acid mine drainage waste streams.

A graduate student works in a lab in the College of Health Professions and Biomedical Sciences at The University of Montana

Supporting Components

- **Graduate program development:** University-based research and graduate education are inseparable, and states with vibrant and productive research activity also have thriving doctoral programs. The doctoral degree is a research-based degree, and graduate students are a mainstay of research productivity in science and technology. A concerted effort to recruit and retain the most talented graduate students from the state, region, nation, and world will pay off in research productivity and in the long term, economic development. There are many examples of this in Montana, where graduate students from one of the universities either founded or form the core research staff of new knowledge-based companies. At the same time, strategic growth of graduate programming through expanded and new doctoral programs will be required in areas relevant to the focus areas described above.
- **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 information technology 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 (e.g., national laboratories or other research universities), private, and non-profit - underlie many (if not most) of Montana's research efforts. State-of-the-art research increasingly will call for collaboration between the institutions of Montana's higher education system and between those institutions and others in the state, nation, and world.
- **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 technology 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** will be a necessary component in the research arena as policies and practices increasingly are drawn from scientific discovery. The scientific research community will 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. Emphasis will be bi-directional – helping scientists understand the expectations and needs of the public and helping non-scientists understand the implication of scientific discovery.

✓ **Reaching Youth** – MUS research provides an ideal "hands on" teaching environment where K-12 and undergraduate university students can share the excitement of discovery. As they have done with past research efforts, MUS researchers and partners will strive especially to serve Montana's American Indian youth. The long-term vitality of Montana's research enterprise will depend upon a healthy pipeline of interested and capable young people who pursue careers in science.

✓ **Engaging Adults** – MUS research has the power to excite and inform. Outreach programs on the campuses, offered through extension and other entities, can help the public participate in the thrill of discovery. Montana citizens who are excited about science can help support its long-term growth.

Strategies for Moving the *Plan* Forward:

1) Develop a permanent funding mechanism for 'required match' dollars for research grant requests (e.g., EPSCoR) as the highest priority;
2) 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) Hold a conference (biannually or annually) on tech transfer and research in Montana to communicate to Montana business and political leaders the opportunities, potential returns, and economic impacts of investment in MUS research;
4) 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;
5) 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;
6) Develop a marketing strategy for Montana "Science and Math Literacy" to include:
   - A "Transfer of Knowledge and Experience" expert pool that engages senior faculty members and senior technology business researchers and engineers in guest teaching at high schools and in undergraduate classes;
   - Experiential opportunities for high school students and undergraduates;
   - Regular communications with the greater public about research and tech transfer.

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National Science Foundation - EPSCoR
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