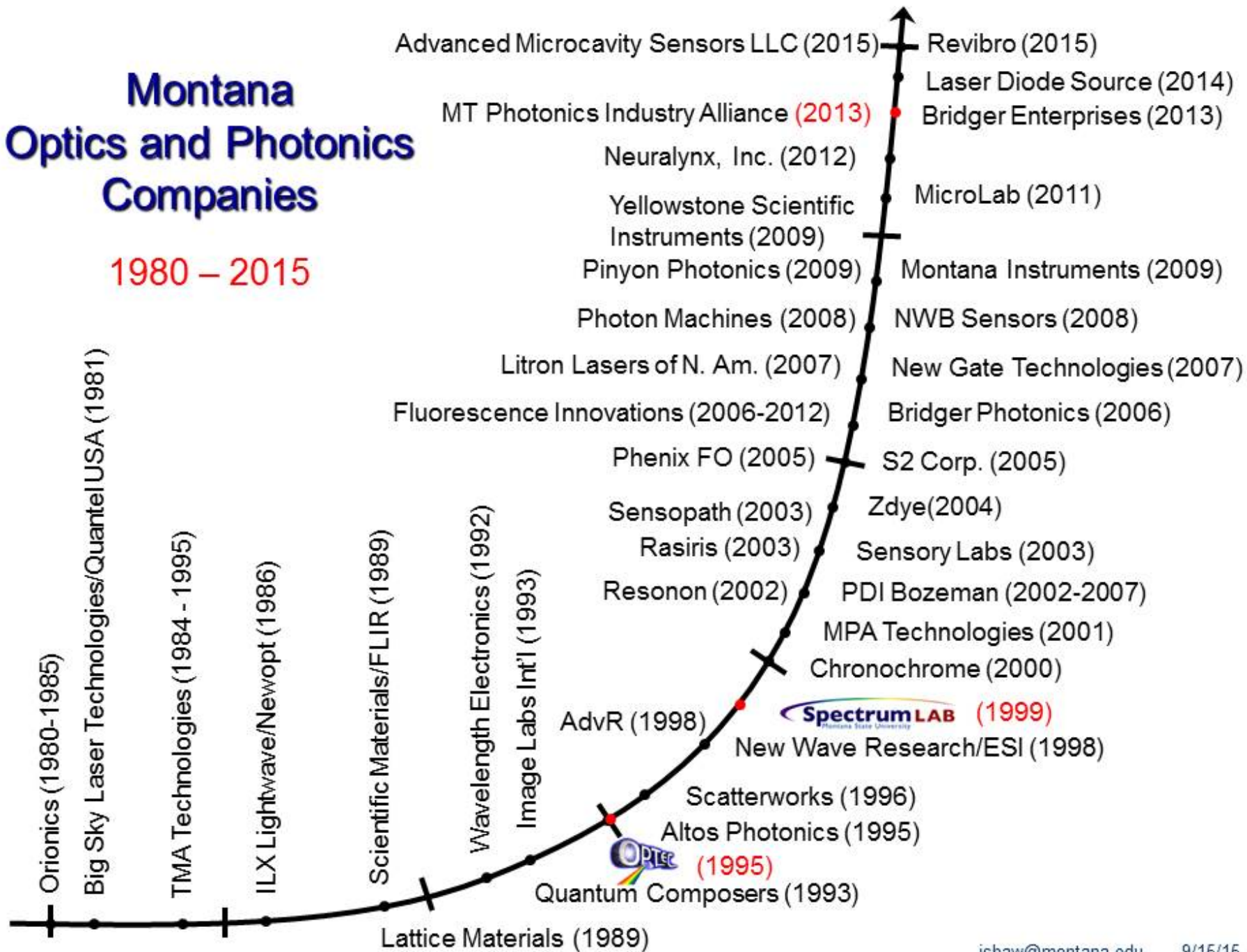
A scenic photograph of a lake at dusk. The sky is dark with some clouds. In the background, there are trees with autumn foliage in shades of yellow and orange. A wooden structure, possibly a gazebo or pavilion, is visible on the left side of the shore. A bright green laser beam originates from a point on the shore, reflecting off the water's surface. The beam is sharp and extends from the top left towards the bottom right of the frame.

Optics and Photonics Research for Montana Economic Development

Dr. Joseph Shaw
Director, Optical Technology Center
Montana State University – Bozeman
jshaw@montana.edu

Montana Optics and Photonics Companies

1980 – 2015



Project Objectives

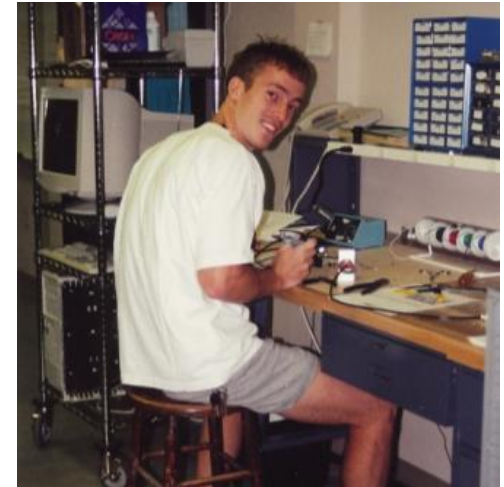
Broaden optics & photonics cluster to include agricultural and medical imaging

Help grow Montana research enterprise in key areas:

- Precision agriculture
- Unattended Aerial Systems
- Microfabrication and nanomaterials
- Medical imaging

Reduce “brain drain” with new high-technology Montana jobs

- 2 new companies
- 7 new commercial products
- 20-25 new jobs with \$60k average salary



Pete Roos – PhD student 1998



Pete Roos – CEO Bridger Photonics 2014

University-industry partnerships for new products

Spectral Imaging for Agriculture & Medical Imaging...

- Combine-mounted imagers for mapping weeds
- Real-time image processing
- Ultra-low-cost miniature imagers



- * Meridian Flying Svcs
- * Freeman Farms
- * Nugent Farms



Advanced
Microcavity
Sensors



Micro-Optical Systems for Advanced Imaging

- Micro-fabricated mirrors for medical imaging...
- Micro-integrated optics and electronics



Laser Sensors

- Lasers of new colors for detecting gas leaks
- Laser sensors to detect water contamination



August 2015 Barley Harvest (Fairfield, MT)



“Translational Science at the Neural Injury Center.”

Alex Philp, PhD
Alex Santos, PhD
Charles Leonard, PT PhD
Cindi Laukes, MA
Erik Guzik, PhD
Sambit Mohapatra, PT PhD
Sarjubhai Patel, PhD
Thomas Rau, PhD



Neural Injury Center (NIC) Mission



Clinical Services

*Assessment & rehabilitation services
for TBI sufferers at UM*

Translational Research

*Develop diagnostics and
treatments to improve TBI outcomes*

Synergy

- *Interdisciplinary collaborations*
- *Generate intellectual property (IP)*
- *Validation of IP via clinical research*
- *Support TBI clinical trials*
- *Clinical services model for MUS*

Our focus: Traumatic brain injury (TBI) in Montana



- 2nd in the nation for TBI per capita (~130,000 diagnosed residents)
- Cost: Estimated at \$50m per year for moderate to severe TBI*
- Lack of diagnosis and treatment options for spectrum of TBI
- Funding the gap to rapidly **implement and commercialize intellectual property (IP)**

Our objectives



Address a Montana issue.

- TBI affects 13% of Montana's adult population (~130,000 residents) resulting in loss of productivity.
- Expansion of Montana Biotech industry (small businesses <20 employees account for 70% of all companies in the US).
- Creating hi-tech high paying jobs for Montana graduates. The biotech industry grows 10x faster than other industries. Salaries are 65% higher.

Create Montana jobs. Using *IMPLAN* economic modeling we project over a 5-year period,

- The direct creation of 135 private jobs.
- Additional 300 jobs through indirect and induced spending.
- Development of IP by the TBI consortium will lead to job creation in the areas of clinical and research sciences, information technology and engineering.

Our Strategy

Area of Focus - *Health and Biomedical Sciences*

#1 Expand current **clinical capabilities of the Neural Injury Center (NIC)** and support translational research

Improve veteran student graduation rates through access to essential clinical and rehabilitative services on UM campus + MUS

#2 Develop a comprehensive panel of objective **tests to diagnose mild TBI** (mTBI)

- *Clinical validation of novel Optokinetic, Oculomotor, Cognitive Fatigue and blood-based medical test*

#3 Develop **novel therapeutic intervention** (miRNA inhibitors) to reduce brain damage after TBI

- *Development of new IP*

TBI
Diagnosis &
Treatment

#4 VAST Next Generation Learning

Complete the development of a **computer-based cognitive training** (CCT) system for TBI subjects with cognitive impairment

- *Development of mobile assessment algorithm*
- *Released for iOS and Android platforms*

#5 N-SITE LLC

Complete the development and testing of a **novel post-traumatic epilepsy diagnostic analysis program**

- *Use proprietary Eidos™ software to identify epileptic signatures in TBI subjects*
- *IBM InfoSphere & Big Data Partnership*

Thank you



Alex Philp, PhD
Alex Santos, PhD
Charles Leonard, PT PhD
Cindi Laukes, MA
Erik Guzik, PhD
Sambit Mohapatra, PT PhD
Sarjubhai Patel, PhD
Thomas Rau, PhD

Special Thanks
Reed Humphrey, PhD



<http://health.umt.edu/nic/>



<http://health.umt.edu/mclab/>

Strong ROI to Montana

- Upon implementation ~\$ 615,500 will be invested in the State through private sector funding

- Generate direct or indirect revenues for the MUS through new grants

- Increase quality employment

- Reduce TBI associated treatment costs

- Enhance the value of IP owned by the MUS that can be collected as in-licensing agreements with the private business sector

- Five-year projections for this proposal are as follows:

- ◆ Cost savings on improved workforce productivity, reduced health care costs, improved graduation rates, and decreased criminal behavior*.

- ◆ \$12-15 million in in-licensing and royalty agreements on developed IP owned by the MUS

- ◆ \$2-6 million in the development of novel IP for the MUS

- ◆ \$5-7 million in grant submissions to DOD, NIH, NSF, VA, and Private Foundations

* *The costs of traumatic brain injury: a literature review.* Humphreys et al., ClinicoEconomics and Outcomes Research, 2013

* *Outcomes and Costs of Acute Treatment of Traumatic Brain Injury.* McGarry et al, J. Trauma, 2002.

Increasing Profitability by Improving Efficiency of Montana's Farm and Ranch Lands




Wheat- Fallow

A wide-angle photograph of a vast, flat landscape under a hazy sky. The foreground shows a mix of brown and tan fields, with some rocky outcrops in the lower right. The horizon is distant and flat.

Now

Wheat-Fallow system - **land use is not optimized**
4.6 million acres that could produce annual income



Cover Crop Mixes-Wheat Forage for Livestock

A photograph of a lush green field with yellow wildflowers in the foreground. In the background, there are power lines and a small building under a clear sky.

4 years data at NARC- winter wheat yields unaffected- 3.7 AUM/A



Peas-Lentils-Wheat Cash crops

A photograph of a green field with a blue sky and mountains in the distance. A digital timestamp '6 15 '99' is visible in the bottom right corner.

The Future - annual cropping with uncertainty managed by products of this research

Increasing profitability by Improving Efficiency of Montana's Farm and Ranch Lands

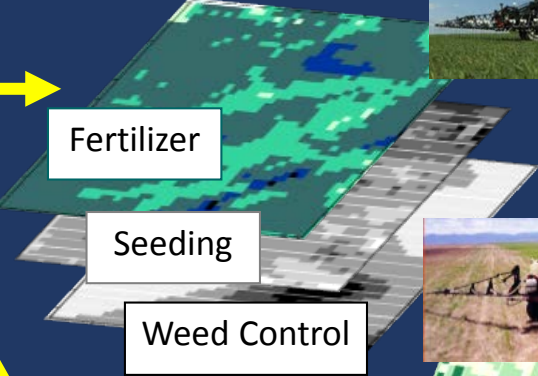
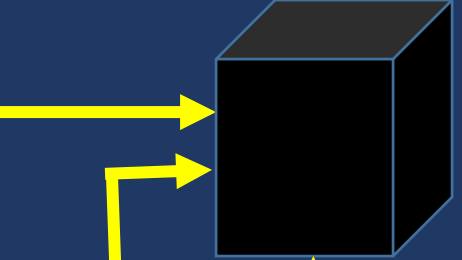
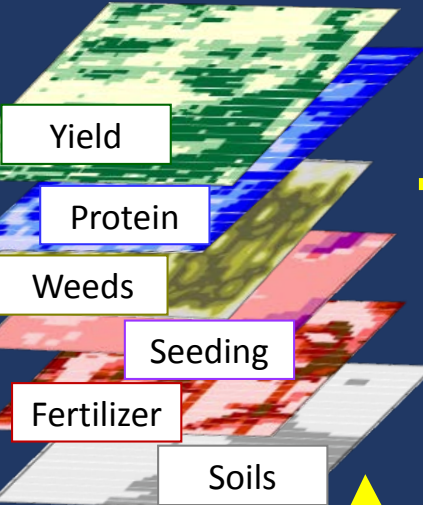
- **Three interrelated goals: Optimize productivity of MT lands**
 - **Intensify pulse and cover crop production of 4.6 million acres of land left fallow each year.**
 - **Crop-fallow-** 1 years income forgone to store moisture for next wheat crop
 - **Pulse and cover crop mixes** can be used safely to produce annual crops or 3 crops in 4 years
 - **Develop new, improved or quality differentiated products, crops or farm practices**
 - **Increase adoption of precision agriculture technologies**
 - Technologies developed in this proposal will take uncertainty and risk out of annual cropping systems

On Farm Precision Experiment Framework

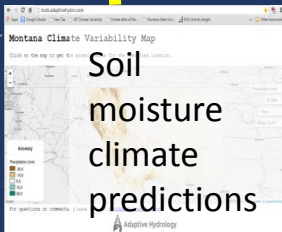
GIS-based maps from sensors

Data Organization & Analysis

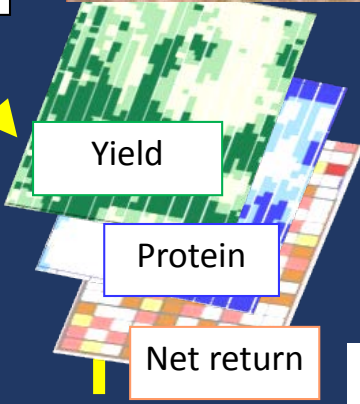
Prescriptions
Maximizing Profit
Optimizing Inputs
Reduce Risk



Fertilize and spray only where needed



Experiment



Inexpensive data

Data on crop performance

*Building the database
Increases the predictive
ability*

*Parameterize
functions*



Funding this proposal

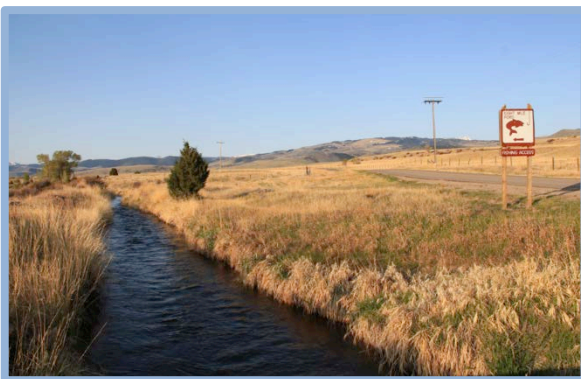
- The time is right- this unique funding as brought together a diverse, experienced team with > \$30 million funding in past 10 years to:
 - Encourage more **rapid adoption** of proven science-based technologies and **new approaches to optimize sustainable use** of Montana land resources.
 - Provide the foundation for new jobs and industries
- No other funding source will provide funding for this Montana-Centric research proposal that will grow and diversify Montana's economy
- The science developed in this proposal will make the MSU/UM team highly competitive for future competitive grants

Outcomes

- **Farm incomes will increase \$15-25 million in 18 months**
 - From pulse crops
 - Forage for livestock
- **Farm incomes will increase \$100s of millions in 5-10 years**
 - Optimized land use
 - Improved pulse crop varieties adapted to MT
 - Improved durum wheat varieties adapted to MT
- **New Montana Jobs-**
 - Production of sensors, software, etc. for precision agriculture
 - Processing facilities for pea protein
 - Crop consultants/Data management consultants
 - On-farm jobs
- **Increased tax revenues-**better schools, infrastructure, communities

Sustainability, farm income, land values and MT tax receipts will increase.

Development and Commercialization of Autonomous Chemical and Biological Instrumentation for Water Quality Monitoring



**Mike DeGrandpre,
Orion Berryman, Chris
Palmer**

Steve Amish

Gordon Luikart

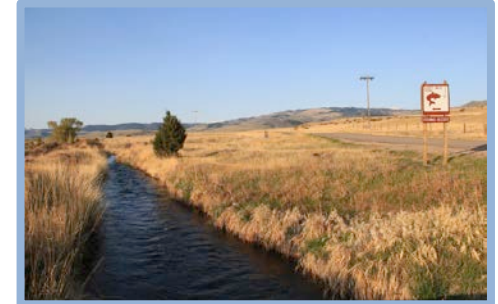


Division of Biological Sciences



Water Resources and Water Quality in Montana

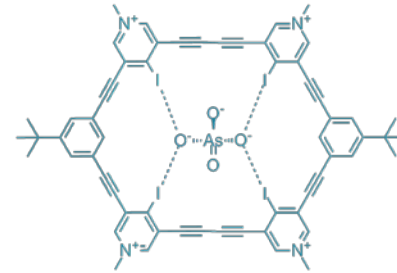
- **Residential**
 - Chemical composition
 - Invasive species
 - Health and safety
- **Recreation and Tourism**
 - Chemical composition
 - Invasive species
 - Health and Safety
 - Aesthetics
- **Irrigation and Agriculture**
 - Chemical composition
 - Invasive species
- **Power Generation**
 - Invasive species
- **Petroleum Production**
 - Chemical composition
 - Health and safety



The Technologies

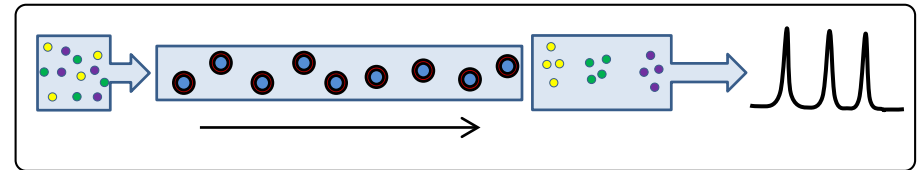
Berryman Lab (UM-Chem)

- **Selective ion sensors and binding**
Groundwater arsenate detection



Palmer Lab (UM-Chem)

- **Microscale water analyser**
Field analysis of nutrients, production water



Amish/Luikart (DBS/FLBS)

- **eDNA sampler**
Robust detection of invasive species

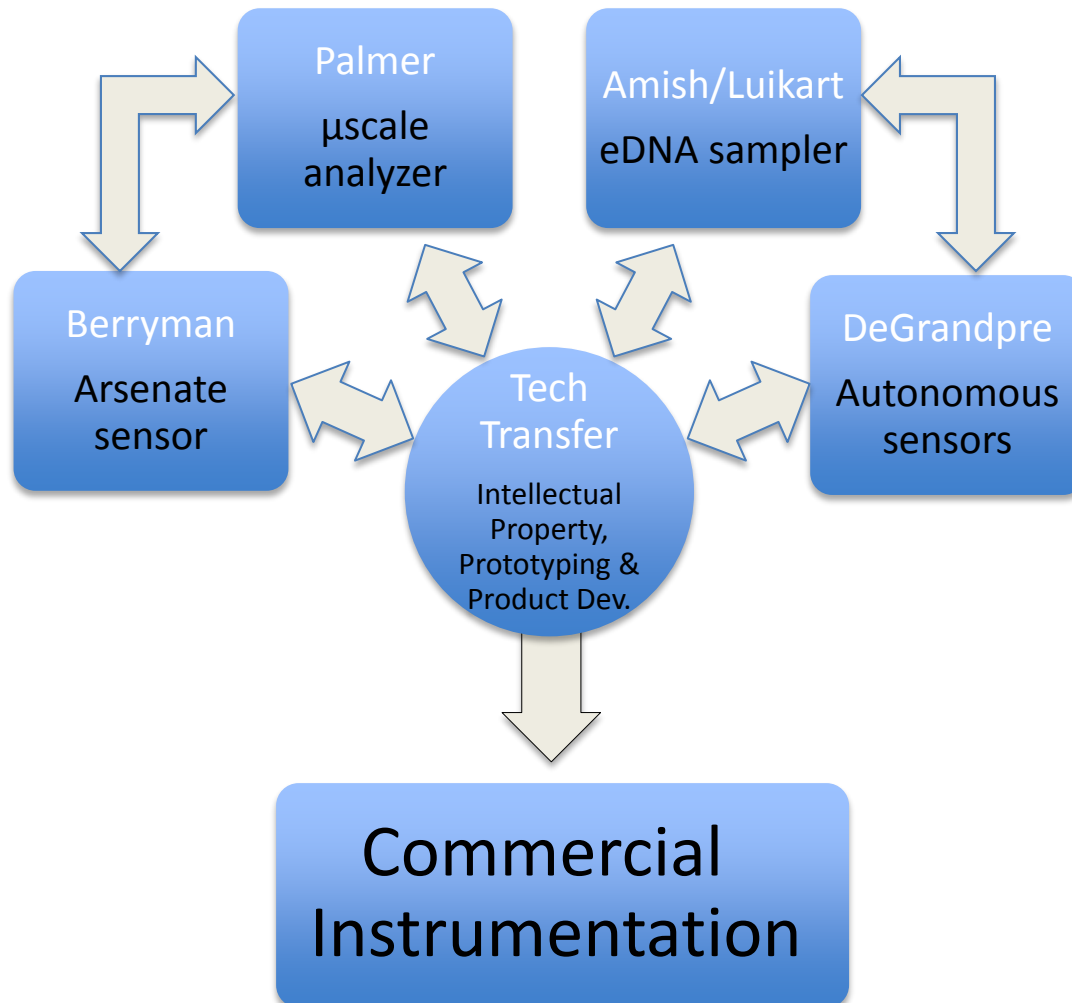


DeGrandpre Lab (UM-Chem)

- **Autonomous analyzers**
simple wastewater pH/alkalinity analysis

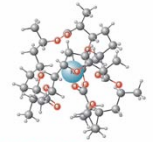


Team Strategy



The University of Montana

DEPARTMENT OF
CHEMISTRY
AND
BIOCHEMISTRY



Division of Biological Sciences



Flathead Lake
Biological Station

Commercial Potential

- \$8.69 billion U.S. Market for analytical chemical instrumentation*
- eDNA industry growing exponentially

Montana Benefits

- Increase in STEM/Manufacturing workforce
- In-field monitoring of water quality
- Early detection of aquatic invasive species
- Follow-on funding (SBIR, MBRCT, Murdock, etc)
- Intellectual property development, licensing

**Highbeam Business Reports*

