

Final Report Summaries as of December 2010 - #06 Projects

#06-01 Montana Value Added Small Grain Safflower for Vegetable Oil-Based Lubricants

**Jerry Bergman – MSU Eastern Agricultural Research Center – Sidney/Bozeman
\$75,000**

Final report approved: January 2008

Summary:

This project identified normal and wild type safflower genetic lines having the gamma form of tocopherol that will improve oil yields and enhance oxidative stability of bio-based products for the lubricant end-use market and other industrial oil applications. High gamma tocopherol lines were identified and hybridized to commercial varieties to recombine gamma tocopherol with high oleic fatty acid profile and thinner hulls. The improved genetic lines will improve oil quality and provide safflower meal co-products with improved feed value (higher protein/less fiber) as a livestock supplement.

Individual seeds of the progeny of the safflower accessions having the gamma form of tocopherol hybridized with commercial lines were evaluated for fatty acid profile, oil quality, meal quality, and agronomic characteristics. Selections from this group are providing future safflower varieties with oils that will best meet criteria needed for a vegetable oil-based lubricant and improved co-product value.

Commercialization:

It is expected that 4.5 years of variety development is still required before a variety is available for commercial production. Varieties developed from this project will allow for the expansion of safflower production for bio-lubricants, provide a preferred base oil for beauty care and pharmaceutical products, and a source of high oleic fatty acid safflower oil for the chemical industry. These new and expanding domestic and international safflower markets and outlets will strengthen the position for safflower oilseed processing in Montana, provide an improved Montana safflower oilseed meal for the livestock feed industry and allow expansion of this alternative broadleaf crop to diversify from mono culture wheat and barley production. High oleic safflower with enhanced oxidative stabilities will result in the development and growth of a premium safflower oil-based lubricant industry in Montana to potentially capture a share of the European bio-lubricant market and the expanding U.S. bio-lubricant market.

Target market including size:

The potential of high oleic safflower oil-based lubricants is now being recognized. It is estimated that 35% of the total European lubricant market by 2010 will be supplied by bio-based products. The need for high oleic feed stock oil will become increasingly important. High oleic safflower oil, with oleic levels over 32%, ideally fits the requirement for vegetable oil-based lubricants. The breeding potential exists to increase safflower oleic levels and drastically improve antioxidant properties for the lubricant market.

#06-02 Camelina Sativa: A Low-Input Oil Crop for Omega-3 Culinary Oil and Animal Feeds

Alice Pilgeram – Montana State University - Bozeman

\$173,500

Final report approved: July 2009

Summary:

The overall objective of this project was to develop *Camelina sativa* as a profitable Montana crop. The successes of this project have resulted from collaboration between University and Extension researchers, Montana producers, small businesses and both state and federal governments. Camelina was first evaluated in Montana in 2004 in a study to identify potential biofuel crops suitable for production in our arid climate. Camelina emerged as a promising Montana oilseed crop suitable for manufacture of cost-competitive biodiesel. The success of this crop in the four-state region of Montana, Idaho, Washington and Oregon has resulted in establishment of four biodiesel companies in Montana. Flathead Biodiesel (Kalispell), Earl Fisher Biofuels (Chester), Great Plains Oil and Exploration (Bigfork) and Sustainable Oils (Bozeman) are actively contracting biodiesel acreage in Montana.

Camelina production as feedstock for biodiesel manufacture is only marginally more profitable than wheat production. The biodiesel industry is a commodity industry dependent upon cheap sources of oil. The price of biodiesel must compete with the price of petroleum diesel and the challenge is to produce inexpensive feedstock oil while generating fair farm profit. The key to this challenge is the meal, the seed byproduct remaining after oil extraction. Camelina meal is a rich source of omega-3 fatty acid, tocopherol and protein with many potential applications in animal and human nutrition, as well as industry. The focus of the project has been to identify and develop these applications.

Commercialization:

Progress to Date:

- Over the past five years, MSU's involvement with the new crop, *Camelina sativa*, has grown from planting a collection of seed to intense activity ranging from selection of varieties to application for AFCO and GRAS listing, to establishment of crushing facilities, to commercial relationships. There is a great deal of interest in the special and unique properties of *Camelina sativa*.
- Acquisition of FDA approvals is the largest hindrance to commercialization of camelina foods and feeds.
- It is expected that FDA will work with the camelina industry to expand its allowance beyond its approval for broiler feeds to other livestock, eggs and dairy.
- There is demand within the organic industry for camelina oil and products.
- The camelina supplement industry will continue to expand, but this is a niche market.
- The cosmetic market should continue to grow. Camelina skin products are superior to most products made from common omega-6 oils, such as soy, canola, and sunflower.
- Camelina meal has value in industrial applications.

□ Economic Impacts

It is projected that acreage will increase in Montana from the present level of about 30,000 acres to 500,000 within the next five years. It will be an additional high value component of wheat/barley and legume rotations because of its high value oil and proteins and their value in Montana's animal feed industry. There are three distinct industries developing around camelina: biodiesel, nutrition and cosmetic.

Biodiesel

- Camelina is less expensive to produce than other oilseed crops and the meal has potential as a valuable feed ingredient, offsetting the cost of the oil and the cost of biodiesel manufacture. Also, the chemistry of the oil allows processing to higher value products such as JP-8 jet fuel.
- Great Plains Oil and Exploration, a renewable fuels energy company and a partner to one of the largest biodiesel producers in the world, is aggressively recruiting camelina producers throughout Montana, Idaho, Washington, and Oregon. The long-term goal is to contract and process 1 million acres/year of camelina in Montana and the Pacific Northwest.
- Sustainable Oils, a joint venture between Targeted Growth and Green Earth Fuels, is focused on research, development and commercialization of camelina for biodiesel production. Early emphasis has been to establish a camelina breeding program at Belgrade and to develop necessary markets and applications for the oil and meal prior to contracting camelina production. As a member of the North America Camelina Trade Association, it took the lead in working with the FDA to obtain approvals for use of camelina meal in livestock feeds. It supplied camelina biofuel to Japan Airline for a recent test flight of a commercial airline using a fuel consisting of 50% jet fuel, 50% biofuel, where 84% of the biofuel was camelina biodiesel.
- Flathead Biodiesel is a medium term company designed to aid in the transition from petroleum fuels and lubricants to renewable, alternative energy sources. The Kalispell company produces and purchases camelina seed. The company awaits acquisition of FDA approvals to market the meal to local dairy and livestock producers.
- The mission of Earl Fisher Biofuels, Chester, is to create economic growth and employment opportunities by building a biodiesel production facility, which will create a self-sustaining industry by creating a market for oilseed crops that can be grown locally, converted to fuel locally, and consumed locally. The long-term plan is to then duplicate the process in small communities throughout Montana.
- Willamette Biomass Processors is a large-scale Oregon commercial oil seed processor working with the University of Oregon to establish camelina production and processing in the Pacific Northwest.
- Blue Sun Biodiesel is a Golden, Colorado, company. [Although the report does nothing more than list this company, it is described on Google as "America's leading biodiesel/biofuel research, production and distribution company".
- There are six Omega-3 Fatty acid companies listed doing business in the camelina culinary and cosmetic industries in Montana and Wyoming, TaDa Soaps (Sheridan, WY, and Bozeman, MT), Montana Loofah (Great Falls), OmegaMax

(Missoula), US Omega Foods (Florence), Wild Flax (Reed Point) and Biomega3 (Bozeman). Their products include soap, supplements, cosmetics, culinary oils, oil, meal and seed.

#06-03 Development of Advanced Materials for Optoelectronics and Optical Communication Technologies

Galina Malovichko – Montana State University - Bozeman

\$180,000

Final report approved: October 2007

Summary:

The project was performed in collaboration with Scientific Materials Corporation and focused on a comparative study of intrinsic and extrinsic defects in nonlinear optical materials for the development of materials suitable for advanced applications.

- It was found that nominally pure crystals contain impurities and samples from different sources have different uncontrolled impurities and, therefore, different physical properties. Stoichiometric crystals have less concentration of intrinsic and extrinsic defects and, thus, have very promising properties for various scientific and industrial applications.
- The research provided basic knowledge about many defects in optical materials. This allows for the selection of materials suitable for definite applications, called “finding know-how” in the report, such as procedures for material optimization, development of materials and which properties are customized and engineered to device specific requirements by means of doping.
- This meets the exact need for integrated optics in telecommunications.

Results of project:

Product description:

The research resulted in basic knowledge* about defects in optical materials, which allows:

- Ability to select materials suitable for definite applications
- Ability to optimize the materials by special treatment
- Ability to develop materials with properties customized/engineered to device specific requirements by means of doping

*According to the report, this knowledge is **exactly** what is required for the integrated optics needed in telecommunications.

Scientific Materials Corporation, and other companies with facilities to produce these materials as well as to fabricate and market components from them, has expressed interest in licensing and commercializing the results. The project has also attracted the attention of NASA and DoE.

Economic Impacts:

Development of intellectual property:

Basic knowledge was obtained and intellectual property was developed. This knowledge and intellectual property may be implemented as a patent in the future.

Other:

- Numerous publications and presentations at national and international conferences are outcomes of the project.
- The materials that have been developed can enable new technologies in laser systems and optical signal processing, which can be employed by federal agencies such as DoE, DOD, and NASA, and by private businesses.
- The seed investment of this project has the potential to leverage by two or three times the amount of the MBRCT grant award from NASA, DoE and DOD.
- The high sensitivity and high resolution of magnetic resonance spectroscopy used in the laboratory offer new capabilities by providing information at the atomic level not previously available. This information affords a competitive advantage in the marketplace for local companies in materials related business.
- Undergraduate and graduate students were able to participate in cutting-edge research and the acquired experience is useful for future work at local companies or in research labs. One student is now working with nonlinear optical materials at Advanced Research, Inc., in Bozeman. This training of highly qualified manpower is beneficial to Montana.

#06-04 Feeding Barley Beta-Glucans to Stimulate the Immune System of Calves

J. P. G. Bowman – Montana State University – Bozeman

\$68,107

Final report approved: December 2007

Summary:

Results of the study were unequivocal and did not translate to improved animal performance. Further research needs to be conducted to determine if there are more long-term immune advantages to barley-based diets and compare them to medicated calf starters. The project is not ready for commercial development.

Commercialization plan:

The project investigated the effect of barley-based feed containing beta-glucan on immune response in cattle. Results **may** contribute to improved animal health and promote an interest in discovering alternatives to the use of preventative antibiotics in livestock feeds, which **could** create new marketing strategies for barley by increasing demand and production of barley.

Product description:

More research is needed before a product can be marketed as a nutraceutical and alternative to medicated products. However, a calf starter pellet made with Montana grown feedstuffs (corn or barley) could be produced and marketed by a Montana feed company without promoting the immunological aspects.

Direct commercialization of this project may allow for the production of a calf starter pellet or calf creep feed containing barley beta-glucan, which could be marketed by Montana companies as an alternative to medicated calf starter rations currently on the market.

New barley feed products could be promoted to local beef and dairy cattle producers as well as to those of state.

Economic Impacts:

Economic impacts are theoretical at this point. Results from this study could potentially:

- Be made available to Montana feed companies for direct commercialization
- A Montana-based feed mill could manufacture a texturized or pelleted calf starter using commodities grown in Montana.

#06-05 Optical Fiber Communications using Electro-optic Transducers

Richard Wolff – Montana State University - Bozeman

\$198,040

Final report approved: October 2007

Summary:

The objective of the project was to develop an electro-optic modulator that offers the advantages of low complexity, ease in manufacture, low operating voltage and compact size. One of the major outcomes was the design and fabrication of a KTP-based electro-optic modulator that can be installed in a fiber optic communications system. Other key outcomes were:

- Design and construction of a compact interferometric receiver to efficiently detect the phase modulated signal.
- Analysis and demonstration of the effectiveness of multi-level frequency shift keyed information encoding. Analytical results, verified by experiments, show that four-level modulation provides the best performance.
- Continued pursuit of a patent for the technology.

Commercialization:

Steps taken to explore commercialization opportunities for the electro-optic modulator include:

Market assessment:

Initially, it was thought the primary opportunity for use of the derived communication channel enabled by the electro-optic modulator would be in fiber to the home (FTTx) applications. This market, although it is growing, is growing at a slower rate than originally forecast. Although the FTTX business opportunity is real and growing, the backlog of fiber optic components has made it difficult for new technologies to compete cost effectively. The market is poised for expansion in the next two to three years.

Identify Commercialization plan:

- Primary activities toward commercialization are to continue to pursue patent position and begin an intellectual property marketing campaign. The patent application was converted from a provisional filing to a regular application and is moving through the patent office process. An information disclosure statement was filed August 2007.
- Working with the MSU Technology Transfer Office to identify license opportunities for the technology and the long-term plan is to continue to pursue licensing opportunities for the technology.

Product description:

Although premature to describe a specific product, in general terms it is a compact, in-line electro-optic modulator capable of providing a phase-modulated secondary communication link with throughput ranging up to 1% of the primary intensity modulated channel rate.

Target market including size:

The potential market is extremely large (over 130 million potential lines in the United States) with small (less than 1%) penetration to date.

Economic Impacts:

Development of intellectual property:

Although premature, the most favorable outcome of the project would be to license the intellectual property to a Montana optical technology firm that can develop a product for the emerging FTTx telecommunications market. This company would serve as a supplier for a larger vendor. A local company that already manufactures KTP-based components would be a probable participant in this market.

#06-06 Accelerated Development of Two-Gene Imidazolinone-Tolerant Wheat Varieties for Montana

Luther Talbert - Montana State University - Bozeman

\$150,000

Final report approved: February 2008

Summary:

This proposal aimed to develop IMI-resistant spring and winter wheat for Montana to increase profitability by providing effective control of jointed goat grass and other problem weeds. The project was a cooperative effort among the winter wheat breeder, spring wheat breeder, and weed scientist at Montana State University. In addition, BASF Corporation, which owns the rights to the IMI-resistance genes, has been a cooperator in providing assays, advice and financial contributions. The goal of the breeding projects was to develop new varieties containing two IMI-resistance genes, as previous research has shown that two genes provides a high level of herbicide resistance. IMI-resistant versions of the most popular Montana wheat varieties have been developed through this program, and have been entered into the breeding programs, and are on track for commercial release. In addition to the breeding work, weed control experiments were conducted at Kalispell to determine the range of weeds that may be controlled in the

system and the appropriate rates and dates for herbicide application to control troublesome weeds in Montana. The primary use for IMI-resistant winter wheat will be for jointed goat grass control. IMI-resistant spring wheat varieties will likely be used for cheat grass control. All varieties will be released cooperatively with BASF and commercialization will follow procedures established with previously released winter wheat varieties, and will involve seed distribution systems already in place in Montana.

Commercialization

Commercialization of the spring and winter wheat lines will proceed through the established procedures of the Montana Agricultural Experiment Station. Since the Imidazolinone technology is owned by BASF, the technology must be released in varieties through companies with valid commercialization agreements with BASF. MSU has good experience with the procedure from the release of one-gene IMI-resistant winter wheat lines. Through a bid process, these varieties were exclusively licensed to Westbred LLC, Bozeman, for commercial seed sales and a similar process will be followed for the two-gene varieties.

Product description

Two-gene IMI-resistant winter wheat and spring wheat lines

Target market including size

Montana seed companies with exclusive licenses with BASF and, ultimately, Montana wheat farmers.

Marketing strategy

To follow established procedure of Montana Agricultural Experiment Station

Estimate of sales revenues for five-year period into the future

Total seed sales are difficult to predict. Over 60,000 acres of one-gene winter wheat varieties were planted in Montana in 2008, which translates into production of more than 240,000 bushels. The economic impact of superior two-gene varieties should be greater with the reduction in herbicide injury to the crop.

Economic Impacts

Primary impacts will be in the form of increased seed sales for the seed industry, more profitable production for Montana wheat farmers, and long-term weed control that will complement traditional wheat farming practices.

#06-07 A New Weapon for Reducing Sawfly Damage in Montana Wheat Fields

David Weaver – Montana State University - Bozeman

\$230,000

Final report approved: July 2010

Summary:

This project focused on the management of the wheat stem sawfly by capitalizing on mortality that occurs in solid stem wheat varieties to reduce financial losses caused by the wheat stem sawfly. The goal of the project was to identify a solid stem wheat variety that

would attract females to lay more eggs in these solid stems and increase mortality, thus reducing losses. The key was to create a solid stem wheat variety that was very attractive and, at the same time, very lethal.

The project identified a highly attractive wheat variety that also kills sawfly larvae. Named Choteau, this variety can readily attract and kill sawfly when paired with an unattractive variety. It is unique in that it has very solid stems and can kill 70% of the sawfly larvae it attracts.

The key finding of the project was the use of the combination of attractive and unattractive wheat stem varieties in trap crop scenarios. That Choteau is highly effective when planted as a small perimeter trap around unattractive hollow stem wheat varieties and less than 50% of the eggs when planted as a trap around another attractive hollow stem variety is significant. This finding has led to new research focused on trap crops, in particular the use of lethal traps. The interest in trap cropping has grown rapidly and has been used in innovative ways by growers. The use of trap crops may boost production profitability in wheat potentially by as much as 10% in impacted fields. This could result in a 3-bushel increase over two million acres, at a conservative price of \$4.50 per bushel, or more than \$25 million per year if adopted by all growers with severe wheat stem sawfly problems.

Commercialization:

This project did not yield a new product, as was anticipated, or a new process. However, use of trap cropping is now a very effective tool because of the information this project garnered on heritability of preference. As can be seen from the many presentations being made to grower organizations, growers, consultants, and elected officials, the researchers are using this information to develop and implement processes and practices. Some of the newest unattractive wheat stem varieties to be used in trap cropping are developed by WestBred, now part of Monsanto, Inc. Although their varieties would represent the majority of acres and acres of MSU-originated Choteau would actually decline, the net gain to growers is quite significant. An economic analysis is underway to determine the extent of that significance.

Economic Impacts:

Economic benefits will come from reduced losses and from direct sales stimulated by the potential increase in acres planted. Depending on the efficacy and the severity of the existing infestation for the producer, these benefits could realistically reach 40% of the total economic loss experienced by individual producers. Widespread adoption could have a direct impact on overall wheat production in the range of 5% of the total net value of the industry, which is \$600 million in Montana.

#06-08 A User Grant Program for the Montana Microfabrication Facility
David Dickensheets – Montana State University - Bozeman
\$64,000
Final report approved December 2010.

Summary:

The Montana Microfabrication Facility (MMF) is a cleanroom facility at MSU offering equipment and training to users to perform microfabrication tasks. Funding from this project was used to award commercial users small grants to cover the cost of the use of the facility for pilot projects. Companies were able to explore innovative new microfabrication processes for developing technologies and improving competitiveness.

The project met its objectives in that it supported 12 pilot projects for six Montana companies. The companies, in turn, leveraged this support to secure 19 subsequent research and development grants or contracts worth more than \$4.6 million. In addition, at least 19 people in the regional workforce were trained in microfabrication processes, and partnerships between the participating companies and the MMF facility were formed. The commercial potential of these efforts is considerable in that these companies have been able to develop unique, proprietary technologies that may very likely form the foundation of future products.

Highlights of the project include:

- 12 user grants awarded to six Montana companies to support technology development objectives
- 19 commercial users trained in microfabrication processes and specialized tools
- MBRCT funds leveraged by almost a factor of three in terms of user fees
- Participating companies attracted in excess of \$4.6 million in new research and development income as a direct result of this funding
- MMF has continued to add capability in response to the needs of commercial and academic users and has formed partnerships with several of these companies.

Commercialization:

There was not a commercialization component of this project. However, economic impacts and outcomes are significant.

Economic Impacts:

- Direct economic impact for the MMF includes additional user fees generated by the companies receiving MBRCT user grant total \$100,385, leveraging the \$52,000 MBRCT funds 1.9x.
- The greater impact has been on the participating companies that report subsequent research funds received from Federal agencies in excess of \$4.6 million, or a leveraging factor of 88x.
- Longer lasting impact will be the enhancement of the technology portfolio of these Bozeman and Helena companies. They have explored new technologies and have a lower barrier to access the MMF facility for future developments.
- Individuals who have received training at the MMF contribute to the local workforce with specific microfabrication skills.

Other: Outcomes associated with companies that received funding from the user-grant program:

- 1) Bridger Technologies – Subsequent funding was sought and received from the Department of Homeland Security and DARPA.
- 2) AdvR, Inc. – This project allowed AdvR to move its microdevice work from labs in California and New York to Bozeman. Preliminary results were useful in subsequent funding from NSF and Navy, totaling \$250,000.
- 3) Crystal Growers – The project was not completed.
- 4) Resonon – Subsequent funding was sought and received from NSF and DOE, totaling \$2.5 million.
- 5) AdvR –Subsequent funding from NASA and USAF, totaling \$1.2 million.
- 6) Bridger Photonics – Funding was sought and received from NSF, totaling \$175,000.
- 7) AdvR – Subsequent submissions to NASA and Air Force, totaling \$200,000 requested.
- 8) American Chemet Corporation – User grant allowed to rule out two compositions as anti-corrosion barriers on electrodes used in the copper purification process.
- 9) Bridger Technologies – project is currently under way.
- 10) Bridger Photonics – project is currently under way.
- 11) AdvR – project is currently under way
- 12) Bridger Photonics – project is currently under way.

#06-10 Functional Analysis of Genes Controlling Malting Barley Grain Protein Concentration

Andreas Fischer - Montana State University – Bozeman

\$174,340

Final report approved: March 2009.

Summary:

The main purpose of this project was to understand the basic plant biology, including specific gene action, which controls grain protein concentration (GPC). GPC is an important quality trait in cereals such as wheat and barley and, in malting barley, high GPC is associated with undesirable formation of beer haze. This understanding is critical for breeding well-adapted, new Montana malting barley varieties. The data obtained from this project show that high GPC is associated with earlier leaf protein degradation and amino-nitrogen retranslocation to developing kernels, which leads to earlier and higher accumulation of grain storage proteins. This data was published in three peer-reviewed publications during 2008. Functional characterization of several genes discerned that the glycine-rich RNA-binding protein may be the most interesting target for the control of barley GPC and its detailed biochemical analysis has been initiated in collaboration with MSU's Department of Chemistry and Biochemistry. Germplasm including low-GPC allele(s) at the original chromosome six loci has been transferred to MSU's barley breeding program for evaluation. All objectives of the original proposal

were met with the exception of tool development to transfer low-GPC allele(s) of novel genes to barley breeding.

Commercialization:

Published manuscripts: Research results have been published in three peer-reviewed manuscripts in scientific journals, including *New Phytologist*, *Physiologia Plantarum* and *Functional Plant Biology*.

Product description: The final commercial product will be improved malting barley varieties with stable, low grain protein concentration under Montana's dryland farming conditions. Malting barley production has moved from the Dakotas and Minnesota into western states including Montana, which opens an economic opportunity and makes the development of well-adapted varieties even more commercially important.

Commercialization of new varieties from this research:

Three near-isogenic lines which exhibit lower GPC and higher yield have been transferred to MSU barley's breeding program for further evaluation and malting barley variety development. This represents the first applied benefit from this project.

Several genes which most likely participate in the control of GPC have also been identified and the best will be exploited using the following approaches:

- 1) Identification of natural variation in key regulatory genes
Development of molecular markers for each gene allows transfer of commercially interesting alleles into breeding lines.
- 2) Modification of key gene expression by transgenics or mutagenesis
Modification would be followed by transfer of created variants into breeding lines.
- 3) In both cases resulting germplasm will again be tested in collaboration with MSU's barley breeding program prior to larger-scale evaluation and variety development.

Estimate of sales revenues for five-year period into the future:

Maltsters and brewers purchased 22, 21.5, 19.5 million bushels of Montana's barley crop in 2005, 2006, 2007 compared to 7.5 and 15 million bushels in 2001 and 2003. Prices per bushel have also increased to \$4.25/bushel in 2007 equal to ~\$135 million. The value of Montana's barley production could be more than \$100 million over the next five years.

Economic Impacts:

The major impact of this project is the generation of novel information to plant science. Specifically, the project has successfully:

- 1) Characterized the physiology of barley nitrogen retranslocation to developing kernels, as directed by the major GPC locus on chromosome six;

- 2) Identified novel (to plant science) genes, which may be important for controlling GPC.

Work will continue to focus on these genes with the goal of exploiting them for further gains in the control of this economically important trait.

Other:

Three manuscripts published in prominent industry journals are attached to the Final Report.

#06-12 Advancing Malting and Feed Quality in Barley

Mike Giroux – Montana State University – Bozeman

\$234,000

Final report approved: September 2008

Summary:

Barley production is an important industry in Montana. The objective of this project was to identify ways to develop new varieties of barley that have enhanced feed and malt quality. Studies demonstrated that the hordoindoline gene locus affects both malt and feed quality. The hordoindoline alleles had large impacts on both barley seed size and grain hardness, indicating that direct selection for individual hordoindoline alleles could be used to select for improved malt and feed quality. The outcome of the project points to excellent commercial potential in that individual hordoindoline alleles can be specifically selected and incorporated into new barley varieties as a way to create value added barley varieties useful in malt or feed applications.

Commercialization:

Product description

The product is barley varieties with improved malt and/or feed quality.

Target market including size

The target market is all barley producers.

Marketing strategy

Varieties developed to be increased in yield or quality may result within 4-6 years. All varieties will be released through the Montana State University Foundation Seed program. Varieties containing technology owned by companies or other universities will require commercialization agreements between MSU and private companies. These agreements have been successful in targeting release of varieties to particular end uses. All releases are targeted to all growing areas in Montana.

Business risk assessment

There is little to no risk involved as the variety release program is well established.

Estimate of sales revenues for five-year period into the future

Sales revenues depend on the method of variety release.

Other:

This project successfully identified variation in genes that will be directly useful in improving barley malt and feed quality. The information will be published in peer reviewed scientific journals and will be widely accessible to all barley geneticists and plant breeders. The unique aspect of the project is that basic research has been conducted and that basic research has a variety of applications.

#06-15 Commercialization of BmJ as a Broad Spectrum Microbial Disease Control Agent**Barry Jacobsen – Montana State University - Bozeman****\$118,900*****Final report approved: March 2007*****Summary:**

The MBRCT project was instrumental in establishing *Bacillus mycoides isolate* (BmJ) as a product with significant commercial potential in agricultural markets. Montana Microbial Products is moving forward with obtaining US EPA registration and plans to begin production in Montana and sales in 2008. This funding was also instrumental in securing a Phase II USDA SBIR grant and obtaining an experimental use permit for large-scale field trials on Sugarbeet.

The project enabled progress toward commercialization of BmJ as a biopesticide for control of Cercospora leaf spot of Sugarbeet, and other fungal diseases. Field efficacy against fungal diseases of cucurbits has been demonstrated as well as reductions in virus diseases in tomato and cucumber and in root disease in geranium and Sugarbeet plants. There are no other reports in published literature of this type of biocontrol agent reducing virus or root disease.

MMP Progress toward Commercialization:

The report lists the BmJ research field trials conducted or in progress through the end of 2006. Trials in both MBRCT and SBIR Phase II projects provide a comprehensive review of progress toward commercialization. In a number of crop disease systems, BmJ has shown disease control comparable to the chemical products now used in the crops.

- BmJ has excellent commercial market potential as a stand alone product or as one of multiple products in control programs. These include ***bacterial spot*** in tomatoes and peppers, ***angular leaf spot and anthracnose*** in cucumber and melons, ***early blight*** in potatoes and ***pecan scab*** in pecans.
 - The bacterial spot organism develops resistance to copper providing an important advantage for BmJ in this market.
 - BmJ provided control of angular leaf spot in cucumber equivalent to copper the only other effective product for this disease.
 - BmJ provided control of anthracnose in the mid range of the standard chemical fungicides used in the trials.
 - BmJ could have a market share as a rotation product in control programs.

- BmJ controlled early blight in potatoes as well as the best chemical fungicides in trials in Montana and in Idaho. MMP sees significant market potential in potatoes for early blight control as a low priced product used as a preventative treatment.
- In pecans, BmJ was the best of the treatments in the trial, providing better control of pecan scab than the standard commercial combination of chemical fungicides. This is the most important disease in pecans and represents a substantial market.
- Trials on Downey mildew and powdery mildew have shown limited control.
- In some trials, BmJ was comparable to biological products now sold into these markets however control was less than with the chemicals. BmJ might find niche markets in these crop disease systems as an organic product.
- Trials in bananas in Costa Rica were delayed by problems with clearing BmJ samples through customs. As of December 2006, issues have been resolved and the trial has started.
- A trial for control of apple scab was completed in Pennsylvania.
- In May 2006, EPA approval for an Experimental Use Permit (EUP) was received to conduct large scale grower trials for Cercospora leaf spot control in sugar beets. The EUP represents an important regulatory milestone. MMP will apply to EPA to extend the EUP to tomatoes/peppers, melons/cucumber potatoes and pecans where positive results were obtained in research trials.

Sugar Beets, Commercial Trial Program:

Commercial trials with grower cooperators in Montana, North Dakota, Minnesota, Michigan and California conclude that BmJ could have a significant market as a low cost product applied as a routine preventative treatment. MMP will move forward to obtain EPA registration and commercialize BmJ for Cercospora leaf spot control in sugar beets.

Commercialization in Additional Markets:

Research trial results suggest priority for commercialization of BmJ in tomatoes, peppers and pecans in the South East United States and in potatoes in the West. Together with sugar beets, these crops are grown on more than two million acres and represent a potential market in excess of \$30 million per year. MMP will continue research and commercial trials in these crops to better define application and marketing strategies and to demonstrate BmJ to extension agents and other market influencers. MMP will seek to expand the Experimental Use Permit in 2007. MMP will target EPA registration and initial sales in sugar beets and possibly in additional crops in 2008.

Economic Impacts:

This grant was instrumental in establishing commercial applications for BmJ as a new generation microbial diseases control agent in agricultural crops. A patent has been applied for covering use of BmJ in disease control in agricultural crops. This project provided important data for obtaining phase 1 and phase II SBIR projects, which brought almost \$380,000 to Montana Microbial Products and MSU. The direct impact of the project will be realized when MMP receives EPA approvals and can begin manufacturing and sales of BmJ in agricultural markets. This will result in Montana jobs producing and

marketing BmJ in national and international markets. Commercializing BmJ will also bring a new product to Montana sugar beet growers.

#06-20 Biomimetic Floating Islands that Maximize Plant and Microbial Synergistic Relationships to Revitalize Degraded Fisheries, Wildlife Habitats, and Human Water Resources

Frank Stewart – Floating Island International – Bozeman

\$310,292

Final report approved: December 2007

Summary:

The purpose of this project was to produce and test Biomimetic, self-sustaining floating treatment wetlands (“floating islands”) that are designed to remove excess nutrients and other contaminants from lakes, streams, and wastewater lagoons. The goal of the research was to produce a family of new products with proven efficacy which are cost effective and environmentally friendly compared to other commercial products that are currently available to treat water and wastewater. The research focused on the design, construction, testing and optimization of floating islands for removal of selected contaminants that are common problems in municipal wastewater, urban storm water, and agricultural runoff.

Major Research Results include:

- The islands demonstrated rapid removal of ammonium, nitrate, phosphate, organic carbon and suspended solids, compared to controls and to previous data by other researchers.
- The BioHaven® floating islands achieved simultaneous aerobic and anoxic removal of ammonium, nitrate, phosphate, and organic carbon within a single island in a single impoundment.
- The BioHaven® floating islands removed phosphate via bacterial processes at approximately the same rate as suspended algae removed phosphate via plant growth. After the phosphate had been removed, water in ponds with floating islands was much clearer than algae-choked water in ponds without the floating islands.
- Performance of BioHaven® floating islands can be optimized by providing proper conditions for the bacterial processes.

Achievement of Objectives

The originally proposed objectives of this project were met. Nutrients concentrations were reduced to target levels; long-term efficacy was demonstrated; commercial and naturally occurring microbes were compared; required micronutrients and other auxiliary requirements were identified; scale-up criteria were developed; wildlife habitat benefits were documented; and, products were successfully introduced into the marketplace.

Assessment of Commercial Potential

The measurable results from this research have been presented to public and private entities throughout Montana, across the United States and worldwide. The strongest and most immediate commercial potential comes in the form of licensing to a Montana firm for a new production facility in Montana. That facility would create new jobs, enhance many existing related businesses, and positively impact economic development in Montana. Additional prospects include the specialized production and placement of islands in California for treatment of the Salton Sea, remediation of the Lower Seletar Reservoir in Singapore, and treatment of millions of acres of degraded waterways throughout New Zealand.

Commercialization plan:

This project provided empirical data that establishes the ability of BioHaven® Floating Islands to improve water quality. This data will enable FII to aggressively market the islands to the Environmental Remediation market.

Product description:

BioHavens® are artificial floating wetlands which offer a concentrated surface area for the grown of microbes and plants providing a natural means to cleanse water of pollutants such as nutrients and heavy metals.

Target market including size:

The commercialization focus will be on Environmental Remediation Specialists, i.e. government entities and private companies that offer diverse environmental services including watershed management and land use planning; wetland determination and mitigation; and environmental education.

The size of the market is immeasurable and includes Environmental Remediation entities located in every state and most cities in the United States. The pressure to clean up water and restore wetlands is increasing every year.

Marketing strategy:

- Distributor-led marketing
- Publications – articles in journals, magazines, newspapers, press releases
- Web site positioning – www.floatingislandinternational.com
- Delphi System – FII contacts use their contacts to introduce potential licensees
- Licensing in Montana – FII is in the final stages of assigning the US license to a Montana organization that will become the production facility for the United States
- Licensing world-wide – FII plans to license production to appropriate entities around the world while retaining R&D in Montana. The first license has been secured and three others are in advanced stages of negotiation.
- Pilot Projects – Large-scale pilot projects in China and Singapore are expected to lead to licenses in those countries.

- Contracting with a world-class marketing firm for a complete go-to-market campaign

Production or manufacturing plan:

- Production is currently taking place in the plant located adjacent to FII’s Shepherd Research Facility, which is limited to islands that are 25 square feet or larger.
- Floating Island America, a Montana-based group, plans to build a larger production facility in Shepherd.
- Growth of FII outside of Montana and the US may lead to additional production facilities outside of Montana, but FII will remain in Shepherd.

Business risk assessment:

- Patent protection
- ❖ FII is protecting itself from piracy within a suspect licensed territory by charging a much higher down stroke and lower royalty than it would elsewhere.
- ❖ Cost of IP Enforcement – Greatest risk may be the company’s ability to cash flow through an IP enforcement action. To mitigate this risk, the company has partnered with an IP enforcement specialist law firm and, in addition, will not move aggressively in countries that do not honor intellectual property.
- Large-Scale Island Failure – FII is negotiating an insurance bonding arrangement with a Montana insurance firm.

Economic Impacts:

Economic impacts resulting from the project are expanding almost daily, in Montana, throughout the United States, and around the world:

New Production Facility in Montana:

FII is in the final stages of assigning the license to a Montana-based group that will become the production entity for the entire US market. The operation, Floating Island America (FIA), will be based in Shepherd, Montana, and is expected to contribute significantly to the state’s economy. The production facility will be designed and built by Montanans, and when complete, will initially create 16 new jobs as well as the need for 5 science and engineering professionals to provide specification support and island launching expertise to support and train franchise holders across the U.S.

Impact on Related Montana Businesses:

In addition to the direct creation of new jobs, the ripple effect will touch other Montana businesses—transport providers like Roadway, plant nurseries, and a network of potential distributors. As FIA franchise holders increasingly place islands into the state’s waterways, numerous related businesses will begin to feel the positive impact. The Montana Invention Company – FII, based in Shepherd, Montana, will continue as an

invention company, developing prototypes and Intellectual Property, and contracting with Montana firms for patent work, engineering, and ongoing scientific research. Royalties generated by FIA's sales will come back to Montana and be used to further develop environmental solutions to benefit the planet.

Returns from Beyond Montana:

The results of this project are set to have a profound affect on FII's business. Though early and municipal authorities are slow to act, some projects have been initiated as a direct result of the data achieved through this project:

- Lower Seletar Reservoir, Singapore – 2000 sq. mile floating island for water remediation. FII will install and supervise a pilot project in February 2008 which is likely to lead to an order generating revenue for Montana-based scientists and engineers.
- Wiconisco – a successful pilot study would open the doors to the islands being used to treat wastewater in communities all over the United States, each installation being worth at least \$1–5 million.
- New River, California – Floating islands are being proposed to treat this heavily polluted waterway which flows into the environmentally sensitive Salton Sea. FII has received initial support from the State government which will enable FII to fulfill the goals to increase plastics recycling and to restore the Salton Sea. This project will utilize Montana expertise in science, engineering, and manufacturing, and will create a revenue flow from sales back to this state.
- New Zealand – The grant's research data with concurring data generated by the National Institute of Water & Atmospheric Research (NIWA) has been influential in Kauri Park Nurseries' decision to purchase a license from FII for New Zealand and Australia. New Zealand has millions of acres of degraded waterways and wants to remediate. Floating islands have been well-received and promise to generate royalty revenue for FII, new patents as R&D continues in a new environment, and partnerships between US and NZ scientists.
- Seven other major projects are in progress with similar benefits to the state of Montana, FII, and its associates.

Other:

Over the course of this grant, the project has appeared in 15 magazine articles, three books and numerous newspapers across the United States and Canada, and on Canadian TV. Many of the news articles are available on the website:

www.floatingislandinternational.com and most will be included in FII's more comprehensive Annual Report. As a result of the empirical data made possible through research funded by this grant, significant strides have been made toward the goal to provide a natural Biomimetic solution to revitalize degraded fisheries, wildlife habitats, and human water resources. The report expresses gratitude to the Montana Board of Research & Commercialization Technology for its support.

#06-22 Research and Development of a Hydraulic Fluid from Montana Grown Oil Seed Crops

Paul Miller/ David Tooke

\$100,000

Summary:

The purpose of this project was to develop and commercialize a biobased hydraulic fluid using a high oleic vegetable oil base stock thereby providing an environmentally friendly, yet versatile ISO VG32 fluid. Commercialization efforts were directed toward non-tactical military construction and other equipment in service. A patent application was filed, a marketing plan initiated, and a contract packager, materials, and a distribution network have been identified.

In the process of developing a final hydraulic fluid formula, several other commercial applications for high oleic base stock and other mid oleic oils were discovered. An expansion of scope was granted in March 2007 to investigate vegetable oil usage in penetrating lubricants and wood coatings. A biobased penetrating wood coating was created from the natural oils of Montana grown oilseeds. A product label was developed, the name *EcoSeal* was trademarked, and materials were sourced for the mass production of this product. *EcoSeal* is available for sale in two Missoula home improvement stores, and new accounts at large retailers are in process.

An all purpose penetrating lubricant was also formulated, blended and packaged on a trial basis through the use of this funding. This lubricant competes with products such as WD-40 as a general purpose lubricant, and is environmentally friendly to manufacture and use. Contract manufacturers and packagers have been identified, and test trials, development of a label, and marketing strategies are in process.

Commercialization Plan:

The commercialization plan is “universal” to each of the products developed. It involves crushing the oilseeds for the respective base oil at the Montola crush facility. The base oil is refined to specifications and shipped to a third party packager for additive, blending, packaging and warehousing prior to distribution. In addition to the three products developed from this project, the company has commercialized three culinary oils in the last year. That effort has provided the methods for developing efficient protocols for bringing other products to market and the PI expresses confidence in the company’s ability to (and limitations for) commercializing new products effectively and efficiently.

Economic Impacts:

This project has the potential to increase production agriculture in Montana by increasing the amount of oilseeds grown. The oilseeds provide rotational benefits to existing small grain operations, break up weed, disease and pest cycles, and have been demonstrated to increase yield per acre on subsequent small grain crops. The result is additional farm gate income. The processing of the oilseeds will create and maintain processing jobs at the crush facility in Culbertson, which will help diversify the Eastern Montana economy and add value to agricultural crops prior to them leaving the state. The sale of these products in Montana will also assist distributors and retailers in offering a broader base of products that have less lifecycle costs in their journey to retail shelves.

#06-26 Commercialization of Miniature Lasers Evolving from Research and Development to Production

Christopher Palassis – AdvR, Inc. - Bozeman

\$250,367

Final report approved: September 2007

Summary:

During this Montana Board of Research Commercialization Technology effort, AdvR successfully developed a pre-production prototype laser. The prototype laser was fully characterized and had the ability to be manufactured in a short time frame. Additionally, research into microlens development was undertaken in collaboration with Montana State University researchers and innovation with laser-waveguide coupling schemes were explored. Critical to the progression of the prototype was the design review process which revealed design shortcomings that ultimately led to research and redesigns undertaken in the second year. The second year also saw the development and refinement of assembly fixtures which have pervaded all aspects of AdvR's optical packaging efforts and the building of a relationship with Kyocera of America and their optoelectronic packaging resource team.

Commercialization:

Results of this project are being utilized in an immediate manner as follows:

- FC-532 Module package uses housing from Kyocera, which is a basic housing design and supplier developed under this project. Kyocera built specialized tooling to meet AdvR specifications, and AdvR has received an initial order of 50 housings from Kyocera to be used in a preproduction run of FC Modules and FC Lasers. These modules and lasers will support product releases at a major photonics conference, Photonics West in San Jose, in January 2008.
- HPFC-532 Module, incorporating improvements to the coupling of laser light into an EPC accomplished under this project, was sold and shipped in September 2007.
- Each of the packages involving FC-532 Module Series, HPFC Module Series, FC Laser Series, FC-488 Lasers and ICC-1064 Series requires proper mounting of the EPC on a temperature controlled surface.

Product description

AdvR's commercial product offerings are based on engineered photonic crystals (EPCs) that alter laser light to achieve desired performance for a wide variety of applications. This project directly created packaging technology and has advanced products from a research or prototype stage to preproduction stages.

Target market including size

- Primary markets for AdvR products are in the high performance end of commercial markets, including the US military, diagnostic medical, research, aerospace, instrumentation, and materials processing.
- Market size is currently estimated in excess of \$40 million and is expected to exceed \$100 million with five years.
- Typical product pricing is in the range of \$1,000 to \$10,000 per unit.

Marketing strategy

AdvR continues to commercialize its EPC packaged lasers, frequency converting modules, and other devices. In addition, it is seeking to integrate its EPCs into lasers made and marketed by others. Promotion currently is primarily word-of-mouth and trade show exposure.

Production or manufacturing plan

Modest volumes initially produced at AdvR facilities, particularly to fabricate the engineered photonic crystal. In some cases, AdvR would see its EPCs to customers who possess complementary components and would perform package product fabrication themselves.

Business risk assessment

Business risks are relatively low due to the diversity of its products and market segments. AdvR protects its intellectual property by obtaining patent licenses, patents, and maintaining trade secret information with non-disclosure agreements with customers and employees.

Economic Impacts:

The forecast is to double the number of employees and triple total revenue within the next five years. As the business matures into providing production products, the employee base will expand to include manufacturing jobs. The company will maintain a strong R&D contracting function as the engine to supply a continuing stream of competitively superior products.

Sales generated

HPFC-532 Module, incorporating improvements to the coupling of laser light into an EPC accomplished under this project, was sold to Aculight Inc. in Bothwell, Washington, and shipped in September 2007.

Patents applied for or granted

The company currently holds licenses to 10 patents and has three patents and patent filings. It is expected to increase past performance of approximately one patent filing per year to average two patent filings per year within five years.

Development of intellectual property

The company maintains a strong intellectual proprietary estate to prevent duplication of its products by competitors.

Acquisition of investment capital

During the next five years, an equity investment is anticipated to support production scale-up and to satisfy operating capital needs.

#06-29 Commercialization of BmJ as a Broad Spectrum Microbial Disease Control Agent

W. Randall Babbitt – Montana State University - Bozeman

\$89,025

Final report approved: March 2007

Summary:

This project focused on developing and securing intellectual property in relation to the Spatial Spectral (S2) technologies developed at Montana State University. S2 technology, which was developed at MSU and transferred to S2 Corporation of Bozeman, enables real-time, high-performance processing of broadband signals. The objectives of the project were: (1) to perform experimental validation of function and performance of S2 based intellectual properties as needed to demonstrate commercial potential; and, (2) to convert present and developed S2 based IP from provisional, or undisclosed, patent stage to full US patent applications. Technology assessment (evaluation of different technologies to determine practical and commercial potential to assess appropriate IP protection) was a key element of the project. Prior to the project, four patents related to the technology had been issued. During this project, one patent has been issued and two have received notice that their claims have been allowed, including the primary S2CHIP patent application. Four provisional patents were filed and four provisional patents (two of which were filed as provisional patents during this project) were converted to non-provisional patent applications. During the project, two corporations, S2 Corporation and Bridger Photonics, were formed.

Commercialization:

- S2 Corporation has licensed 8 technologies, including the patent filed and issued under the support of this grant and the two patents with allowed claims.
- MSU will market the S2 related technologies to S2 Corporation.
- MSU will market licensing of the ADC technology, likely to S2 Corporation, after successful demonstration of the technology.
- Market for S2 products is mainly defense contractors and agencies.
- UFB technology license will be marketed after demonstrations.
- Market for UFB technology initially will be the Department of Defense and its prime contractors.

Economic Impacts:

- Bridger Photonics is a spin-off company, still in the embryonic stage. Employment depends on securing federal contracts.
- The number of employees at S2 Corporation (formerly the S2CHIP division of Scientific Materials Corporation) has grown from 2 employees in October 2003 to 14 employees in June 2005 to 18 employees in December 2006, and continues to

- grow. (Note: At least one employee, a former Montana native and MSU graduate, returned to Montana from Seattle to work for the company.)
- The ratio of federal dollars to state dollars is 30 to 1. From the \$580,000 MBRCT grants and \$245,000 IDC match, \$24,900,000 federal dollars have been obtained. The report emphasizes the importance of the grant funding and matching funds that have helped at critical points in development and protection of the intellectual property.
 - Several provisional patents and patents were written or filed during this grant. This grant helped also to develop some of the technologies and to assess the patenting of those technologies.

#06-30 Innovative Manufacturing Techniques for Polysaccharide-Protein Conjugate Vaccines

EndoBiologics Incorporated - Missoula

\$250,000

Final report approved: April 2007

Summary:

The project was part of EndoBiologics' program to develop refined conjugate vaccines to protect humans against dysentery (shigellosis) caused by *Shigella* bacteria. The goals of the SBIR project were to develop cGMP manufacturing of *Shigella flexneri* 2a conjugate vaccines and test their immunogenicity and cross-reactivity in mice.

Significance of Results. Endobiologics is collaborating with a large global health organization in an application to the Bill and Melinda Gates Foundation for a grant to develop vaccines against shigellosis and other enteric diseases. The vaccines will be targeted to infants and small children, and a special emphasis has been given to development of needle-free delivery for these vaccines. From this perspective, the most important discovery in the present project was that both types of vaccines were highly immunogenic when administered intranasally. This discovery prompted a license agreement between Delsite Corporation and EndoBiologics that will enable. EndoBiologics is also collaborating with the U.S. army in development of conjugate *Shigella* vaccines to protect U.S. military forces that are deployed to regions in the world where shigellosis is endemic, and the present project directly involved collaborative studies with army scientists.

Commercialization Plan

- EndoBiologics has an ongoing collaboration with USAMRMC to complete development of *Shigella* conjugate vaccines that are suitable for protecting deployed military forces. The next step in this collaboration is the performance of clinical trials, and the company is currently discussing options for the Phase III study with USAMRMC.
- EndoBiologics is also collaborating with a large health organization in a grant to the Bill and Melinda Gates Foundation to fund clinical development of *Shigella* vaccines to protect infants and young children in under developed countries.

- EndoBiologics has a license agreement with DelSite Corporation to develop a needle-free delivery system for the *Shigella* conjugate vaccines.
- EndoBiologics will use data collected under this grant to support a license application for marketing conjugate *Shigella* vaccines to international travelers. Estimates for this market to prevent diarrheal disease are more than \$1 billion/year within the next 10 years.

Economic Impacts

- Enhanced collaborations with the U.S. Defense Department to develop *Shigella* conjugate vaccines
- Enhanced potential to establish a collaboration with the Bill and Melinda Gates Foundation for *Shigella* vaccines
- These collaborations have potential to provide sufficient grant funds to support expansion of EndoBiologics manufacturing facilities and work force.

#06-31 Discovering Anti-TSE Agents

Timothy L. Nagel – BioPred – Bozeman

\$400,000

Final report approved: October 2007

Summary:

The primary objective of this project was to develop an automated prototype software system that accurately predicts TSE (Transmissible Spongiform Encephalopathy) bioassay results for TSE disease research such as mad cow and chronic wasting diseases. Working with Rocky Mountain Laboratories scientists, and Dr. Subhash Basak and Dr. David Optiz, the PI researched the ability of an innovative computational system that applies mathematical representations to chemical structure and chemical activity to advanced machine-learning for the purpose of accelerating the discovery and commercialization of anti-TSE agents.

The results of this research have the potential for direct and long-term benefits by: Shortening research and development times for discovery, development and commercialization of new drugs; (2) Diminishing discovery and development costs; (3) Expanding knowledge of modeled compounds and related mechanistic biochemical processes; (4) Validating the functionality of the prototype to support capture of commercialization capital; (5) Providing value-added services to clients by augmenting their research compound portfolios; (6) Mitigating disease morbidity and mortality; (7) Positioning the company as a viable commercial entity with proven technology and established revenue streams from contract R&D services and developed compound intellectual property.

Commercialization Plan:

Product description

Prototype computational chemistry tool – automated software (prototype) imports other data (computational chemistry theoretical descriptors and bioassay results) relevant to a set of compounds with unknown bioactivity.

Target market including size

The total computational chemistry market estimates for capturing laboratory R&D range from 5-15%

- Initial target markets include anti-TSE (mad cow disease), radiopharmaceuticals, federal government – capture by 2010 approximately \$100 million
- Other target markets include anti-fungal and anti-cancer – capture \$2.5 billion by 2010
- Other market sectors include agrochemical and industrial chemical – capture \$700 million by 2010

Marketing strategy

Short-term commercialization strategy involves use of prototype software to evaluate, identify and develop new pharmaceuticals via contract services to existing R&D collaborators and pharmaceutical companies

Long-term commercialization strategy involves extension of the above services to other laboratories and companies and capture and development of a pharmaceutical and industrial agents' intellectual property portfolio

Potential customers

Initial customers for BioPred™ services are scientists and research managers engaged in R&D for the discovery and development of bioactive compounds.

Business risk assessment

Business risk assessment is minimal because the company has successfully leveraged existing business resources of two co-founders and a third collaborator to capture significant R&D capital including funds resulting in development of prototype software. The overhead will remain minimal.

Economic Impacts:

This funding has provided BioPred™ the opportunity to export low cost services, capture significant revenues to the state, and develop/create high-paying jobs in the event of marginal growth of the company.

New businesses created or expanded

This project will help launch BioPred™ as a Montana high-tech computational chemistry company.

#06-35 Noninvasive Diagnosis and Treatment of Lung Cancer Using Two-Photon Photodynamic Therapy

Charles W. Spangler – MPA Technologies, Inc. - Bozeman

\$240,000

Final report approved: March 2008

Summary:

The original purpose of the project was to develop a noninvasive approach to the diagnosis and treatment of lung cancer using a revolutionary therapeutic agent that combines three functions: (a) imaging of the cancerous tissue; (b) targeting of the tumor receptor sites, and (3) treatment of any cancerous tissue by activating the photosensitizer portion of this triad using two-photon irradiation in the tissue transparency window. The work proceeded well until the final benchmark when the wrong type of mice was provided to the lab. This caused significant delays and an extension of the project to complete the final experiments. Even then, these experiments could not be completed as, for an unexplained reason, the tumors grew rapidly and it became impossible to deliver drugs to them individually. It has become apparent that an animal model larger than SCID mice (i.e. rabbits) is necessary in order to prepare for human trials. Completing this benchmark appears to have gone beyond the scope of this project and will be undertaken in a new proposal to MBRCT to assist in obtaining preliminary data for a potential project supported by the American Lung Association. The path to commercialization for this type of research is not short-term and, as the Final Report indicates, the “next most likely monetizing event” is approximately seven years away at a cost of about \$33 million. However, the project achieved all but one of its objectives and it appears the technology has a good likelihood for success in the medium- to long-term.

This represents an excellent collaborative model between Montana State University and a private Montana company with the technology licensed to a start-up joint venture company and venture capital company investing substantial cash into the joint venture.

Commercialization:

Introduction:

- MPAT is a Montana materials research and development company founded in September 2001 for the purpose of designing, synthesizing and developing new materials exhibiting enhanced multi-photon absorption.
- In 2003 MPAT and Pacific Horizon Ventures, a Seattle-based venture capital firm specializing in early stage development of biotechnology companies, launched a joint venture company, Rasiris, Inc.
- Rasiris is engaged solely in the development of targeted photodynamic therapeutic (PDT) agent for the noninvasive treatment of subcutaneous tumors.
- Rasaris licensed the technology from Montana State University and MPAT.
- Pacific Horizon Ventures has invested ca. \$750,000 in the MPAT/Rasiris joint venture.
- MPAT continues to explore a wide variety of research projects that expand the potential commercial capabilities of targeted, image-driven, two photon PDT. The expectation is that many will be commercialized by Rasiris in a clinical setting.

Pathway to Commercialization:

- Current business model anticipates that MPAT may continue to manufacture and distribute porphyrins for PDT applications during the pre-clinical stage of development.
- A significant issue is to determine how deep into tissue the technology will be efficacious.
- In order to assess the efficacy of two-photon PDT, animal models larger than SCID mice will need to be treated before human trials are conducted.
- Rasiris is raising a Series A financing round that will include treatment of spontaneous tumors in canine models.
 - These studies will be carried out at the College of Veterinary Medicine at Washington State University, the Veterinary center closest to Bozeman (MPAT and MSU) or Seattle (Rasiris).
 - In addition to lung cancer, recurring head and neck carcinomas will likely be a focus of human trials because these cancers offer opportunities that maximize the 3D spatial advantages of two-photon PDT.
 - After completion of validation or optimization of the triad therapeutic agents (one year), development of the imaging prototype that will guide the laser beam through the tumor treatment will begin.
 - The first prototype should be available for large animal studies in 2009.
 - Preclinical phase will begin in 2010 in collaboration with a recognized Contract Research Organization (CRO) and IND will be obtained from the FDA.
 - Phase I trials will begin in 2011 at 3-5 sites.
 - Rasiris will participate in M&A activities early in Phase II clinical trials.

#06-39 Development of a Novel Tissue Valve for Surgical Replacement of Diseased Aortic and Pulmonary Valves
Carols Duran/James Maxwell – International Heart Institute of Montana - Missoula
\$166,792
Final report approved: April 2009

Summary:

The purpose of the study was to compare *in vivo* performance and histologic data of aortic, pulmonic and pericardial homograft valves treated with the D-Hydro™ process and implanted in the right ventricular outflow tract (RVOT) of a young sheep. The pericardial valve graft was eliminated early in the project and the focus was on the pulmonic homograft valve. Nineteen surgeries were performed and 11 animals were enrolled into the study (six pulmonic and five aortic homograft implants). After a six-month implantation period the implanted pulmonic and aortic valves functioned similar

to normal pulmonic valves. The valves had partial host cell rehabilitation and little evidence of calcification.

Conclusions/Discussion:

The principal objectives of this project were:

Aim 1. Complete necessary requirements to achieve Good Laboratory Practice (GLP) compliance.

Aim 2. Perform animal implantation studies according to GLP regulations.

Aim 3. Perform atomic absorption spectroscopy on valve leaflet samples for calcium content.

The process of completing requirements for GLP compliance took considerable time and Aim 2 was on hold pending GLP certification and availability of the appropriate sheep, necessitating the first extension of the project (from 12/01/06 to 12/31/07). Standard operating procedures to fulfill GLP requirements were implemented by 12/31/07; however, sheep valves proved too small for implantation and, since sheep of the appropriate size were not available until June 2007, a second extension to December 31, 2008, was requested and approved. The project was again on hold pending receipt of the appropriate size sheep. Dave Desch made a site visit to the project on 2/28/07 to review the status of the project and discuss a probable change in the PI due to Dr. Duran's plan to retire. Dr. Matt Maxwell was approved to replace Dr. Duran as the PI per Dr. Duran's letter dated May 1, 2007. Project activities resumed as anticipated during the May-July 2007 reporting period and the project remained on track thereafter. Surgical implantation took place and this Final Report describes the animal implantation studies that were performed according to GLP regulations. The significant conclusion from the studies is that, taken together, the data suggests that the patented process (L+D-Hydro™) valves are functional, biocompatible and resist calcification. However, further study is needed to explore the long-term outcomes of these valves in a sheep model.

#06-42 Technology to Complete Program for Market Launch of Innovative Native Seed Harvester

Lee Arbuckle – Arbuckle Ranch, Inc. - Billings

\$66,850

Final report approved: June 2007

Summary:

High Speed Video – High Speed Video (HSV) recording, a tool for accelerated R&D

- Establishment of High Speed Video (HSV) is estimated to have reduced time to market for the *Seedster* by at least two years with a cash savings of over \$100,000 in R&D costs.
- HSV was used as a powerful, cost-effective research tool to validate design assumptions to assure model design was on track and to observe HSV images as part of an adaptive experimental protocol to quickly explore poorly understood issues.
- HSV analysis of seed flight pattern accelerated had a significant effect on accelerating product development.

- Two HSV filming sessions confirmed seed dislodgement operated approximately as assumed, validation which permitted firm conclusions to be made so full attention could be focused on other unresolved issues.

Conclusions and Outlook:

- In July 2006 pre-production prototype meshed the pneumatic conveyance system with the seed dislodgement system and the fully integrated Seedster worked in its first field trial.
- HSV played a crucial role, accelerating design, construction and testing with an estimated savings of development time by two years and cost savings of at least \$100,000.
- The HSV “best practices” protocols developed are available for any Montana firm considering use of HSV to assess the operation of high speed machinery.

Seed Morphology of Native Perennial Grasses with Relevance to the Arbuckle Native Seedster

This study has produced a dichotomous key to native grass plant and seed morphologies and a comprehensive database of 205 native grasses of economic interest in 21 western and central U.S. states. Products resulting from this study are:

- A Dichotomous Seed Morphology Key Including Native Perennial Grasses of 21 Western and Central States
- Native Perennial Grasses in 21 Western and Central States
- Native Perennial Grasses in Western and Central U.S. having Current or Potential Economic Value
- The Native Perennial Grass Seed Database

Commercialization Plan:

Product description:

Arbuckle Native Seedster, a new approach to seed harvest, which is quickly calibrated, easily operable, and adaptable to recover a high percentage of available seed from a wide spectrum of species

Target market including size:

1) Native grass seed producers are a small niche with very specific product requirements. Segments include:

- a. Less than 300 producers in the U.S. who specialize in native grass seed production
- b. Somewhat larger number who, although not specialized in native grass seed, are persistent producers.
- c. Several thousand opportunistic producers when conditions are advantageous or due to some transitory circumstance
- d. High performance harvesters from such entities as the Plant Materials Centers of the USDA, restoration or recovery foundations, or state and local commissions interested in habitat restoration represent some demand.
- e. Non-users of any harvest technology who may be induced by simplicity, good value and adaptability of the Seedster to produce

difficult to harvest species of grass and specialty crops represent an unknowable market segment size.

- 2) Specialized producers are considered to be the earliest adopters of this new harvest technology because of the number of acres in production, the opportunity to use the technology for several crops, and greater producer understanding of the complexity of seed recovery from the most difficult-to-harvest species.
- 3) A loan from Growth through Agriculture financed extensive market research. Interviews with native seed producers produced a prospect list of over 100 producers who expressed interest in the Seedster.
- 4) There are five geographically distinct areas each with a different time for the preponderance of harvest.
- 5) Distribution system, positioning, and publicity
 - a. The Seedster will be shipped directly from the factory.
 - b. The product will have no dealers or formal distributors.
 - c. The Seedster requires almost no maintenance and most components are available at any local supplier. Parts will be maintained, if needed, by Midland West of Billings.
 - d. Native Seedsters, Inc. will be positioned as a producer of carefully designed high performance harvesters of difficult to harvest species of grass and other specialty crops; as dependable, durable, low maintenance, a good value and highly productive.

Production or manufacturing plan

- a. Midland West Manufacturing, Billings, known for good quality control, will manufacture the Seedster.
- b. One-third down payment at time of sale
- c. Commitment to delivery in two months
- d. Actual production time 3-4 weeks
- e. Inventory on hand of three harvesters
- f. Cash flow at approximately the fifth unit, breakeven for 2007 at approximately eight units.

Business risk assessment

- a. Risks of a “disruptive technology” such as this in general are much lower than that of sustaining technologies that are simple extensions or modification of existing technologies.
- b. Seedster technology may be engineered around by a firm that leapfrogs to another level without patent violations. However, engineering specifications that have grown out of the development process make it difficult to duplicate the technology.
- c. Performance of the Seedster may not live up to expectations formed as a result of field testing.

- d. There is a risk Native Seedsters, Inc. addressed the wrong issues in its ongoing R&D to develop a better Seedster.

Economic Impacts:

New businesses created or expanded:

A new business, Native Seedsters, Inc. was created and began to function April 29, 2007.

Increase in employment levels:

Lean firm, estimating six jobs created in the firm over the next five years. Indirect effect on employment generation includes: approximately one manufacturing job created for every 10 Seedsters sold; one to 10 engineering jobs created for ongoing product design and R&D; Web engineering jobs expected to equal ½ person per year; market research, advertising and promotion will total at least one full-time person.

#06-46 Development of Fluorescent Detection Technology for Proteomics

Don Thorne – Zdye, Inc. – Gallatin Gateway

\$371,250

Final report approved: October 2007

Summary:

Zdye LLC carried out a technology development project to produce greatly improved proteomics detection products. A work plan was conducted in collaboration with another Montana company, Resonon Inc, to foster the development of a powerful new Resonon hyperspectral 2D gel fluorescence imager prototype that is being developed and refined with the support of a two year NSF phase II STTR grant, that was awarded in the second year of the present project, in cooperation with the Dratz laboratory at MSU. The performance of the Resonon prototype presents attractive commercial opportunities. The present project synthesized new fluorescent Zdyes that were designed to take advantage of the Resonon 2D imaging system, and initiated modification of the Resonon system for the measurement of fluorescent Zdyes currently available or being synthesized. The NSF phase II award freed up some resources, and we added the development of a new “real time” 1D gel, full spectrum fluorescent imaging system as a target of opportunity, which offers some attractive advantages for very broad-based applications.

Commercialization:

Three of the four leading companies in the gel based proteomics field have expressed on-going interest in the research.

The next step in commercialization is external beta testing, a process that has been delayed due to stability problems with the initial red Zyde, a problem which has been resolved under the MSU project with MBRCT (#07-17). A localized background problem with the blue Z dye is in the process of being resolved. Once this is resolved in the near future, Z dye sets will be sent out to select beta testing sites. MSU beta test projects are nearing completion and research publications and presentations at research conferences will provide publicity that will launch the commercialization phase. The

Zdye website will be expanded to include promotional information and booths at research conferences will be set up.

Product description

New generation of multicolor proteomics fluorescence detection dyes

Marketing strategy

- Product marketing will involve preparation and circulation of in-house test results, beta test posters and scientific manuscripts/reprints and technology white papers to prospective customers and commercial partners.
- Market presence will be enhanced by presentations at major proteomics conferences
- Zdye will target beta testers and begin customer visits in 2008.

Production or manufacturing plan

- Production objectives are to achieve low costs and high profit margins that will appeal to investors.
- Stocking and inventory issues will be minimal until the company has experienced considerable growth.
- If 1D gels are pursued, they will be handled through a distribution partner such as Bio-Rad.

Economic Impacts:

New businesses created or expanded

Work under this project has formed the foundation for a new NIH Center for Biomedical Research Excellence (COBRE) proposal for \$10 million for building systems biology and infrastructure at MSU. This proposal reviewed well (3rd out of 35 submitted) and is pending.

Increase in employment levels

Zdye currently employs 12 people and Resonon employs 7 people in Bozeman and it expected both companies will grow as production of their products is carried out in Bozeman and sold throughout the United States and the world.

Patents applied for or granted

- Four patents on Zdye products and concepts have been applied for.
- Three patents are in preparation.

Other:

- This project has formed the foundation that secured a DOD grant for MSU's Department of Veterinary Molecular Biology April 2007 for \$888,000 the first year. The project is providing an internal beta test of Zdye technology capabilities. This project is particularly valuable because they are investigating virus resistance mechanisms using DIGE technology and Dr. Thorne and his research team will investigate the system using the higher sensitivity of the Zdye technology.

- This project has helped Resonon secure a two-year NSF STTR Phase II grant for \$500,000 in cooperation with the Dratz lab at Montana State University for development of an engineering prototype of the Hyperspectral gel/microwell/microarray scanner licensed by Zdye LLC for biological applications.
- This work has formed the foundation for a new thio-saturation labeling Zdyes expected to provide the full 30-100 fold sensitivity enhancement of the Zdyes and formed the basis for the revised NIH STTR Phase II application for \$1.2 million.
- This work supported the foundation for a new NIH Phase I proposal for \$400,000 on differential glycoprotein detection that is expected to be funded in late 2007. This is a further extension of the Zdye technology.
- A new “real time” multicolor 1D gel scanner has been initially developed with the support of this project. This scanner could occupy an empty niche in the protein biotechnology field.
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#06-51 Developing and Testing of a Metallic Filter to Remove Mercury from Gas Streams

Kumar Ganesan – Montana Tech – Butte

\$77,350

Final report approved: December 2007

Summary:

The focus of this project was to address the need in the coal-fired power plant industry by developing a cost-effective filter to remove mercury vapor from industrial plumes. A patent-approved metallic filtering system was developed and tested based on initial funding from the Department of Energy. This MBRCT project tested and evaluated its economic feasibility.

Two different types of metallic filters were tested individually for mercury removal efficiency and both tested above 90% efficiencies. Field testing in a coal fired power plant proved that the metallic filter has great potential as a mercury control device. Results of two different metallic filters tested in series in the laboratory confirmed that the combined mercury removal efficiency of the filters was cumulative. Preliminary tests conducted in a coal fired flue gas stack at PPL’s Colstrip power plant indicated mercury removal efficiency as at or above 90% for the entire six days of testing. Unlike other systems, this metallic filter will remove mercury from the flue gas effectively and the mercury can be recovered and prevented from entering into the environment, making it a desirable and environmentally friendly option.

Based on laboratory results, a full-scale metallic filter consisting of two different metallic filters in series was designed according to characteristics of PPL’s JE Corette power plant in Billings. An economic analysis and evaluation of the cost effectiveness of the metallic filters were performed. The total cost of the full-scale filter is \$52,730,120.

Conclusion:

The coal-fired power plant industry has a great need for effective mercury control devices to reduce mercury emissions and comply with EPA regulations. The two different metallic filters developed by Montana Tech show great potential to remove mercury vapor from flue gas of coal-fired power plants. The main advantage the metallic filters have over other proposed mercury control options is that the metallic filters completely remove mercury from the system. There is no contaminated scrubber sludge or fly ash byproduct to dispose of after the mercury is captured. The end result is mercury concentrate, which can be utilized or sold by the power plant. A full-scale metallic filter consisting of two different metallic filters in series and designed according to the characteristics of PPL's JE Corette power plant in Billings will cost \$52,730,120. The report did not address a Commercialization Plan or Economic Impacts.

#06-52 Development of Disposable and Reusable Acoustic Bioreactors

Todd McAdams – Resodyn - Butte

\$350,000

Final report approved: August 2009

Summary:

The primary objective of the research was the design and operation of two prototype reusable and disposable 2-liter and 20-liter **ResonantAcoustic® Bioreactor (RAB)** systems for use in a wide range of biotechnology processes. This objective was achieved by completing three secondary objectives:

- (1) Develop an optimal design for a 2-liter **ResonantAcoustic® Bioreactor (RAB)** that can utilize both reusable and disposable vessels.
- (2) Determine the levels of acoustic mixing that are compatible with a wide range of mammalian and fungal cell types.
- (3) Design, build and test a 20-liter commercial prototype RAB for intensive operational testing under industrial conditions.

The overall purpose of the project was to use Resodyn Corporation's acoustic mixing technology to develop improved bioreactors when compared to existing technologies on the market. As a result of the success of this project, Resodyn will launch its first commercial reusable acoustic bioreactor in the first quarter of 2010 and has successfully demonstrated the feasibility for a second generation bioreactor device for future commercial release. Resodyn Corporation has developed a strong commercial partnership with Applikon Biotechnology, which is very excited about the commercial potential for the device as well as for future follow-on, line-extension offerings. The bioreactor has been exhibited at three international trade shows and has received positive early reaction from the market.

Conclusion

Development of the reusable and the disposable RAB systems was successful at both the 2 liter and the 20 liter levels. Culture performance of all organisms tested in the various RAB systems was equivalent to, or better than, the performance of currently marketed systems. The reusable RAB has now proceeded to the commercialization phase through

partnership with Applikon Biotechnology. Further development of the culture bag-based reusable RAB will require additional development in the form of designing custom culture bags more of a more robust nature that are better suited to the demands of the acoustic agitator. Resodyn Corporation plans to pursue this opportunity as time and resources permit.

Commercialization:

Product description

Resodyn will employ ResonantAcoustics® as the basis for developing a highly efficient laboratory-scale ResonantAcoustic® Bioreactor (RAB) for reusable and disposable culture applications. The tool may be able to substantially accelerate the investigation and production of biotechnology therapeutics. Successful results demonstrated the efficacy of the process and provided the leverage for Applikon Biotechnology to become a strategic partner for taking the technology to market.

Commercial application

The commercial application of the RAB is as a superior-performing replacement for the shake flasks and stirred bioreactor technologies currently used for the routine culture of bacteria and fungi in microbiology laboratories. The RAB is superior and innovative in three ways: (1) capability to operate at multiple agitation levels at the same time; (2) superior gas-liquid and mixing capabilities; (3) capability to enhance the transfer of gas across the sterile barrier of the flask, further increasing performance.

Integration with Resodyn Corporation Business Plan

Resodyn has been laying the groundwork for entry into the biotechnology scientific and business sector over the past five years. Over \$6 million in research grants from NIH, NSF, USDA, and US Army has assisted the effort. Resodyn has leveraged its existing biotechnology infrastructure to attract industrial investment and establish strategic partners from industry as well as partner with biopharmaceutical and biomedical research and development experts with national and international presence. The RAB technology will enter the market as OEM equipment with the Applikon Biotechnology Division.

Target market including size

The current shake flask world market is \$36 million, with 50% of the market in the U.S. The annual growth rate for shaker flask equipment is about 10%. The target market group includes pharmaceutical companies, agricultural and chemical companies, other industrial customers engaged in biotechnology, medical schools, universities, research institutes, hospitals, and private and governmental laboratories.

Marketing and Sales Strategy

The business relationship that Resodyn Corporation has established assures the marketing and sales strategy has already been put in place. This strategy utilizes the existing, world- wide capabilities of its partner to market, distribute and sell biotechnology products. Through this partnership, Resodyn will also be able to conduct beta testing at leading industrial and academic sites.

Production or manufacturing plan

Design, manufacture and assembly of the RAB hardware will take place at Resodyn's 23,000 sq. ft. manufacturing facility in Butte. Currently Resodyn has the capacity to deliver approximately 50 units per month. Long-term, subcontracted vendors will be used to supply specialty services as needed. As the RAB market grows, Resodyn will expand the assembly area floor space and skilled labor force.

Business risk assessment

The typical barriers such as product acceptance, distribution, cost, regulatory issues, competition, pricing, market size, and pricing for adequate return on investment all apply to this product. It will take time for scientists to become aware of the advantages of the RAB and to take a chance on a new technology. Having a partner such as Applikon Biotechnology is critical to success in the market place. The RAB product will entail a broad range of devices, e.g. small bench-top devices through environmentally controlled shaker systems in self-standing cabinets. A second income opportunity, e.g., stoppers and single use flasks, also has great earnings potential.

Strategic Alliance

Resodyn Corporation and its partner have agreed to a binding "Joint Product Development Agreement", which establishes mutual exclusivity for the application of resonance-mixing with shaker and bioreactor technology.

Current Competition

This is a mature technology and, therefore, a number of manufactures sell various types of orbital shaking equipment and stirred bioreactors. The three major suppliers of this technology are New Brunswick Scientific, Sartous Stedium, Infors, and Therma Electron.

Economic Impacts

The economic impact has been substantially positive.

New businesses created or expanded/Increase in employment levels

Research funding enabled Resodyn Corporation to hire an additional full-time B.S. level scientist and that position will be maintained with revenue from commercial sales of the resulting product. Additional assembly/fabrication positions are expected to be required depending on the commercial success of the RAB device.

Sales generated

The project has already led to the sale of several of commercial prototypes.

Patents applied for or granted/Development of intellectual property

A Patent Cooperation Treaty (PCT), which covers the RAB configuration and control, which will include resonance-tracking (a feature developed for ResonantAcoustic Mixer technology) has been filed. Resodyn Corporation has an issued patent covering the resonant shaker concept. Continuation in part filings are in process for variances that include specific attributes associated with discoveries included in this work. A PCT patent filing incorporating the novelty of the bellows cap will also be immediately filed.

Patents developed during the Phase II are also being applied for. A Trademark will be filed for the term 'BioResonance'.

Acquisition of investment capital

The strategic OEM relationship lends itself well to conventional debt financing through Resodyn's bank and terms have already been completed with that bank.