Colorado State University

Department of Biology

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From the Chair

Dear alumni and friends,

Greetings from the Department of Biology at Colorado State University! When I last wrote last spring, you heard about the outstanding seven year review of the Department and how well we are moving forward! We're already well into another fall semester with a great group of faculty members and students. I'm always amazed at the fast pace of life at a vibrant institution like CSU.

It is my pleasure to introduce here a newsletter written by one of our undergraduate students in Biology, Ms. Blaire Steinwand. In addition to a rigorous schedule of science classes and undergraduate research, Ms. Steinwand is taking a science writing class in the department of English. While looking for a writing project for that class, we discussed putting together a newsletter for the department. Blaire took the project by the horns and has generated a great piece of science writing. I hope you find her stories on new faculty, sabbatical leaves, and departmental accomplishments as much fun to read as I have.

As you can see, our Department continues to grow and thrive. This could not be done without the support from our alumni and friends. I would like to ask you to consider making a gift today, to support the areas of undergraduate and graduate research and allow us to continue providing our students with the education they deserve. To make a gift, please visit www.supportcns.colostate.edu and click on Donate Online in the upper right hand side of the page. I want to thank you in advance for your generous support of the Department.

Warmest regards,
Daniel R. Bush

Welcome Dr. Rachel Mueller

Three Questions for Dr. Mueller

1.) If you could invite any scientist to dinner, who would it be?
Darwin or Galileo

2.) What is something most people do not know about you?
The movie Dennis the Menis was filmed in the house that I grew up in. Basically Mr. Wilson's house was my house .

3.) Do you have any advice for students?
Don't spend too much time worrying if things will turn out okay. Instead, spend time enjoying what you do.

The Department of Biology at Colorado State University welcomes Dr. Rachel L. Mueller. Dr. Mueller joined us this fall as an Assistant Professor of Biology.

Dr. Mueller earned her Ph.D. at the University of California at Berkeley and completed post-doctoral work at the University of Chicago before coming to CSU. Her research focuses on the evolution of genes and genomes in Plethodontidae, also know as the lungless salamanders. Although primarily concerned with Plethodontidae, much of her work also aims to guide further investigations within the broad field of evolutionary biology and the construction of the tree of life.

The tree of life describes relationships among all forms of life on earth and depicts the homology, or similarity due to common ancestry, among various groups of organisms. Organisms within the tree of life include single celled examples such as those in the domain Bacteria, to more complex organisms like ourselves.

An abundance of biodiversity exists on this planet along with a wealth of organisms to investigate. So why has Dr. Mueller decided to study the evolution of the Plethodontidae?

The Plethodontid salamanders possess several unique features that pose interesting questions concerning their evolutionary history and place in the tree of life.

Plethodontid salamanders have large nuclear genomes which include large amounts of sequence variation. The size of some of these organisms on the other hand, are relatively small, approximately 40mm in the smallest species (genus *Thorius*) and up to 320mm in the largest species (genus *Pseudoeurycea*). Such a large genome in such a small organism has consequences in morphology, physiology, and development, all traits that Dr. Mueller addresses in her research.

The Plethodontidae also have a unique mitochondrial genome. Typically, vertebrates contain a mitochondrial genome consisting of 13 conserved and ordered genes. Plethodontid salamanders, however, exhibit unusual rearrangements and even duplications of genes contained in their mitocondrial genomes. This unusual reordering of the plethodontid mitochondrial genome is more similar to that seen in some groups of invertebrates rather than vertebrates, the classification to which Plethodontidae belongs.

In addition to their unique nuclear and mitochondrial genomes, Plethodontidae have unique red blood cell morphology. One common characteristic of mammalian red blood cells is that they are enucleated, or lack a nucleus, meaning they contain no DNA. However, almost all other vertebrates retain the nucleus. The only known exceptions to this are found in the plethodontid salamanders.

This rearrangement and duplication of genes in the mitochondrial genome is is shared with invertebrate organisms, yet, the enucleation of red blood cells is more similar to mammalian organisms than to any other classified vertebrate. The paradox is driving Dr. Mueller's interest in defining the evolutionary history of Plethodontidae and their place in the tree of life.

Tenure Track Promotions

Congratulations to Dr. Joe von Fisher who has been promoted to tenure track beginning this fall. Dr. Fisher completed his Ph.D at Cornell University and went on to do post-doctoral work at Princeton University in the Department of Biology. In his research, Dr. Fisher investigates ecosystem effects of methanotrophic soil bacteria. He is interested in how plants, soil, and soil microbes contribute to ecosystem function.

Extremely dynamic network of "microhabitats" exist. These habitats affect the distribution and activity of plant roots and soil microbes. In his work, Dr. Fisher seeks to characterize the composition of soil microbes and their habitats as well as understand how they affect ecosystem function. In particular, Dr. Fisher's interest lies in soil generation of the greenhouse gas methane, which involves two different organisms in the soil; anaerobic archeabacteria (which produce methane) and aerobic bacteria (which consume methane). Dr. Fisher investigates factors affecting the status of oxygen in soils and how its abundance impacts the relative activity of these extremely different organisms. Dr. Fisher will continue his research on how soil diversity affects the function of ecosystems while also teaching courses in ecology and ecosystem sciences.

Congratulations to Dr. Lisa Angeloni who was also promoted to tenure track beginning this fall. Before coming to Colorado State University she completed her Ph.D at the University of California, San Diego and post-doctoral work at the University of Wisconsin.

Continuing her work on behavioral ecology and evolutionary biology, Dr. Angeloni's research will focus on sex allocation and mating strategies of animals. For example, she will investigate how animals maximize the fitness of their population as a whole through individual choices which vary within that same population. In addition, Dr. Angeloni has a growing interest in conservation biology and plans to extend her future research into this important area of science. Dr. Angeloni will teach classes in evolution and behavioral ecology.

Recently, Dr. Angeloni has spent time in northern Wisconsin where she has done research on a small mouth bass population, and the investment of resources in life history strategies. Dr. Angeloni has observed two different reproductive strategies. Individuals either chose to invest in reproduction earlier in life (3 years old), while others chose to wait, investing their energy into growth and mating later in life. Dr Angeloni weighs the benefits against the consequences of both strategies as she seeks to understand at what age smallmouth bass should initiate reproduction in order to maximize their fitness.

Exercise Without Breathing?

Weddell Seal near Tent Island.

At nine minutes and eight seconds, 30 year old German Tom Sietas currently holds the world record for holding his breath under water. Holding his breath so long is remarkable for a human, but far from what some marine mammals are capable of. The Weddell seal can actively spend 40 minutes underwater. During such a long dive, the seal experiences no harmful effects associated with the lack of available oxygen. This extraordinary adaptation requires unique changes in the organism's physiology. It should not surprise you that the unique ability of these animals to exercise without breathing has significant implications in human medicine!

Research in the lab of Dr. Shane Kanatous (Assistant Professor in Biology) explores the mechanisms by which these animals function under conditions of low oxygen. Researchers in the Kanatous lab attempt to make sense of how the seal's physiology allows it to sustain aerobic metabolism for such long periods of time. Understanding mechanisms that allow the Weddell Seal to work under low oxygen conditions has implications for treating conditions that arise in humans suffering from an inadequate oxygen supply such as hypoxia. People suffering from hypoxia experience a reduction of oxygen in the blood. In addition to hypoxia, a condition known as ischemia affects blood supply and in turn restricts oxygen availability. This research may also provide insight applicable to metabolic myopathies, neuromuscular diseases in which muscle fibers do not function normally.

In their research, the Kanatous lab has found that the seals exhibit unique muscle adaptations that allow them to exercise without breathing. They have demonstrated enhanced oxygen storage and diffusion in muscle tissue.

To better understand the seal's physiology, Dr. Kanatous monitors the animals throughout their development from a completely terrestrial pup to a diving adult seal. These animals undergo a dramatic change in physiology when they make the transition from purely land animals to the elite divers that they become, thus performing biochemical assays at various life stages is a key component to the research In addition, the Kanatous lab is investigating molecular controls that regulate physiological changes. Understanding differences in gene expression and proteins produced should provide new insight about what is happening at the cellular level.

"By understanding how another mammal has successfully overcome the debilitating effects of working under low oxygen conditions, we may be able to learn new therapeutic approaches to assist humans with heart or lung disease."

-Dr. Shane Kanatous

Female seal and nursing pup

The Polar Science Project

Last year Dr. Kanatous and his collaborators partnered with the National Science Foundation in the McMaster University "Yes I Can! Science Project." This project, offered at no cost to any school interested in participating, allowed kids in classrooms all around the world to see how research is conducted and discoveries are made.

Throughout the duration of the project, teams both in the field at the McMurdo Station in Antarctica, and in the laboratory at York University in Toronto maintained constant communication with students through e-mails and web blogs. These contained information that provided the students with weekly updates, photographs, and even challenged them with homework assignments and study questions.

Over 100 classrooms engaged in the 2006 Polar Science project, and since it has concluded, the team has continued to post updates on their research conducted back at home.

This project is supported by Dow Chemical Ca Inc. and Encana Corporation. To read more visit:

http://extremephysiology.biology.colostate.edu

Faculty Sabbaticals

Bonjour From France

Romanesque style housing lines the streets of the historical city of Poiters, France. This old town is known for its ancient architecture and is home to the oldest church in France. Poiters is also where Dr. Marinus Pilon and Dr. Elizabeth Pilon-Smits are spending their sabbatical.

Dr. Pilon and Dr. Pilon-Smits are currently at the University of Poiters in the lab of Dr. Remi Lemoine where they hope to gain experience with a variety of techniques to explore protein-protein interactions in plants. Specifically, Dr. Pilon and Dr. Pilon-Smits are learning how to use YFP, yellow fluorescent protein, as a tool to examine protein-protein binding in living cells. Dr. Pilon and Dr. Pilon-Smits are also interested in learning new techniques that will allow them to isolate transcription factors, proteins involved in the regulation of gene expression. They hope to apply these new techniques to research conducted in their laboratories at CSU.

In addition to spending time in the lab they have also attended several scientific meetings. Dr. Pilon-Smits was a keynote speaker at a European COST meeting in Vilnius, Lithuania on phytoremediation and also gave a talk at a photosynthesis meeting in Glasglow. Dr. Pilon gave a talk at a Gordon Conference on the Cell Biology of Metals in Rhode Island. He also spoke at a meeting in Villard-de Lans in France on Iron-Sulfur clusters along with Dr. Pilon-Smits.

Plant Peptides Down Under

Dr. Pat Bedinger has recently returned from a sabbatical at La Trobe University in Melbourne Australia where she spent time working on a putative pollen growth regulator, PRALF.

During just 3 months she was able to express PRALF in bacteria and use the purified protein to produce antibodies. The antibodies are an important tool in Dr. Bedinger's research that will allow her to visualize the PRALF protein within cells and help her elucidate the role of PRALF in pollen growth.

"Moore" Animal Behavior Books!

Dr. Janice Moore is on sabbatical this fall. She is busy traveling around the world attending meetings and visiting colleagues. In September, Dr. Moore attended an Aldo Leopold Leadership Fellows meeting held in conjunction with the Society of Environmental Journalists at Stanford University. Dr. Moore then headed off to the University of Glasgow to discuss current writing projects with Dr. Felicity Huntingford. Visits to the University of Keele and University of Oxford were on the agenda for October and beginning in December, Dr. Moore will spend time in San Diego working on one of her largest projects, an animal behavior encyclopedia with Michael Breed from the University of Colorado, Boulder. The Encyclopedia of Animal Behavior is to be published by Elsevier/Acedemic Press. In addition, Dr. Moore is also involved in writing an animal behavior textbook. Look for these books in the future.

Sustainable Solutions for the Future of Biofuels

"Large and cost-effective energy production on a scale that significantly impacts petroleum use calls for new crops with yield and productivity not currently available..."

-U.S. DOE, Energy Efficiency and Renewable Energy

Over the past few years heightened concern over global warming and our reliance on oil has made the use of biofuel a topic of increasing importance. As a result, many scientists (including several at Colorado State University) are putting biofuels at the forefront of their research. Research on biofuels remains important because current methods of biofuel production are not sustainable solutions for a promising energy source.

Biofuel Production Today

Nearly all of the ethanol currently used as biofuel in the United States comes from corn. According to Dr. Daniel Bush, Chair of the Department of Biology at CSU, corn grain is currently a good source because it harbors a wealth of starch, which are polymers of sugar. These sugars are fermented by yeast to produce alcohol, such as ethanol, that can be used to fuel our automobiles. However, corn is not a long-term sustainable solution simply because the amount of corn available for biofuels is limited due to the fact that it is a staple food crop.

Most foods consumed in this country contain corn. For example, some commonly consumed foods include corn flakes, corn tortillas, corn bread, and even high fructose corn syrup. The "New York Times" March 11, 2007 article entitled, "Biofuels Boom Raises Tough Questions," stated that animals alone consume half of the nation's corn produced each year.

At Colorado State University, researchers from the Department of Biological Science, Bioagricultural Sciences and Pest Management, Soil and Crop Science, Microbiology, and the Department of Engineering are forming collaborations to combat the challenges associated with creating a sustainable alternative for the future of biofuels

Cellulose: The Sustainable Solution

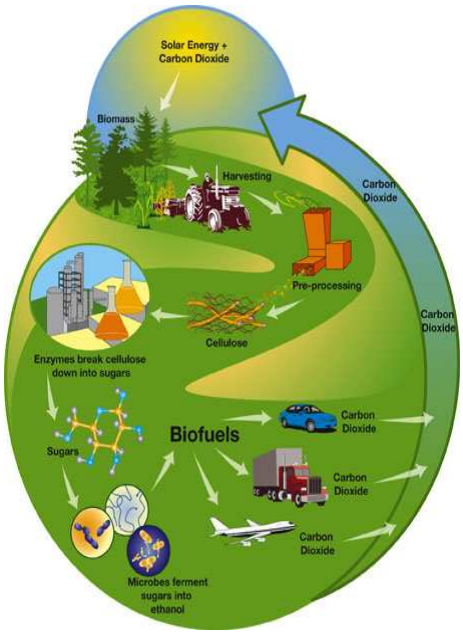
Cellulose, the primary component of the plant cell wall, is constructed from sugar polymers and is rich in carbon. Like the sugar polymers of starch found in the corn grain, complex sugar polymers of cellulose could also be fermented into alcohol. Unlike corn, which constitutes only the reproductive portions of the plant, cellulose is a necessary component of the plant cell wall and is found in all parts of the plant, which makes cellulose a more abundant source of sugar polymers with the potential to yield greater quantities of ethanol per plant. For example, cornstalks contain the bulk of the plant's biomass, and consequently the bulk of the cellulose. In fact, the Department of Energy considers cellulose the most abundant biological material on earth. As a result, cellulose has the potential to help us meet energy needs for a country that consumes so much gasoline that even all the corn in the world may not meet its needs.

The problem with cellulose, however, is that it naturally resists biological and chemical degradation, making it extremely hard to access the sugar polymers locked within it. This property of cellulose has raised many new challenges for scientists. In order to further understand and eventually gain access to the sugar polymers of cellulose, research needs to address how the plants synthesize their cell wall to resist degradation. In addition, the mechanisms by which microbes are able to disrupt the cell wall are also poorly understood. These investigations will serve as critical components in expanding capabilities relevant to biofuels.

In addition to problems associated with cellulose degradation, historically crops have been selected for maximal grain production, rather than biomass, or carbon content. Selection for grain production makes current seed crops very inefficient bioenergy crops. "In corn, fifty percent of the carbon is left in the field and twenty percent of the grain is not even carbohydrate," explains Dr. Daniel Bush, Chair of the Department of Biology at Colorado State University. In order to attain desirable characteristics in seed crops such as corn used in biofuel production, we would have to override thousands of years of plant domestication, probably not the most feasible approach.

Development of New Energy Crops

Scientists believe new energy crops offer many advantages because they would be designed specifically for the production of biofuel. They would be selected for different traits than seed crops and prove more efficient to the growing industry of biofuels. Besides high biomass yield, such crops would possess desirable agronomic traits such as high water efficiency and pest and herbivore resistance. Additionally, bioenergy crops would have a minimal environmental impact. These crops would burn clean and not have weedy characteristics.



One important component of the research on new energy crops is the goal to improve current biomass yield, thus increasing the amount of cellulose to be harvested, and as a result, the amount of available carbon for maximal ethanol production. In order to increase yields of biomass, we must understand the mechanisms of photosynthesis, the process by which plants use carbon dioxide and water together with sunlight to generate sugars in the plant. The significance of understanding photosynthesis is that the sugars produced from photosynthesis constitute the substances for ethanol production. Furthermore, science has shown that plants do not regularly achieve maximal photosynthetic rates. In order to improve biomass we need to achieve a better understanding of limiting factors within this process.

With this knowledge, scientists may be able to engineer bioenergy crops absent of such limiting factors allowing for maximal photosynthetic rates and, in return, maximal biomass. Dr. Bush's lab is currently investigating potential feedback mechanisms that may play a role in limiting photosynthetic rates in plants.

Related research has also focused on perennials as biofuel crops. Most agricultural crops in the field today are annuals; however, according to the U.S. Department of Energy, perennials have a significantly higher overall biomass per unit of land compared to other species of plants making them an ideal crop for maximizing biomass yield. Perennials achieve their superior biomass because of their ability to establish a canopy earlier in the spring than annuals and persist longer into the fall. Early establishment of a canopy allows plants to intercept more light throughout the season and as a result photosynthesize longer than plants that establish their canopy later in the season. Perennials have other benefits including lower fertilizer run off, one-eighth the nitrogen run off, and one-hundredth the soil erosion. Moreover, perennial grasses provide a habitat for five times as many bird species relative to annuals.

Genetic Markers to Accelerate Plant Breeding

It has taken thousands of years to obtain plants possessing the desirable traits seen in agronomic crops of today. So how do scientists plan to implement desirable bioenergy traits into crops so quickly?

Today, one important goal in plant breeding is to identify genes involved in conferring desirable bioenergy crop traits. In order to follow desirable traits throughout generations of breeding, scientists look for DNA polymorphisms, or genetic markers, in individual progeny. These markers are linked to, or are in very close proximity to, the gene of interest and are thus a tool used in identification. DNA polymorphisms are comparable to a landmark in the genome. They are identifiable in the lab and a direct indication of a particular genotype. Identified genes can then be tracked in progeny of a sexual cross between separate plant lineages. For example, genes identified may be involved in drought tolerance, disease resistance, or increased biomass.

This method allows breeders to progress faster and more efficiently through generations, selecting the most productive ideal plants and eliminating decades of the expensive time and efforts necessitated by the classical breeding approach.

Bioenergy Crop Research in the Laboratory

In order to understand physiological processes and uncover traits important for development of bioenergy crops, many plant scientists turn to model organisms. Model organisms have many advantages such as small size, rapid generation time, large populations, simple genome, easy maintenance, and genetic resources. These characteristics make model organisms conducive to the laboratory.

One of the most commonly studied model organisms is *Arabidopsis thaliana. Arabidopsis however*, is an annual and not an ideal model system for studying cell wall composition in woody or grass energy crops. Perennial crops such as Brachypodium and Populus on the other hand would help researchers identify genes and their functions pertaining to energy crop quality, productivity, and their cellulosic properties. In addition to its characteristics as a model organism, the genome of Populus was sequenced and completed in 2004.

Further research needs to associate genes more specifically with their function and roles relevant to energy traits. Identification of such roles requires a variety of approaches in the lab including the generation of mutants, as well as gene silencing and over-expression of genes suspected to play key roles in successful bioenergy crops. Furthermore, these kinds of approaches can be used to create advanced genotypes for future energy crops.

Advancements in biofuel research are certainly within reach. It is important we invest time, money, and thought into the future of biofuels in order to ensure that not only our own generation, but also those to come, have a sustainable source of energy and fuel.

C2B2

The Colorado Center for Biorefining and Biofuels, also known as C2B2, was established by Executive Director Alan Weimer, a professor at the University of Colorado at Boulder, in March of 2007 to increase the use of renewable resources in use and production of energy. The center includes Colorado State University, the Colorado School of Mines, the University of Colorado at Boulder, and the National Renewable Energy Laboratory and industry. "The mission of C2B2 is to improve the fundamental understanding of the conversion of biomass to fuels and products and develop viable technologies that can be commercialized by our industry partners in relatively short order" said Weimer.

Members of C2B2's industry sponsors such as Chevron, ConocoPhillips, Dow Chemical and Shell Global Solutions will be allowed to patent discoveries in order to quickly commercialize new technologies. Industry sponsors have also selected 10 grant recipients. Among these is Professor Daniel Bush from the Department of Biology for a grant to study sugar beets as a model renewable energy crop.

C2B2 will administer fellowships to undergraduate students, graduate students, and post doctoral researchers in addition to outreach activities with K-12 schools.

For more information visit:
http://www.colorado.edu/che/c2b2/index.html

http://www1.eere.energy.gov/biomass/

Grants, Awards and Presentations

Presentations:

Professor Gregory Florant visited Spelman College in Atlanta, GA September 12th–15th where he was selected as a CBR Visiting Scientist and presented a seminar and met with faculty and students.

NIH intern Keyona Gullet, in the lab of **Assistant Professor Shane B. Kanatous**, was awarded 2nd place for best oral presentation at the NIH Summer Research Symposium in Los Angeles, California.

Assistant Professor Mark Simmons presented a seminar on September 10th to CSU's Department of Biochemistry. Dr. Simmons also presented a talk on October 3rd to the Fort Collins Colorado Native Plant Society chapter entitled "Celastraceae and Friends in Madagascar."

Professor Don Mykles gave a seminar to the Department of Biology at the University of Kentucky on September 12th - 15th.

Assistant Professor Debbie Garrity presented a seminar on October 1st entitled "Catch the beat: The onset of heart rhythm in embryonic zebrafish" at the University of Colorado Health Sciences Center's Cardiology Research Conference.

Professor Mike Antolin and Ph.D. candidate Reesa Conrey presented their work on grasslands entitled, "Colorado Grasslands and Population Dynamics of Burrowing Owls" to the Denver Museum of Natural Science on September 24th.

Assistant Professor Dhruba Naug presented his research to the University of Wyoming's Department of Zoology.

Assistant Professor Joe Von Fisher is co-organizing a meeting entitled "Microbial Genomics in the LTER Program." This meeting will take place in East Lansing, Michigan from November 10th-12th.

Grants:

Professor Mike Antolin, together with colleagues from Cornell University, Penn State, and University, University of Georgia received a grant for $370,000 from the National Science Foundation for "Training Workshops on the Ecology and Evolution of Infectious Diseases."

Assistant Professor Debbie Garrity received a grant for $300,000 from the National Science Foundation for "Calcium Channel Beta Subunits in Early Development."

Professor Mike Antolin and Assistant Professor Collen Webb, along with Simon Tavener and Don Estep from the Department of Mathematics, and John Moore of the Natural Resources Ecology Laboratory were awarded a $900,000 grant from NSF entitled "UBM Institutional: Towards a Flexible and Extendable Scientific Undergraduate Experience: Blending Mathematics and the Life Sciences."

Professor and Distinguished Ecologist Alan Knapp received a grant from the US Department of Agriculture National Research Initiative for "Grassland structure and function in response to warming and more extreme precipitation patterns." The amount of this grant is $400,000.

Professor Mike Antolin, Indy Burke, Gene Kelly, and Nicole Kaplan from the Short Grass Steppe Long Term Ecological Research project were awarded $270,000 from the National Science Foundation for "Improvements to the Shortgrass Steppe Biological Field Station."

Congratulations Dr. Jim Detling!

On September 19, 2007, Dr. Jim Detling, or according to his graduate students, "The Great One," was honored for his excellence both as a mentor and ecologist in the 2007-2008 Distinguished GDPE Ecologist Award for the Graduate Degree Program in Ecology. In addition to accepting the award, Dr. Detling also presented a seminar entitled, "Plant-Animal Interactions: The Critical Role of Graduate Students in the Evolution of a Research Program." Throughout his seminar, Dr. Detling attributed his own personal successes to the collaborative efforts of his graduate students, describing them as both "valued" and "critical components" to his achievements.

Among his many accomplishments over the years, Dr. Detling has been awarded over 18 million dollars in grant support, has mentored 42 graduate students, and will retire as the director of Life Sciences at Colorado State University. Congratulations Dr. Jim Detling!

Colorado State University
Knowledge to Go Places

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COMMENTS

Do you have comments on the newsletter? Do you have suggestions for what we could do better? If so, please feel free to e-mail them to: blairejs@simla.colostate.edu