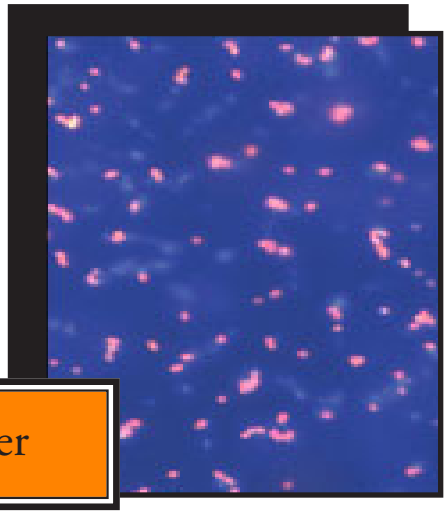
The MicroScope



The 2008-2009 Department of Microbiology Newsletter

Little Bacteria, Big Potential:

Thanks to research conducted by Dr. Alison Buchan's lab, a little-studied bacteria could now give us the chance to help save our planet.

The Georgia salt marshes where Dr. Buchan collected many of her samples.

If you have ever been in a river or stream and put your feet down only to have them slip right out from under you because of slimy feeling rocks below the water's surface, you have been the victim of biofilm. That slippery rock that betrayed you is actually covered in a collection of millions of microbes that are holding on to that stone for dear life.

The microbes could be algae, but they also could be composed of one of the many different strains of roseobacter. This extremely abundant heterotrophic bacteria exists in just about every marine environment imaginable, according to Dr. Alison Buchan, an assistant professor in microbiology.

"Actually, growing as a biofilm can, in many cases, confer some sort of selective advantage," said Dr. Buchan. In the case of the roseobacter clade, this selective advantage can be seen in the way the bacteria behave while interacting with other microbes.

When faced with a perceived enemy, some roseobacter strains release indigoidine, a blue compound that acts as an antibacterial agent, preventing the other bacterium from growing and potentially taking over roseobacter territory. Indigoidine basically behaves like roseobacter's guard dog, barking and growling until the trespassing bacteria retreats.

Dr. Buchan has recently discovered that the release of indigoidine is actually governed by quorum sensing, a form of cell-to-cell communication that is characterized by the transfer of compounds across cell membranes.

-Continued Page 2-

Words from the Department Head

Professor Jeffrey M. Becker

"It was the best of times; it was the worst of times…" (From A Tale of Two Cities). This classic first line from Dickens' novel encapsulates the predicament of Microbiology in 2009. It's the best of times regarding the pre-eminence of exciting scientific research available to microbiologists unleashed by the age of genomics, but it's the worst of times regarding scientific funding.

According to all accounts, obtaining major grant funding from NIH and NSF, the two federal agencies that fund the vast majority of biomedical and biological research in the U.S., has never been more difficult, despite the availability of "stimulus money." *Nevertheless, UT's Microbiology Department is doing very well. Faculty members continue to obtain new and renewed funding, and our research is robust.*

Most importantly, our students, both at the graduate and undergraduate level are exceeding expectations in their research productivity and participation. This summer (2009) over fifteen undergraduates participated in laboratory research. These students were funded by the special Departmental Summer Research Award, UT's Office of Research Summer Awards, and the host laboratories.

-Continued on Page 3-

It has been theorized that quorum sensing may play a large part in the microbes' ability to colonize a surface. Once enough roseobacter bunches together and begins producing indigoidine in preparation for colonization, a whole array of regulatory changes take place within any given cell. New pathways, or series of reactions paired with chemical compounds, are exposed and different genes that assist in colonization begin to function at higher than normal levels.

In order to fully understand the roles of quorum sensing and indigoidine in the life of a roseobacter cell, Dr. Buchan and her team had to develop the ability to turn off quorum sensing all together. They achieved this through random transposon mutagenesis, a form of lab-engineered intentional mutation, in which a transposon is dropped into a chromosome and bounces around randomly causing a single different mutation in each cell. In theory, this type should create an entire mutated genome with every microbe identical except for one, traceable mutation.

When the transposon disrupts the genes that code for quorum sensing, the cell is unable to make indigoidine and is therefore put at a seemingly great disadvantage when attempting to colonize a surface.

Along with mutations that prevent indigoidine from forming, Dr. Buchan has also engineered hyper-pigmented roseobacter. These super blue cells were pitted against their normally colored cousins to see if the modified cells could inhibit the growth of the non-mutated strains.

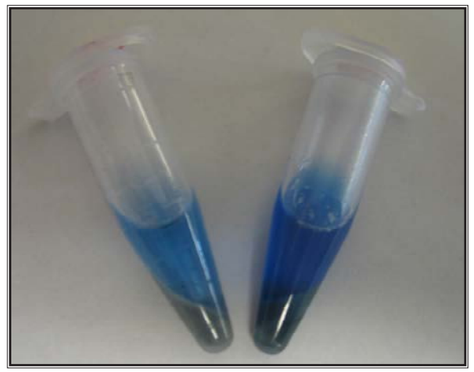
"The answer was very definitively yes," said Dr. Buchan. The strain of roseobacter that created more indigoidine is able to halt the growth of a non-mutated cell, just like a cell that produces normal levels of the blue pigment is able to stop the growth of an intruding microbe.

Dr. Buchan knows that many different roseobacter strains colonize together on one surface, but what she is trying to understand is how they are able to co-operate without inhibiting the growth of their other cousin strains. Hopefully further research by the Buchan lab will uncover if the biofilms are formed by independent pockets of different roseobacter strains, or by many different cells mixed together in a slippery hodgepodge.

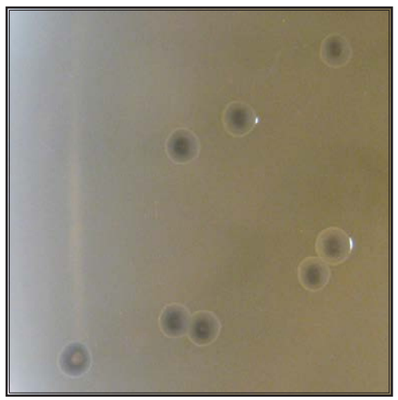
Recently the Buchan lab has also received funding from bioenergy sources to conduct research

Dr. Buchan collecting samples.

This blue pigment, indigoidine, could be one of the reasons that some roseobacter strains are so adept at colonization.



Roseobacter



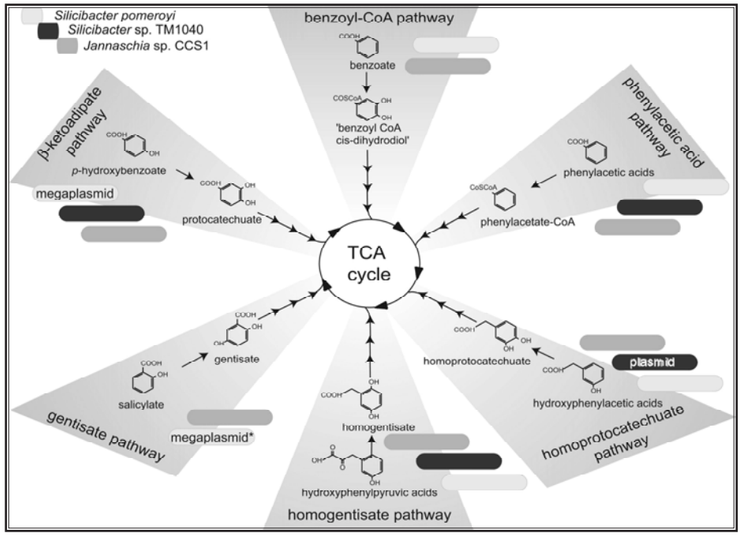
This particular form of roseobacter produces the pigment indigoidine, making it very interesting for researchers in the Buchan lab.

into whether roseobacter can be used to aid in the creation of more effective forms of bioethanol from plants like switchgrass.

One of the obstacles working against using switchgrass as a major fuel source is the fact that there are very few organisms that can break down the tough lignin, or plant material, containing the cellulose that can eventually be converted into bioethanol.

For many scientists and environmentally conscious politicians, other sources of bioethanol are far superior to the widely used and land consuming corn ethanol. Biofuels created with switchgrass or other convertible plants can be made with relatively little damage to the Earth and actually have a higher yield per acre than the cornfields needed for corn based ethanol. The only real metabolic barrier to using non-corn based bioethanol more readily is the tricky process of breaking down lignin.

According to Dr. Buchan, it has been shown that roseobacter can use the cellulose liberated at the end of lignin breakdown, but there have not been studies into whether some roseobacter strains can actually achieve the breakdown through their own enzymes. The overarching hope that rests on the shoulders of these little bacteria is that they will be able to make the cellulose available to fermentative organisms, like fungus, that can use the cellulose to create other, more efficient bioethanols.



The figure above is representative of the various pathways found in roseobacters used for the degradation of plant-derived aromatic compounds, like lignin.

If the Buchan lab does discover that a few, or even one, of the many strains of roseobacter they have documented can breakdown lignin, it will be a huge step forward for bioenergy research. Through these important studies it is possible that switchgrass and other natural plants will become viable sources of biofuel all because of a tiny, yet prolific organism that might be able to help us save our planet.

-Miriam Kramer-

Words From the Head Continued:

Graduate students presented their work at a number of national and international meetings, and a number of awards were won by our students. *We thank our alumni and supporters for their generous gifts that allow our students to participate in research and attend scientific meetings.*

In addition, our staff members continue to perform at an outstanding level. Rachelle Allen received the Glustoff Award, awarded yearly to one staff member in the entire College of Arts & Sciences who demonstrated outstanding customer service, positive attitude, and a strong and efficient work ethic.

The discipline of Microbiology is going through a tremendous growth spurt with the re-dedication of the Nation to biofuels as an energy source and the explosion in genomic information. Microbes will play a major role in conversion of plant materials to usable fuels, and many of our faculty members are engaged in research in this area. An understanding of the connections between genes, multiple pathways, and thousands of proteins in living cells emphasizes the need to study microbial model systems. Furthermore, the continuing attack of epidemics, including the up-coming threat of a swine flu pandemic, the rise of drug resistant microbes, and the recognition of the huge numbers of uncultured microbes that play important roles in the environment all point to the continued importance of research in microbiology. We truly live in The "Golden Age" of Microbiology!

I thank you for the opportunity and privilege to serve you as Head of Department.

From Ghana to U.T.

A story of two students and their journeys to the U.S.

Life has a funny manner of working out in oddly coincidental ways. In the case of Lydia Mosi and George Umanah, two graduate students working in Prof. Pam Small's and Prof. Jeffery Becker's labs respectively, those odd twists of fate have had a marked impact on each of their lives.

Both students began their college careers at the University of Ghana. George trained as a medical technician before attending university, becoming interested in biochemistry, and subsequently receiving his B.S. in the subject. As fortune would have it, George was actually Lydia's teaching assistant while still in Ghana. He then moved to the United Kingdom and received his Master of Research in biotechnology from the University of Essex.

Lydia took a slightly different approach to her education while at the University of Ghana. When she did her undergraduate honors thesis she was placed with the Noguchi Institute, an organization based in Africa that focuses specifically on understanding and hopefully eradicating the Buruli Ulcer.

The ulcer is caused by a particularly dangerous bacteria found mostly in Western Africa. No pain is associated with the ulcer and no secondary infections occur at the initial site, making it even more dangerous for those it infects. Many people that contract the bacterium are miles away from a hospital, so much of the time the infection goes untreated. On many occasions Lydia would have to convince reluctant parents to take their children to the hospital for treatment.

"They [the parents] take you [the infected child] to some forgotten relative and say 'when you're healed come back home'," said Lydia of some of the superstitions she encountered while working with the Noguchi Institute. "That hit me. Whatever I could do, I would."

Lydia stayed on with the Noguchi Institute after graduating from the University of Ghana. Her work there initially got her interested in coming to UT to conduct research on the Buruli Ulcer in Prof. Small's lab. Lydia specifically picked the Small lab because it is the only one in the United States that primarily works with the ulcer.

George also came to the U.S. to work specifically at U.T., in Prof. Becker's lab. George's research is mainly focused on attempting to more fully understand the relationship between a yeast pheromone and its receptor.

"What we do in this lab is try to characterize the interactions between the alpha factor pheromone and its receptor, STE2P," George explained. "We're using it as a model to understand the hormone and pheromone receptors in humans."

By having a clearer understanding of the way

The Ghanian flag hanging in the Small lab.

alpha factor interacts with STE2P and the way it interrelates with other molecules and compounds, new and more effective therapies and drugs can be created to help counteract diseases that affect these model receptors according to George.

STE2P is a member of one of the most responsive, largest and most varied protein receptor families: the G-protein coupled receptors (GPCRs). Over 50 percent of all drugs on the market specifically target GPCRs. Because of this fact, it is very important to have a more complete understanding of how to best manipulate these protein receptors in order to most effectively treat those with GPCR related diseases. George is on the frontline of that research in Prof. Becker's lab.

Although George and Lydia both enjoy living in the United States now, it was a hard adjustment when they first started going to school at U.T. Lydia had trouble finding any food that she could eat without feeling sick, and even though George lived in the U.K. before coming to the U.S. it was still a hard transition.

"I was kind of in a strange land where I didn't have any family members," said George of coming to the United States after living near family in the United Kingdom.

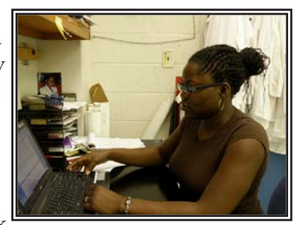
Despite the fact that George did not have any family living in the U.S., he still was able to carve out a niche with the help of his newfound friends and Professor Becker's guidance.

"He has been a very good mentor," George said of Prof. Becker. "He always pushes you to go further than what you think you can do."

Lydia also doesn't have family in the US, but she liked living in Knoxville as soon as she got here.

"I turned on the tap in my apartment, and the water was flowing, and I turn on the hot water and the water was hot," said Lydia speaking on her first few weeks in the U.S. "It was a big deal for me. At home, if I wanted to take a shower I would sometimes have to fetch water half a mile away."

Although Lydia and George had similar paths that brought them to the United States, their post graduation plans differ greatly. George is currently searching for a U.S. university to conduct his postdoctoral research, and Lydia intends to return to Ghana to work with the Noguchi Institute.



Overall their experiences in the U.S. have given them and everyone they have taught a different perspective on life and the world.

When reflecting on her life in the United States, Lydia expressed gratitude: "It's one of those experiences that I would never trade because now I feel like a well rounded person."

-Miriam Kramer-

Dr. Thandi Onami and Her Quest to Understand Our Immune System

The immune system is our bodies' most effective guard against pathogens that successfully break through our outer defenses. In truth, no matter how many times we wash our hands or work out, everyone ultimately gets sick at some point in their lives. But Dr. Thandi Onami, with the help her lab team, is trying to make that inevitable truth at least a little easier to swallow.

Dr. Onami has spent most of her career as a microbiologist working with T-Cells, the white blood cells that rid the body of any foreign virus or bacterium that may enter. More specifically, Dr. Onami focuses on CD8 T-Cells, or killer cells. These cells have task of searching out and destroying any unwanted pathogens in the body.

Although most of Dr. Onami's professional career has centered on killer T-Cell research, the nature of immunological study dictates that most researchers must at least have a basic understanding of all the components of the immune system. In Dr. Onami's case, her lab analyzes the roles of enzymes that are critical to immunological function, not only concerning T-Cells but all cells involved with the body's immunological response.

"Because we're looking at the impact of a loss of certain enzymes on immune function, as a consequence of the fact that those enzymes are expressed by multiple immune cells, it has resulted in us focusing on multiple arms of the immune system," said Dr. Onami of her eclectic research interests.

This past year Dr. Onami collaborated with another microbiology professor, Dr. Mark Sangster, when they discovered an enzyme that was differentially expressed in CD8 cells, meaning that the enzyme functions differently when the cell is naïve, triggered by a pathogen, or mature with immunological memory. The enzyme and therefore immune cell almost act like a police officer for the body; at first the enzyme is new on the job, then it gets its first action on the force, and after that the cell understands what to expect and matures with experience.

The odd thing about this certain enzyme that Dr. Onami and Dr. Sangster found through further investigation, is that it is also expressed in helper T-Cells-- the bossy cells that call the others into action-- and even B-Cells, the part of the immune system responsible for producing antibodies. Because Drs. Onami and Sangster were able to narrow down where the enzyme was expressed, they could start experimentation knocking out the enzyme itself.

"We can start to pick apart and say what's the function of this gene in this cell and how does that influence our immune response," said Dr. Onami.

The team began mix and match experiments with the flu virus and started to notice a pattern of irregularity when the B-Cell enzyme's function was marginalized. When this particular enzyme is compromised it prevents an immediate immunological response to whatever pathogen is harming the body at the time.

According to Dr. Onami, it can be fatal if an immediate response to a pathogen is undermined. Because of the newfound understanding of this enzyme, it is now possible to develop new treatments for diseases.

Dr. Onami explained that "there are ways in which we can now modulate the immune response either in a positive way or maybe in a negative way that could have therapeutic potential."

Recently, Dr. Onami has been very excited about an unexpected discovery made in her lab. As the team was manipulating different genes, they found that a few enzymes seem to code for a specific kind of T-Cell traffic.

"When you don't have these enzymes, your T-Cells end up being targeted to the lungs," said Dr. Onami. These enzymes are usually coded to target T-Cells to the lymph nodes, but if they do not function correctly, it appears that the T-Cells meant for those nodes collect in the lungs.

"We're very interested in understanding if these enzymes are playing a role in whether or not T-Cells end up in the lungs in these diseases [asthma, COPD, etc.], and there is some evidence for that," she said.

Another potentially revolutionary discovery made by Dr. Onami's team is that they may have disproved a common dogma among immune system researchers. Most immunological researchers have long believed that immature or naïve T-Cells do not enter the lungs, but Dr. Onami's research shows some evidence to the contrary. When this set of enzymes is knocked out, immature cells are sent to the lungs.

The ultimate goal of Dr. Onami's research is to aid in the development of new vaccines and therapies that may ultimately lead to the elimination of diseases that still plague our world today. Her research into this set of enzymes may even help scientists and doctors understand T-Cell traffic in a way that they never have before.

"If you block the ability of T-Cells to go to the lymph nodes, then you can have an unexpected role in where those T-Cells end up," Dr. Onami explained.

Above all, these findings reflect the very nature of scientific research.

Dr. Onami said of her unanticipated conclusions, "That's science. Sometimes you have to be open to the unexpected."

-Miriam Kramer-

Branching Out:
Department Service on Editorial Boards

One of the marks of a truly great department is not only what the faculty and staff contribute to the university but what they help contribute to the breadth of knowledge in their field. At the U.T. Department of Microbiology, it is not only enough for faculty to publish their research in acclaimed journals, but many professors also serve on editorial boards in order to help deliver the research done by their colleagues to a wide array of readers. This is only a sample of their extensive service.

Environmental Microbiology
&
Environmental Microbiology Reports

Dr. Zinser serves on the editorial board for *Environmental Microbiology* (E.M.), a publication devoted to the most inovative research concerning microbial processes, microbial interactions and microbial communities. Dr. Zinser also serves on the editorial board for *Environmental Microbiology Reports*, an electronic companion journal to E.M. that publishes brief articles on single subject findings.

Dr. Erik Zinser

Professor Gary Sayler

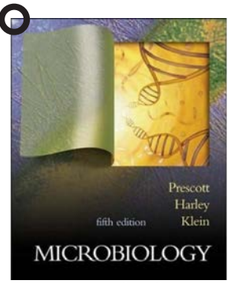
Professor Sayler is an associate editor for *Environmental Science and Technology*, an interdisiplinary publication that covers environmental research and break-throughs. The journal publishes research papers as well as objective analysis of news related to environmental technology, policy and science.

Environmental Science and Technology

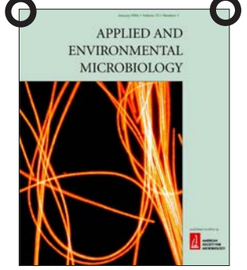
Dr. Alison Buchan

Dr. Buchan and Professor Wilhelm are both members of the *Applied and Environmental Microbiology* editorial board. The journal covers a broad range of issues including microbial ecology, biotechnology, and medical microbiology.

Dr. Buchan serves on the Academic Advisory Board for Annual Editions as a consultant for the textbook, *Microbiology*.



Microbiology



Applied and Environmental Microbiology

Professor Jeffrey Becker

Professor Becker serves on the editorial board for the journal, *Antimicrobial Agents and Chemotherapy,* one of the foremost publications in microbiology and pharmacology. He is also Associate Editor for *Microbiology*, published by the British Society of Microbiology.

Antimicrobial Agents and Chemotherapy

Microbiology (B.S.M.)

The Journal of Clinical Microbiology

Professor Brad Fenwick

Vice Chancellor for Research and adjunct professor Brad Fenwick is an editor for the *Journal of Clinical Microbiology*. This publication focuses mainly on research related to the microbiological components of animal and human infection.

Dr. Gladys Alexandre

Professor Steven Wilhelm

Professor Wilhelm is an associate editor for the online publication, *Limnology and Oceanography: Methods.* This journal functions as a companion publication to *Limnology and Oceanography*, a print journal published by ASLO (Advancing the Science of Limnology and Oceanography).

Limnology and Oceanography: Methods

Dr. Zhulin is an editor for the *Journal of Bacteriology*. Dr. Alexandre serves on the editorial board for the publication as well. The journal focuses on current research pertaining to microorganisms, specifically bacteria.

Professor Pam Small

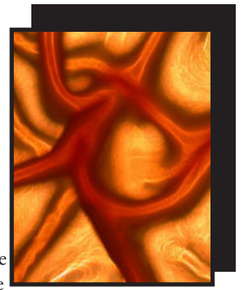
Professor Small works as the deputy editor for the online publication, *Journal of Neglected Tropical Diseases*. She also serves on the editorial board for *Infection and Immunity*, a journal that publishes work investigating infections caused by parasites, bacteria and fungi.

PLoS Journal of Neglected Tropical Diseases

Infection and Immunity

Dr. Igor Zhulin

Microbiology Lab Updates



Gladys Alexandre, a member of Microbiology (25%) and BCMB has been awarded a new NSF grant for her research on the molecular basis of chemotaxis signal transduction in bacteria and the role of chemosensory behaviors in regulating multiple cellular responses. She currently mentors 3 graduate students, including Microbiology MS student Calvin Green who is characterizing the molecular basis for cell-to-cell aggregation (clumping), an adaptive behavior regulated by a chemotaxis-like signal transduction pathway. Amber Bible (a BCMB fourth year PhD student) is studying the role of a novel multipass membrane protein, widely distributed and conserved in prokaryotes and eukaryotes (including humans). She made the recent discovery that this protein interacts with chemotaxis signal transduction proteins in bacteria. Part of Amber's work was recently published in the Journal of Bacteriology. She was also invited to give a talk at the BLAST conference, a presentation recently highlighted in a conference microreview in Molecular Microbiology. Amber was awarded the 2009 Hollaender award for her scientific accomplishments thus far at UT. Several undergraduate students are also involved in on-going research projects. Danielle Harrell is working on a collaborative project with Prof. Barry Bruce's lab (BCMB) to characterize the lifecycle and carbohydrate production in a dessication-resistant photosynthetic cyanobacterium, which can be applied in the field of bioenergy production. For this she received the top award for all biology projects at the 2009 EURCA competition and was named the winner of the overall College of Arts and Sciences competition.

Sample Publications:

Wasim M, AN Bible, ZH Xie, and **G Alexandre**. 2009. Alkyl hydroperoxide reductase has a role in oxidative stress resistance and in modulating changes in cell-surface properties in *Azospirillum brasilense* Sp245. Microbiology-Sgm 155:1192-1202.

Miller LD, MH Russell, and **G. Alexandre**. 2009. Diversity in bacterial chemotactic responses and niche adaptation, p. 53-75, Advances in Applied Microbiology, Vol 66, vol. 66.

The Becker Lab was awarded a competitive renewal of their NIH grant on "Peptide-Cell Interactions in Yeast" for years 32-35 of this continuously funded (35 years) NIH grant. The work covered by this grant involves the study of the structure and function of a receptor in yeast that is used as a model for understanding hormone function in human cells. They have started a new project involving discovery of the intestinal fungal flora of mammals. The development of powerful new DNA sequencing technologies has led to the discipline of 'metagenomics', the sequencing and analysis of DNA from mixed population samples without the need to culture each individual organism. Using the mouse as a model system the lab has been using a metagenomic approach to catalog the fungal diversity in a region of the large intestine selected based on its role in gastrointestinal disease in humans. This work complements the investigations of ORNL scientists to correlate the microbial population to the health of genetically defined strains of mice with predispositions to specific diseases, including obesity, hypertension, and various cancers.

Sample Publications:

Huang LY, Umanah G, Hauser M, Son C, Arshava B, Naider F, and **Becker JM** 2008. Unnatural amino acid replacement in a yeast G protein-coupled receptor in its native environment. Biochemistry 47:5638-5648.

Cohen LS, Arshava B, Estephan R, Englander J, Kim H, Hauser M, Zerbe O, Ceruso M, **Becker JM**, and Naider F 2008. Expression and biophysical analysis of two double-transmembrane domain-containing fragments from a yeast G protein-coupled receptor, Biopolymers 90:117-130.

Umanah GKE, Son CD, Ding F, Naider F, and **Becker JM** 2009. Cross-linking of a DOPA-containing peptide ligand into its G protein-coupled receptor. Biochemistry. 48:2033-2044.

The Buchan Lab welcomed two new graduate students this past academic year. William Cude, a MS-seeking student, is studying interactions between marine bacteria on surfaces in an attempt to understand what dictates observed colonization patterns and the impacts these have on degradation of solid substrates. Chris Gulvik, a PhD-seeking student, is investigating marine microbes capable of breaking down plant material, with an emphasis on structures that may have value in bioenergy sectors. We have also been fortunate to host Paul Ruschitzka, a Marshal Plan Fellow and visiting student from Austria, who has been gaining valuable experience working with Chris this summer. Charles Budinoff, a third-year PhD student, is continuing his work on identifying and characterizing viruses that infect marine bacteria. His efforts have led to the recent selection of four of his viral isolates for genome sequencing by the Broad Institute at MIT, with funding provided by the Gordon and Betty Moore Foundation. Finally, the lab recently received Department of Energy funding for a 5-year collaborative project with an Energy Frontier Research Center managed by Purdue University. The focus of this nearly $20 million project is catalytic conversion of biomass to biofuels. The Buchan lab is working with chemists at UTIA and UTK to develop "hybrid" biological and chemical catalysts capable of transforming wasted byproducts of bioethanol refineries to polymers with commercial value.

Sample Publications:

Zhao Y, K Wang, C Budinoff, **A Buchan**, A Lang, N Jiao, and F Chen. 2009. Gene transfer agent (GTA) genes reveal diverse and dynamic Roseobacter and Rhodobacter populations in Chesapeake Bay. The ISME Journal. 3: 364-373.

Buchan, A. and JM Gonzalez. Roseobacter (In press). In Microbiology of Hydrocarbons, Oils, Lipids and Derived Compounds. In K. M. Timmis (ed.), Microbiology of hydrocarbons, oils, lipids, and derived compounds. Springer-Verlag, Germany.

The main goal of the research in **the Onami laboratory** is to understand how the immune system recognizes and eliminates infectious microorganisms such as viruses. The studies in our laboratory will help us understand the basic mechanisms of immune recognition and lymphocyte differentiation that result in pathogen clearance and immunological memory. These studies may yield important insights critical to our understanding of how the immune response is regulated. Potentially, this information could be used for therapeutic purposes relevant to vaccination, autoimmunity, and infectious disease.

Sample Publications:

Prabakaran N, **Onami TM**, Rajagopalan S, Kania S, Donnell R and Venkatachalam S (2009) Role of chromodomain helicase DNA binding protein 2 (Chd2) in DNA damage response signaling and tumorigenesis. Oncogene 28(8): 1053-62

Zeng J, Joo HM, Bheemreddy R, Wrammert JP, Sangster MY, and **Onami TM** (2009). The generation of influenza specific humoral responses is impaired in ST6Gal I deficient mice. Journal of Immunology 182(8): 4721-27

The Reynolds lab congratulates its first two graduates, Ying-Lien (Joseph) Chen, PhD, and Emily Bethea, MS. Joseph is now a postdoc at Duke University with Dr. Joseph Heitman, and Emily is teaching at a private school in Mississippi. While in the Reynolds lab, Joseph received a travel award to attend the Candida and Candidiasis Meeting in Jersey City, New Jersey (2008), where his abstract was picked for an oral platform presentation, and he won an award for the high quality of his talk. Joseph was also accepted into the Wood's Hole Molecular Mycology Course (summer 2008), for which he received a scholarship. Joseph and Emily both submitted manuscripts based on their graduate research, which are both currently being revised. In addition, Joseph is first author on a paper published in Infection and Immunity (2008). Joseph and Emily had projects that concentrated on the roles of phospholipid biosynthesis in the virulence of the fungal pathogens *Candida albicans* and *Candida glabrata*, respectively. The Reynolds lab also published two other papers recently, one in Eukaryotic Cell (2008), and an invited review in Microbiology (2009). We welcomed a new graduate student, Anthony Montedonico (seeking a PhD), to the lab in the Fall of 2008. Anthony will continue the work Joseph Chen pioneered in examining the role of phospholipid biosynthesis in the virulence of *Candida albicans*. Neha Sarode (third year PhD candidate from the GST program) is continuing her work on biofilm formation in yeast, and Marissa Rodrigues (second year Microbiology student seeking her PhD) is beginning a new project in collaboration with the Becker lab on hypervirulence genes in *Candida albicans*. The Reynolds lab also just received a three year grant from the National Science Foundation for studying biofilm formation and sliding motility in fungi, and Dr. Reynolds will be presenting an invited seminar on this topic at the 4th Molecular Mechanisms of Fungal Cell Wall Biogenesis Meeting in Warsaw, Poland in early September.

Sample Publications:

Reynolds TB, A Jansen, X Peng, GR Fink, Mat formation in *Saccharomyces cerevisiae* requires nutrient and pH gradients. Eukaryotic Cell. 2008 Jan;7(1):122-30.

Chen YL, S Kauffman, **TB Reynolds**, *Candida albicans* uses multiple mechanisms to acquire the essential metabolite inositol during infection. Infection & Immunity, 2008 76(6):2793-801.

Reynolds TB Strategies for acquiring the phospholipid metabolite inositol in pathogenic bacteria, fungi and protozoa: making it and taking it. Microbiology 2009 155:1386-96.

At **the Sayler lab** Drs. Gary Sayler, Steve Ripp, James Fleming, and Stacey Patterson received an NSF award to develop real-time bioreporter sensor and therapeutic effector loops for monitoring physiological fluctuations. This bioengineering strategy integrates biophotonic sensors with tissue-based cellular bioreporters and microelectronic gene regulatory circuits to create a new sensory technology for autonomous detection, quantification, and countermeasure response to aberrant or out-of-range therapeutic conditions. This research builds on progress in the research areas of (i) expression of the Photorhabdus luminescens lux operon in mammalian cells and (ii) controlling gene expression by electrical induction. The Joint Genome Institute has completed sequencing the genome of Thauera "eastmanii"MZ1T for CEB. Analysis of the genome is being led by Ke Jiang and other members of CEB. Ke Jiang is primarily interested in gene regulation and metabolic pathways responsible for exopolysaccharide production. Recently, Alice Layton and Dan Williams of CEB as well as Julia Gouffon (Nutrition) were trained on the Roche Genome FLX Titanium High Throughput Sequencer (454 sequencing) at the Joint Institute for Biological Sciences (JIBS). During this training, they sequenced and are currently annotating Pseudomonas fluorescens HK44, a naphthalene-lux¬ bioreporter that was used in a field release experiment at ORNL. They are now accepting outside projects for 454 sequencing. CEB welcomes Jun Wang and Tommy Mead as new graduate students. Jun will be utilizing our yeast bioreporters for the analysis of hormonally active agents in water. Tommy will be working with Dr. Steve Ripp on a USDA funded project to perform environmental risk assessment of lambda bacteriophage transduction in wastewater. CEB has also hosted two undergraduate students, Nathan Simmons and Kyle McIntosh, who received summer fellowships from Microbiology and the Office of Research. Kyle is working under the guidance of Dr. Melanie DiClaudio to develop an arsenic bioluminescent bioreporter. Nathan is working under the guidance of Dr. Steve Ripp to develop a fluorescent bioreporter for Bacteroides to be used in water quality monitoring.

Sample Publications:

DeBruyn JM, TJ Mead, SW Wilhelm, and **GS Sayler.** 2009. PAH biodegradative genotypes in Lake Erie sediments: evidence for broad geographical distribution of pyrene-degrading mycobacteria. Environmental Science & Technology 43:3467-3473.

Lab Updates Continued

Hawkins SA, KG Robinson, AC Layton, **GS Sayler**. 2008. Response of *Nitrobacter* spp. ribosomal gene and transcript abundance following nitrite starvation and exposure to mechanistically distinct inhibitors. Environmental Science & Technology. 42: 901-907.

Koirala SR, RW Gentry, E Perfect, JS Schwartz, **GS Sayler**. 2008. Temporal variation and persistence of bacteria in streams. Journal of Environmental Quality. 37: 1559-1566.

Research in **the Small lab** focuses on understanding the pathogenesis and ecology of *Mycobacterium ulcerans*. The major virulence determinant of *M. ulcerans* is an immunosuppressive toxic macrolide mycolactone. Mycolactones are a family of polyketide-derived molecules made by a number of pathogenic environmental mycobacterial species. We are particularly interested in understanding the genetic basis of mycolactone production as well its regulation. We are also involved in the discovery, isolation and chemical characterization of novel mycolactones from aquatic mycobacteria. Investigations into structure-function relationships of mycolactone are being conducted in collaboration with the labs of Prof. Richard Lee, St. Jude Hospital, and Prof Yoshito Kishi at Harvard University. To prevent the loss of limbs which occurs as a result of late diagnosis of Buruli ulcer, we are working with the World Health Organization and the Kishi lab to develop a simple, inexpensive, mycolactone-based point-of-care diagnostic for use in rural villages in West Africa. *M. ulcerans* is a particularly important cause of morbidity in West Africa where it causes severe crippling disability. With teams from the Noguchi Institute of Medical Sciences, Ghana, Buruli Ulcer Control Program, Benin, and Professor Merritt's lab at Michigan State University we are investigating the ecology of *M. ulcerans*. Much of this work involves the molecular analysis of environmental samples gathered in Buruli ulcer endemic and non-endemic sites in small rural villages in West Africa. Our evidence suggests that although there are ecological constraints to the distribution of *M. ulcerans*, there are also important behavioral risk factors associated with disease. To identify behavior risk factors for infection we have recently begun collaboration with medical anthropologist Prof. Mark Nichter at Arizona State University to study behavioral components.

Sample Publications:

Mosi L, Williamson H, Wallace JR, Merritt RW, **Small PLC** (2008) Persistent association of *Mycobacterium ulcerans* with West African predaceous insects of the family Belostomatidae. Applied Environmental Microbiology 74:7036-7042

Williamson HR, ME Benbow, KD Nguyen, DC Beachboard, RK Kimbirauskas, MD McIntosh, C Quaye, EO Ampadu D, Boakye RW Merritt, and **PLC Small**. 2008. Distribution of mycobacterium ulcerans in buruli ulcer endemic and non-endemic aquatic sites in Ghana. PloS Neglected Tropical Diseases 2.

Simmonds RE, FV Lali, T Smallie, **PLC Small**, and BM Foxwell. 2009. Mycolactone inhibits monocyte cytokine production by a posttranscriptional mechanism. Journal of Immunology 182:2194-2202.

The Sparer lab: In thinking of my career since coming to the University of Tennessee six years ago, I realize that you just never know where your data will take you and your lab. I was trained as a viral immunologist and have always been interested in how viruses, in particular *Cytomegaloviruses*, usurp our own immune responses for their evolutionary success. Turns out that these viruses steal our genes and use them against us for their survival. As my lab was studying how some of these "stolen" host proteins (called chemokines) are used for attracting and activating immune cells, which the virus then uses as a "taxi" for its dissemination throughout the body, we began to delve into how host and viral chemokines activate chemokine receptors on cells. In collaboration with Dr. Becker's lab, we set up a high throughput screen for looking at the activation of chemokine receptors and discovered a novel constitutively active chemokine receptor. Think of it as a switch stuck in the "on" position. What does this mean for human disease? It turns out that chemokines and activation of their receptors play a role in cancer metastasis and tumorigenesis. Metastasizing cancers are often the real killers of cancer patients. Cancers become much harder to treat once they have spread throughout the body and to vital organs such as the brain, liver, and lungs. If a chemokine receptor is stuck in the "on" position, it could help regular cells transform into cancerous cells and contribute to their ability to metastasize. And in following my data down that road, the next thing I knew, I was a viral immunologist studying cancer biology!

Sample Publications:

Heo J, S Petheram, G Demmler, and JR Murph, S Adler, J Bale, **TE Sparer.** 2008 Polymorphisms within cytomegalovirus chemokine (UL146/UL147) and cytokine receptor (UL144) genes lack correlation with CMV sequelae in congenitally infected children. Journal of Virology. 378:86-96

Miller-Kittrell M, and **Sparer TE**. 2009. Feeling manipulated: cytomegalovirus immune manipulation. Journal of Virology. 364:454-65.

In the past several years, **the Su Lab** has made significant contribution to the understanding of *T. gondii* population diversity. We developed a multiplex multilocus nested PCR-RFLP method that is highly sensitive and can provide high resolution in genotyping the parasite. Through international collaborations, we have collected over a thousand *T. gondii* samples from animals (domestic and wild) and from human patients. These samples were genetically characterized by the PCR-RFLP method 140 genotypes were identified. The results showed that, rather than a well-accepted view of a simple, clonal population structure, *T. gondii* is highly diverse and has distinct subpopulations in different geographical regions. At present, we are working with the J. Craig Venter Institute (JCVI) to deep sequence a number of divergent *T. gondii* strains and a few closely related apicomplexan species. Accomplishment of this large scale genome study will lay the foundation to investigate the evolution of virulence, host range expansion and the ability of horizontal transmission of the wide spread zoonotic pathogen *T. gondii*.

Sample Publications:

Velmurugan GV, Dubey JP and **Su C.** Genotyping studies of *Toxoplasma gondii* isolates from Africa revealed that the archetypal clonal lineages predominate as in North America and Europe. 2008. Veterinary Parasitology. 155:314-318.

Pena HFJ, Gennari SM, Dubey JP, **Su C.** Population structure and mouse-virulence of *Toxoplasma gondii* in Brazil. International Journal for Parasitology. 2008. 38:561-569.

The Wilhelm lab had a productive 2008 and 2009 (so far). Five new *National Science Foundation* grants sent lab members to study viruses and trace elements in New Zealand, toxic algae in China and bacteria in the Great Lakes (in the dead of winter!) Lab members Janet Rowe (PhD, and now a NIH post doctoral researcher in Nebraska) and Star Loar (MSc) had successful defenses. Matt Saxton received the IAGLR Fellowship to continue his work on linkages between herbicides and toxic cyanobacterial blooms. All of this contributed to 23 peer-reviewed publications the lab has co-authored since January 2008. Currently the lab is working with UT and ORNL collaborators to establish capabilities in the genomic and proteomic analyses of viruses, toxic algae and microbial communities. Highlights include a new project to sequence the genomes of recently described "viral leviathans" (giant viruses that rival bacteria in physical and genomic size). As well 2 new projects, with ORNL collaborator Nathan VerBerkmoes, will use high-throughput proteomic analyses of lab strains and populations to begin to understand the environmental factors that make toxic algae grow.

Sample Publications:

Allender CJ, GR LeCleir, JM Rinta-Kanto, RL Small, MF Satchwell, GR Boyer, **SW Wilhelm.** 2009. Identifying the source of unknown microcystin genes and predicting microcystin variants by comparing genes within uncultured cyanobacterial cells. Applied and Environmental Microbiology 75: 3598 - 3604

Sharma AK, K Sommerfeld, GS Bullerjahn, AR Matteson, **SW Wilhelm**, J Jezbera, U Brandt, W F Doolittle, MW Hahn. 2009. Actinorhodopsin genes discovered diverse in freshwater habitats and among cultivated Actinobacteria. The ISME Journal 3: 726-737.

Brussaard CPD, **SW Wilhelm**, F Thingstad, MG Weinbauer, G Bratbak, M Heldal, SA Kimmance, M Middelboe, K Nagasaki, JH Paul, DC Schroeder, CA Suttle, D Vaqué, KE Wommack. 2008. Commentary: Global scale processes with a nanoscale drive - the role of marine viruses. The ISME Journal 2:575-578

Among other notable achievements, **the Zhulin lab** is proud to report that Oak Ridge High School students Katherine Xue and Albortz Benjood, who carried out their research project in our laboratory, won 2nd place in team competition at the Intel International Science and Engineering Fair (Reno, Nevada, 2009), the largest international science competition for students. In one paper this year, we used ORNL supercomputer Cray XT4 known as "Jaguar" to match all proteins in the NCBI non-redundant database to all protein domain models from the Pfam database. The procedure, which would have taken years to complete on a desktop computer and several months on a medium-size Linux cluster, was done in less than 22 hours. This paper opens a new direction for the lab in pursuit of analyzing massive genomic data. Another paper recently published is a result of successful matching our computational expertise and a new experimental technique, cryoelectron tomography, provided by our collaborators at California Institute of Technology. The project led by Ariane Briegel and Grant Jensen at Caltech resulted in a significant insight into organization of the chemosensory system in bacteria.

Sample Publications:

Fredrickson JK, Romine MF, Beliaev AS, Auchtung JM, Driscoll ME, Gardner TS, Nealson KH, Osterman AL, Pinchuk G, Reed JL, Rodionov DA, Rodrigues JLM, Saffarini DA, Serres MH, Spormann AM, **Zhulin IB,** Tiedje JM (2008) Towards environmental systems biology of *Shewanela.* Nature Reviews Microbiology 6:592-603

Zhulin, IB 2009. It is computation time for bacteriology! Journal of Bacteriology 191:20-22.

Belas R, **IB Zhulin**, and Z Yang. 2008. Bacterial signaling and motility: sure bets. Journal of Bacteriology 190:1849-1856.

This was a productive year for **the Zinser Lab**. Jeff Morris, a PhD student, published his first research article, in the journal Applied and Environmental Microbiology. In this work, we described our new method of using helpful bacteria to facilitate the growth of *Prochlorococcus*, which is a highly abundant marine photosynthetic bacterium that is very difficult to cultivate in the lab. Jeff has since used "helper" bacteria to isolate several new species of algae from the Chesapeake Bay, including those of no known close relatives. He has been awarded a Grant-In-Aid from the Phycological Society of America (PSA) to continue this study, and has also received a travel award from the PSA to present his findings at their annual meeting in Honolulu, Hawaii. Jeff joined another PhD student, Marty Szul, for a two-week cruise from North Carolina to the Sargasso Sea, on the research vessel R/V Cape Hatteras. During his cruise they sought evidence that the "helping" phenomenon occurs in nature as well as in lab cultures. Last but not least, PhD student Jeremy Chandler has been busy analyzing the samples he collected on our prior cruise from Hawaii to Australia. His goal is to characterize the populations of *Prochlorococcus* in the Pacific Ocean, and to understand how they may respond to climate change. Finally, Erik Zinser was invited to join the editorial board of Environmental Microbiology and Environmental Microbiology Reports, one of the top journals in the field of microbial ecology.

Sample Publications:

Zinser ER, Lindell D, Johnson ZI, Futschik ME, Steglich C, Coleman ML, Wright MA, Rector T, Steen R, McNulty, Thompson LR, and SW Chisholm. 2009. Choreography of the transcriptome, photophysiology, and cell cycle of a minimal photoautotroph, *Prochlorococcus*. PLoS ONE, 4: e5135

Morris JJ, R Kirkegaard, MJ Szul, ZI Johnson, and **ER Zinser.** 2008. Robust growth of *Prochlorococcus* colonies and dilute liquid cultures: facilitation by "helper" heterotrophic bacteria. Applied Environmental Microbiology. 74: 4530-4534.

2008-2009 Departmental Awards & Non-Departmental Awards

Julie Akin (pictured) was awarded the Lisa Kahn Undergraduate Research Award for outstanding achievement in research studies as an undergraduate student.

Bo-Jhih Guan, Aarthi Sundararajan, Chris Gulvik, George Umanah, Lydia Mosi, Jinho Heo, Heather Benedict-Hamilton all received the David White Travel Award in the amount of $1,000 for their research.

Dr. Todd Reynolds (left) was awarded the Undergraduate Faculty Teaching Award for excellence in undergraduate instruction.

From **Professor Pam Small's lab, Lydia Mosi** (left) and from **Dr. Steven Wilhelm's lab, Star Loar** (center) have been awarded the Graduate Teaching Award for excellence in undergraduate teaching.

Lecturer Elizabeth McPherson (pictured left) has been awarded the Microbiology Staff Award for excellence in teaching.

Rob Arnold (right) and **David Wang** (not pictured) have been awarded the D. Frank Holtman Undergraduate Academic Achievment Award for outstanding academic achievement in microbiology.

Other Awards

Hye Mee Joo, George Umanah, and Jinho Heo have won the Division of Biology Science Alliance Award for Outstanding Scholarly Achievement by a Graduate Student.

Matt Saxton received the International Association of Great Lakes Researchers scholarship to continue his studies on the linkages between herbicides and the proliferation of toxic algae in the Great Lakes

Professor Steven Wilhelm received the Chancellor's Award for Research and Creative achievement for his internationally recognized research into toxic algal blooms and aquatic bacterial viruses.

Dr. Melanie DiClaudio was one of ten exceptional educators who were chosen to receive the 2009 Early-Career Faculty Travel Award from the American Society for Microbiology Conference for Undergraduate Educators.

Rachelle Allen received the Glustoff Award, given annually to one staff member in the College of Arts & Sciences who demonstrates outstanding customer service, a positive attitude, and a strong and efficient work ethic.

Jeff Morris won a Grant-in-Aid of Research from the Phycological Society of America. This award is given to student members of the P.S.A. to enable them to continue their research. P.S.A. also awarded Jeff a student travel award.

Suneeta Acharya, Jenna Burton, Amanda Deyo, Caylan McIntosh, Kellina Morris, Geet Parekh, Andrew Poole and Lydia Siebert all received an Undergraduate Summer Internship position for 2009. The chancellor's office funds these internships in order to stimulate undergraduate participation in research.

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