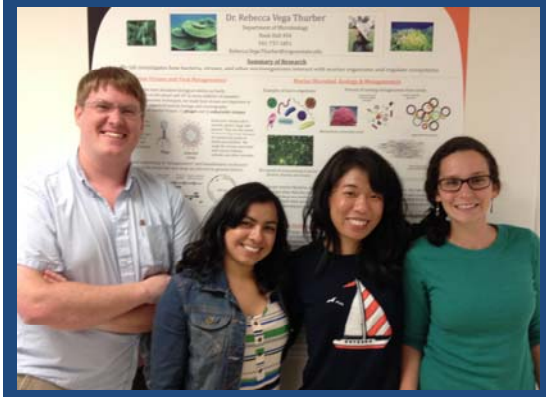
DEPARTMENT OF MICROBIOLOGY

December 2014

Research and Higher Education

OBSERVE

DISCOVER



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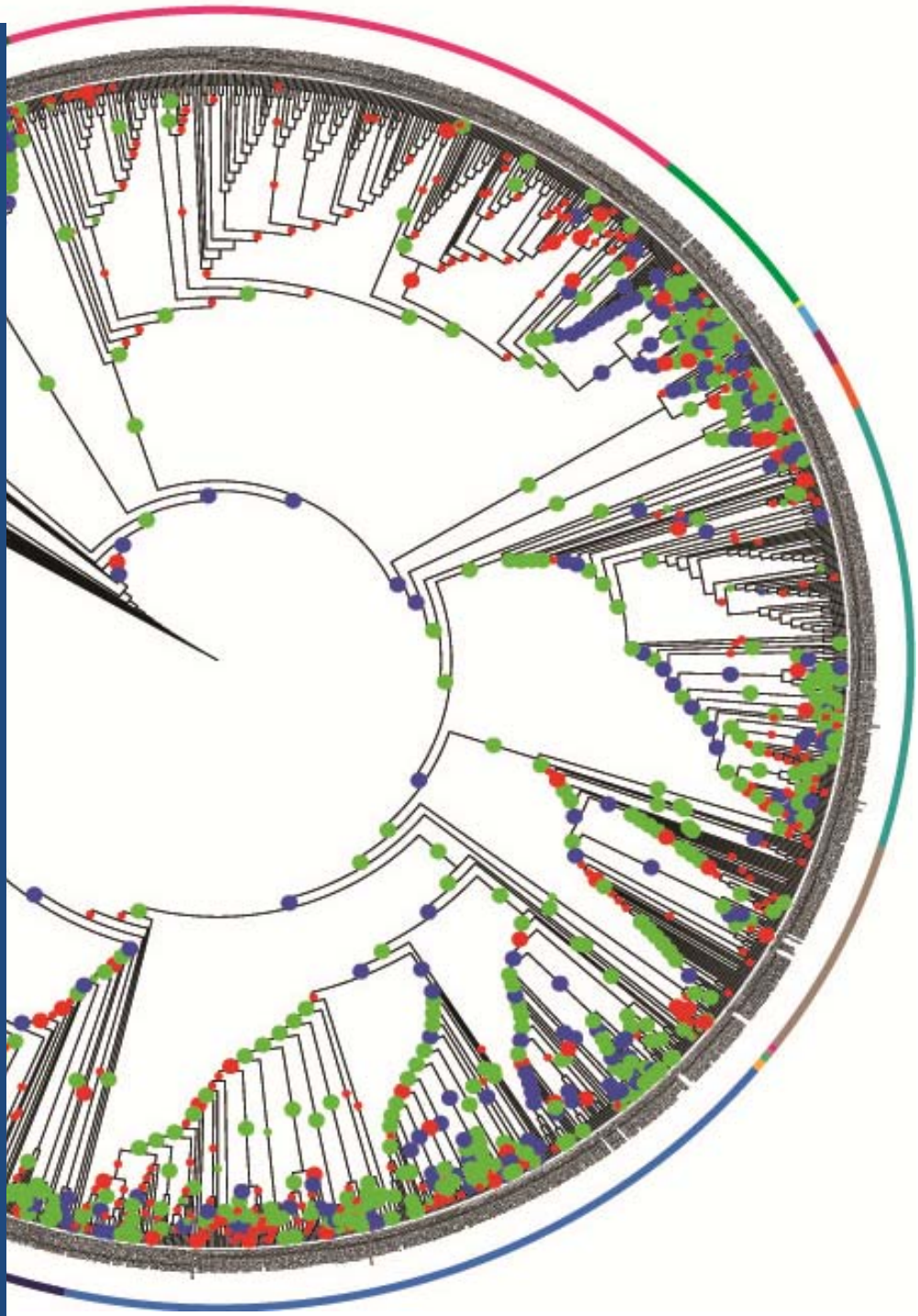


Oregon State University

FROM THE CHAIR: Out with the old, and in with the new!

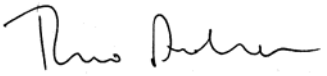
Dear Friends of Microbiology, with 2014 closing, it's my pleasure to once again provide you with some of the latest news from Microbiology and Nash Hall. And first on the list is to say that, as I come to the end of ten years as Department Chair, I'm delighted to welcome our colleague, Prof. **Jerri Bartholomew**, as the next Head of the Department of Microbiology. Jerri will take over department leadership on January 1, when I step down to return to my cyanobacterial bloom research and Virology teaching. Jerri has led a distinguished research program focused on diseases of native fish, particularly parasites afflicting salmon, and is the Director of the John L. Fryer Salmon Disease Laboratory (see article on page 9).

It has been a privilege for me to lead the department over the last years. We are a small but productive department. Each tenure-stream professor conducts research that has been consistently funded by external grants and contracts supporting world-class research: no dead wood here! For well over a decade, we have involved numerous undergraduate students in integral roles in the research enterprise, alongside graduate students, post-doctorals and other research staff. Such experience, together with required Microbiology lab classes, produces students with practical skills that remain advantageous for job placement after graduation or for successful transition to graduate school. Our Instructors are dedicated teachers whose impact has been great in making Microbiology a highly sought-after major: between 2009 and 2014, our major count rose from about 140 to 325, far higher than overall OSU enrolment growth. We are well-positioned for the future, with five young colleagues hired since 2011, correcting a demographic that was formerly dominated by senior faculty. Among those senior faculty is **Janine Trempy**, recipient of the 2014 OSU Bressler Teaching Award (see back page). Our FTE distribution is now about 2/3 College of Science and 1/3 College of Agricultural Sciences, and many faculty have appointments in both colleges.

Working with such professional faculty colleagues has made my job enjoyable and rewarding. I've also been very fortunate to be able to rely on a few other dedicated staff, who have been valued members of the department for many years. Many of you will remember **Cindy Fisher** and **Camille Partridge** from your lab classes on the 3rd floor of Nash Hall; Cindy and Camille continue to make those lab classes tick, and Cindy has been vital to facility improvements in Nash Hall. Many alumni will also remember **Mary Fulton**, doyenne of administrative affairs and hospitality, who started as Assistant to the Chair/Department Manager at about the same time I began as Chair. I have enormously enjoyed our close working relationship, forged when we both struggled with "learning on the job."

But before running out of space, there's another important change in the department to mention. Starting this academic year, the Department of Microbiology is the home of a second undergraduate major: BioHealth Sciences (BHS). This major was formerly known as General Science, serving over 700 students interested in a career in the health professions, and with Options (tracks) such as Pre-Pharmacy, Pre-Dental, Pre-Medicine, etc. Three professional Advisors, **Alex Aljets, Chris Wheeler** and **Ariella Wolf**, joined our faculty this year, with primary responsibility for the BHS major (see article on page 5). Together, we have had excellent discussions for ways to enhance the BHS major in its role of preparing students with the science that will underlie a career in the various health professions. Most of the courses currently taken by BHS students are offered by other majors, but we have already developed two new courses specifically for BHS: Mechanisms of Disease (Prof. Mike Kent) and Emerging Infectious Diseases (Prof. Kate Field). Exciting changes lie ahead!

The following pages describe some of the teaching and research activities in the department. Check the department website for more information. Please do drop me a line if you are so inspired, such as by taking on a new job, etc. I've met many current students, alumni and department benefactors over the last 10 years, and have really valued those contacts. Have a Happy, Healthy and Peaceful Holiday Season and New Year, Beaver Microbiologists!



KIMBERLY HALSEY LAB:

Assistant Professor, hired 2011

As we grow phytoplankton, so does the lab grow…

2014 was a year of growth for the Halsey lab. Two graduate students joined the laboratory in the fall to pursue research that extends our core focus on marine phytoplankton physiology into studies of community ecology. Eric Moore is studying interactions between single celled plants (autotrophs) and bacterioplankton (heterotrophs) in the ocean. Understanding the metabolic linkages between these organisms will help clarify processes controlling the marine carbon cycle, which plays a major role in controlling climate.

Kelsey McBeain is investigating how nutrient-limited phytoplankton affect the growth and fitness of their microzooplankton predators. As the oceans continue to warm, areas of nutrient limitation are predicted to expand. Earlier this year, post-doctoral researcher, Bethan Jones, showed that the carbon composition of nutrient-limited phytoplankton has significantly less caloric content than cells grown under nutrient-replete conditions. One potential consequence of decreased energetic carbon quality in phytoplankton is loss of fitness and reproductive rates of organisms in higher trophic levels. Collectively, these studies illustrate how we are integrating highly controlled monoculture investigations to assess cellular biochemistry with mixed culture work to gain a broader view of marine food-web dynamics.

Graduate student, Nerissa Fisher, and I spent three summer weeks in the Atlantic Ocean aboard the R/V Endeavor to study phytoplankton productivity. During these action-packed weeks at sea, we measured phytoplankton growth rates and rates of photosynthesis, with the goal of linking these data directly to information collected by satellite (i.e., ocean color and particle concentrations). This NASA-funded field campaign coordinated the ship, airplane, and satellite positions to facilitate simultaneous data collection.

Working aboard the R/V Endeavor was not always smooth sailing. For several days we encountered 17-foot seas, giving us the feeling that we were trying to conduct our experiments on a roller coaster.

A final major accomplishment this year was publication of a major review article, *Phytoplankton strategies for photosynthetic energy allocation* (Halsey and Jones, 2015) in Annual Review of Marine Science. We are pleased to have had the opportunity to synthesize research to-date on processes phytoplankton use to acclimatize to the dynamic marine environments. This article also includes new data from our lab that illustrates changes in subcellular carbon processing across day-night cycles and in response to nutrient limitation. These metabolic shifts enable cells to optimize growth and strongly impact interpretations of photosynthetic data collected in the field or by remote sensing.

To read more: Halsey, K.H., and Jones, B.M. (2015) Phytoplankton strategies for photosynthetic energy allocation. In *Annual Review of Marine Science*. Carlson, C.A., and Giovannoni, S.J. (eds). Palo Alto, CA, USA: Annual Reviews, pp. 5.1-5.33.

TASHA BIESINGER:

Instructor, hired 2012

The Undergraduate Research Colloquium Opportunity

A student survey conducted last year indicated that microbiology students would like more presentation opportunities in the department. Motivated by this feedback from the students, the Microbiology Department recently approved the addition of an Undergraduate Research Colloquium as part of the Departmental Colloquium Series. The Colloquium series has traditionally been used as a venue for graduate students and faculty members to share their progress with the Department and the greater university community. This new opportunity, specifically for undergraduates, will strengthen the department by fostering the skills and attitudes necessary for successful research in the undergraduate community.

There are significant benefits available to students who participate in research with faculty, including the experience of working on real world issues, personal interactions with faculty and graduate students, opportunities for publication in peer-reviewed journals, networking potential at professional conferences, and letters of recommendation from faculty. For many years, those benefits have prompted faculty to encourage undergraduate students to hold positions on their research teams. Now, with the Undergraduate Research Colloquium, undergraduates will be able to couple their real world research experience with a presentation venue which is open to the public. Students participating in the Undergraduate Research Colloquium will gain experience preparing a presentation, giving a presentation to large and diverse audience, answering questions from researchers, and receiving feedback from departmental faculty.

Faculty will also provide a numerical critique of each presentation and, at the conclusion of the academic year, awards will be presented to students with the highest presentation rankings. These awards benefit students by providing additional recognition on their CVs, job applications, and other professional portfolios. Finally, the University recently initiated a transcript-visible Research Fellow notation for students who participate in research AND give a presentation (open to the public) on that research. The coupling of the Undergraduate Research Colloquium and MB 401 research satisfies these requirements.

Samson Tong, Matthew Borchers, Johannes Vielbig, Stephanie Wood and Lucero Garcia.

Changes Coming to the Pathogenic Microorganisms Laboratory Course: Spring 2015

The Microbiology teaching lab on the third floor of Nash Hall will be getting a new look this upcoming spring. Every Monday afternoon during Spring Term, the room will be transformed to more closely resemble the biosafety level 3 (BSL-3) laboratories in which deadly airborne pathogens (and other dangerous pathogens) are studied. This will help students to learn the procedures and protocols that may well save their lives – and the lives of others – as they progress through their careers.

This change will allow students to learn and put into practice the most relevant considerations when working with dangerous human pathogens. Some examples of this include containment of certain pathogens, the use of personal protective equipment (PPE), and facing the challenges of working in biosafety cabinets (BSCs) with pathogens. Students will also become familiar with the process of gowning up before entering, and de-gowning before exiting, the lab. Mock autoclaves will help students visualize the process of autoclaving all material before it exits the lab. Up to now students have not had an opportunity to work in anything other than BSL-2 settings in their laboratory coursework.

Building a Lab Within a Lab

Reconstruction plans are underway for converting the lab space of Nash 304 into a mock BSL-3 laboratory complete with individual mock BSCs (figure 1). The "walls" of the biosafety lab will be erected from sturdy conduit pipes and a light cloth material cut into sections, so that they will be easily moved and stored, and to keep the normal emergency exit routes accessible at all times. The "doors" leading into the antechamber and the main chamber will also be constructed from conduit pipes with hanging plastic strip door material. BSCs will be assembled from conduit pipes, flame-resistant material, and a clear plastic front to allow the students to explore the combined challenges of working in PPE, the BSC, and under BSL-3 regulations simultaneously.

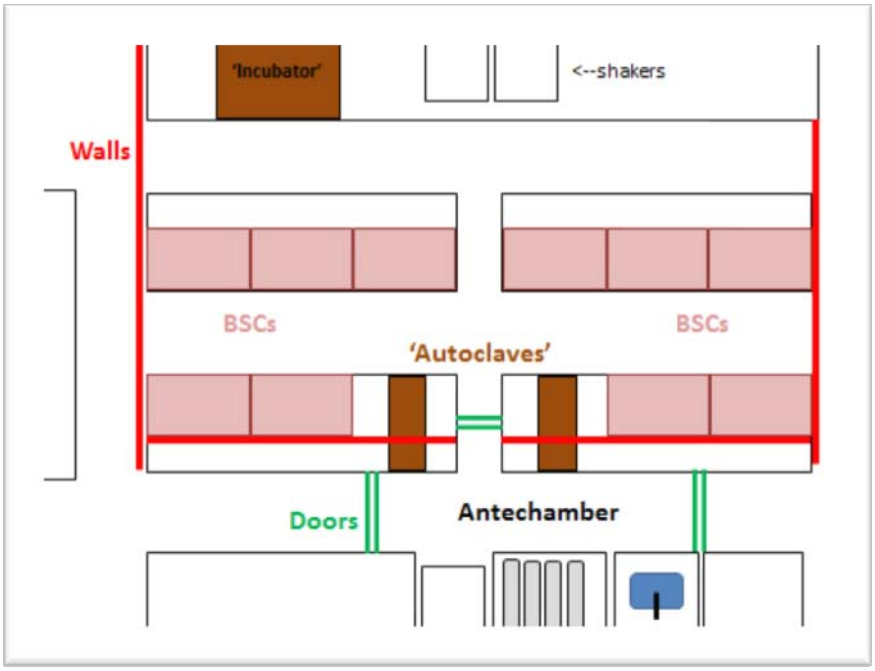


Figure 1: Conversion of Nash 304 space into mock BSL-3 laboratory.

The mock BSL-3 lab environment will give the students exposure to a realistic laboratory setting, correct use of PPE during lab procedures (including the process and order during gowning and de-gowning) and experience working within the strict BSL-3 regulations. We have all become more aware of the importance of these procedures during the recent Ebola virus epidemic.

Credit Where Credit Is Due

This remodeling project has been undertaken by Tasha Biesinger, the instructor of the Pathogenic Microorganisms Laboratory course, in partnership with the campus Biosafety Officer, Matthew Philpott, as well as Microbiology lab technician/building manager, Cindy Fisher. These professionals have provided their excellent guidance and input regarding lab safety issues and protocols.

MARTIN SCHUSTER: SABBATICAL IMPRESSIONS

Associate Professor, hired 2006

Bavarian Alps

During the 2013-14 academic year I took a sabbatical leave from OSU. I spent 5 months each at two research institutes in Germany to learn about mathematical modeling, and conduct research in this area. I had been interested in this aspect of biological research for a while, but had no formal training in it. As biological research is becoming increasingly integrative and complex – encapsulated in the interdisciplinary field of systems biology – the use of quantitative approaches is becoming more necessary.

The project I did was a continuation of my lab's research on cooperative behaviors in bacteria. Specifically, I investigated a class of products called siderophores that bacteria, including the pathogen *Pseudomonas aeruginosa*, secrete to acquire iron from the environment. I did experimental as well as modeling work with my colleagues at the Max Planck Institute in Magdeburg, and the Helmholtz Center in Munich. I estimated the costs of siderophore production in a computational model of *P. aeruginosa* metabolism, and I modeled the effect of these costs on the evolutionary stability of siderophore production. I finally tested these predictions experimentally using a continuous culture system. The main finding from this work is that the cost of siderophore production is low whenever iron is the limiting nutrient, because the siderophore molecule itself doesn't contain any iron. The fact that siderophore production is cheap when it matters most inherently promotes the maintenance of this cooperative trait in *P. aeruginosa* populations. Thanks to Skype I was able to keep in touch with my lab and keep the grad students, Brett Mellbye, Joe Sexton, and Kyle Asfahl, on track (although, on second thought, they almost did better without me!). I also briefly returned to OSU for Brett's graduation in November 2013.

The whole sabbatical experience was much more than science. As a native of Germany, it was homecoming for me and my family, our two kids spending time with their grandparents, interesting cultural experiences, trips around the country, and last but not least the realization of how different the two countries are. One thing that comes to mind is space – lots of it in the US, not so much in Germany. There's no real wilderness in Germany but you're sure to find a beer garden around every corner (and no poison oak anywhere!). In addition, the Alexander von Humboldt Foundation that supported my stay provided a superb framework, from dealing with practical issues like health insurance and various registrations, to organizing conferences and a visit with the German president. The most important thing, though, was that Germany won the World Cup!!

BioHealth Sciences Undergraduate Program:

Academic Advisors: Alex Aljets, Chris Wheeler, and Ariella Wolf

Greetings from the BioHealth Sciences Program, the newest addition to the Department of Microbiology! Our program, formerly known as General Science, joined the department officially this fall when the program was brought under the umbrella of the Department of Microbiology. We are happy to have an academic home in such a wonderful department with excellent faculty and a rich history of successful graduates. The BioHealth Sciences Program is currently home to 743 undergraduate students who are preparing to enter a variety of health professions, including pharmacy, dentistry, medicine, nursing, occupational therapy, optometry, physical therapy, physician assistant, podiatry, and clinical laboratory science.

For the first time this fall, we offered a first-year orientation course for incoming freshmen in the BioHealth Sciences major. Taught by the BHS academic advisors, the course was designed to help new students successfully transition to Oregon State University and to introduce them to career options within the health professions. We also invited several juniors and seniors to visit the class and talk with first-year students about how to get involved in outside the classroom activities such as undergraduate research, study abroad, and student organizations. This orientation course has helped students register on time and make well-informed decisions about their major and career direction.

We are gearing up for many future improvements to the BioHealth Sciences program. The BHS Curriculum Committee is hard at work drafting new program outcomes, evaluating the curriculum, and proposing new courses and opportunities. Mechanisms of Disease, an introductory human pathology course, is one such new course which was taught for the first time in Spring 2014 by Dr. Mike Kent. Other proposed courses include a writing intensive course and a health-related Spanish language course to help future health care providers communicate with Spanish-speaking patient populations. We look forward to updating you on these and other exciting future developments as we continue to grow and improve the BioHealth Sciences Program.

REBECCA VEGA THURBER LAB:

Assistant Professor, hired 2011

It has been a very busy and exciting year for the Vega Thurber Lab. The postdoctoral researchers, graduate students, undergraduates, as well as Dr. Vega Thurber herself have been hard at work on several marine microbiology, virology, and ecology projects.

Microbiology of Coral Reefs: 'Project Herbivore'

A major ongoing research endeavor in the Vega Thurber lab is our collaboration with marine ecologist Deron Burkpile at Florida International University called lovingly, Project HERBVRE (Habitat Enrichments and Removals: Bacteria, Viruses, and Reef Ecology). This long term empirical experiment aims to evaluate how various environmental factors alter marine ecosystems at both the macro scale and the microbial scale. Specifically, we focus on two main factors (overfishing and nutrient pollution) thought to contribute to the degradation of coral reefs, which are some of the most diverse and economically valuable coastal resources. To test how these factors change coral reefs, we have conducted a 3-year underwater experiment that *removes* fishes and *enriches* several sections of coral reef in the Florida Keys. Throughout the experiment we have monitored the reef and the microbiology associated with it. This experiment was the first of its kind and in this last year of the project, we have uncovered a remarkable finding…that elevated nutrients, such as those in common garden fertilizer induce disease and bleaching outbreaks on corals (Vega Thurber et al., 2014 *Global Change Biology*). Both disease and bleaching (the loss of a coral's algal symbiont) are known to be major causes of coral mortality, and thus we have identified one way that human activities are contributing to reef decline. What's more, we found that after removal of the nutrients, corals recovered from the disease and bleaching within 6 months! This was a remarkable and encouraging finding that suggests that if we clean up coastal waters, reefs can potentially recover. This work made quite a splash, and was highlighted in several media outlets including the BBC, ABC, CBS, Wired Magazine, the Gazette Times, and at the National Science Foundation.

Coral Reef Viruses

Along with our work on how environmental factors alter the microbial communities associated with corals, we also have authored several publications this year on coral and coral reef viruses. This work aims to determine first what kinds of viruses are present in corals and if they may be causing disease. For example, we recently showed that viruses are likely to be contributing to a major disease of corals called 'white plague' that causes death of many types of corals, including several endangered species (Soffer et al., *International Society for Microbial Ecology Journal* 2014). If corroborated this would be the first coral viral disease ever discovered. We have also begun to explore how phages, the viruses of bacteria, may be involved in regulating bacterial community dynamics on corals (Soffer, Zaneveld, and Vega Thurber, *Environmental Microbiology* 2014). Lastly our focus on the viruses of corals has lead us to explore how viral dynamics in the overlying water column may be affecting coral reef health and biogeochemistry. For example, postdoc Dr. Jerome Payet and graduate student Ryan McMinds, went to the island of Moorea in French Polynesia last year to evaluate how phage-bacterial dynamics differ across reef habitats. They recently reported that viruses contribute to an unprecedented amount of bacterial mortality and nutrient recycling in these habitats (Payet et al, *Frontiers of Microbiology* 2014). We hope to continue this work in the future and will ideally have more to report in the newsletter next year.

Coral-Microbe Co-evolution

To wrap up, we recently received a $2 million dollar NSF grant to study the co-evolution of microbes with corals. This work will be conducted in collaboration with Dr. Monica Medina at Penn State University and will be the major focus of our lab for the next four years. What's more, Ryan McMinds, the newest addition to the Vega Thurber lab, received an NSF EAPSI award to work in Australia on aspects of this work. The goal of his project was to gain further insight into the functional relevance of coral microbes to their host. Microbes as a whole have been shown to play important roles in coral health by providing essential nutrients, resisting pathogens, and even by cueing development. However, it has been challenging to identify the specific microbial taxa that provide these benefits. The health consequences to corals of stressor-mediated microbial community shifts are thus difficult to assess. Therefore Ryan is using culturing, metagenomics, and deep amplicon sequencing, to describe for the first time the microbial communities of diverse coral hosts in an evolutionary context.

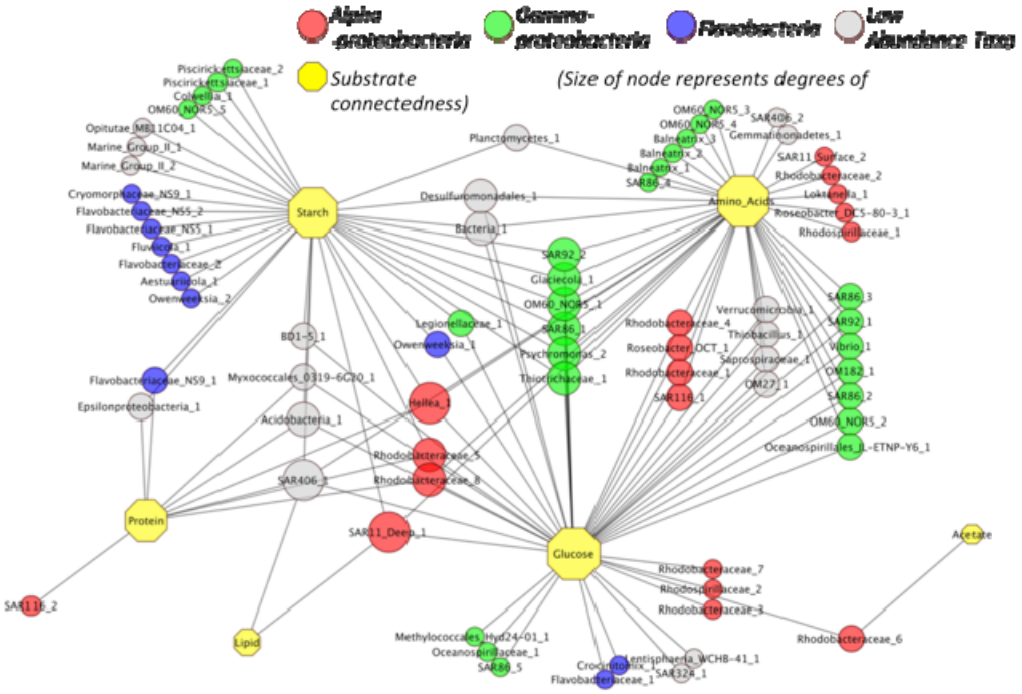
To read more: Payet JP, McMinds R, Burkepile DE, Vega Thurber R. Unprecedented evidence for high viral abundance and lytic activity in coral reef waters of the South Pacific Ocean. (2014) *Frontiers in Microbiology* 5: 493 doi: 10.3389/fmicb.2014.00493

RYAN MUELLER LAB:

Assistant Professor, hired 2012

I am very happy to report that the lab has grown significantly this past year with the addition of two new Ph.D. students. Hanna Kehlet joins our lab from Lewis-Clark State College in Lewiston, Idaho. As an undergrad Hanna performed research examining the effects of antibiotic treatment on mixed sub-populations of *E. coli* within biofilms, with an overall emphasis on the ecology and evolution of microbial populations. She will be continuing to explore these themes by developing a dissertation project that looks to examine the effect of predator-prey interactions on pathogenic and non-pathogenic populations of *Vibrio cholerae*. Hanna's work will focus on identifying the diversity and conservation of mechanisms of resistance to eukaryotic grazers across *V. cholerae* strains, and understanding how grazing processes may act to shape the population structure of these bacteria in natural reservoirs. The second new addition to the lab is Brandon Kieft, who has left the comfy confines of the Midwest to study microbial community interactions in marine and estuary systems. Brandon's dissertation project will look to expand on current work within the lab by using "omics" techniques to explore community structure and carbon cycling within estuary systems along the Pacific Coast. Specifically, Brandon will be using genomic and proteomic techniques to understand the flow and turnover of terrestrially derived organic matter within estuary systems.

As for ongoing research within the lab, Sam Bryson is currently entering his third year within the lab and is continuing to examine questions related to identifying functional guilds and resource partitioning patterns within marine microbial communities. During these past two years Sam has gained a wide variety of experience through the completion of many experiments related to these Gordon and Betty Moore Foundation funded activities. Sam, Brandon, myself, and Xavier Mayali (our collaborator from Lawrence Livermore National Lab) have recently finished an experiment that looks to investigate the resource partitioning of different forms of fixed carbon produced by multiple types of phytoplankton within marine microbial communities collected from Newport, OR.



Resource Utilization Network of Monterey Bay Microbial Community

This experiment will rely heavily on the "Proteomics-SIP" methodology that Sam has developed over the past two years. Based on previous experiments using defined substrates, Sam has shown this methodology to be extremely useful for understanding the assimilation of carbon compounds into the biomass (i.e., nascent polypeptides) of defined populations of marine microbial communities. Results from initial experiments in Monterey Bay using this technique have revealed resource preference patterns for distinct taxonomic groups within the communities, which generally supports our current understanding and predicted metabolism of these populations (see figure). Importantly, though, Sam's research has allowed us to not only gain insight into "who is eating what?" in these systems, but also into which proteins are synthesized in response to nutrient uptake. These data provide a better understanding of what specific metabolic capabilities and adaptations these populations have that drive competitive interactions within these communities. Sam has made tremendous progress on this project over the past two years and I am looking forward to working with him to summarize his findings in publications that we will submit over the coming year.

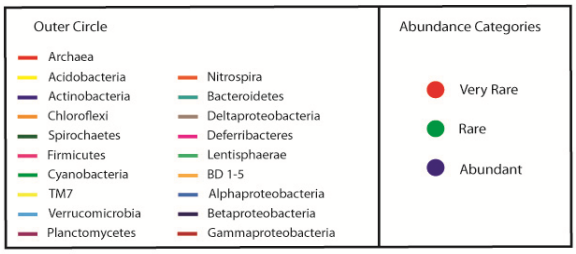
To read more: ***Proteomics-SIP approach being developed for this research see:*** Pan, C., *et al.*, (2011). Quantitative Tracking of Isotope Flows in Proteomes of Microbial Communities. *Molecular & Cellular Proteomics* **10:**M110.006049

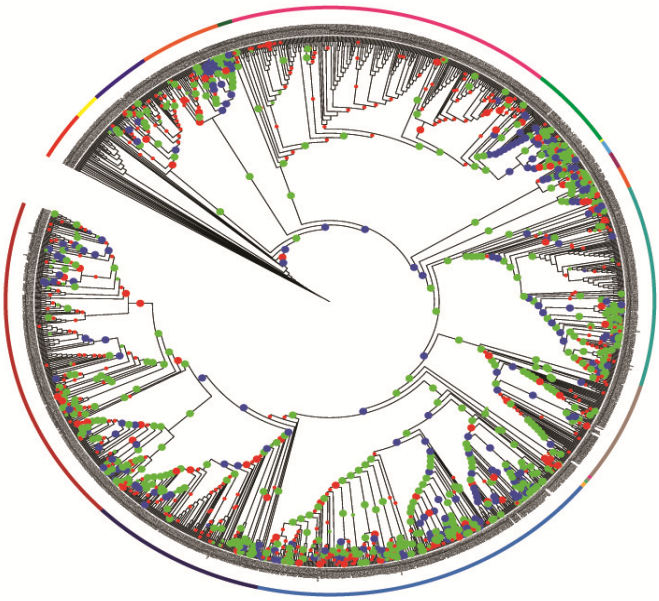
Kevin Vergin @ Steve Giovannoni Lab:

It is with mixed emotions that I anticipate the completion of my Masters degree in Microbiology and the end of my 23 year tenure as a technician in Dr. Stephen Giovannoni's laboratory. While I look forward to new challenges in research and analysis, I will look back with fondness on my time at Oregon State University.

I started working in Dr. Giovannoni's lab in 1993 in the early days of cloning and sequencing as a method to study marine bacterial species and communities. Almost nothing was known about the major inhabitants of open ocean waters, so I experienced the thrill of being an early explorer in this field. Very early on, we discovered that bacterial communities had seasonal abundance patterns and that particular species had depth-specific and cosmopolitan distributions. Many of the clones that we sequenced and described are still used today as short-hand identifiers of major, important groups such as SAR11, SAR116, and SAR202. I also had my first experience working aboard a ship in the Sargasso Sea near Bermuda, made more memorable by the fact that we were deploying instruments and collecting samples as a hurricane was approaching. We obviously made it back and I was even persuaded to go out again many times, although usually off our own Oregon coast aboard the R/V Elakha. I can't honestly say that I will miss going out on research cruises but, looking on the positive side, I was able to find the seasickness medicine that works best for me.

Our research then took a turn towards the culturing of isolates representing these major bacterial groups to learn more about their physiologies. We successfully cultured an Oregon Coast representative of the SAR11 clade and have spent many years studying this fascinating organism, now known as *Candidatus* Pelagibacter ubique (note: *Candidatus* is an interim taxonomic term used for recently described organisms). This group of organisms is numerically dominant in large parts of the ocean despite having one of the smallest genomes of any free-living organism. Being a long-term member of this laboratory has made me a first-hand observer of several milestones that will be highlights of my career. I remember being one of the first researchers to see the bright pink pellet of cells that are formed when SAR11 cells are concentrated. I completed the final few difficult steps when we sequenced the genome and put the puzzle pieces together to form the circular chromosome. We were able to isolate several strains of SAR11 from a small population allowing me to be the first to discover an extremely high level of recombination between the DNA in different isolates. A few years later, I was the first person to sequence a virus, isolated by an undergraduate researcher in our laboratory, that infects SAR11. These projects illustrate the reason why I have enjoyed working with Dr. Giovannoni for all these years; we were, and still are, always on the brink of new, important discoveries while using the latest technologies making the laboratory an exciting place to work.





As the research in our laboratory and around the world has evolved, it has become ever more important to be able to use computers in new ways to analyze very large data sets. I recognized this trend and have responded by returning to graduate school to develop a foundation in statistics and bioinformatics to stay at the forefront of scientific research. I am now applying these new skills to our Bermuda time-series data set of marine bacterial communities from several depths collected over about nine years, including the samples that I helped collect on the infamous hurricane cruise. Using a custom designed sequence data analysis pipeline, PhyloAssigner, I have discovered that SAR11 communities have distinctive genetics and ecological distributions and that the overall community is a highly connected network of correlated groups.

I will always treasure being an integral part of this dynamic research group. I have had the privilege of working with many amazing undergraduate and graduate students as well as post-doctoral researchers, fellow technicians, visiting faculty, and collaborators around the world. Of course, we do not work in a vacuum and have been well supported by many fine colleagues in the department and university. But almost more importantly, I have enjoyed working with our incredible staff and administrative support personnel (far too many to try to list). My experiences here indeed set a high standard as I seek new challenges in scientific research but I feel well prepared and am proud to represent Oregon State University wherever I may land.

To read more: Vergin, K. L., Done, B., Carlson, C. A., and Giovannoni, S. J. 2013. Spatiotemporal distributions of rare bacterioplankton populations indicate adaptive strategies in the oligotrophic ocean. *Aquatic Microb. Ecol.* 71:1-13. doi:10.3354/ame01661.

JOHN L. FRYER SALMON DISEASE LABORATORY (SDL)

Energy efficient facility Upgrade at the SDL provides more opportunities for temperature related research.

The SDL is a regional fish disease facility dedicated to the study of organisms infectious for salmonids and other species of freshwater fish. The disinfection of effluent water before it returns to the Willamette River allows studies with infectious agents in tanks large enough to hold salmon and other large fish. The laboratory is named for Dr. John L. Fryer, who pioneered the fish disease research program at Oregon State University and was Chair of the Department of Microbiology from 1976 to 1996. The SDL was constructed through a grant from the Bonneville Power Administration with matching funds from OSU and completed in 1994.

The SDL recently received funding for a major facility upgrade. The funds (committed by the OSU Sustainability Office, Research Office, College of Agricultural Sciences, College of Science, Department of Microbiology and the College of Veterinary Medicine will supply heated and chilled water between 5°C and 30°C to all 300 experimental fish tanks. New plumbing infrastructure means that each tank will have the option of up to 4 different set temperatures, and researchers can program up to 8-step temperature cycles mimicking the natural environment.

The research facility will celebrate its 25th year of research on the health of salmonids, and this expansion in capability will allow research to extend to both warm and cold water aquatic species, and provide opportunities to study ecological and environmental questions such as the effects of temperature stressors and climate change on aquatic animal health.

The upcoming facility upgrade, scheduled to be completed in the Spring of 2015, will not only provide an increased capacity for heated water to all experimental fish tanks, but will be at least 3 times more energy efficient than the current system. The state of the art design utilizes "waste" energy from the facility's effluent and re-uses it to source a series of water sourced heat pumps. This system also has the environmental benefit of reducing any potential thermal load on the adjacent Willamette River.

In addition, the new design incorporates digital controls that not only provide SDL staff with remote access to monitor the system, but also eliminate the need for power-thirsty controls. Meanwhile, variable-frequency drive pumps deliver the heated/chilled water to the tanks and adjust their work to fit demand, thus saving energy when demands are lower.

This, in conjunction with the 2012 installation of a 482 kilowatts capacity ground-mounted Solar electric (photovoltaic) array that supplies all the annual electricity to the facility, makes the Salmon Disease Lab an energy efficient and sustainable research facility. **Dr. Jerri Bartholomew** is the Director of the SDL and **Ruth Milston-Clements** is the Manager.

For more information: http://microbiology.science.oregonstate.edu/sdl

MALCOLM LOWRY: IMMUNOLOGY IN THE CLASSROOM

Dr. Lowry has been teaching Immunology lecture (MB 416) and lab (MB 417) annually since 2004
"Translating Immunology concepts to medical practice and research"

Immunology as a subject matter for a class seems complex at first, yet once the basics are understood, there are many concrete examples found in our daily experiences. Most of us are familiar with getting vaccines to prevent disease or seeking out remedies for seasonal allergies to pollens and grass seed, especially here in the Willamette Valley. Have you ever wondered exactly how vaccines work to protect you, or what your body is doing to flush those irritating pollens out of your nose? Well, your immune system is hard at work to protect you each day against new and recurring challenges.

In the Medical Immunology class that I teach here in the Microbiology Department, I strive to integrate concepts with practical applications and recent research so that students feel the excitement and possibilities available in this field. Luckily, it is not difficult to find exciting research topics to engage students with in class. Over the last few years, I have focused on extending particular areas where innovations are occurring, such as in vaccine design, new treatments for autoimmune diseases, and the targeting of cancer in what is now a very exciting field, called cancer immunotherapy. I started a new class module on cancer immunotherapy in 2009, and each year I have had to revise it significantly as new ideas and breakthroughs have occurred in the last few years. The basic premise of cancer immunotherapy is using the highly specific recognition of immune system cells to target cancer and limit off target effects that are more common to standard treatments such as chemotherapy. The other

inherent feature of the immune system that we are trying to activate is immunological memory, where lymphocytes essentially store information on what the body has reacted to before, and can recognize it again if it comes back. This feature holds the promise of designing durable cancer treatments, where the immune system may be able to clear a tumor specifically and "remember" it to prevent future occurrences. Current research has opened up many new immune mechanism based treatments, some of which are actually in Phase II or III clinical trials and some are now FDA approved.

Both undergraduate and graduate students have really enjoyed these research modules, and they have inspired some students to pursue careers in research and medicine. Probably the most gratifying aspect of teaching is when I have students contact me and tell me about what career they are pursuing now and what the class meant to them. In the last few years, there are some examples that stand out to me. After graduation with a B.Sc. in Microbiology, Josh Alinger did research at the Rocky Mountain National Labs in infectious disease, where he received a Masters degree. He then went on to get into an MD - Ph.D. program at Washington University in St. Louis where he is now doing basic Immunology research that he hopes to use as a platform for clinical research in the future. During 2014, several undergraduate and graduate students have gone on to medical school at OHSU, where they have put their training to a more clinical focus. Other current and past undergraduates have done research internships at prestigious institutes like the MD Anderson Cancer Center in Houston, Texas, focusing on cancer immunotherapy, or at OHSU working in hematology. Others have gone on to graduate school to pursue Ph.D. training in Immunology at North Carolina State, the University of Minnesota and many more. I have been fortunate to have so many excellent students over the years who have really put their education to work for them. As an educator, it really is what makes the whole job worth it.

KATHARINE FIELD LAB:

In spite of years of extensive monitoring, conservation programs, and implementation of improvements in agricultural practices, much of the waters in the US remain impaired by microbial contamination. Our lab's research projects examine the effects of microbial contamination in water, ranging from studying the occurrence, survival, spread, and correlation among fecal pathogens, molecular markers, and public health indicators, to establishing their temporal and geographic frequency, and their relative persistence and decay.

Nearly 15 years ago, the Field Lab published the first paper to use genetic markers from uncultivated microbes to identify sources of microbial pollution. Recently we have shifted focus from marker and technology development and validation to probing factors behind the persistence or decay of targeted fecal indicator bacteria (FIB) and molecular markers in the environment.

Graduate student Lauren Brooks is improving our understanding of discrepancies in reported decay rates. Using Bayesian Modeling, she has conducted a meta-analysis to determine what environmental variables have a significant effect on decay of microbial contaminants. Through the results of this analysis, she has been able to estimate average decay rates of indicator bacteria, as well as identify important knowledge gaps. This has led her to design and undertake her own decay study, which will combine FIB enumeration with metagenomics-based Community Analysis to determine how the microbial constituents of the receiving waters respond to influxes of cattle feces. Lauren's study will utilize the unique facilities of the John L. Fryer Salmon Disease Laboratory to create continuous flow mesocosms in river water, to mitigate the "bottle effect" found in typical mesocosms and better mimic natural conditions for nutrients and predators.

In addition to our research into the decay of FIB, we have been experimenting with a new methodology for the instantaneous and continuous enumeration of *E. coli*, a common FIB used to measure water quality. With the help of two undergraduate researchers, Deirdre McAteer and Josh Hay, our lab has conducted a series of experiments to determine the abilities of the ZAPS LiquID Station, a new technology from ZAPS Technologies (Corvallis, OR). Prior to placement in the field, we have been testing how various conditions, such as salinity and turbidity, alter the readings of the LiquID Station. We have currently wrapped up in-lab testing, but have relocated the machine to the Salmon Disease Lab for further testing in a more naturalistic setting.

The lab-based studies we conduct are most important when viewed in the context of the real world. Our work has practical applications for pollution source identification and mitigation. We are currently involved in a field project in Tillamook, OR, combining our methods to identify the sources of fecal contamination with the high-resolution temporal data provided by the ZAPS LiquID Station. We plan to link grab samples to the real-time data, to identify specific sources that are present at periods of high FIB levels. The Tillamook watershed has intensive dairy farming on land and oyster farming in the estuary. Our past studies in Tillamook have identified microbial contamination from cattle, humans, and birds. Our goal is to establish and test real-time, field scale monitoring and use the monitoring results to measure the outcomes of various farm management decisions.

To read more: Wang, D., A. F. Farnleitner, K. G. Field, H. C. Green, O. C. Shanks, and A. B. Boehm. 2013. *Enterococcus* and *Escherichia coli* fecal source apportionment with microbial source tracking markers – is it feasible? *Water Research* 47: 6849-6861.

THOMAS SHARPTON LAB:

Assistant Professor, hired 2013

The Sharpton lab's first year at Oregon State University was action packed as we established our laboratory infrastructure, advanced our research on the human microbiome, and initiated new educational opportunities in bioinformatics.

The lab is now up and running and full of researchers studying the human microbiome. We started by renovating an old microscopy teaching lab and outfitted it for molecular and bioinformatic investigations. This included installation of ergonomic computing workstations, which are now occupied by our research team: Dr. Christopher Gaulke (posdoc), Melissa Conley (graduate student), Nicole Kirchoff (graduate student), Courtney Armour (graduate rotation student), and three undergraduate researchers. We also established our virtual laboratory through the purchase of several cutting edge computing resources, including a 120 node 1 TB compute server, a 10 Gb data server, and a 24 Tb fileserver. We are grateful to the Department of Microbiology, especially Dr. Theo Dreher and Cindy Fisher, and the Center for Genome Research and Biocomputing, especially Dr. Brett Tyler, Rosa Hill, and Chris Sullivan, for their help in setting up this research environment.

We've also forged new ground in our research objectives. We published five manuscripts this year on topics related to the microbiome. This includes our analysis of the relationship between human obesity and the diversity of the gut microbiome. Prior research found that obese and lean humans harbor distinct groups of microbes in their gastrointestinal tracts. However, several studies produced conflicting observations about which specific microbes were associated with obesity. We analyzed a larger and more diverse patient population and applied sensitive statistical tests to reevaluate previously reported data and found that there is no simple relationship between obesity and gut microbiome diversity. Instead, this is a complex association that appears to be influenced by cryptic parameters, such as diet or frequency of exercise. We are following up on this work with collaborators at Oregon State University to identify specific gut microbes and metabolites that contribute to various human metabolic disorders, including obesity.

We also reported the first characterization of the oral microbiome associated with the Khoesan bushmen of southern Africa, the most anciently diverged human population. We compared the diversity of their oral microbiome to that of healthy Americans and found several microbes that significantly differentiate these two groups of humans. With our collaborators at Stony Brook and Stanford, we are expanding our analysis to additional human populations with the aim of understanding how humans and their microbiomes have coevolved.

We are currently carving out new research frontiers. We are about to release open source software that accurately infers the biological functions of microbial communities given DNA sequences (i.e., metagenomes). With collaborators at UCSF, we received a grant from the NIH to study how the gut microbiome changes over time in association with inflammatory bowel disease. Working with Dr. Kent's lab, we've additionally begun to characterize the physiology of the zebrafish gut microbiome, which provides important insight into this major biomedical model organism. We are grateful to the surrounding research community for their support in our endeavors.

Finally, our lab has been intimately involved in the development of bioinformatics education at Oregon State University. Tom taught a course through the Statistics Department in Quantitative Genomes and co-taught a Microbiology course in Microbial Genomics and Bioinformatics with Drs. Mueller and Giovannoni. He also led efforts in collaboration with Drs. Brett Tyler (CGRB) and Molly Megraw (Botany & Plant Pathology) to develop a graduate curriculum in bioinformatics and quantitative biology at Oregon State. Any success in these activities is largely due to the support of the surrounding academic community, which paved the way for rigorous biological informatics training. The future of this research and educational field at Oregon State is truly exciting, and we look forward to seeing how our students advance it.

Tom Sharpton, Chris Gaulke, Courtney Armour, Nicole Kirchoff, Sean NcNall, Melissa Conley

To read more: Mariel M. Finucane, Thomas J. Sharpton, Timothy J. Laurent, Katherine S. Pollard. (2014). A Taxonomic Signature of Obesity in the Microbiome? Getting to the Guts of the Matter. *PLOS One* doi: 10.1371/journal.pone.0084689

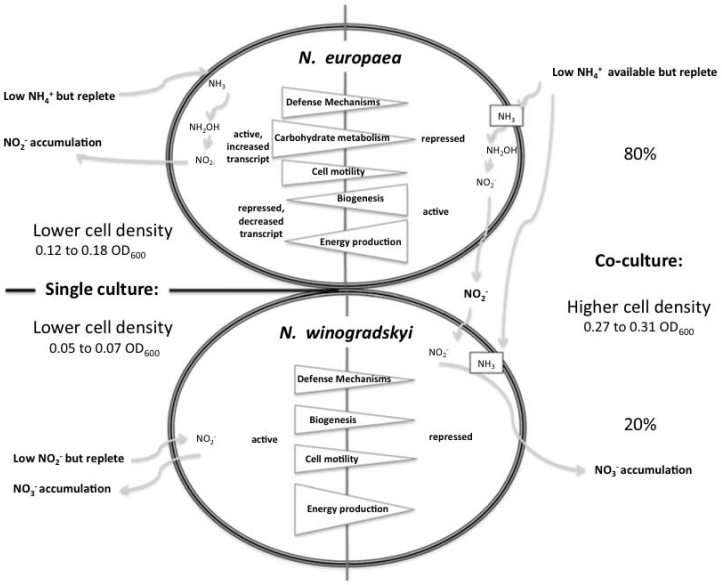
PETER BOTTOMLEY LAB:

Professor, hired 1979

Despite retirement looming, and some preemptive retirement "temptations" that successfully dragged me away from Corvallis this year, I'm still having fun with the research. We continue to focus on the process of nitrification with studies in soils and in chemostat cultures. If you recall from General Microbiology MB302, nitrification is the process that transforms ammonium into plant-available nitrate, which supports crop production at the high levels required to support the world's population. Nitrification also accounts for most of our nitrogen pollution problems that occur due to run-off of nitrates from agricultural lands. Nitrification is also a major contributor to the production of nitrous oxide N_2O ("laughing gas" for those of us old enough to remember the trauma of toothache and an effective "relaxant" at the dentist's office). Unfortunately, N_2O is 300 fold more potent than CO_2 as a greenhouse gas, plus it destroys ozone. We have been interested in how soil properties influence nitrification, and how that affects the production of N_2O by nitrification. We and others have discovered that microorganisms from the two domains of prokaryotes (Bacteria and Archaea), are involved in soil nitrification and we have developed a method to discriminate between their relative contributions. Using this method we have shown that the proportion of NH_3 oxidized and released as N_2O by Archaea is much less than the proportion released by bacteria. Furthermore, the contribution of bacteria to N_2O production increases as the amount of fertilizer N application increases, whereas the contribution of Archaea is saturated by much lower amounts of fertilizer. Down the road it might be possible and even necessary to try to selectively inhibit the bacterial activity, thereby slowing down nitrification and reducing both the release of N_2O as well as excess nitrate.

We are also involved in a totally different project on nitrification that has a strong molecular slant. This project is a collaboration with Luis Sayavedra-Soto, in the Department of Botany and Plant Pathology. This work involves coculturing nitrifying bacteria in continuous flow steady state chemostats. If you recall there are two parts to nitrification, namely ammonia oxidation and nitrite oxidation. For several years I have been interested in asking the question: do the ammonia oxidizing and nitrite oxidizing bacteria interact in a synergistic manner? We have cultured both bacteria together in coculture, as well as separately in pure culture, under the same growth conditions, and found that there is a benefit in coculture shown as a greater cell yield of the ammonia oxidizer. We have extracted and sequenced the mRNA of both bacteria. There are substantial differences in the gene expression profile of coculture versus pure cultures, with expression of ~30% and 11% of genes changing significantly in the ammonia oxidizers and nitrite oxidizer, respectively. Now we need to figure out what all of that means!

Oh boy!…. more work!…. or …. bag it, and get on with retirement!……I'll keep you posted…

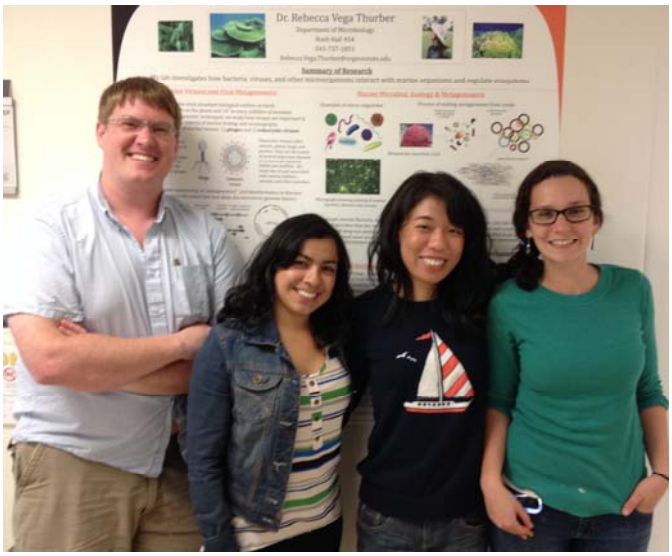


To read more: Perez, J., A. Buchanan, B. Mellbye, R. Ferrell, J. Chang, F. Chaplen, N. Vajrala, P. J. Bottomley, and L. Sayavedra-Soto. 2014. Interactions of *Nitrosomonas europaea* and *Nitrobacter winogradskyi* grown in coculture. *Archives of Microbiology*. DOI 10.1007/s00203-014-1056-1

WEI WEI AND FRIENDS:

Winter Wonderings Microbiology Course for 5th Graders

Microbiology graduate students Stephanie Rosales, Ryan McMinds, Lauren Brooks and Wei Wei designed and taught a microbiology lab course during winter 2014 for gifted and talented 5th graders through OSU's Winter Wonderings Precollege Program. The 6 week long Saturday lab class introduced students to the topic of microbiology, which is often not presented in elementary school science classes. Students were taught about the huge importance and impact microbes have on their daily lives. Topics discussed included how microbes impact human and environmental health, food and plant microbiology, microbes used in biotechnology, virology, antibiotics and ways to identify different types of microbes. Lab activities included viewing microbes under microscopes, DNA extractions, Gram staining, genetic engineering of plants using bacteria, identifying microbes using simple biochemical assays, and viral coat structure modeling. For most of the students, this was their first exposure to the amazing world of microbiology. The class received a lot of positive feedback from the students and their parents, so hopefully we will get the opportunity to teach it again in the future.



Microbiology Graduate Students:

Ryan McMinds, Stephanie Rosales, Wei Wei, Lauren Brooks

LINDA BRUSLIND:

Senior Instructor, hired 1997

Microbiology Student Association Outreach Activities

"Hi! Would you two like to isolate DNA?" asked Jenna, beckoning to two young girls cautiously approaching the booth. Jenna, an enthusiastic microbiology undergraduate, smiled reassuringly at the kids. "Would you like to isolate DNA from a strawberry or your cheek cells?" The two girls turned to each other, eyes wide. "My cheek cells!" squealed the first one. The other girl enthusiastically nodded her head. "O.K.," said Jenna, "here's what you do…."

On my left I could hear Sarah, another microbiology undergraduate, encouraging kids to spin the prize wheel to select a specific microbiological topic ("microbe size," "foods made with microbes," "microbes in the environment," etc.) and then answer a simple question on the topic, such as "what is a food made with the help of microbes?" All participants could select from a variety of microbiology themed prizes: a pencil with microscopes on it, a small container of germ goo, or a microbe magnet.

Sarah Hammer and Jenna Lennon at a Science Night in Albany .

On my right I could hear Alexis, yet another microbiology undergraduate, helping a young boy focus a microscope so he could see diatoms, or single-celled algae, underneath. "That's really neat!" he gushed. "They look like shells crossed with snowflakes!"

This is just one of the many Science Nights that Microbiology Student Association (MSA) members participate in every year, in elementary schools throughout the Willamette Valley, from Monroe to Salem. Three to five student volunteers staff a booth with a variety of rotating activities, introducing kids to the wonders of microbiology. The children get a chance to learn more about science and OSU, while the MSA members acquire an experiential learning opportunity, the chance to teach others and to be an ambassador for their chosen major. And that, as the young boy said, is really neat.

Department of Microbiology

Oregon State University

Professor Janine Trempy Awarded the 2014 Oregon State University RICHARD M. BRESSLER SENIOR FACULTY TEACHING AWARD