Environmental Genomics

BISP 194 ~ Spring 2012
3010 York Hall
Mondays 10:00 – 11:30 am

DATE	LECTURE & PRESENTATION TOPIC
Introduction to Environmental Genomic Approaches	
Apr 02	1) Course Description & Introduction
Apr 09	2) Overview of Environmental Genomics
Apr 16	3) Bioinformatics: Assembly, Binning & Annotation
Environmental Genomics in Action	
Apr 23	4) Environmental Gene Inventories
Apr 30	5) Community & Population Genomics
May 07	6) Environmental Post-Genomics
May 14	7) Functional Metagenomics
May 21	8) Single Cell Genomics
May 28	Memorial Day Observance
Jun 04	9) Viral Metagenomics
Jun 12	****Reports due via email****

Professor Eric Allen
Email: eallen@ucsd.edu
Phone: (858) 534-2570
Office hours by appointment
Office: 4170 Hubbs Hall (Scripps Institution of Oceanography campus)
The SIO shuttle: pick up outside Peterson Hall – get off at SIO Library (white van every 15 min)
Shuttle information: http://blink.ucsd.edu/Blink/External/Topics/Policy/0,1162,12960,00.html

Course Web Site: http://classes.biology.ucsd.edu/bisp194-4.SP12/ (lectures, assigned readings, etc.)

Course Prospectus: The field of environmental genomics is a rapidly evolving discipline driven by advances in computational biology, DNA sequencing technologies, and the techniques of systems biology with the goal of delineating the taxonomic and metabolic diversity of environmental microorganisms. The field cuts across many disciplines and the *power and the promise* of environmental genomic approaches are being applied to several lines of scientific inquiry including biomedicine, biotechnology, bioenergy, biogeochemical cycling, phylogenetics, evolution, and good old fashion molecular ecology. From this class, you will gain an admiration of the (mind-boggling) taxonomic, genetic and metabolic diversity of microorganisms and an appreciation of the tools (computational and molecular) that can be deployed to analyze environmental microorganisms with acute genetic detail.

Textbook: Environmental genomics is a sufficiently nascent field that an authoritative textbook on the topic does not exist. I have included a link on the course website (under "DOWNLOADS") that will take you to the National Academies Press website where you can download a report called *"The New Science of Metagenomics: Revealing the Secrets of Our Microbial Planet"* (2007) [click on 'DOWNLOAD FREE PDF']. This report provides a thorough introduction to all things metagenomics. Please use this is a reference text for background understanding of topics presented and discussed in class. All primary assigned readings (journal articles and reviews) will be posted on the course website as .pdf files.

Grading & Evaluation Criteria: Our 90 minutes meetings will conform to the following schedule:

40 minute lecture covering various topics led by Professor Allen
30 minute group presentation of primary research article(s) to the class led by student(s)
20 minute interactive discussion about the day's lecture & presentation

*******The final grade in the class will be based on one of two possible options in addition to class participation:

(A) Oral Presentation:

Lead a 20 - 30 minute presentation to the class covering a contemporary journal article (or multiple articles) that is relevant to environmental genomics. In consultation with Professor Allen, choose a paper that is of interest. Prepare a PowerPoint (or other media) presentation that covers an introduction to the scientific question being addressed, a description of the methods used, and an analysis of the results from the study. Be prepared to field questions from the class and engage in discussion! It is recommended that you use ancillary references (additional papers) to research the topic as you prepare your presentation.

Presentation Format: Each member of the presenting team should prepare 2-5 PowerPoint slides, overhead transparencies, handouts, or chalkboard sketches (finger puppets are okay too...). It is recommended that presenting teams coordinate their efforts by organizing meetings (the more the better) to discuss the order of presentation and determine who is doing what! Also, if you plan to use PowerPoint, decide who in the group is bringing a laptop and be sure that everyone has included their content into the single presentation file. As noted above, each group should prepare a cumulative presentation of approximately 20 - 30 minutes.

Guidelines for Oral Presentations: The oral presentations should hit upon several essential elements. By following the guidelines below, you will be able to strategically prepare an effective presentation that will be applauded by all! Importantly, focus on preparing clear visual aids to present the data and illustrate your points. This will assist your audience in grasping the topics being presented.

I. Introduction/Background Information
It is important to set the appropriate stage to introduce the research being presented. Familiarize yourself with background information on the topic so as to project a clear and concise rationale for why the research was conducted. Questions to ask in preparing an introduction include: Why is this system interesting? What is already known regarding this environment/organism/system? What is the problem? What is the motivation for this research? What is the big picture of this scientific endeavor?

II. Experimental Approach
Now that you have introduced the context of the research, explain the methodology and experimental protocols used in this study to dissect a biological problem or explore a novel biological system. What approaches were used? Why did the authors choose this approach?

III. Results
When presenting the results, it is important to reiterate the methodologies employed to generate the data. The data should be summarized to allow a reviewer (or in this case audience member) to begin to consider

conclusions on her/his own without interjecting the author's interpretations. You should also contemplate the integrity of the experimental results. Please feel free to include your opinions, likes, or dislikes of the data and begin to describe some conclusions about the results that can be drawn.

IV. Conclusions
Present the major conclusions of the report. Be sure to include your independent interpretations of the data and provide these in concert with the author's interpretations. What is the significance of the results? Do you believe the author's conclusions? What additional experiments might have been performed to strengthen the conclusions? In wrapping up your presentations, discuss the long-term implications of the research. What should be done next?

(B) Written Report (Research Proposal):

After 10 arduous weeks of learning about environmental genomic methods and applications to ecological, evolutionary and biotechnological questions, it is time to put all that you have learned together and run with it. Once you have learned all the wonderful opportunities and analyses available to your genomically-enabled mind, you are well armed to design a project and venture forth as an independent researcher.

We will have covered a fair amount of material this quarter:

- Sampling the environment
- Bioinformatic practices (assembly, phylogenetic binning, annotation, etc. of genomic data)
- Functional metagenomics
- Environmental gene inventories
- Community and population genomics
- Environmental post-genomics (proteomics & transcriptomics)
- Metagenomics of viruses

Prepare a <u>three to four page report</u> (≤ 1.5 point spacing) describing a hypothetical research project of your choosing. Specifically, you will prepare a research proposal in which you will conceive of a research project and describe how you would go about exploring the biology of a system ("environment") using environmental genomic methodologies. The report should identify a target community or environment and discuss the importance of this system, the methods to be used to examine the system and the expected outcomes of the research. Relevant literature cited in preparing your report MUST be included.

When designing a research topic, think about the project's goals and what hypotheses you set out to confront. What kinds of organisms and what kinds of metabolisms do you expect to encounter? This could simply involve investigating the diversity of microbes that live in Antarctic sea ice (permanently cold environments) or microbes associated with the basalts of deep-sea hydrothermal vents (permanently hot environments). Alternatively you may wish to be imaginative and explore perhaps less exotic, yet equally interesting, sites such the cooling towers of nuclear power plants, chlorine resistant microbes in your swimming pool, microbes associated algae ponds used for biofuel production, the flora found in the guts of koalas, or the zoo of bugs found on a shower curtain. Be creative!

The format of the report should include the following elements:

I. Title (20 words or less)
Be explicit as is necessary to adequately describe the proposed project. (20 words or less)

II. Abstract (0.5 page)
Provide a brief overview of the project including the system to be explored, the methods used, and why this project is important.

III. Introduction (0.5 – 1 page)
Provide an introduction to the system ("environment") in the form of background information. The introduction should provide sufficient information to acquaint the reader with the importance of this particular biological system. It is important to justify why the environment you have chosen is of interest and there should be a scientific basis for exploring this environment's organismic and genetic. The point here is to get the people who read your proposal excited about what you plan to do!

IV. Specific Aims/Goals (< 0.5 page)
Explicitly state what you plan to accomplish with this research. This can be presented in the form of bullet points or a brief description of what the project aims to accomplish.

V. Project Description & Methods (1.5 – 2 pages)
You must logically progress through how you will go about performing the research. This includes sampling techniques and the methods used to assess the diversity of the environment (who is in there?) and gain insight into the metabolic abilities of these populations (what are they doing?). This section is the most important part of the proposal and should provide enough detail that the reader can evaluate if you know what you are talking about and if the proposed project is technically sound! Remember that this is a proposal – you are justifying WHY a project is worthy of being funded and thus you do not have all of the answers up front. Answers are what you seek! You do however have access to PubMed and Google so you can research background information about your system before you begin to propose a study. Do it!

VI. References (no page limit)
In order to adequately prepare a proposal you must know something about the system under investigation. To do so you will have to access primary scientific literature (e.g. PubMed or Google Scholar) and read through relevant literature to obtain sufficient information to describe the system. No less than three references should be included in your report. Use the following reference style in your report:

Narasingarao P, Podell S, Ugalde JA, Brochier-Armanet C, Emerson J, Brocks JJ, Heidelberg KB, Banfield JF, Allen EE (2011) *De novo* metagenomic assembly reveals abundant novel major lineage of Archaea in hypersaline microbial communities. *ISME J.* 6:81-93.

Class Participation:

******* In addition to the grading criteria described above, you will be responsible for *active participation* in this class! After each lecture and presentation, we will have a brief discussion period where we will evaluate a paper's scientific methods, results and the author's interpretations. YOU SHOULD CRITICALLY READ THE ASSIGNED PAPERS BEFORE CLASS so that you are prepared for the discussions.

General Guidelines for Reading Scientific Papers:

Familiarize yourself with the related topics:
Read and understand the Abstract and Introduction. Do background reading on related material (via PubMed searches; see links below) in order to become familiar with the subject matter. Research papers are written for people who already know something about the subject matter!

Try to answer the following questions as you read the papers:

1. What questions were addressed in this paper?
   Frequently the introduction will present background information and raise the questions that will be addressed in the paper.

2. What were the main conclusions from the paper?
   The main conclusions will be summarized in the abstract, and further discussed in the discussion section. Why were these conclusions important?

3. What experiments were performed to answer these questions?
   These will be briefly summarized in the abstract and discussed at length in the materials & methods and results sections of the paper.

4. For each experiment:
   What conclusion did the experiment allow? What were the caveats of each experiment? (i.e., were there alternative explanations?) What experiments ruled out these alternatives?

Useful Websites:

PubMed: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?tool=cdl&holding=ucsdlib (journal literature portal)

Google Scholar: http://scholar.google.com (literature search portal)

Small Things Considered: http://schaechter.asmblog.org/schaechter/ (odds and ends from the microbial world)

Microbe wiki: http://microbewiki.kenyon.edu (resource for exploring a rich variety of microbes)