

## Functional Genomics for Research

11:776:485 (3 credits)

Fall Semester (yearly)

Monday, Wednesday (lecture) 12:35 – 1:55 PM 124 Foran Hall

### CONTACT INFORMATION

Instructor: Dr. Dana C. Price  
Office Location: 106B Foran Hall, 59 Dudley Rd., New Brunswick, NJ 08901  
Phone: 848-932-6259  
E-mail: d.price@rutgers.edu  
Office Hours: by arrangement

### COURSE DESCRIPTION

This course will focus on execution of tools and protocols used to elucidate the biology, ecology and life histories of organisms through analysis of their genomes. Using genome research projects recently completed by the instructor and collaborators as templates, students will carry out each step of the research pipeline (unique to that project) in depth – from taxon selection, bioinformatic analysis of next-generation sequencing data, genome assembly, gene prediction/functional annotation, and finally how these data answer a functional biological hypothesis or question about the target organism. As new topics are introduced, they will be framed in the context of their applicability to the current project. At the end of the course, students will be able to select the appropriate protocols and analysis pipelines to complete the majority of today's genome research. Each topic (or introduced research project) will consist of one or more lectures with background discussion, tool and material review, and a second hands-on computer (or dry) lab period during which students will apply the concepts and tools to complete a phase the genomic analysis. This course illustrates evolutionary concepts current tools in a hands-on manner within the confines of a goal or results-oriented genome research project.

**Student audience:** Advanced undergraduate (especially Plant Biology and Biotechnology) and graduate students at SEBS and SAS will benefit from training in approaches to genomics and its application in a research environment.

### COURSE WEBSITE, RESOURCES AND MATERIALS

- Course website: Sakai
- Required textbook: none
- Readings: Selected scientific articles, book chapters, and writings from the popular press. Each lab will use a research paper authored by the instructor as a model for the analyses to be carried out with expected results

### PREREQUISITE

01:119:115 General Biology AND (11:216:251 Fundamentals of Evolution/486 Principles of Evolution OR 01:447:380 Genetics OR 11:115:301 Introductory Biochemistry/403 General Biochemistry OR 01:694:315 Introduction to Molecular Biology and Biochemistry Research/407 Molecular Biology and Biochemistry)

### COURSE LEARNING GOALS

(Link to Plant Biology Undergraduate Program Goals: <http://plantbiology.rutgers.edu/undergrad/plantbiology/>)

By the end of this course, the student will be able to:

Course goal 1: Apply knowledge of genome sequencing and bioinformatics analyses to test hypotheses regarding organismal biology and evolution (addresses program goals 1 and 4)

- Course goal 2: Communicate effectively how various bioinformatic analyses are impacted by similarities and differences in eukaryote genomes (addresses program goal 3)
- Course goal 3: Apply appropriate bioinformatic tools and analysis protocols for individual genome sequencing projects (addresses program goals 1 and 2)
- Course goal 4: Analyze and report on recent published research in the field of genomics (addresses program goal 4)

## ASSIGNMENTS/RESPONSIBILITIES AND ASSESSMENT

### Grading:

- Paper discussion: 10%
- Mid-term: 30%
- Final exam (cumulative): 30%
- Final project: 30%
- Scale: 90-100% = A; 80-89 = B; 70-79 = C; 60-69 = D

**Paper discussion:** Students will present a recent genome paper on a topic of their choosing and recap the methods used and conclusions inferred from the analyses.

**Final project:** Students will assemble, annotate and describe a mock genome project using public and/or simulated sequence data.

### Learning goals assessment:

- Goal 1: Specific questions on exams; final project
- Goal 2: Specific essay/long-answer questions on exams; paper discussion; final project
- Goal 3: Final project; exam questions; class participation
- Goal 4: Paper discussion; presentation and class participation

The percentage score on these assessments will determine the level of mastery: >90% outstanding; 80-89% good; 70-70% satisfactory; <69% unsatisfactory.

## PARTICIPATION GRADE AND ABSENCE POLICY

Students are expected to attend all classes; if you expect to miss one or two classes, please use the University absence reporting website (<https://sims.rutgers.edu/ssra/>) to indicate the date and reason for the absence. An e-mail is automatically sent to the instructor.

## COURSE SCHEDULE

### Topics

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- Introduction / Why sequence genomes; next-gen sequencing
- Basics I: Genome/transcriptome assembly; gene prediction and annotation
- Basics II: Sequence alignment, phylogenetics, phylogenomics
- Lab I: Illustrating the basics
- The algal tree of life; origins of photosynthesis – The *Cyanophora paradoxa* genome
- The MAT hypothesis; plastid establishment – The *Cyanophora paradoxa* genome
- Lab II: Working with *C. paradoxa* genome data
- Extremophilic vs. mesophilic genomes; horizontal gene transfer (HGT) – The *Porphyridium purpureum* genome
- Lab III: Working with *P. purpureum* genome data
- Genomic adaptation to environmental stress; HGT revisited – The *Picochlorum spp.* genome

- Basics II: Sequence alignment, phylogenetics, phylogenomics
- Lab I: Illustrating the basics
- The algal tree of life; origins of photosynthesis – The *Cyanophora paradoxa* genome

#### Spring recess, Mid-term

- Differential expression: Lipid production, nitrogen starvation in *Phaeodactylum tricorutum*
  - Differential expression: Lipid production, nitrogen starvation in *Phaeodactylum tricorutum*
  - Lab VI: Differential expression analyses illustrated with *P. tricorutum* data.
  - Metabolism and physiology inferred from genome data – The *Gambierdiscus caribaeus* genome
  - Lab VII: Metabolic pathways, KEGG and gene ontologies illustrated with *G. caribaeus* data.
  - **Paper discussion I**
  - **Paper discussion II**
  - TBD
  - Single nucleotide polymorphisms and directed evolution – *Chlamydomonas reinhardtii* resequencing
  - Lab VIII: Calling SNPs and estimating functional consequences
  - Genetic divergence and natural selection as evidenced in genome data.
  - Phylogenetic networks and alignment-free methods to illustrate shared ancestry
  - **Exam review**
- Final exam (cumulative)**
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#### FINAL EXAM DATE AND TIME

The final exam is cumulative.

The Online Final exam Schedule: <http://finalexams.rutgers.edu/>

#### ACCOMODATIONS FOR STUDENTS WITH DISABILITIES

Please follow the procedures outlined at <https://ods.rutgers.edu/students/registration-form>. Full policies and procedures are at <https://ods.rutgers.edu/>

#### ACADEMIC INTEGRITY

The university's policy on Academic Integrity is available at <http://academicintegrity.rutgers.edu/academic-integrity-policy/>

The principles of academic integrity require that a student:

- Properly acknowledge and cite all use of the ideas, results, or words of others.
- Properly acknowledge all contributors to a given piece of work.
- Make sure that all work submitted as his or her own in a course or other academic activity is produced without the aid of impermissible materials or impermissible collaboration.
- Obtain all data or results by ethical means and report them accurately without suppressing any results inconsistent with his or her interpretation or conclusions.
- Treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference. This requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress.
- Uphold the canons of the ethical or professional code of the profession for which he or she is preparing.

Adherence to these principles is necessary in order to ensure that:

- Everyone is given proper credit for his or her ideas, words, results, and other scholarly accomplishments.
- All student work is fairly evaluated and no student has an inappropriate advantage over others.
- The academic and ethical development of all students is fostered.
- The reputation of the University for integrity in its teaching, research, and scholarship is maintained and enhanced.

Failure to uphold these principles of academic integrity threatens both the reputation of the University and the value of the degrees awarded to its students. Every member of the University community therefore bears a responsibility for ensuring that the highest standards of academic integrity are upheld.

## STUDENT WELLNESS SERVICES

**Just In Case Web App** <http://codu.co/cee05e>

Access helpful mental health information and resources for yourself or a friend in a mental health crisis on your smartphone or tablet and easily contact CAPS or RUPD.

**Counseling, ADAP & Psychiatric Services (CAPS)**

(848) 932-7884 / 17 Senior Street, New Brunswick, NJ 08901 / [www.rhscaps.rutgers.edu/](http://www.rhscaps.rutgers.edu/)

CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professional within Rutgers Health services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include: individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community and consultation and collaboration with campus partners.

**Violence Prevention & Victim Assistance (VPVA)**

(848) 932-1181 / 3 Bartlett Street, New Brunswick, NJ 08901 / [www.vpva.rutgers.edu/](http://www.vpva.rutgers.edu/)

The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

**Disability Services**

(848) 445-6800 / Lucy Stone Hall, Suite A145, Livingston Campus, 54 Joyce Kilmer Avenue, Piscataway, NJ 08854 / <https://ods.rutgers.edu/>

Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: <https://ods.rutgers.edu/students/documentation-guidelines>. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the ODS web site at: <https://ods.rutgers.edu/students/registration-form>.

**Scarlet Listeners**

(732) 247-5555 / <http://www.scarletlisteners.com/>

Free and confidential peer counseling and referral hotline, providing a comforting and supportive safe space.