IB 465 – Methods in Molecular Genetics and Genomics
Spring 2025

Meeting day and time: Lecture: Monday, Wednesday 3-3:50 pm
Discussion: Friday 3-3:50 pm

Course Format: In person, full term (16 weeks)

Location: 2084 Natural History Building

Weekly Hours Expected: 6 in addition to 3 in-class time (Undergraduate)
8 in addition to 3 in class time (Graduate)

Number of Credit Hours: 3 undergraduate, 4 graduate

Name of Instructor: Dr. Steven Burgess

Instructor contact: sjb287@illinois.edu

Instructor Office Location: 283 Morrill Hall

Instructor Office Hours: Wednesday 2-3 pm NHB 2084

Learning Outcomes

- Form a working knowledge of reverse genetic analysis.
- Design a plasmid for plant transformation using modular cloning.
- Explain methods of plant transformation.
- Analyze data from a genotyping experiment.
- Design and analyze an experiment to delete a plant gene using CRISPR/Cas9.
- Design and analyze a qPCR experiment using best practices.
- Design and analyze an immunoblot experiment using best practices.
- Become familiar with modern methods in genomics.
- Use comparative analysis to infer gene function.
- Analyze RNA-SEQ data.
- Describe genomic approaches for analysis of gene regulation.
- Analyze ChIP-SEQ data.
- Explain the concept of a Biological Network and identify key components.
- Identify best practices in peer review.
- Be able to critically analyze scientific literature in a constructive manner.

Pre-requisites

- IB204 or the consent of the instructor

Course Description

Mapping genotype to phenotype is a key challenge in biological research. Understanding gene function has importance for processes ranging from how species evolve to developing new crop varieties. This class is designed to be of practical relevance to students interested in conducting molecular and genomic analysis, with a mixture of lectures, hands-on-tutorials and discussion sections. Examples are mainly drawn from plant biology the concepts and approaches are broadly applicable to areas of molecular biology, genomics and biotechnology. Over the course of the semester, you will follow the steps involved in creation, and analysis of, transgenic plants. You will also be trained in the process of peer review as preparation for a career in research science.

Learning Management System

This course uses the Learning Management System Canvas (https://canvas.illinois.edu/), tutorials will be performed using Benchling (https://www.benchling.com/) and Galaxy (https://galaxyproject.org/).

Required and Recommended Reading Materials (Textbook)

- None

Required Equipment
Students will need to bring a laptop to class as the course involves completion of online activities. Pen and paper are also necessary for group work.

Absence Policy
As outlined in the student code (https://studentcode.illinois.edu/article1/part5/1-501/) regular attendance and engagement with course is expected and non-attendance may affect financial aid. Student attendance is defined as active participation in the course as described in the course syllabus. This course will have multiple mechanisms for student participation, which can be documented by any of the following methods:

- Submission/completion of assignments
- Communication with the instructor
- Or other course participation

In the case of an anticipated absence, such as religious observances, the student should contact the instructor in advance and make arrangements to complete the required assignments. Each student will receive a total of two lecture attendance and one discussion section drop. In the case of further absences you should contact the instructor as soon as possible providing a letter from the Dean of Students (https://odos.illinois.edu/resources/students/absence-letters). If you have any questions regarding these policies, please see the instructor. If you foresee having any long-term problems, please contact us immediately to make arrangements at the beginning of the semester; such accommodations cannot be made after the fact.

Late Assignment Policy
All work is expected to be submitted on time, and a 5% penalty will be applied for each day late for up to five days. No points will be deducted if the instructor is contacted 24 hours in advance of the due date to arrange for an alternative time in the event of extenuating circumstances such as illness or bereavement.

Grading
In addition to receiving marks for attendance, 20 points for the semester, you will be graded on the following assignments.

Assignments

- **Tutorials**: 8 tutorials covering molecular and genomic analysis, 50 points each. Each tutorial will be a step-by-step guide to performing a particular aspect of molecular or genomic analysis and are designed to be of practical use (topics are listed in the table below). The estimated time to complete each tutorial is between 1-3 hours. Each will be graded pass/fail based on successful completion. Multiple attempts will be allowed, and feedback given after each attempt to allow for successful completion. Graduate students will be required to complete a supplementary task for 4 tutorials.
- **Presentations:** two group presentations on topics relating to genetics and genomics will be done within class time and graded based on completion of peer-evaluation forms. Each presentation will be 10-15 minutes long. Presentation 1 will be based on a poster created during class time, and presentation 2 a group PowerPoint. Assessment will be by peer evaluation, whereby group members will be asked to assess their fellow students on five criteria (10 points each) using and a rubric provided. 50 points total per presentation.
- **Discussion sections:** will provide training in the process of peer review using examples from the literature. Each session will be graded based on answering a set of five questions on a handout following a rubric which will be provided. 13 sections at 10 points each.
- **Reviewer report:** At the end of the semester, groups will apply their knowledge to produce a peer review of an unpublished preprint to be submitted via Canvas. Students will be given a list of pre-prints from which to choose ahead of time. The report will follow a standard outline of an academic review of a manuscript including summary of the work, minor and major points to be addressed. The expected total length of the report is 2-3 pages, size 11 text. This will be completed across the last two discussion sessions, with an initial draft submitted at the first week then corrections made following peer feedback in week 2. 50 points.
- **Exams:** Two, 50-minute, exams will cover contents in the first and second part of the semester respectively. Each exam will comprise of 10 multiple choice questions, three short response questions, and one essay.150 points each.
- **Graduate only requirements:** To fulfill requirements, graduate students will complete three additional assignments putting best practices in writing and presenting data learned during

discussion sections. These include writing an abstract, preparing a figure and writing a methods section for their own research projects which can serve as a basis for thesis work or conference presentations. There will be a first draft, a peer review assessment and submission of revised draft for each item. 50 points each.

Assignment Due Dates:

Assessment	Topics	Due Date
Assignment 1	Comparative gene analysis	Sunday 23:59; Week 2
Assignment 2	Design a plasmid	Sunday 23:59; Week 3
Assignment 3	Design CRISPR guides	Sunday 23:59; Week 5
Assignment 4	Analyze qPCR data	Sunday 23:59; Week 6
Assignment 5	Design an antibody	Sunday 23:59; Week 7
Assignment 6	Using Galaxy	Sunday 23:59; Week 10
Assignment 7	RNA-SEQ analysis	Sunday 23:59; Week 11
Assignment 8	ChIP-SEQ analysis	Sunday 23:59; Week 13
Presentation 1	CRISPR techniques	In-class Wednesday; Week 4
Presentation 2	Chromatin analysis	In-class Wednesday; Week 12
Review Report Draft	Manuscript of choice	Sunday 23:59; Week 13
Review Report Final	Manuscript of choice	Sunday 23:59; Week 15

Graduate specific assignments

Assessment	Topics	Due Date
Draft 1	Draft an abstract for research project	Sunday 23:59; Week 4
Peer Feedback 1	Give feedback on 2 abstracts	Sunday 23:59; Week 5
Assignment 1	Submit finalized abstract	Sunday 23:59; Week 6
Draft 2	Prepare a publication standard figure	Sunday 23:59; Week 7
Peer Feedback 2	Give feedback on 2 figures	Sunday 23:59; Week 9
Assignment 2	Submit finalized figure	Sunday 23:59; Week 10
Draft 3	Write a section of methods	Sunday 23:59; Week 11
Peer Feedback 2	Give feedback on 2 methods	Sunday 23:59; Week 12
Assignment 3	Submit finalized methods	Sunday 23:59; Week 14

Grading Breakdown: Undergraduate

Assessment Type	Points
Assignments (8 non-cumulative)	400
Group presentations (2 non-cumulative)	100
Discussion Section (13 non-cumulative)	130
Reviewer Report	50
Exam 1	150
Exam 2	150
Attendance	20
Total	1000

Grading Breakdown: Graduate

Assessment Type	Points
Tutorials (8 non-cumulative)	400
Group presentations (2 non-cumulative)	100
Discussion Section (13 non-cumulative)	130
Reviewer Report	50
Exam 1	150
Exam 2	150
Attendance	20
Grad assignments (3 non-cumulative)	300
Total	1300

Final letter grades (Undergraduate)
The grading scale is set at 1000-980 (A+), 979-920 (A), 919-900 (A-), 899-880 (B-), 879-820 (B), 819-800 (B-), 799-780 (C+), 779-720 (C), 719-700 (C-), 699-680 (D+), 679-620 (D), 619-600 (D-), <600 (F). Grades for each assignment are satisfactory based on completion / or unsatisfactory in the case of failure to turn in work, feedback will be provided with multiple attempts allowed until successful completion.

Final letter grades (Graduate)
The grading scale is set at 1300-1275 (A+), 1274-1200 (A), 1199-1175 (A-), 1174-1150 (B-), 1149-1075 (B), 1074-1050 (B-), 1049-1025 (C+), 1024-950 (C), 949-925 (C-), 924-900 (D+), 899-825 (D), 824-800 (D-), <800 (F). Grades for each assignment are satisfactory based on completion / or unsatisfactory in the case of failure to turn in work, feedback will be provided with multiple attempts allowed until successful completion.

Course Expectations

- Each student is expected to attend all classes in person, which means arriving on time and being present for the duration of class period.
- Assignments will be designed to be completed during class time, but students will have until before the following lecture to submit if additional time is required. Failure to submit will result in a 'U' for a given assignment.
- Each student will give two group presentations during the semester.
- Each student is expected to participate in group discussions and in class activities.
- During group work, such as presentations, each member is expected to contribute equally to developing the slides and communicating the group's findings to the class.

Communication
Announcements will be made via Canvas page. General questions regarding course materials are best posted to the Q&A forum on canvas, and any questions specific to an individual's situation should be directed to the instructor at sjb287@illinois.edu. Office hours can be scheduled by appointment.

Accommodations
If you require special accommodations, please tell faculty or the lecture coordinator within the first two weeks of class. All accommodations will follow the procedures as stated in Article 1-110 of the Student Code (http://studentcode.illinois.edu). To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 217-333-4603, e-mail: disability@illinois.edu or go to the DRES website. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available on campus that can help diagnosis a previously undiagnosed disability by visiting the DRES website and selecting "Sign-Up for an Academic Screening" at the bottom of that page.

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/.

Family Educational Rights and Privacy Act (FERPA) Statement
Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Sexual Misconduct Policy and Reporting Statement
The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here:

https://wecare.illinois.edu/resources/students/#confidential. Other information about resources and reporting is available here: https://wecare.illinois.edu.

Inclusivity Statement
The effectiveness of this course is dependent upon the creation of an encouraging and safe classroom environment. Exclusionary, offensive or harmful speech (such as racism, sexism, homophobia, transphobia, etc.) will not be tolerated and in some cases subject to University harassment procedures. We are all responsible for creating a positive and safe environment that allows all students equal respect and comfort. We expect each of you to help establish and maintain an environment where you and your peers can contribute without fear of ridicule or intolerant or offensive language.

Schedule

Week	Month	Day	Topic
1	Jan	19	No class
	Jan	22	Introduction: logistics and overview
	Jan	24	Discussion 1: manuscript on applied goal of Plant Genetics
2	Jan	27	Genetic Screens I: forward genetic analysis in plants
	Jan	29	Genetic Screens II: reverse genetic analysis in plants
	Jan	31	Discussion 2: how to find papers and journal impact factors
	Feb	2	**Due date Assignment 1** (23:59)
3	Feb	3	Cloning I: designing plasmids with classical cloning
	Feb	5	Cloning II: introduction to modular cloning techniques
	Feb	7	Discussion 3: What makes a good Abstract and Title?
	Feb	9	**Due date Assignment 2** (23:59)
4	Feb	10	Reverse lecture I: gene editing
	Feb	12	Presentation I: gene editing
	Feb	14	Discussion 4: gene editing and figure design
	Feb	16	Due date [Graduate student] Research abstract draft 1 (23:59)
5	Feb	17	Designing CRISPR guides
	Feb	19	Plant transformation
	Feb	21	Discussion 5: manuscript on gene-editing in crops
	Feb	23	**Due date Assignment 3** (23:59)
			Due date [Graduate student] peer review abstracts (23:59)
6	Feb	24	Gene expression analysis I: introduction to qPCR
	Feb	26	Gene expression analysis II: analysis of qPCR data
	Feb	28	Discussion 6: analyzing methods sections
	Mar	2	**Due date Assignment 4** (23:59)
			Due date [Graduate student] Research abstract final (23:59)
7	Mar	3	Protein analysis I: introduction to immunoblots
	Mar	5	Protein analysis II: interpreting data and scientific fraud
	Mar	7	Discussion 7: comparing results and discussion sections

	Mar	9	**Due date Assignment 5** (23:59)
			Due date [Graduate student] figure draft (23:59)
8	Mar	10	Protein analysis III: pulldowns and epitope tags
	Mar	12	Review session
	Mar	14	Exam 1
			Spring Break
9	Mar	24	Introduction to plant genomics I: plant genomes and ploidy
	Mar	26	Introduction to plant genomics II: using Galaxy workbench
	Mar	28	Discussion 8: insights from comparative genomics of plants *Salojärvi, J. et al. The genome and population genomics of allopolyploid Coffea arabica reveal the diversification history of modern coffee cultivars. Nat Genet **56**, 721–731 (2024). https://doi.org/10.1038/s41588-024-01695-w*
	Mar	30	Due date [Graduate] peer review figures (23:59)
10	Mar	31	Genome analysis I: introduction to short-read sequencing
	Apr	2	Genome analysis II: organelle genome analysis
	Apr	4	Discussion 9: How life history influences genome structure Wicke, S. et al. Mechanisms of Functional and Physical Genome Reduction in Photosynthetic and Nonphotosynthetic Parasitic Plants of the Broomrape Family. *The Plant Cell*, Volume 25, Issue 10, October 2013, Pages 3711–3725,
	Apr	6	**Due date Assignment 6** (23:59)
			Due date [Graduate student] final figure (23:59)
11	Apr	7	RNA-SEQ analysis I: theory and practice
	Apr	9	RNA-SEQ analysis II: processing RNA-SEQ data in Galaxy
	Apr	11	Discussion 10: insights from comparative transcriptomics Libourel, C. *et al.* Comparative phylotranscriptomics reveals ancestral and derived root nodule symbiosis programmes. *Nat. Plants* **9**, 1067–1080 (2023). https://doi.org/10.1038/s41477-023-01441-w
	Apr	13	**Due date Assignment 7** (23:59)
			Due date [Graduate student] draft methods section (23:59)
12	Apr	14	Reverse lecture II: chromatin packaging
	Apr	16	Presentation II: chromatin packaging
	Apr	18	Discussion 11: Genomic analysis of gene regulation Wang, J., *et al.* Natural variation in *BnaA9.NF-YA7* contributes to drought tolerance in *Brassica napus* L. *Nat Commun* **15**, 2082 (2024). https://doi.org/10.1038/s41467-024-46271-2
	Apr	20	Due date [Graduate student] peer review methods (23:59)
13	Apr	21	Regulation of DNA packaging, ATAC-SEQ
	Apr	23	Transcription factor analysis using ChIP-SEQ
	Apr	25	Discussion 12: review of selected paper
	Apr	26	**Due date Assignment 8** (23:59)
			Due date draft of reviewer report (23:59)

14	Apr	28	Single cell sequencing
	Apr	30	Introducing biological networks
	May	2	Discussion 13: feedback and refining paper review
	May	4	Due date [Graduate] submit final methods (23:59) **Due date final reviewer report** (23:59)
15	May	5	Review Session
	May	7	Exam 2