Bi 282H Winter 2023
Course Syllabus

In this course we will examine the genetic and molecular mechanisms responsible for the inheritance of physical characteristics. We will begin with the key role of DNA as the hereditary material in cells. We will then learn how DNA directs the synthesis of proteins, including how that synthesis is regulated. Finally, we will explore the ways in which DNA is inherited and thereby passes molecular information to subsequent generations.

Overall learning outcomes

By the end of this course, you will be able to demonstrate an understanding of:

1. how DNA directs the synthesis of proteins, including how protein synthesis is regulated
2. how variations in DNA sequence affect proteins and thereby phenotype
3. how DNA is inherited and thereby specifies the phenotypes of subsequent generations
4. how to design and interpret experiments that test #1-3.

Learning objectives and optional readings for each lecture

You are responsible for understanding the material presented in pre-lecture videos, lecture, and lab. The listed "Optional readings" may contain more - or fewer - details than necessary and are just suggestions.

Lecture	Learning objectives	Optional readings
1. DNA is necessary & sufficient to confer heritable traits	• learning is iterative - expect to feel confused: ask lots of questions, & work on solving the assigned problems • be able to interpret and design experiments that test necessity and sufficiency	Biology2e Links to an external site.section 14.1

	• be able to interpret and design experiments that identify DNA as the chemical responsible for heredity	
2. DNA has a structure remarkably suited to making copies of itself	• science is iterative: guess at possible models, determine what new data would distinguish between these models, design experiments to get this new data • understand how the structure of DNA allows accurate copies to be made (ensuring heritability) • be able to interpret and design experiments that distinguish between conservative, semi-conservative, and dispersive models of DNA replication	Biology2e Links to an external site.section 14.2 & 14.3
3. Replicating a molecule of DNA requires a set of ordered operations	• understand the ordered, enzymatic steps of DNA replication: initiation, unwinding, synthesis of RNA primers, new DNA strand synthesis, removal of RNA primers, filling in gaps, and completing the phosphate backbone • understand the "end replication problem" that linear chromosomes face and how telomerase solves it • understand how, in the lab, DNA polymerases are used to amplify and thereby detect trace amounts of a specific DNA sequence ("PCR")	Biology2e Links to an external site.section 14.4 & 14.5
4. DNA sequences can change - mutants and mutations	• understand that and how the sequence of bases in DNA can change (mutations/mutants) • be able to design and interpret experiments that measure mutation	Biology2e Links to an external site.section 14.6 Griffiths 461-3Download Griffiths 461-3

	rates and/or determine whether a chemical is a mutagen • be able to design and interpret experiments that determine whether mutations occur spontaneously or in response to an environmental challenge	
5. DNA has separable units of function that can encode proteins	• be able to design screens for auxotrophic mutants in E. coli and Neurospora • be able to design and interpret experiments that distinguish whether a mutation is recessive or dominant to wild type • be able to to design and interpret complementation tests • be able to design and interpret experiments that use auxotrophs to identify the order of enzymes/genes acting in a biosynthetic pathway	Griffiths 187-90Download Griffiths 187-90 MeneelyDownload Meneely
6. The genetic code is non-overlapping, not separated by commas, and triplet	• be able to design and interpret experiments that distinguish whether a genetic code has codons that overlap • be able to design and interpret experiments that distinguish whether a genetic code has "commas" • be able to predict and interpret the effects of 1 bp insertions and deletions on comma-less codes, comma-containing codes, and codes with fully overlapping codons • be able to design and interpret screens for suppressor mutations	Griffiths and CrickDownload Griffiths and Crick

7. The genetic code is degenerate, unambiguous, and universal; mutations can alter zero, one, or multiple amino acids within a protein	• understand what properties make the genetic code "degenerate", "unambiguous", and "universal" • be able to explain and interpret evidence that RNA is the intermediary between DNA and protein production • determine the effects that DNA sequence changes within protein-coding sequence have on amino acid sequence • understand the effects that DNA sequence changes within protein-coding sequence can have on that protein's function (can cause it to lose or to gain function) • understand how to distinguish between null and hypomorph mutations	Biology2e Links to an external site.section 15.1 Hartwell et al.Download Hartwell et al.
8. Changes to a protein's amino acid sequence may cause the protein to lose or gain function - or may have no effect	• understand "haploid" and "diploid" and be able to use genetic nomenclature (e.g. "m/+", "+/+", "m/m") • be able to interpret evidence that a gene is haploinsufficient • understand how to distinguish among the different types of mutations - nulls, hypomorphs, hypermorphs, dominant negatives, and neomorphs - and understand why doing so is important (e.g. for knowing how to treat disease patients)	The suggested Hartwell et al reading for lecture 7 is useful for lecture 8 too!

9. DNA for each gene is transcribed into RNA by RNA polymerase	• be able to design and interpret "pulse-chase" experiments • understand the properties of RNA polymerase, including how and where it starts transcribing • be able to design and interpret experiments that identified the DNA sequences ("promoters") that are necessary and sufficient to initiate transcription in *E. coli* • understand what a "consensus" sequence is • understand the relationship between promoter sequence and transcription frequency	Biology2e Links to an external site.section 15.2
10. Non-amino-acid-coding DNA sequences denote the start and stop sites for transcription and translation	• be able to recognize and create "dyad symmetry" in a DNA sequence and hairpins/stem-loops in RNA • be able to design and interpret experiments that identify E. coli TX terminators • be able to draw RNA pols transcribing mRNAs as ribosomes translate them (as happens in prokaryotes ONLY) • understand the relationship between RBS sequence and translation frequency	Biology2e Links to an external site.section 15.2 & 15.5
11. Aminoacyl-tRNA synthetases and the ribosome allow mRNAs to be	• understand what it means for genes to be in an "operon" (prokaryotes) • understand what an "ORF" ("open reading frame") is • understand the "second genetic code" – how are tRNAs charged with the correct amino acid?	Biology2e Links to an external site.section 15.5

translated into protein	• understand how there can be fewer tRNAs than amino-acid-coding codons • understand the steps of translation elongation and how translation stops	
12. Regulatory pathways, AND gates, OR gates, activators, repressors, cis, trans	• understand what it means for a gene to be "inducible" vs "constitutive" • understand how to interpret gene regulatory pathways, including "AND gates" and "OR gates" • understand how allosteric E. coli repressors and activators regulate transcription initiation • understand the phenotypes of E. coli mutants in which beta-gal and permease are either uninducible or constitutively expressed	Biology2e Links to an external site.section 16.1 & 16.2
13. How prokaryotic repressors work (example: response of the *lac* operon to lactose)	• be able to design and interpret experiments that distinguish whether a DNA sequence acts in cis or in trans • be able to design and interpret experiments that distinguish whether an inducible E. coli operon is regulated by a repressor or an activator • understand how lacI (lac repressor), lacO, P_{lac} (the lac operon promoter), lacZ (which encodes beta-gal), lacY (which encodes lac permease), allolactose (the natural lac operon inducer), IPTG (an artificial lac operon inducer) - affect expression of the lac operon	Griffiths 305-315 Download Griffiths 305-315(contains error: **allolactose** is the lac inducer that binds the lac repressor (NOT lactose)

	• understand how mutations in lacI, lacO, P_{lac}, lacZ and lacY alter expression of the lac operon	
14. How prokaryotic activators work (example: response of the *lac* operon to glucose). AND gates and OR gates revisited.	• understand how CAP (an activator), the CAP binding site, adenylate cyclase (an enzyme that synthesizes cAMP from glucose), and cAMP affect expression of the lac operon • understand how mutations in CAP, the CAP binding site, and adenylate cyclase alter expression of the lac operon • understand how an E. coli operon can respond to two different external cues • understand how an E. coli operon can be controlled by an "AND gate" or an "OR gate" • be able to design transgenes with new properties by manipulating known DNA sequences - and be able to deduce the properties of new transgenes based on the DNA sequences they contain	The suggested Griffiths reading for lecture 13 has info on CAP too
15. Eukaryotic DNA is organized into chromatin within the nucleus; how does	• understand that and why multicellular eukaryotes have less compact genomes (lots of "junk" DNA) • understand the purpose and consequences of chromatin • understand how eukaryotic transcriptional activators and repressors work: mediator complex, chromatin looseners and tighteners • example of yeast Gal gene regulation: Gal1, Gal7, Gal10, Gal4, Gal80, Mig1	Biology2e Links to an external site.section 16.1, 16.3, 15.3

eukaryotic TX work?	• be able to interpret "epistasis" tests	
16. How eukaryotic cells turn gene expression ON and OFF in response to external conditions	• understand that, in eukaryotes, the presence of external signals must be "transduced" to the nucleus if transcription is to change • example of yeast Gal gene regulation continued: introducing Gal3, galactose restricts Gal80's ability to enter the nucleus, and glucose promotes Mig1's ability to enter the nucleus • understand that (most) multicellular plants and animals are clonal • understand the principles underlying cell-cell signaling - under what circumstances can a cell receive/transduce a signal from another cell?	Links to an external site. Cox 743-6 Download Cox 743-6(contains error: **Gal80** leaves the nucleus in the presence of galactose)
17. Eukaryotic RNAs undergo significant modification before being translated	• understand the principles of splicing, introns vs. exons, the implications for translation, and the possible consequences of splicing errors and mutations that alter splice site sequences • know the differences between pre-mRNAs and mature mRNAs • understand the mechanisms by which eukaryotic transcription terminates and translation initiates	Biology2e Links to an external site.section 15.4
18. Mitosis (DNA replication	• be able to ascertain the ploidy and n of cells - including whether they are aneuploid	Biology2e Links to an external site.section 10.2

followed by cell division) generates genetically identical cells	• understand the steps of mitosis and their effects on ploidy and n • be able to predict the consequences of mistakes during mitosis - non-disjunction, in particular • understand the principles underlying asymmetric cell division	
19. Example of how cells become different during development: the early *C. elegans* embryo	• understand the steps by which each cell in the four-cell *C. elegans* embryo contains a unique set of mRNAs and proteins • understand how to design and interpret experiments that distinguish whether cells in an embryo are different and whether cells in an embryo that are different become different because of asymmetric cell division or cell-cell signaling	Gilbert 251-7Download Gilbert 251-7
20. What does it mean for a cell to "differentiate"?	• know the definitions of: "totipotent", "multipotent", "pluripotent", "differentiated", "binary fate choice" • understand the concept of "reprogramming" a differentiated cell • be able to interpret and design experiments that identify how genes in a linear regulatory pathway determine a binary fate choice	Khan Academy intro to developmentLinks to an external site.
21. Meiosis and single Mendelian traits	• understand the steps of meiosis and their effects on ploidy and n • be able to predict the consequences of mistakes during meiosis - non-disjunction, in particular • understand how meiosis explains how a single mutation is inherited during	Biology2e Links to an external site.section 11.1, 12.2

	sexual reproduction in unicellular and multicellular eukaryotes	
22. Independent assortment, linkage, and recombination	• understand how meiosis explains how multiple mutations are inherited during sexual reproduction, whether unlinked or linked • be able to calculate recombination distances between DNA sequences and construct recombination "maps" containing multiple genes • understand how organisms (and scientists!) use recombination to maintain and manipulate genomes	Biology2e Links to an external site.p.316-321, 330-334
23. Sex-linked traits	• be able to recognize and interpret patterns of inheritance that indicate a mutation is on a sex chromosome (either X or Z)	Biology2e Links to an external site.p.311-314
24. Maternal-effect genes	• be able to recognize and interpret patterns of inheritance that indicate a gene has a maternal-effect	Brooker Download Brookersection 5.1
25. An introduction to epigenetic effects	• be able to recognize and interpret patterns of inheritance that indicate a gene is imprinted	Brooker Download Brookersection 5.2
26. Cytoplasmic inheritance and other sources of mosaicism	• be able to recognize and interpret patterns of inheritance that indicate a gene is extranuclear • understand the mechanisms and consequences of mosaicism (e.g.	Brooker Download Brookersection 5.3

	caused by X-inactivation) and chimerism in multicellular individuals	
27. Pedigree analysis and genome sequencing	• be able to interpret pedigrees • be able to identify the properties of DNA sequences that cause heritable human traits	Griffiths 42-8, 52-6Download Griffiths 42-8, 52-6
28. Establishing causation can be complicated		Lander and SchorkDownload Lander and Schork

Teaching philosophy

- be organized, clear, and consistent
- provide multiple opportunities per week for active learning, problem-solving
- provide multiple opportunities per week for interactions with instructors
- provide multiple opportunities to earn points

Grading Rubric

	number	may I work on this with others?	number of lowest scores dropped	number in final grade calculation	points each	points in final grade calculation (total = 1000)
pre-lecture quizzes	28	yes	5	23	2	46
post-lecture quizzes	28	yes	5	23	2	46

weekly lecture-based homeworks	9	yes	1	8	35	280
midterm exam	1	NO	0	1	75	75
final exam	1	NO	0	1	153	153
pre-labs	8	yes	0	8	5	40
lab reports	9	yes	1	8	20	160
lab puzzles	9	yes	1	8	20	160
presentation	1	yes	0	1	40	40

- Letter grades will be determined based on total points, not on individual exams and assignments. Getting:
    - >90% of the points (900) guarantees an A-
    - >80% (800), B-
    - >70% (700), C-
    - >60% (600), D-
    - And <60% (600), F

  In the event that scores are skewed downward, the final scores will be curved with breaks between each bin determined by "jumps" in the grade data that separate groups of students. This curve is designed so that it can only help you. If the entire class receives >90%, every student would receive an A-.

Late policy: late work will not be accepted for most assignments . This is because we immediately post keys for each assignment when the due date closes. Lab reports may be turned in late with a 10% deduction per day up to 1 week late.

This class is governed by UO community standards. We expect everyone to:

- Respect the dignity and essential worth of all individuals.

• Promote a culture of respect. This includes **not distracting others during class time** (e.g. no side conversations, no cell phone usage), and **staying home if you're sick**. Lectures will be available (and recorded) on zoom.

• Respect the privacy, property, and freedom of others.

• Reject bigotry, discrimination, violence, or intimidation of any kind. Practice personal and academic integrity and expect it from others.

• Do your own work. Cheating, plagiarism and any other form of academic dishonesty will not be tolerated. Group work is allowed on many, though not all, assignments (see table above). However, all work you turn in should be your own. Exactly copying text and/or graphs is not permitted.

General university policies

A reminder that the following support services are available to you as students:

- *University Health Services or call (541) 346-2770*
- *University Counseling Center or call (541) 346-3277 or (541) 346-3227 (after hrs.)*
- *MAP Covid-19 Testing*
- *Academic Advising or call (541) 346-3211*
- *Dean of Students or call (541)-346-3216*

Academic Disruption due to Campus Emergency

In the event of a campus emergency that disrupts academic activities, course requirements, deadlines, and grading percentages are subject to change. Information about changes in this course will be communicated as soon as possible by email, and on Canvas. If we are not able to meet face-to-face, students should immediately log onto Canvas and read any announcements and/or access alternative assignments. Students are also expected to continue coursework as outlined in this syllabus or other instructions on Canvas.

In the event that the instructor of this course has to quarantine, this course may be taught online during that time.

Accessible Education

The University of Oregon is working to create inclusive learning environments. Please notify Tory as soon as possible if there are aspects of the instruction or design of this course that result in disability-related barriers to your participation. You are also encouraged to contact the Accessible Education Center in 360 Oregon Hall at 541-346-1155 or uoaec@uoregon.edu. . Please provide a notification letter from the Accessible Education Center (http://aec.uoregon.edu/) outlining your approved accommodations.

Academic Misconduct

The University Student Conduct Code (available at conduct.uoregon.edu) defines academic misconduct. Students are prohibited from committing or attempting to commit any act that constitutes academic misconduct. By way of example, students should not give or receive (or attempt to give or receive) unauthorized help on assignments or examinations without express permission from the instructor. Students should properly acknowledge and document all sources of information (e.g. quotations, paraphrases, ideas) and use only the sources and resources authorized by the instructor. If there is any question about whether an act constitutes academic misconduct, it is the students' obligation to clarify the question with the instructor before committing or attempting to commit the act. Additional information about a common form of academic misconduct, plagiarism, is available at https://researchguides.uoregon.edu/citing-plagiarism.

Inclement Weather

It is generally expected that class will meet unless the University is officially closed for inclement weather. If it becomes necessary to cancel class while the University remains open, this will be announced on Canvas and by email. Updates on inclement weather and closure are also communicated in other ways described here: https://hr.uoregon.edu/about-hr/campus-notifications/inclement-weather/inclement-weather-immediate-updates

Reporting Obligations

Both Tory and Laurel have "assisting employee" status. For information about our reporting obligations, please see Employee Reporting Obligations on the Office of Investigations and Civil Rights Compliance (OICRC) website. Students experiencing sex or gender-based discrimination, harassment or violence should call the 24-7 hotline 541-346-SAFE [7244] or visit safe.uoregon.edu for help. Students experiencing all forms of prohibited discrimination or harassment may contact the Dean of Students Office at 5411-346-3216 or the non-confidential Title IX Coordinator/OICRC at 541-346-3123. Additional resources are available at investigations.uoregon.edu/how-get-support. I am also a mandatory reporter of child abuse. Please find more information at Mandatory Reporting of Child Abuse and Neglect.

Mental Health and Wellness

Life at college can be very complicated. Students often feel overwhelmed or stressed, experience anxiety or depression, struggle with relationships, or just need help navigating challenges in their life. If you're facing such challenges, you don't need to handle them on your own--there's help and support on campus.

As your instructors, if we believe you may need additional support, we will express our concerns, the reasons for them, and refer you to resources that might be helpful. It is not our intention to know the details of what might be bothering you, but simply to let you know we care and that help is available. Getting help is a courageous thing to do—for yourself and those you care about.

University Health Services help students cope with difficult emotions and life stressors. If you need general resources on coping with stress or want to talk with another student who has been in the same place as you, visit the Duck Nest (located in the EMU on the ground floor) and get help from one of the specially trained Peer Wellness Advocates. Find out more at health.uoregon.edu/ducknest.

University Counseling Services (UCS) has a team of dedicated staff members to support you with your concerns, many of whom can provide identity-based support. All clinical services are free and confidential. Find out more at counseling.uoregon.edu or by calling 541-346-3227 (anytime UCS is closed, the After-Hours Support and Crisis Line is available by calling this same number)."

Basic Needs

Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live and believes this may affect their performance in the course is urged to contact the Dean of Students Office (346-3216, 164 Oregon Hall) for support.

This UO webpage includes resources for food, housing, healthcare, childcare, transportation, technology, finances, and legal support: https://blogs.uoregon.edu/basicneeds/food/

Accommodation for Religious Observances

*The university makes reasonable accommodations, upon request, for students who are unable to attend a class for religious obligations or observance reasons, in accordance with the university discrimination policy which says "*Any student who, because of religious beliefs, is unable to attend classes on a particular day shall be excused from attendance requirements and from any examination or other assignment on that day. The student shall make up the examination or other assignment missed because of the absence." *To request accommodations for this course for religious observance, visit the Office of the Registrar's website (https://registrar.uoregon.edu/calendars/religious-observances) and complete and submit to the instructor the "Student Religious Accommodation Request" form prior to the end of the second week of the term.*