Natural Science II: Genomes and Diversity
V55.0314
Spring 2007
Mondays and Wednesdays, 2:00 p.m. – 3:15 p.m.
Silver 207

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Course Description

Millions of species of animals, plants and microbes inhabit our planet. Genomics, the study of all the genes in an organism, is providing new insights into this amazing diversity of life on Earth. We begin with the fundamentals of DNA, genes and genomes. We then explore microbial diversity, with an emphasis on how genomics can reveal many aspects of organisms, from their ancient history to their physiological and ecological habits. We follow with examinations of animal and plant diversity, focusing on domesticated species, such as dogs and tomatoes, as examples of how genomic methods can be used to identify genes that underlie new or otherwise interesting traits. Genomics has also transformed the study of human diversity and human disease. We examine the use of DNA to trace human ancestry, as well as the use of genomics as a diagnostic tool in medicine. With the powerful new technologies to study genomes has come an increased power to manipulate them. We conclude by considering the societal implications of this ability to alter the genomes of crop plants, livestock and potentially humans.

Course Objectives

- To gain an appreciation of the diversity and unity of life on Earth
- To acquire a foundation of knowledge of how organisms store and process information encoded in DNA
- To understand technological advances that will shape the future of our world
- To develop skills in problem solving and interpreting scientific information
- To engage in various methods of scientific investigation in the laboratory
- To critically evaluate popular media reports on the latest developments in biological research
- To become adept at conveying scientific concepts to others
- To address the complex ethical, social and legal consequences of genetic information

Course Texts and Readings

Required Text

Rob DeSalle and Michael Yudell, *Welcome to the Genome: A User's Guide to the Genetic Past, Present, and Future* (John Wiley & Sons, 2005).

Required Multimedia DVD

DNA Interactive (Cold Spring Harbor Laboratory Press, 2003).

Required Coursepack

Articles about recent discoveries in genomics from *The New York Times*, *Scientific American* or other sources will be assigned throughout the semester as part of the required readings. Some articles are available online through the course Blackboard site. Others are compiled in the coursepack.

Lecture and Laboratory Schedule

	Date	*Lecture Topic*	*Reading**	*Laboratory*
1	W Jan 17	Introduction and Overview	D&Y Intro	
				No laboratory
		GENES AND GENOMES		
2	M Jan 22	DNA	D&Y Ch. 1	

				Lab 1: Chromosomes
3	W Jan 24	The Genetic Code	D&Y p. 27-36	
4	M Jan 29	Recombinant DNA & DNA Sequencing	D&Y p. 37-40	
				Lab 2: DNA isolation
5	W Jan 31	Genome Sequencing Projects	D&Y Ch. 3	
6	M Feb 5	Genomics & Systems Biology	D&Y p. 119-124; [1,2]	
				Lab 3: Genetic Code; form presentation groups
		GENOME DIVERSITY: MICROBES		
7	W Feb 7	Bacterial Genes and Genomes	[3,4]	
8	M Feb 12	Microbial Diversity and the Universal Tree of Life	D&Y Ch. 6; [5]	
				Lab: Meet with presentation groups
9	W Feb 14	Metagenomics, Ecological Genomics *(Homework #1 assigned)*	[6,7]	
	M Feb 19	No class: Presidents' Day		
				Lab: Review for Midterm; Homework #1 due; presentation proposals due
		GENOME DIVERSITY: ANIMALS		
10	W Feb 21	Animal Genes and Genomes	[8]	
	M Feb 26	**Midterm Exam 1**		
				Lab 4: Restriction enzymes and plasmids
11	W Feb 28	Origin of Domestic Dogs, Phylogeny	[9,10]	
12	M Mar 5	Breed Discrimination, Genotypes and Phenotypes	[11,12]	
				Lab 5: Microbial diversity I
13	W Mar 7	Other Animal Genomes	[8]	
	M Mar 12	No class: Spring Recess		
	W Mar 14	No class: Spring Recess		
		GENOME DIVERSITY: PLANTS		
14	M Mar 19	Plant Genes and Genomes, Breeding	[13]	
				Lab 6: Microbial diversity II
15	W Mar 21	Genome-wide Mapping of Traits	[14]	
16	M Mar 26	Agricultural Traits: Rice, Tomatoes, Corn	[15]	
				Lab: Student presentations
		GENOME DIVERSITY: HUMANS		
17	W Mar 28	Genetics of Human Disease	D&Y Ch. 7	
18	M Apr 2	Genomics for Diagnosis	[16]	
				Lab: Student presentations
19	W Apr 4	DNA Fingerprinting *(Homework #2 assigned)*	D&Y p. 162-164; [17,18]	
20	M Apr 9	Human History and Diversity	D&Y Ch. 5; [19-21]	
				Lab: Review for Midterm; Homework #2 due
21	W Apr 11	Student Presentation Highlights		
	M Apr 16	**Midterm Exam 2**		
				Lab 7: DNA fingerprinting

		MANIPULATING GENOMES		
22	W Apr 18	Transgenic Plants and Animals; Cloning	D&Y p. 135-139, Ch. 8; [22]	
23	M Apr 23	Ethics and Societal Implications of GMOs *Presentation reports due*	[23]	
				Lab: Review for Final Exam & Evaluations
24	W Apr 25	Ethics and Societal Implications of Gene Therapy	D&Y Ch. 4, 9; [24-26]	
25	M Apr 30	Conclusion: Genomics & The Future	[27]	

*Readings will be supplemented with assignments from the *DNA Interactive* DVD. Numbered readings are given below. Those with numbers in italics are available online through links on Blackboard. Those with numbers in bold are in the coursepack.

[1] Hamadeh H and Afshari CA, 2000. Gene chips and functional genomics. *American Scientist* 88:508–515.
[2] Pennisi E, 2003. Tracing life's circuitry. *Science* 302:1646–1649.
[3] Goffeau A, 1995. Life with 482 genes. *Science* 270:445–446.
[4] Pennisi E, 1997. Laboratory workhorse decoded. *Science* 277:1432–1434.
[5] Doolittle WF, 2000. Uprooting the tree of life. *Scientific American* 282:90-95.
[6] Pollack A, 2003. A new kind of genomics, with an eye on ecosystems. *The New York Times*, 21 October 2003.
[7] Pollack A, 2004. Groundbreaking gene scientist is taking his craft to the oceans. *The New York Times*, 5 March 2004.
[8] Howard Hughes Medical Institute, 2001. *The Genes We Share with Yeast, Flies, Worms, and Mice.*
[9] Morell V, 1997. The origin of dogs: running with the wolves. *Science* 276:1647–1648.
[10] Wade N, 2005. Dog's genome could provide clues to disorders in humans. *The New York Times*, 8 December 2005.
[11] Derr M, 2004. Collie or pug? Study finds the genetic code. *The New York Times*, 21 May 2004.
[12] Hede K, 2004. Bow WOW! *HHMI Bulletin*, Fall.
[13] Goff SA and Salmeron JM, 2004. Back to the future of cereals. *Scientific American* 291:42–49.
[14] McCouch S, 2004. Diversifying selection in plant breeding. *PLoS Biology* 2:e347.
[15] Pääbo S, 1999. Neolithic genetic engineering. *Nature* 398:194–195.
[16] Friend SH and Stoughton RB, 2002. The magic of microarrays. *Scientific American* 286:44–49,52–53.
[17] Adler J and McCormick J, 1998. The DNA detectives. *Newsweek*, 16 November 1998, p. 66–71.
[18] Church GM, 2006. Genomes for all. *Scientific American* 294:46–54.
[19] Wade N, 2006. Still evolving, human genes tell new story. *The New York Times*, 7 March 2006.
[20] Harmon A, 2006. Seeking ancestry in DNA ties uncovered by tests. *The New York Times*, 12 April 2006.
[21] Shreeve J, 2006. The greatest journey. *National Geographic* 209:60–73.
[22] Lanza RP, Dresser BL and Damiani P, 2000. Cloning Noah's ark. *Scientific American* 283:84–89.
[23] Brown K, 2001. Seeds of concern. *Scientific American* 284:52–57.
[24] Cibelli JB, Lanza RP and West MD, 2001. The first human cloned embryo. *Scientific American* 286:44–51.
[25] Duster T, 2005. Race and reification in science. *Science* 307:1050–1051.
[26] Mahowald MB, 1997. An overview of the human genome project and its implications for women. *Women's Health Issues* 7:206–208.
[27] Collins FS and Jegalian KG, 1999. Deciphering the code of life. *Scientific American* 281:86–91.

Laboratory Sessions (Silver 201)

Lab Section	*Day and Time*	*Lab Instructor*
Section 2	Tuesday, 3:00 pm – 4:40 pm	Joe Sarro
Section 3	Tuesday, 5:00 pm – 6:40 pm	Joe Sarro
Section 4	Wednesday, 9:00 am – 10:40 am	Matt Teater
Section 5	Wednesday, 11:00 am – 12:40 pm	Matt Teater

Grades*

15% Midterm Exam 1
15% Midterm Exam 2
25% Final Exam
25% Laboratory and Quizzes
15% Group Presentation and Report
5% Homework

* see also **Altruism Points** below

Coursework and Policies

Exams

The exams will contain questions covering the **lectures, readings and laboratory projects**. The final exam will be **cumulative**, covering topics throughout the course. In most aspects of science, researchers faced with a problem have many resources at their fingertips to aid in finding a solution. In this spirit, you may use any book and/or notes you wish during the midterm and final exams (for fairness to those without laptops, and to avoid distraction, computers and other electronic devices will not be allowed). As you might guess, open book/notes exams are less likely to test you on recall of facts and more likely to test you on your ability to integrate and think critically about new information. Study questions provided at the end of each lecture will provide practice with some types of questions that will appear on the exams. Homework assignments will also provide such practice (see **Homework** below).

If you will miss **one midterm exam** because of illness, you must contact Professor Siegal by e-mail **before** the start of the exam and provide a doctor's note explaining your absence. **No make-up exams will be given for the course.** Instead, the final exam will count as **40% of your course total**. If you miss **two midterm exams** you will be required to withdraw from the course.

A make-up will be given for the final exam only under **exceptional circumstances** that must be discussed with Professor Siegal **prior to the exam**. In this case a grade of **incomplete** will be given for the course and the make-up will be scheduled for the Fall 2007 semester. No alternative date for the final exam will be offered at the end of the spring semester so avoid making travel plans to leave NYU before the date of the final exam.

Homework

Homework assignments will contain questions that review the course material and questions that relate to the laboratory. All homework must be submitted on time for full credit. If you miss a lecture or laboratory session due to a documented absence you are still required to complete the homework assignment. Contact your laboratory instructor to arrange a suitable deadline for submitting the work.

Group Presentations

The transmission of scientific knowledge to the general public is a difficult and under-appreciated task. In this course, you will not only be responsible for increasing your own knowledge of genomics, but will also contribute to broader dissemination of this knowledge. You will work in teams to develop creative ways of conveying a key concept or new discovery to a general audience. Each team will form during the

laboratory (week of Feb 5) and will submit a **1-page proposal** of its topic and presentation format (week of Feb 19). Group **presentations** will take place in the laboratory (weeks of Mar 26 and Apr 2). Each member of a team must participate in the presentation, and each member will submit a separate **final report** on his or her group's presentation (due Apr 23).

Altruism Points

Contrary to the popular image of the lonely scientist toiling away in isolation, science is a collective activity that depends on the sharing of ideas. Typical college courses, especially college science courses, actively discourage such sharing and engender a competitive environment by grading students almost entirely by exams and quizzes. In this course, you will be rewarded for helping your peers increase their knowledge. There are three ways to earn these "altruism points," each worth up to 15 points:

- Regularly contribute to answering other students' questions on the course's on-line newsgroup
- Maintain a weblog or produce a series of short podcasts explaining material covered in class
- Maintain a weblog or produce a series of short podcasts on relevant current events related to the course (but not directly covered in the course)

Altruism points will be used to adjust your final course grade by the formula:

$$\text{adjusted course grade} = \text{course grade} * \frac{100 - \text{altruism points}}{100} + \text{altruism points}$$

For example, a student with a course grade of 60 can increase his grade to 70 by earning 25 altruism points; a student with a course grade of 80 can increase her grade to 89 by earning 45 altruism points. Altruism can easily make a difference in your final letter grade. The lower your course grade the more altruism helps!