Natural Science II: Genomes and Diversity
V55.0314
Spring 2008
Mondays and Wednesdays, 2:00 p.m. – 3:15 p.m.
Silver 206

Professor Mark Siegal
Department of Biology
854 Brown Building
Phone: 998-7908
E-mail: mark.siegal@nyu.edu
Office Hours: By e-mail appointment

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 Articles
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 and are available online through the course Blackboard site.

Lecture and Laboratory Schedule

	Date	Lecture Topic	Reading*	Laboratory
1	W Jan 23	Introduction and Overview	D&Y Intro	
				No laboratory
		GENES AND GENOMES		
2	M Jan 28	DNA	D&Y Ch. 1	
3	W Jan 30	DNA Replication & The Genetic Code	D&Y p. 27-34	
				Lab 1: Chromosomes
4	M Feb 4	Splicing, Translation & Recombinant DNA	D&Y p. 35-39	
5	W Feb 6	DNA Sequencing & Genome Projects	D&Y p. 40, Ch. 3	
				Lab 2: DNA isolation
6	M Feb 11	Genomics	D&Y p. 119-124; [1]	
		GENOME DIVERSITY: MICROBES		
7	W Feb 13	Bacterial Genes and Genomes	[2]	
				Lab 3: Genetic code; form working groups
	M Feb 18	No class: Presidents' Day		
8	W Feb 20	Bacterial Genomes and Diversity	[3-5]	
				Lab 4: Bacterial transformation and gene regulation I
9	M Feb 25	Universal Tree of Life & Ecological Genomics	D&Y Ch. 6; [6-8]	
10	W Feb 27	Review: Genes, Genomes & Microbes		
				Lab 5: Bacterial transformation and gene regulation II; meet with working groups; review for midterm
	M Mar 3	**Midterm Exam 1**		
		GENOME DIVERSITY: ANIMALS		
11	W Mar 5	Animal Genomics & Origin of Domestic Dogs	[9-11]	
				Lab 6: Restriction enzymes and plasmids
12	M Mar 10	Breed Discrimination & Genotypes and Phenotypes	[12-17]	

13	W Mar 12	Other Animal Genomes: Similarities and Differences	[9]	
				Lab 7: Microbial diversity I
	M Mar 17	No class: Spring Recess		
	W Mar 19	No class: Spring Recess		
				No laboratory
		GENOME DIVERSITY: PLANTS		
14	M Mar 24	Plant Genes and Genomes & Breeding	[18]	
15	W Mar 26	Genome-wide Mapping of Traits	[19]	
				Lab 8: Microbial diversity II
16	M Mar 31	Agricultural Traits: Rice, Tomatoes, Corn	[20]	
		GENOME DIVERSITY: HUMANS		
17	W Apr 2	Genetics of Human Disease	D&Y Ch. 7; [21,22]	
				Lab: Work with working groups
18	M Apr 7	Genomics for Diagnosis	[23]	
19	W Apr 9	DNA Fingerprinting & Personal Genomes	D&Y p. 41-42, 162-164; [24-28]	
				Lab: Student presentations I
20	M Apr 14	Human History and Diversity	D&Y Ch. 5; [29-31]	
21	W Apr 16	Review: Animal, Plant & Human Genomics		
				Lab: Student presentations II; review for midterm
	M Apr 21	**Midterm Exam 2**		
		MANIPULATING GENOMES		
22	W Apr 23	Transgenic Plants and Animals & Student Presentation Highlights	D&Y p. 135-139, Ch. 8	
				Lab 9: DNA fingerprinting
23	M Apr 28	GMOs and Society *Presentation reports due*	[32,33]	
24	W Apr 30	Cloning, Gene Therapy & Complex Human Traits	D&Y Ch. 4, 9; [34-38]	
				Lab: Review for final exam & Course evaluations
25	M May 5	Conclusion: Genomics & The Future	[39,40]	

*Readings will be supplemented with assignments from the *DNA Interactive* DVD. Numbered readings are given below, and are available through links on Blackboard.

Readings

[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] Wade N, 2007. Scientists transplant genome of bacteria. *The New York Times*, 29 June 2007.
[6] Doolittle WF, 2000. Uprooting the tree of life. *Scientific American* 282:90-95.
[7] Pollack A, 2003. A new kind of genomics, with an eye on ecosystems. *The New York Times*, 21 October 2003.
[8] Gross L, 2007. Untapped bounty: sampling the seas to survey microbial biodiversity. *PLoS Biology* 5:e85.
[9] Howard Hughes Medical Institute, 2001. *The Genes We Share with Yeast, Flies, Worms, and Mice*.
[10] Morell V, 1997. The origin of dogs: running with the wolves. *Science* 276:1647–1648.
[11] Wade N, 2007. Study traces cat's ancestry to Middle East. *The New York Times*, 29 June 2007.
[12] Pennisi E, 2007. The geneticist's best friend. *Science* 317:1668–1671.
[13] Derr M, 2004. Collie or pug? Study finds the genetic code. *The New York Times*, 21 May 2004.
[14] Hede K, 2004. Bow WOW! *HHMI Bulletin*, Fall.
[15] Pennisi E, 2004. A ruff theory of evolution: gene stutters drive dog shape. *Science* 306:2172.
[16] Physorg.com, 2007. Ancient genetic material keeps pups pint-sized. 5 April 2007.
[17] Harmon A, 2007. As breeders test DNA, dogs become guinea pigs. *The New York Times*, 12 June 2007.
[18] Goff SA and Salmeron JM, 2004. Back to the future of cereals. *Scientific American* 291:42–49.
[19] Doebley J, 2006. Unfallen grains: how ancient farmers turned weeds into crops. *Science* 312:1318–1319.
[20] Pääbo S, 1999. Neolithic genetic engineering. *Nature* 398:194–195.
[21] Daitz B, 2007. Heirs to a rare legacy in New Mexico. *The New York Times*, 4 September 2007.
[22] Harmon A, 2007. Cancer free at 33, but weighing a mastectomy. *The New York Times*, 16 September 2007.
[23] Friend SH and Stoughton RB, 2002. The magic of microarrays. *Scientific American* 286:44–49,52–53.
[24] Adler J and McCormick J, 1998. The DNA detectives. *Newsweek*, 16 November 1998, p. 66–71.
[25] Church GM, 2006. Genomes for all. *Scientific American* 294:46–54.
[26] Liptak A, 2007. Study of wrongful convictions raises questions beyond DNA. *The New York Times*, 23 July 2007.
[27] Cohen J, 2007. Venter's genome sheds new light on human variation. *Science* 317:1311.
[28] Harmon A, 2007. My genome, myself: seeking clues in DNA. *The New York Times*, 17 November 2007.
[29] Harmon A, 2006. Seeking ancestry in DNA ties uncovered by tests. *The New York Times*, 12 April 2006.
[30] Shreeve J, 2006. The greatest journey. *National Geographic* 209:60–73.
[31] Kintisch E, 2007. Ancient DNA reveals Neanderthals with red hair, fair complexions. *Science* 318:546–547.
[32] Brown K, 2001. Seeds of concern. *Scientific American* 284:52–57.
[33] Service RF, 2007. A growing threat down on the farm. *Science* 316:1114–1117.
[34] Lanza RP, Dresser BL and Damiani P, 2000. Cloning Noah's ark. *Scientific American* 283:84–89.
[35] Cibelli JB, Lanza RP and West MD, 2001. The first human cloned embryo. *Scientific American* 286:44–51.
[36] Couzin J and Kaiser J, 2007. Closing the net on common disease genes. *Science* 316:820–822.
[37] Shriner D et al, 2007. Problems with genome-wide association studies. *Science* 316:1840–1842.
[38] Dobbs D, 2007. The gregarious brain. *The New York Times*, 8 July 2007.
[39] Collins FS and Jegalian KG, 1999. Deciphering the code of life. *Scientific American* 281:86–91.
[40] Pennisi E, 2007. Breakthrough of the year: human genetic variation. *Science* 318:1842–1843.

Laboratory Sessions (Silver 201)

Lab Section	*Day and Time*	*Lab Instructor*
Section 2	Thursday, 3:00 pm – 4:40 pm	Janice Cheng
Section 3	Thursday, 5:00 pm – 6:40 pm	Janice Cheng
Section 4	Friday, 9:00 am – 10:40 am	Pubali Chatterjee
Section 5	Friday, 11:00 am – 12:40 pm	Pubali Chatterjee

Grades*

15% Midterm Exam 1
15% Midterm Exam 2
25% Final Exam
25% Laboratory and Quizzes
15% Group Presentation and Project
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.

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 2008 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.

Working Groups

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 small groups to develop creative ways of conveying key concepts and discoveries to a general audience. Each working group will form during the laboratory (week of Feb 11), and will be responsible for communicating information related to one of the four main themes of the course: 1) how genes and genomes work, 2) how genes and genomes reveal the history of life, 3) how genes and genomes reveal the unity and diversity of life, and 4) how technological advances in genomics impact scientific discovery and society. There will be two main forums for communication: postings to individual weblogs throughout the course, and a group presentation toward the end of the semester. These are described below.

Homework (Blogs)
Each student will maintain a weblog, and homework credit will be given for contributions to these blogs. Postings will be related to the topic of the student's working group and should either explain pertinent material covered in class or comment on relevant current events or news stories. The goal is to create an online community resource for students to share information about the course and the topics it raises. The blogs will also serve as repositories of information that each working group will use in crafting its presentation. More details and instructions for posting to blogs will be given in class and posted on Blackboard.

Group Presentations and Final Projects
Group presentations will take place in the laboratory (weeks of Apr 7 and Apr 14). The presentation should convey specific scientific information related to the group's topic. Each member of a team must participate in the presentation, and each member will submit a separate final project related to his or her group's presentation (due Apr 28). More details on the format of the group presentations and projects are available on Blackboard.

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. These "altruism points" are earned by online contributions that go beyond what is required for homework credit. Three types of posts will be considered, each worth up to 15 points:

- answers to other students' questions about lecture or lab material
- lecture notes or explanations of material covered in class
- commentary on relevant current events related to the course (but not directly covered in the course)

Altruism points will be tallied and posted to the Blackboard gradebook at 3 times during the course (at the time of each exam). Earning full altruism points requires regular contributions — points not earned by the time of tallying cannot be made up later 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!