

## Seminars on Science

# GENETICS, GENOMICS, GENETHICS

## Syllabus

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### Course Title

Genetics, Genomics, Genethics: Molecular Biology

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### Course Description

Since the 1944 discovery that DNA is the universal genetic code, this young science has advanced by leaps and bounds: scientists can now decipher, examine and modify the blueprints for life. As its title suggests, this course emphasizes the relation between the underlying science of **genetics**, the study of genomes (**genomics**), and the social, ethical, and legal issues that this work gives rise to **genethics**. Learners investigate topics such as the history of genetic discovery and molecular lab techniques, and emerge with an understanding of the science and the technology behind breakthroughs like therapeutic cloning and the sequencing of the human genome.

The first part of the course gives learners an opportunity to grapple with the basics of genetics: the underlying science that deals with the transmission of hereditary characteristics and their mechanisms. Starting with an examination of the work of Gregor Mendel, it brings learners up to date on the foundations of modern genetics and explores related issues such as the nature-nurture debate, the theory of evolution, and the role of genetic diversity. The course goes on to investigate what's involved in genomics: the study of all of the genes of a cell, at the DNA, mRNA, or protein levels. Discussions focus on the nature of genomic science as well as medical and technological advances.

Advances in genome research lead directly to **genethics**, the social, ethical, and legal implications of developments such as genetically modified organisms, cloning for therapeutic and reproductive purposes, genetic enhancement of humans, and the ownership of genetic information.

Throughout the course, online interaction, scientist-authored essays, videos, and simulations enable students to investigate genetic variation and similarities, and to develop a structure for thinking about ethical issues.

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### Class Schedule

This is a six-week online graduate course with an additional week to complete assignments. The course is asynchronous and does not have specific meeting times. Assignments and discussions change on a weekly basis. Students are expected to complete work within the week it is assigned.

For the current schedule of offerings, please visit [www.amnh.org/learn/calendar.php](http://www.amnh.org/learn/calendar.php).

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## Instructors

This graduate course is co-taught by an experienced educator along with a research scientist. **For example**, a recent course featured:

**Mr. Steve Ryan**

Walsh Jesuit High School  
Cuyahoga Falls, Ohio

**Dr. Claudia Englbrecht**

Bioformatics  
National Research Center for Environment and Health

For current instructor information, please contact [seminfo@amnh.org](mailto:seminfo@amnh.org).

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## Format

1. **Genetics, Genomics, Genethics** is a six-week online graduate course with an additional week for assignment completion. Enrollment is restricted to current or future educators. No prior course in evolutionary science is required.
2. **Weekly activities** introduce the basic tools of biotechnologists. They use a framework for examining ethical issues to examine the impacts of genetic technology on society. Computer interactives, image galleries, and videos help learners visualize and master the content.
3. **Online discussions** encourage reflection on course content, support and model the inquiry process, and sustain interaction between the offering scientists, seminar instructors, and course members.
4. **Final course projects** take one of two forms. Learners can develop a proposal that describes how they might research a particularly interesting seminar topic, or they can create an inquiry-based lesson plan focused on a key course concept that could be incorporated into their teaching practice.

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## Required Textbook

This course requires the following textbook.

**Welcome to the Genome: A User's Guide to the Genetic Past, Present, and Future**

by Rob DeSalle, Michael Yudell

Hardcover: 240 pages; Dimensions (in inches): 9.6 x 7.7 x 0.7

Publisher: Wiley; (September 2004)

ISBN: 0471453315

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## Recommended Textbooks

The following textbooks are recommended as general references but are not required.

**The Impact of the Gene: From Mendel's Peas to Designer Babies**

*Limited availability — out of print*

by Colin Tudge

Hardcover: 375 pages; Dimensions (in inches): 1.29 x 8.56 x 5.76

Publisher: Hill & Wang Pub; (July 2001)

ISBN: 0374175233

**Genome: The Autobiography of a Species in 23 Chapters [ABRIDGED]**

by Matt Ridley

Hardcover: 344 pages; Dimensions (in inches): 1.25 x 9.50 x 6.50

Publisher: HarperCollins; (February 2000)

ISBN: 0060194979

**The \$1,000 Genome: The Revolution in DNA Sequencing and the New Era of Personalized Medicine**

by Kevin Davies

Hardcover: 352 pages

Publisher: Free Press; (September 7, 2010)

ISBN: 1416569596

**Drawing the Map of Life: Inside the Human Genome Project**

by Victor K. McElheny

Hardcover: 384 pages

Publisher: Basic Books (June 22, 2010)

ISBN: 04650433X

**The Double Helix: A Personal Account of the Discovery of the Structure of DNA**

by James D. Watson, Lawrence Bragg

Paperback: 143 pages; Dimensions (in inches): 0.50 x 7.00 x 4.25

Publisher: New American Library; Reissue edition (February 1991)

ASIN: 0451627873

**The Science of Jurassic Park and the Lost World: Or, How to Build a Dinosaur**

by Rob Desalle, David Lindley

Hardcover: 194 pages; Dimensions (in inches): 0.75 x 8.25 x 5.75

Publisher: DIANE Publishing Co; (1997)

ISBN: 0788159364

**Inside the Human Genome: A Case for Non-Intelligent Design**

by John C. Avis

Hardcover: 240 pages

Publisher: Oxford University Press, USA (February 12, 2010)

ISBN: 0195303439

**The Human Genome: Book of Essential Knowledge**

by John Quackenbush

Hardcover: 176 pages

Publisher: Imagine! Publishing (February 1, 2011)

ISBN: 9781936140152

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## Support Services

Technical support is available for technical issues on a 24/7 basis. Please call (303) 873-0005 or email [helpdesk@amnh.college.com](mailto:helpdesk@amnh.college.com).

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## Grading

**Assessments** are based on a detailed grading rubric developed for this course:

Course Assignments	30%
Course Participation & Communication	40%
Final Project	30%

1. **Course assignments** will include reflection questions and written assignments.
2. **Class participation** will be evaluated based on the quality and consistency of contribution to the discussion forum. The grades for participation will be posted two weeks after each question opens.
3. **Final Project:** There are two options:

**Option I: Teaching Practice**

This is for learners who would like to develop an application based on the course content that could be taught to students or other educators. The final form may be a unit, or a workshop plan if it will be used as part of a professional development experience.

**Option II: Research Question**

This is for learners who would like an opportunity to grapple further with the science and skills presented in this course. The task is to develop a research question based on some particularly interesting element of the course content.

4. **Policy:** Everything submitted as an assignment, project, or discussion post must be original. References to source materials and proper citations are required.

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## Weekly Overview and Expectations

### Week 1: Introduction

During the first week learners are introduced to the course authors, Drs. Rob DeSalle and Claudia Englbrecht, and begin to explore the history of the science of genetics. An introductory essay defines key terms and previews the science, technology, and ethics of molecular biology. The history of genetics is examined with a detailed look at Gregor Mendel's experiments. A foundation for the rest of the course is established by reviewing some of the basic, including how hereditary units (genes) are transmitted and expressed. Learners are also introduced to a structure for thinking ethically about the social issues that arise as our knowledge grows.

#### Expectations:

- Review the course orientation.
- Determine the difference between genetics and genomics.
- Trace Gregor Mendel's work as the father of genetics, and become familiar with Mendel's basic tenets.
- Examine basic principles of inheritance such as autosomal dominant, autosomal recessive, sex-linked, and complex traits.
- Begin to build an organizational structure for thinking about ethical issues.
- Respond to the Discussion Question: Mendel
- Respond to the Discussion Question: Genetic Basis for Disease

### Week 2: Nature versus Nurture

"Nature vs. nurture" is a phrase used widely to express the long-standing debate about whether genes are the primary influence on human development or whether the role of environmental influences is greater. The first essay explores the evidence showing that neither of these extremes is correct; we are the result of cooperation between genes and the environment. Next we consider the evolution of species by means of mutation, natural selection, and chance. In the final essay, we look at the science of epigenetics, which explores how changes to

DNA that aren't mutations can be passed on to future generations.

**Expectations:**

- Examine the way genes and environment “cooperate.”
- Learn how studies of twins tease out the effect of the environment on traits.
- Analyze what determines the evolution of a species.
- Trace the history of the genetic modification of plants.
- Respond the Discussion Question: Nature vs. Nurture
- Respond to the Discussion Question: DNA and Variety

**Week 3: The Human Genome**

In the year 2000, the company Celera and the official Human Genome Project jointly announced the first working draft of the human genome. Since then genomic technology has advanced considerably and the focus of research has changed. The week begins by defining what a genome is and how it differs from person to person. We then explore what coding and non-coding DNA is, and examine some ways that the latter functions in a cell. A review of the history of genetic lab techniques helps put the rapid advance of genomic science into perspective. An assignment allows learners to explore an online catalog of human genes and genetic disorders. This week, learners also begin to consider the final project options.

**Expectations:**

- Learn about the Human Genome Project.
- Recognize the elements of a genome.
- Learn about our current understanding of microRNAs.
- Trace the genetic discoveries and the development of molecular lab techniques from the 1940s to the present
- Become familiar with the molecular laboratory techniques used for extracting, sequencing, and analyzing DNA sequences.
- Learn about the Human Microbiome Project.
- Respond to the Discussion Question: OMIM
- Present preliminary thoughts on the final project
- Complete the assignment:

**Week 4: Applications of Genomics**

Modern genomic techniques have raised issues about how to handle and use the enormous amount of data that's being generated. This week, learners find out how the technique of metagenomics is changing the way we understand the diversity of life around us, including the microbes that live in and on our own bodies. The role of model organisms is introduced. One of the major long-term goals of the Human Genome Project was the assessment of human variation. Why is human variation so interesting, and what are its implications for our species? Finally, learners explore what our growing knowledge of the human genome allows us to infer about our past, and the potential for genomics to influence medical treatment. A computer simulation will help us understand the process of Polymerase Chain Reaction (PCR).

**Expectations:**

- Recognize tools used for measuring gene activity.
- Consider the implications of the enormous amounts of data generated by the Human Genome Project.
- Explore the idea of differences between genomes, and genetic variation within humans.
- Examine why particular organisms (e.g., the fruit fly) are considered genetic model organisms.
- Recognize important genetic similarities and differences and the implications of these constants and variations.
- Interact with the Polymerase Chain Reaction simulation to determine what lab techniques can reveal about DNA sequence.
- Complete the PCR assignment
- Respond to the Discussion Question: The Human Genome Project and You

### **Week 5: The Ethical Implications of Reshaping our World**

The Genomic Age has yielded amazing breakthroughs, but it will also affect and challenge conventional ethics. In a short summary, Dr. Rob DeSalle introduces the complex subject of genethics and defines several questions that society is likely to face in the near future. In a guest lecture, David and Sheila Rothman discuss the pros and cons of using human gene-technology for life improvement rather than to cure disease. The implications of new cloning technologies are presented, including the issue of cloning humans. We discuss the application of PCR to identify and conserve an endangered species, as well as the implications of genomic technology for agriculture. An assignment addresses ethical issues involved in the treatment of Parkinson's disease. Learners submit an outline of their final project.

#### **Expectations:**

- Learn about the ethical issues that arise as our knowledge of our genome increases.
- Reflect on possible uses and abuses of the new genetic technology.
- Investigate the differences between cure and genetic enhancement in humans.
- Review the techniques used in cloning.
- Examine the pros and cons of increasing our life spans.
- Complete the Assignment: Parkinson's Disease
- Respond to the Discussion Question: Cure and Enhancement
- Complete an outline of the Final Project

### **Week 6: The Ethical Implications of Reshaping our World (Part II)**

This week, our growing knowledge of our genome gives us new ways to think about who we are. Eminent bioethicist Arthur Caplan uses real-life examples to describe some of the moral dilemmas that genetic information poses, and that promise to become more common and more problematic in the near future. The second essay discusses "DNA fingerprinting," a molecular technology that has become central to forensics, paternity testing, conservation biology, evolutionary biology and ancestry research. "Darwin's Pedigree" traces his mitochondrial lineage to arrive at some findings that might have intrigued the great scientist. The final essay address the thorny relationship between race and ancestry, and how genetic information can inform who we *think* we are. Learners submit their final project.

#### **Expectations:**

- Learn about the implications of genomic technology on identification of individuals and ancestry.
- Trace Charles Darwin's ancestry through his Y Chromosome.
- Examine our understanding of the genetics of race.
- Respond to the Discussion Question: Hypothetically . . .
- Complete the Assignment: Parkinson's Disease Part II
- Complete the Final Project