This course is a unique classroom-based undergraduate research experience. It is part of the Howard Hughes Medical Institutes Science Education Alliance Phage Research Program. Throughout this semester, you will learn about the biology of bacterial viruses by identifying a new one from the environment. Your work will be connected to a larger community of undergraduate and graduate-level research scientists that are exploring the biology and evolution of bacteriophages. The research is centered at the University of Pittsburgh in Dr. Graham Hatfull’s laboratory and your lab work in our lab will be a new and novel contribution to this ongoing scientific project. If this semester excites you, there will be the opportunity to continue next semester as we explore one of your phages newly sequenced genomes.

Course objectives:
By the end of this class, you should be able to:
- Isolate a novel bacterial virus from the environment
- Work comfortably with bacteria and bacteriophage
- Conduct scientific research by keeping lab notes, labeling materials, and tracking your experimental work
- Explain the basics of bacteriophage biology
- Understand and perform the following lab techniques; aseptic pipetting, plating of bacteriophage, PCR, gel electrophoresis, genomic DNA isolation, restriction enzyme digestion, and preparing a sample for transmission electron microscopy.
- Form hypotheses, test them experimentally, and form conclusions.
- Interpret experimental data

Biology 111 Lab Student Learning Objectives can be found in the syllabus section on OAKS

Electronics Policy: We will be working with Biosafety Level 1 (BSL1) bacteria on a daily basis. All cell phones will need to be stored in your backpack and cannot be at your lab bench during the lab. Laptops may be used, when needed for lab activities, in the seating area of the lab. Laptops cannot be used at your lab bench.

Lab Safety: We will be following the approved School of Science and Math lab safety procedures. We will go over these guidelines in class a copy of them can be found in the syllabus section of our OAKS page.
Course Activities

- Participation 25%
- Pipetting Quiz 5%
- Quizzes and Pre-Lab Homework 25%
- Notebook Checks 10%
- Phage Paper Assignments 20%
- Lab Final Practical Exam 15%

Quizzes: There will be 2-3 quizzes that will be taken in class that will assess your understanding of the lab protocols, procedures, and experimental findings.

Pre-Lab Homework: Prior to each class period you will complete an online quiz in OAKs that asks you questions about that week’s laboratory protocols and experimental goals. This homework will be untimed and open note. In fact, I encourage you to use the protocols that are online to complete the homework.

Phage Paper Assignments: These short homework assignments will involve learning to read papers about phage biology, provide an opportunity to build some analytical skills, and help you build confidence in your ability to read the and understand primary literature

Lab Practical Exam: There will be a final practical exam that will test your knowledge of our semester of research. This exam will focus on the practical lab skills we have learned through out the semester.

Notebook Checks: You will be required to keep a detailed record of all that you do in phage lab. This will occur in a Google document that you and I will have access to. I will start the document and then share it with you using your g.cofc.edu account. You will be responsible for properly documenting your experiments by taking notes in your notebook. I will periodically comment on your notebooks for clarity and content

Participation: Your participation grade in lab will be determined by your attendance, daily lab notes and the development of your lab skills.

- Development of your lab skills and general attitude –
  - Skill in executing and interpreting experiments
  - Manipulation of hypotheses using new information
  - Communication of results and ideas
  - Intrinsic curiosity about the world
  - Willingness to fail multiple times before giving up
  - Independence and objectivity
  - Asking good questions
Office Hours: I encourage you to see me as the first person that you go to when you are in need of additional help in my class or would like general advice about your academic path here at the college. As your FYE faculty member, I consider myself an unofficial advisor for your first year on campus. In addition to my schedule office hours, please feel free to come by my office at any time. I will also be happy to meet with you in my office anytime by appointment.

Missing Class Time: You must attend all lab meetings since each day builds on the previous day’s work. All the good stuff is going to happen in the interactions between us as we work together in the lab. If for whatever reason you cannot make it to class, it is your responsibility to communicate that to me and arrange to catch up with the lab work. Students must provide a valid and documented excuse from the Undergraduate Dean’s Office in the case of missing an exam. Acceptable excuses include illness, personal tragedy or circumstances beyond the student’s control.

Tardiness: Showing up late to class is both disrespectful and prevents you and your fellow students from being fully engaged in the course. Showing up in the last quarter of the class meeting time will be treated as an absence.

Course Grade: I will ask a lot of you in this class and I am confident that you are up to the challenge. There is no curve in this class; your grade depends only on your own effort put forth in the class. Grades will be assigned based on the total points you have accumulated.

Grading Scale and Expectations: A (93.5-100), A- (90-93.49), B+ (88.5-89.9), B (83.5-88.49), B- (80-83.49), C+ (78.5-79.9), C (73.5-78.49), C- (70-73.49), D+ (68.5-69.9), D (63.5-68.49), D- (60-63.49), F (<60)

Equal Access: I am happy to work with all students to ensure that they have equal access to the educational experience of this class. The College will make reasonable accommodations for persons with documented disabilities. Students should apply at the Center for Disability Services / SNAP, located on the first floor of the Lightsey Center, Suite 104. Students approved for accommodations are responsible for notifying me as soon as possible and for contacting me one week before accommodation is needed.

Honor Code and Academic Integrity
Lying, cheating, attempted cheating, and plagiarism are violations of our Honor Code that, when identified, are investigated. Each instance is examined to determine the degree of deception involved. Incidents where I believe that a student’s actions are clearly related more to ignorance, miscommunication, or uncertainty, will be addressed by consultation with me. We will craft a written resolution designed to help prevent future repetition of this error in the future. This resolution, submitted by form and signed by both the student, and me is forwarded to the Dean of Students and remains on file.

I will report cases of suspected academic dishonesty directly to the Dean of Students. A student found responsible for academic dishonesty will receive a XF in the course, indicating failure of the course due to academic dishonesty. This grade will appear on the student’s transcript for two years after which the student may petition for the X to be expunged. The student may also be placed on disciplinary probation, suspended (temporary removal) or expelled (permanent removal) from the
College by the Honor Board.

It is important for students to remember that unauthorized collaboration--working together without permission--is a form of cheating. Unless I specify that you can work together on an assignment and/or test, no collaboration is permitted. Other forms of cheating include possessing or using an unauthorized study aid (such as a PDA), copying from another’s exam, fabricating data, and giving unauthorized assistance.

You can find a complete version of the Honor Code and all related processes in the Student Handbook.
# Tentative Schedule of Lab Activities

**Due to the research-based nature of this lab, dates and course content on this syllabus are subject to change**

<table>
<thead>
<tr>
<th>Date</th>
<th>Lab Activities</th>
<th>Reading Before Lab</th>
<th>Pre-Lab Assignments</th>
</tr>
</thead>
</table>
| Aug 25 | • Course overview  
• Aseptic technique  
• Using pipettes  
• Label tubes for environmental sample collection | | |
| Sept 1 | • Bacteriophage biology/Phage vocabulary  
• Labeling and note taking  
• Direct Phage Isolation  
• Enrichment Preparation  
• Plaque Assay | • Phage and Host Basics  
• Direct Phage Isolation  
• The Gene Weavers | • Environmental Sample Collection  
• Pre-Lab Homework in OAKs quiz section |
| 8 | • Purify the phage: Plaque Assay | • Picking a Plaque  
• Plaque Assay for Purification  
• Serial Dilutions | • Homework 1  
• Pre-Lab Homework in OAKs quiz section |
| 15 | • Purify the phage: Plaque Assay | • To Be Determined | • Homework 2  
• Pre-Lab Homework in OAKs quiz section  
• In Class: Pipetting Quiz |
| 22 | • Plate Lysate/Spot Titer | • Collecting Plate Lysates  
• Spot Titer | • Homework 3  
• Pre-Lab Homework in OAKs quiz section |
| 29 | • Full Plate Titer | • Full Plate Titer | • Homework 4  
• Pre-Lab Homework in OAKs quiz section |
| Oct 6 | • Titer Determination  
• Infection for High Titer Lysate | • Making a Webbed Plate  
• Actinobacteriophage Database | • Homework 5  
• Pre-Lab Homework in OAKs quiz section |
| 13 | • High Titer Plate Lysate  
• Final Titering  
• Lysogen Creation | • Creating and Testing Lysogens  
• Archiving Your Samples | • Homework 6  
• Pre-Lab Homework in OAKs quiz section |
| 20 | • Determine Titer  
• Genomic DNA Isolation  
• DNA Concentration  
• Lysogen Creation | • DNA Extraction | • Homework 7  
• Pre-Lab Homework in OAKs quiz section |
<table>
<thead>
<tr>
<th>Date</th>
<th>Genomic DNA – Restriction Digest</th>
<th>TEM – Phage Preparation</th>
<th>Restriction Enzyme Digests</th>
<th>TEM Preparation</th>
<th>Homework 8</th>
<th>Pre-Lab Homework in OAKs quiz section</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Genomic DNA – Restriction Digest</td>
<td>TEM – Phage Preparation</td>
<td>Restriction Enzyme Digests</td>
<td>TEM Preparation</td>
<td>Homework 8</td>
<td>Pre-Lab Homework in OAKs quiz section</td>
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<tr>
<td>Nov</td>
<td>Gel Electrophoresis</td>
<td>Lysogen Creation</td>
<td>Gel Electrophoresis</td>
<td>Lysogen Creation</td>
<td>Homework 9</td>
<td>Pre-Lab Homework in OAKs quiz section</td>
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<tr>
<td>3</td>
<td>Flex Days</td>
<td>Lysogen Creation</td>
<td>Gel Electrophoresis</td>
<td>Lysogen Creation</td>
<td>Homework 9</td>
<td>Pre-Lab Homework in OAKs quiz section</td>
</tr>
<tr>
<td>10</td>
<td>Flex Days</td>
<td>Lysogen Sensitivity Testing</td>
<td>Gel Electrophoresis</td>
<td>Lysogen Creation</td>
<td>Homework 10</td>
<td>Pre-Lab Homework in OAKs quiz section</td>
</tr>
<tr>
<td>17</td>
<td>Flex Days</td>
<td></td>
<td></td>
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<tr>
<td>24</td>
<td>Thanksgiving Break</td>
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<tr>
<td>Dec</td>
<td>Flex Days/ Lab Practical Exam</td>
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Introduction to Cell and Molecular Biology/Evolution, Form, and Function of Organisms
BIOL 111 & 111L/BIOL 112 & 112L
Department: Biology

Learning Goals & Objectives

This general education science sequence provides a background for understanding and evaluating contemporary topics in biology. Students develop a foundational understanding of core concepts to use and on which to expand in upper level courses. They also develop the critical competencies that form the bases for the practice of science and use of scientific knowledge.

Core Concepts

This 2-semester course sequence in general biology addresses fundamental principles in biology to prepare students for sophomore and upper level courses in biology:

- **EVOLUTION**: The diversity of life evolved over time by processes of mutation, selection, and genetic change. The theory of evolution by natural selection allows scientists to understand patterns, processes, and relationships that characterize the diversity of life.
- **STRUCTURE AND FUNCTION**: Basic units of structure define the function of all living things. Structural complexity, together with the information it provides, is built upon combinations of subunits that drive increasingly diverse and dynamic physiological responses in living organisms. Fundamental structural units and molecular and cellular processes are conserved through evolution and yield the extraordinary diversity of biological systems seen today.
- **INFORMATION FLOW, EXCHANGE, AND STORAGE**: The growth and behavior of organisms are activated through the expression of genetic information at different levels of biological organization and depend on specific interactions and information transfer.
- **PATHWAYS AND TRANSFORMATIONS OF ENERGY AND MATTER**: Biological systems grow and change by processes based upon chemical transformation pathways and are governed by the laws of thermodynamic and will be explored to understand how living systems operate, how they maintain orderly structure and function, and how physical and chemical processes underlie processes at the cellular level (i.e. metabolic pathways, membrane dynamics), organismal level (i.e. homeostasis) and ecosystem level (i.e. nutrient cycling).
- **SYSTEMS**: Living systems are interconnected and interacting and biological phenomena are the result of emergent properties at all levels of organization, from molecules to ecosystems to social systems. The course will explore the dynamic interactions of components at one level of biological organization to the functional properties that emerge at higher organizational levels.
The specific topics covered in each course include:

**Biology 111 & Biology 111L**

- Chemical and physical properties of life
- Cell form & function
- Energetics, metabolism, and photosynthesis
- The cell cycle
  - Mitosis and cell reproduction
  - Meiosis and sexual reproduction
- Mendelian genetics / Patterns of inheritance
- Human Inheritance
- The molecular basis of inheritance
- DNA and protein production
- Regulation of gene expression
- Some aspects of biotechnology

**Biology 112 & Biol 112L**

- The development of evolutionary thinking
- Basic evolutionary processes
- Comparative plant form & function
- Comparative animal form & function

**Core Competencies**

- **Nature of Scientific Knowledge**
  - Understand the intellectual standards used by scientists to establish the validity of knowledge, evidence, and decisions about hypothesis & theory acceptance. These standards include: 1) science relies on external and naturalistic observations, and not internal convictions; 2) scientific knowledge is based on the testing of hypotheses and theories, which are under constant scrutiny and subject to revision based on new observations; 3) the validity of scientifically generated knowledge is established by the community of scientists through peer review and open publication of work.
  - Understand that new ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.
  - Understand that science operates in a world defined by the laws of chemistry and physics.
  - Understand the differences and relationships among scientific theories, hypotheses, facts, laws, & opinions.
  - Understand the differences between science and technology, but also their interrelations.
  - Understand the dynamic (tentative) nature of science.

- **Scientific Methods of Discovery**
Understand the methods scientists use to learn about the natural world (observing; questioning; formulating testable deductive hypotheses; controlled experimentation when possible; observing a wide range of natural occurrences and discerning (inducing) patterns).

Apply physical/natural principles to analyze and solve problems.

- **Develop a Scientific Attitude**
  - Develop habits of mind that foster interdisciplinary and integrative thinking (within biology; between biology and other sciences; between science and other disciplines).
  - Develop an appreciation for the scientific attitude - a basic curiosity about nature and how it works.

- **Develop scientific analysis and communication skills**
  - Develop quantitative reasoning skills (quantitatively expressing the results of scientific investigations, or patterns in nature and using knowledge of biological concepts to explain quantitatively-expressed data or patterns).
  - Understand the probabilistic nature of science and the use/application of inferential statistics to test hypotheses.
  - Develop scientific information literacy (library, internet, databases etc...); find and evaluate the validity of science-related information.
  - Communicate scientific knowledge, arguments, and ideas in a variety of different contexts (scientific, social, cultural), utilizing a variety of different media (scientific articles, policy statements, editorials, oral presentations etc.).
  - Develop cooperative problem-solving skills (working effectively in teams), but also habits of mind and skills that foster autonomous learning.

- **Develop an appreciation for the impact of science on society**.
  - Develop an appreciation of humans as a part of the biosphere and the impact of biological science on contemporary societal/environmental concerns.
  - Knowledge of the history of the biological sciences and the influences of politics, culture, religion, race, and gender on the scientific endeavor.

Signature assignments for measuring learning outcomes

**Learning Outcome 1: Students apply physical/natural principles to analyze and solve problems.**

This learning outcome is assessed using the poster (or scientific article) generated in Biology 112 lab as part of the multi-week student-directed independent research project. In this project students use data they collect (or has been collected in actual research investigations) to test an hypothesis of their choosing. These projects may be themed, with all student groups addressing different aspects of a larger question, emphasizing the interdependence of various research groups needed to address complicated problems. This

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1 This learning goal will be measured as part of the general education assessment. The specific learning outcome to be measured is: **Students can apply physical/natural principles to analyze and solve problems.**

2 This learning goal will be measured as part of the general education assessment. The specific learning outcome to be measured is: **Students can demonstrate an understanding of the impact that science has on society.**
A multi-week project begins the class identifying what questions need to be addressed in the larger problem. Individual student groups then become experts in these areas of the larger problem. The smaller research teams develop a hypothesis, and write a research proposal to test their hypothesis. Students collect (or use already collected data), summarize and statistically analyze the data, and draw conclusions.

**Learning Outcome #2** - Students demonstrate an understanding of the impact that science has on society.

**Biology 112 lab** Students produce a written document based on one of the case-based labs (examples - policy statement, article, stake-holder professional letter or poster) that requires them to research and apply biological knowledge or evidence to defend or critique a proposed solution to a biology-related societal issue. Although the choice of the specific issue or proposed solution is course-section specific, some examples of potential issues include:

- exploring environmental/health impacts of genetically modified organisms
- the use of performance enhancing drugs in sports
- the development of antibiotic resistance in disease organisms