Term Information

Effective Term	Autumn 2017

General Information

Course Bulletin Listing/Subject Area	Biology
Fiscal Unit/Academic Org	Introductory Biology - D0326
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	1110
Course Title	Biology for the Health Sciences
Transcript Abbreviation	Bio for Health Sci
Course Description	Catalog Description: A survey of biological topics including evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems intended as preparation for Pre-Nursing and Pre-HRS students. Not intended for students on a Pre-Medicine or related track, or for students intending to major in biology or related areas.
Semester Credit Hours/Units	Fixed: 4

Offering Information

Length Of Course	14 Week, 12 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Laboratory, Lecture
Grade Roster Component	Lecture
Credit Available by Exam	Yes
Exam Type	EM Tests via Office of Testing
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus

Prerequisites and Exclusions

Prerequisites/Corequisites	None.
Exclusions	Not open to students with credit for 1101 (101), 1102 (102), 1113 (113), or 1114 (114).

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	26.0101
Subsidy Level	General Studies Course
Intended Rank	Freshman, Sophomore, Junior, Senior

Requirement/Elective Designation

General Education course:

Biological Science

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Apply core concepts in biology through the study of Structure and Function.
- Apply core concepts in biology through the study of Pathways and Transformations of Energy and Matter.
- Apply core concepts in biology through the study of Information flow, Exchange and Storage.
- Apply core concepts in biology through the study of Evolution.
- Apply core concepts in biology through the study of Systems.
- Synthesize core biological concepts to explain observations of current events in the natural world.
- Demonstrate an understanding of the nature of science.
- Analyze the significance of technological innovation and its interaction with science on society. Explore potential consequences of technology on society.
- Demonstrate the ability to work collaboratively.

Content Topic List

- Identify properties of life
- Identify macromolecules of biological systems and the role diet plays in their acquisition.
- Identify structural differences in prokaryotes, eukaryotes, viruses, retroviruses, and prions and how they relate to treatment of disease.
- Explain processes of cell growth, reproduction, and apoptosis.
- Explain variation in processes of cellular division between various cell types.
- Analyze how instances of loss of control in cellular regulation processes result in various medical conditions.
- Describe processes of osmosis and diffusion and apply concepts to human health.
- Explain the biochemical pathways of energy flow through biological systems and how they are governed by the laws of thermodynamics.
- Explain the interaction between the processes of photosynthesis, cellular respiration, and fermentation and the variations that exist between taxa.
- Apply effects of diet and exercise on cellular respiration.
- Apply the effects of fermentation on energy production.
- Explain the role of enzymes in biological systems.
- Explain Gene Theory and its origins.
- Identify the role of DNA and RNA in biological systems.
- Describe applications of recombinant DNA technology and evaluate social implications that continue to arise as a result of technological developments.
- Explain principles of Mendelian genetics and Heredity Theory.
- Apply Mendelian genetics to explain inheritance of disease.
- Explain basic assumptions and conclusions of natural selection.
- Explain the role of genetic drift in evolution of populations.
- Explain how two populations can diverge genetically over generational time.
- Apply concepts of evolution to the dynamic problem of antibiotic resistance and vaccine production.
- Identify biodiversity of taxonomic kingdoms and select animal phyla.
- Identify the nature of pathogenic organisms.
- Apply ecological and evolutionary principles to interactions between taxa as related to energy flow.
- Identify various human impacts on the environment and evaluate potential solutions.
- Explain the role of hypotheses and theories in the scientific method.
- Apply knowledge of the scientific method to derive hypotheses and design experiments to test those hypotheses.
- Interpret data presented through tables or graphs and apply quantitative reasoning when reading and writing scientific papers.
- Communicate conclusions drawn from own experimental data and evaluate those of others.
- Explain the nature of science as a human endeavor with its assumptions and limitations.
- Explain the self-correcting nature of science.

Attachments

- Proposal for Biology 1110.docx: Course Proposal

  (Other Supporting Documentation. Owner: Andrews,Adam Lee)

- Biology 1110 Sample Syllabus.pdf: Course Syllabus

  (Syllabus. Owner: Andrews,Adam Lee)

- Biology 1101 Proposal Addendum.pdf: Proposal Addendum 10/26/16

  (Other Supporting Documentation. Owner: Andrews,Adam Lee)

Comments

- I have addressed each of the Panel's concerns in the document entitled Proposal Addendum (10/26/16) *(by Andrews,Adam Lee on 10/26/2016 12:54 PM)*
- see email 10-20-16 *(by Hogle,Danielle Nicole on 10/20/2016 12:07 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Andrews,Adam Lee	09/20/2016 02:09 PM	Submitted for Approval
Approved	Misicka,Matthew Alan	09/20/2016 02:32 PM	Unit Approval
Approved	Fink,Steven Scott	09/21/2016 10:44 AM	College Approval
Revision Requested	Hogle,Danielle Nicole	10/20/2016 12:07 PM	ASCCAO Approval
Submitted	Andrews,Adam Lee	10/26/2016 12:55 PM	Submitted for Approval
Approved	Misicka,Matthew Alan	10/26/2016 02:44 PM	Unit Approval
Approved	Fink,Steven Scott	10/27/2016 09:23 AM	College Approval
Pending Approval	Nolen,Dawn Vankeerbergen,Bernadette Chantal Hanlin,Deborah Kay Jenkins,Mary Ellen Bigler Hogle,Danielle Nicole	10/27/2016 09:23 AM	ASCCAO Approval

Appendix E: Sample Syllabus
Biology 1110: Biology for the Health Sciences
Autumn 2017 – 4 credit hours

Lecturer:

Course Coordinator: Adam L. Andrews
Center for Life Sciences Education
255B Jennings Hall
1735 Neil Avenue
Phone: 247-6345
email: andrews.171@osu.edu

Program Assistant: Valerie Gilbert
Center for Life Sciences Education
240A Jennings Hall
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Assistant Coordinator: Erica Szeyller
Center for Life Sciences Education
255D Jennings Hall
1735 Neil Avenue
Phone: 688-5495
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Head Teaching Associate:

Safe Ride Service
Service available from 7:30P-2:40A
614-292-3322
https://dps.osu.edu/safe-ride
Twitter: OhioStateSSS

Class Meeting Schedule

Lecture: 3 hours weekly
Lab: 3 hours, once weekly – *See your BuckeyeLink schedule*

Required Course Materials

Biology: Concepts and Investigations (3rd Edition) by Mariëlle Hoefnagels – ISBN: 978-0-07-352554-9
Biology 1110 Laboratory Manual 2017-2018 Edition; ISBN:
Cell Phone or Internet-connected device (i.e. smart phone, laptop, tablet, etc.)

Internet Access: Your access to Carmen is an integral and necessary part of this course. You must activate your OSU email account to have access to Carmen. The Carmen URL is http://carmen.osu.edu and Biology 1110 should be listed under My Courses on your Carmen homepage. The username to log on is your OSU name.# and the password is the one you use with all OSU email and registration systems. If you have a problem logging in or using Carmen, contact 688-HELP or carmen@osu.edu. IMPORTANT: The CLSE and its course staff will send email ONLY to your official OSU email account.

General Education Natural Science Goals & Objectives

Students who successfully complete this course will fulfill the following GE Natural Science goals and objectives:

Goals/Rationale: Students understand the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

Learning Objectives:

1. Students understand the basic facts, principles, theories and methods of modern science.
2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.
3. Students describe the inter-dependence of scientific and technological developments.
4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

Students in Biology 1110 will be exposed to a survey of the biological world, using foundational knowledge to apply core concepts in biology (evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems) to a variety of topics of current interest. Themes in the course will include the dynamic nature of scientific discovery and how the fundamental science is translated to applied science through technology. Students will analyze the ethical consequences to and impacts on society that come with technology. The laboratory component of the course will give students the opportunity to experience a hands-on approach to the concepts and technology introduced in lecture, while the assignments throughout will both address core concepts and require reflection on philosophical issues resulting from scientific discovery.

Biology 1110 Learning Outcomes:

Upon successful completion of Biology 1110, students will demonstrate the ability to:

1. Apply core concepts in biology through the study of specific subject areas:
    a. Structure and Function
        i. Identify properties of life
        ii. Identify macromolecules of biological systems and the role diet plays in their acquisition.
        iii. Identify structural differences in prokaryotes, eukaryotes, viruses, retroviruses, and prions and how they relate to treatment of disease.
        iv. Explain processes of cell growth, reproduction, and apoptosis
        v. Explain variation in processes of cellular division between various cell types
        vi. Analyze how instances of loss of control in cellular regulation processes result in various medical conditions
        vii. Describe processes of osmosis and diffusion and apply concepts to human health
    b. Pathways and Transformations of Energy and Matter
        i. Explain the biochemical pathways of energy flow through biological systems and how they are governed by the laws of thermodynamics.
        ii. Explain the interaction between the processes of photosynthesis, cellular respiration, and fermentation and the variations that exist between taxa.
        iii. Apply effects of diet and exercise on cellular respiration.
        iv. Apply the effects of fermentation on energy production
        v. Explain the role of enzymes in biological systems.
    c. Information flow, Exchange and Storage
        i. Explain Gene Theory and its origins.
        ii. Identify the role of DNA and RNA in biological systems.
        iii. Describe applications of recombinant DNA technology and evaluate social implications that continue to arise as a result of technological developments.
        iv. Explain principles of Mendelian genetics and Heredity Theory
        v. Apply Mendelian genetics to explain inheritance of disease
    d. Evolution
        i. Explain basic assumptions and conclusions of natural selection
        ii. Explain the role of genetic drift in evolution of populations
        iii. Explain how two populations can diverge genetically over generational time
        iv. Apply concepts of evolution to the dynamic problem of antibiotic resistance and vaccine production.
    e. Systems
        i. Identify biodiversity of taxonomic kingdoms and select animal phyla.
        ii. Identify the nature of pathogenic organisms.
        iii. Apply ecological and evolutionary principles to interactions between taxa as related to energy flow.
        iv. Identify various human impacts on the environment and evaluate potential solutions.
2. Synthesize core biological concepts to explain observations of current events in the natural world.
3. Demonstrate an understanding of the nature of science, including:

a. Explain the role of hypotheses and theories in the scientific method.
b. Apply knowledge of the scientific method to derive hypotheses and design experiments to test those hypotheses.
c. Interpret data presented through tables or graphs and apply quantitative reasoning when reading and writing scientific papers.
d. Communicate conclusions drawn from own experimental data and evaluate those of others.
e. Explain the nature of science as a human endeavor with its assumptions and limitations.
f. Explain the self-correcting nature of science.

4. Analyze the significance of technological innovation and its interaction with science on society. Explore potential consequences of technology on society.
5. Demonstrate the ability to work collaboratively.

Grading and Evaluation

Your mastery of the course material will be based on seven quizzes administered through Carmen, two midterms, and a comprehensive final exam. Both exams will be administered in class according to the schedule at the end of the syllabus. Material on the quizzes and exams will come from the lectures and labs.

Midterm and Final Exam:

There will be two midterms given during the normal lecture time that will each be worth 100 points. A comprehensive final exam worth 150 points will be given at the time prescribed by the University Registrar. Both exams are listed on the course schedule below. The format for both exams will be multiple choice, true/false, and short answer.

Online Quizzes:

There will be 6 quizzes in this course, worth 15 points each. Use these quizzes to gauge your understanding of course material. Quiz questions will be all multiple choice and administered through the Carmen outside of class. Quizzes **will be open for 72 hours** and you will have until **11:59 pm on the day listed on the syllabus** to complete the quiz. Quizzes will be timed (15 minutes) and you will have **two attempts** at each with the higher score recorded. Questions will be pulled from a pool of questions so that quizzes will not necessarily be the exact same across students. Due to the extended window of time you have to complete the quizzes, extensions and makeup opportunities will not be given except in the most extreme of situations. You are strongly encouraged not to wait until the last minute to complete the quiz as technological issues (i.e. internet or power failures, etc.) will not be grounds to extend the quiz window. Should a technological issue arise, please contact the lecturer immediately. It may be possible to reset a quiz attempt during the quiz window, but deadlines will not be extended if the attempt is not reset or technical problems are not solved before the deadline.

Lecture Participation**:**

We will use TopHat every time we meet in lecture to allow students to become active participants. **No makeup opportunities will be available for missed lectures or non-functioning technology.** For each *correctly answered* question in lecture, you will earn one point. Once you earn 70 points, the next 10 correctly answered questions will be worth 0.5 *bonus* points each. The subsequent 20 correctly answered questions will be worth 0.25 bonus points each, for a total of 10 possible bonus points. It is therefore beneficial for you to come to lecture and participate, even after you have earned the 70 participation points!

**Please note that responding to questions as a proxy for another student will result in BOTH students being reported to the Committee on Academic Misconduct and immediate loss of ALL Lecture Participation points for the course.*

***TopHat Registration:** At the beginning of the semester, we will provide instructions on how to register so that we will be able to link your answers to your OSU name.#; this allows us to know who was in class and to record your answers to the questions. Proper registration is **required** by **Monday, August 28, 2015**. After this deadline, a student will not be eligible to recoup points from previous

lectures***. You must check your grade on Carmen to verify you are earning points.*** Please see announcements on Carmen for further details.

Discussion Articles:
Twice throughout the semester, you will be asked to read an article posted to Carmen. There will be two parts to the assignment associated with each article. First, you must write a one page reaction to the article, consisting of at least two paragraphs (approx. 100-150 words each). The first paragraph is a short summary of the article. The second paragraph is to be your reaction to the article. This page must be typed, and turned in *to the Carmen dropbox* NO LATER than the start of the class period in which the discussion is occurring. You will receive up to 10 points for the summary. During the respective class discussions in lab, all students will be expected to vocally express their comments regarding the article. You will receive 10 points for your **active** participation. No makeup points are available if you are not in class for the discussion, or choose not to say anything. No late summaries will be accepted.

Laboratory: will be assessed on the basis of 290 points:

- Lab Exercises: Each of 9 laboratory exercises will be graded on a 20 point scale. Two points will be for the pre-lab to be completed and turned in *by the start of the lab period*. 18 points will be for completion of the lab report *as a group during lab*.
- PARE: The PARE project will be integrated throughout the lab periods. There will be three pre-lab assignments (2 points each), 3 lab exercises to be completed and turned in (18 points each), technique points worth 20 points, a final report worth 50 points, an oral presentation of results worth 20 points, and a poster worth 50 points.
- Lab Instructor Points: Your participation in lab exercises and cooperative learning opportunities will be monitored by your lab instructor and graded on the basis of 30 points. Your lab instructor will individually specify exactly how these points will be distributed.
- Peer Evaluation: During the last week of the semester you will be asked to evaluate the efforts of your group mates in lab. Your score will be an average of the scores assigned to you by each of the group members and a rating of your own participation, with maximum points of 20. Failure to complete the survey will result in a zero for that student but will not affect group members.

Student Assessment of Learning Gains:
During the last week of the semester you will be asked to complete a survey of the course through Carmen. Completion will be worth 5 points.

LECTURE

2 Midterm Exam (100 pts each)	200
1 Final Exam	150
6 Quizzes (15 pts each)	75
2 Discussion Articles (20 pts each)	40
Lecture Participation	70
SALG	5
	540

LAB

10 Lab Exercises (20 pts each)	200
PARE Project	200
Lab Instructor Points	30
Peer Evaluation	20
	450

Final Grades:
Your final grade will be based on the percentage of the 990 points that you earn during the course of the semester, as indicated below. Please note that we do not grade the course on a curve and *Carmen* does not round scores up to the next nearest percentage point, so 92.11% and 92.97% both earn the grade of A-.

Grade Scale

93-100%:	A	80-82.9%:	B-	67-69.9%:	D+
90-92.9%:	A-	77-79.9%:	C+	60-66.9%:	D
87-89.9%:	B+	73-76.9%:	C	≤59.9%:	E
83-86.9%:	B	70-72.9%:	C-		

Posting Of Grades:
All grades will be posted on Carmen. After grades are posted you have 10 working days to challenge any grade or inquire regarding an unposted or missing grade. **After that time, grades are final as posted or zero if missing.** To challenge or inquire about an in-class activity, contact your TA. To challenge or inquire about exam grades, contact the lecturer to set up an appointment to find your scantron. IMPORTANT: Make sure that all of your grades are properly posted on Carmen as you receive them. Challenges about grades, particularly after the end of the semester, cannot be entertained after the 10-day grace period.

Late Assignments Policy:
No late assignments will be accepted. All assignments will have significant windows in which the assignment can be submitted. Please do not save assignment completion for the 'eleventh hour'. Deadlines will not be extended.

Absences:
If you are unable to take the exam at the regularly scheduled time, you must contact Adam Andrews (andrews.171@osu.edu) within 24 hours to schedule a makeup. If your absence is excused for a university-sanctioned event, if you are ill and have been seen by a medical practitioner on the day of the exam, or have other documentable reasons for missing, you may be offered a makeup exam without penalty. If you have no documentation to support your absence, or your absence from the exam is not for an excused reason, you will still be offered the opportunity for a makeup exam, with a 25% overall deduction on your exam score. Lack of transportation, loss of electricity, travel plans, etc. will not be considered as valid excuses. Arrivals to the exam after the first student has turned in an exam will be considered an unexcused absence, and the policy above will apply. The format for makeup assignments is at the discretion of the instructor.

The final exam is scheduled for TBA. Make sure that this time does not conflict with your future plans. No early exams will be given. The only makeup exam will be held on Friday, December 15 at 9:00am in Jennings Hall 270, and is available only with pre-approval from the course coordinator.

The laboratory portion of this course is an integral part of the learning experience. You are expected to come prepared to all lab sessions. This includes wearing appropriate clothing and footwear, having completed the pre-lab assignment, and having read and understood the lab you will be conducting that day – **this is critical**. (See the schedule below.) Each lab will have a pre-lab that must be submitted in person by the start of the lab period. Once class has begun, no further pre-lab activities will be accepted. Students arriving more than 15 minutes after the beginning of the lab session will not be permitted to stay, nor to earn credit for the missed lab. **Missing more than three labs (*excused or unexcused*) will result in the student being automatically assigned a failing grade for the course.** Students must contact their LAB INSTRUCTOR within two days of the original missed lab. There is no opportunity for a make-up assignment if a student contacts her/his LAB INSTRUCTOR on the third day or later. As part of this goal, makeup opportunities will only be given for circumstances beyond the student's control and must be accompanied by written documentation validating the absence. If you are too ill to attend class, you must receive documentation from a medical practitioner from the day of the absence. Attending a lab section other than your regularly scheduled lab is not permitted.

Section Changes: All section changes and adds are done by the Course Coordinator. Due to the need to keep up-to-minute availability of seats in each recitation, the lecturer and Lab Instructors are unable to sign any permission forms.

Academic Misconduct: It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed, illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/. We will adhere to this policy.

- Unless otherwise specified for a particular assignment, all submitted work should be a student's own unique effort. Collaborative efforts are not permitted unless expressly sanctioned for a particular assignment.
- Using others' verbatim words without the use of quotation marks *and* citation is plagiarism. Paraphrased work requires citation to denote the use of others' ideas. Copying other's words without quotation while using citations is still considered plagiarism.
- Use of any technology during a quiz or exam (including but not limited to cell phones, smart watches, headphones, electronic dictionaries, etc.) is strictly prohibited.

Diversity and Inclusion: The Center for Life Sciences Education promotes a welcoming and inclusive environment for all students and staff, regardless of race, age, religion, gender, ethnicity, national origin, disability, or sexual orientation. There is no tolerance for hateful speech or actions. All violations of this policy should be reported to the OSU Bias Assessment and Response Team (BART, www.studentaffairs.osu.edu/bias).

Sexual Harassment: OSU and the CLSE consider sexual harassment to be unacceptable behavior that destroys opportunities for learning. While all members of the staff involved in this course have been trained in the OSU sexual harassment policies and procedures, this is not true for all OSU students. Please report any concerns about questionable or unwanted behavior to the lecturer or Mr. Andrews.

Accommodation of Special Needs: Students with disabilities (including mental health, chronic or temporary medical conditions) that have been certified by the Office of Student Life Disability Services will be appropriately accommodated and should inform the course coordinator as soon as possible of their needs. Please do this within the first week of the semester. Only the course coordinator is authorized to sign ODS forms. Please fill out those parts of the proctor sheet forms that are to be completed by the student before bringing the form for signature. This will help us ensure that your individual needs will be met appropriately and fairly. The Office of Student Life Disability Services is located in 098 Baker Hall, 113 W. 12th Avenue; telephone 292-3307, slds@osu.edu.

Issue Resolution: The CLSE believes that student concerns are usually most effectively addressed by the staff closest to the situation. Therefore, students are ordinarily expected to address issues or concerns with their TAs first. If the issue cannot be resolved by your TA, or for some reason you feel that you absolutely cannot address your concern with your TA, please feel free to contact Adam Andrews, or Assistant Director Matt Misicka.

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Safe Ride Service: Safe Ride (614-292-3322) is a service provided to university students, faculty, and staff who would like safe transportation across campus. Rides are scheduled on a first-come first-serve basis. Phone lines open at 7pm and rides are available until 3am. For more information and service boundaries, please visit https://dps.osu.edu/safe-ride.

AUTUMN 2017 TENTATIVE SCHEDULE

Information in this syllabus is subject to change with as much notice to students as possible.

Week	Date	Lecture Topic	Reading	Laboratory (Week runs Wednesday through Tuesday)	Assignments
1	8/22-25	• Introduction to Biology 1110 • Why ask why? How and why do we do science? Themes in Life	Ch 1	Ex. 1: Nature of Science	
2	8/28-9/1	• Life's chemistry	Ch 2	Ex. 2: Macromolecules and Nutrition	
3	9/4-8	• **NO CLASS 9/4** • Where did cells come from? (Evolution of cells) • What does a cell look like and do?	Ch 3	Ex. 3: Osmosis and Diffusion	**Quiz 1 due**
4	9/11-15	• Biodiversity and microbiology • Viruses and Prions	Ch. 16-17, 18.1,18.6, 19.1, 20.1, 20.7, 21.1, 21.4, 21.7, 21.16	Ex. 4: Cell diversity	
5	9/18-22	• Its all about energy (Metabolism, Energy, Respiration and Photosynthesis)	Ch. 4, 5, 6	Ex. 5: Photosynthesis and cellular respiration	**Quiz 2 due**
6	9/25-9/29	• DNA, gene expression	Ch. 7	PARE I & II	**MIDTERM #1 in lecture** **Discussion #1 in Recitation**
7	10/2-6	• Chromosomes, Cell division	Ch. 8.1-8.5, 9	Ex. 6 Cell division	
8	10/9-13	• Cancer • **NO CLASS 10/12-13**	Ch. 8.6-8.8	**Recitations Only**	**Quiz 3 due**
9	10/16-20	• Genes and Inheritance • Genetic Disease	Ch. 10	PARE III & IV	
10	10/23-27	• Biotechnology	Ch. 11	PARE V & VI	**Quiz 4 due**
11	10/30-11/3	• Evolution and Natural Selection	Ch. 12-13	Ex. 7 Natural Selection	**MIDTERM #2 in lecture** **Discussion #2 in recitation**
12	11/6-10	• Speciation • **NO CLASS 11/10**	Ch. 14	Ex. 8 Speciation	**PARE Draft Report Due**
13	11/13-17	• Populations and Population Dynamics	Ch. 37	Ex. 9 Virulence	**Quiz 5 due**
14	11/20-24	• Ecological Relationships • **NO CLASS 11/22-24**	Ch. 38	**No Labs Sessions Meet**	**PARE Final Report Due**
15	11/27-12/1	• Human Impacts	Ch. 39-40	Ex. 10 Biofuels	**Quiz 6 due**
16	12/4-6	• Global Outlook	Ch. 39-40		
FINALS		**TBA**			

Proposal for Biology 1110: Biology for the Health Sciences
4 credit hours
3 lecture hours, 3 lab hours

Catalog Description: A survey of biological topics including cell structure and function, energetics, genetics, evolution, and ecology intended as preparation for Pre-Nursing and Pre-HRS students. Not intended for students on a Pre-Medicine or related track, or for students intending to major in biology or related areas.

Biology as a discipline can be broken into 5 core subject areas (evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems), all of which are typically addressed to some extent in introductory surveys of the biological sciences. The Center for Life Sciences Education currently offers two tracks for students in introductory biology. Students majoring in the life sciences take a two semester sequence, Biology 1113 and 1114, which when combined cover all five of these areas. Students taking Biology in fulfillment of a General Education (GE) Natural Science requirement who are not science majors have two primary options. Biology 1102 is a single-semester, non-laboratory course covering all of the subject areas, but with a primary focus in human form and function. Biology 1101 also covers the spectrum of the five areas with an additional required laboratory component, but with minimal emphasis on anatomy and physiology.

The endeavor to cover the entire spectrum of Biology in a semester is one that requires a specific approach for Biology 1101 and 1102. In our instruction, we aim primarily at a goal of scientific literacy for students. To be sure, students learn core facts and methods in science. We aim to focus on the bigger picture, however, so as to build students' core understanding of the nature of science and give instruction on how to best find reliable sources of information they may need in the future. Instructors have a great deal of freedom in deciding the depth of investigation and context of applications that they use to help the students learn the biological concepts.

We have been very successful using these methods, as borne out by our multiple methods of assessment, and have historically believed we were offering the best selection of courses possible to meet the needs of the Ohio State student population. Discussions with the College of Nursing have brought to our attention, however, that there is a population of students for whom our models are not ideal. Students enrolled in the Pre-Nursing track are required to take either Biology 1101 or Biology 1113 as the prerequisite to their program, with the majority opting for Biology 1101. Students in programs within the School of Health and Rehabilitation Sciences (HRS) take only Biology 1113. Students who take 1113 learn only three of the five core subject areas, while students who take 1101 learn the subject areas in a variety of application contexts. Therein lies the problem as Pre-Nursing track students would benefit from learning concepts in all 5 subject areas as they apply to human contexts.

We propose to create Biology 1110, which will serve this particular niche of students at Ohio State, and will in some ways be a hybrid of other courses in the CLSE catalog. As laid out in the course learning outcomes (*See Appendix B*), the course learning goals will cover the spectrum of biological topics, but with more defined learning outcomes associated with human contexts within each area than exist in Biology 1101. For example, students in Nursing are expected to

come out of Biology with an understanding of membrane transport, a topic that may or may not be covered in an offering of Biology 1101. By making the outcomes more specific, we can ensure that this population of students is better prepared for future programmatic coursework. Organismal form and function will be de-emphasized as students in these programs will be introduced to this topic when taking courses in Anatomy and Physiology. The specific topics chosen will have real-world applicability, and will illustrate the intersection of multiple biological topics. Many of the topics will be approached at a depth similar to that in our majors biology courses, but as a trade-off, we will cover less overall breadth.

Biology 1110 will fulfill a general education laboratory requirement with required weekly laboratory sessions. While some weeks will have stand-alone exercises, we intend to integrate a Classroom Undergraduate Research Experience (CURE) in the 1110 laboratory. The CURE module, called Prevalence of Antibiotic Resistance in the Environment (PARE), spans multiple weeks and has students conduct authentic research. By completing this research project, students will learn laboratory techniques in molecular biology, microbiology, and field collection. The project culminates with oral and poster presentations on their research to peers and the community. These are all skills which will serve pre-health professional students well in future coursework and careers. While working through the PARE project in the laboratory component of the course, the lecture will have the opportunity to use antibiotic resistance as a model to teach cell structure and function, genetics, evolution, and ecology. Other weekly laboratory exercises will potentially include macromolecular chemistry, cellular diversity, cell division, natural selection, and production and use of biofuels.

The topics chosen for the course are those that are not only the most relevant to the students' programmatic success, but also those which allow us to fulfill the general education requirements most effectively. As illustrated by PARE, but as will be encapsulated by every topic in the course, the facts and principles of modern science are at the core of the content. The technology which will allow students to perform tasks such as analyzing DNA sequences during the PARE project provides an opportunity in the course to discuss how we have gone from understanding the structure of DNA in 1953 to being able to manipulate the genome in the 21st century. The progression of technology is but one example of meeting the second GE objective regarding the evolving nature of science. With advancing technology comes the inevitable effect on society. Students will be asked to reflect upon philosophical questions such as the ethics of rewriting one's genome and what societal problems may arise as a result. Genetics is just one example where we can point to achieving the GE objectives for a natural science course. When we talk about drug development or human impacts on the environment, a new set of ethical questions arises surrounding the development of and use of technology.

As the course will fulfill a General Education Natural Science requirement, it will be open to any undergraduate student. The course will have no required prerequisites, as University standards for admission suggest that all students will have had high school biology or an equivalent. We intend to build upon that base-knowledge, but expect students will largely be taking this course as first-term freshmen without other prior college coursework. To ensure sufficient space for students in Pre-Nursing and HRS we will place reserve capacities on the enrollment, however, the course will be left to open GE enrollment for any student. The model for course enrollment will be based on a lecture limited only by classroom size. A lecture capacity of up to 700 would

not be problematic. The laboratory portion of the course is taught by Teaching Associates. Each lab section will be capped at a maximum of 24 students, which is the capacity of our departmental lab rooms. While initially offered only as a face-to-face course, we envision future offerings of a hybrid course where the lecture is taught online and students attending face-to-face laboratory sessions. At this time, we do not plan for a completely distance learning version of the course as the laboratory component cannot be adequately replicated in the online environment.

Appendix A: Natural Science Learning Outcomes and Justification
(*See Attached*)

Appendix B: Biology 1110 Course Learning Objectives
(*See Attached*)

Appendix C: Assessment Plan
(*See Attached*)

Appendix D: Sample Course Syllabus
(*See Attached*)

Appendix A: Natural Science General Education Objectives and Justification

General Education Natural Science Goals & Objectives

Students who successfully complete this course will fulfill the following GE Natural Science goals and objectives:

Goals/Rationale: Students understand the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

Learning Objectives:

1. Students understand the basic facts, principles, theories and methods of modern science.
2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.
3. Students describe the inter-dependence of scientific and technological developments.
4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

Students in Biology 1110 will be exposed to a survey of the biological world, using foundational knowledge to apply core concepts in biology (evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems) to a variety of topics of current interest. Themes in the course will include the dynamic nature of scientific discovery and how the fundamental science is translated to applied science through technology. Students will analyze the ethical consequences to and impacts on society that come with technology. The laboratory component of the course will give students the opportunity to experience a hands-on approach to the concepts and technology introduced in lecture, while the assignments throughout will both address core concepts and require reflection on philosophical issues resulting from scientific discovery.

Appendix B: Biology 1110 Course Learning Objectives

Upon successful completion of Biology 1110, students will demonstrate the ability to:

1. Apply core concepts in biology through the study of specific subject areas:
    a. Structure and Function
        i. Identify properties of life
        ii. Identify macromolecules of biological systems and the role diet plays in their acquisition.
        iii. Identify structural differences in prokaryotes, eukaryotes, viruses, retroviruses, and prions and how they relate to treatment of disease.
        iv. Explain processes of cell growth, reproduction, and apoptosis
        v. Explain variation in processes of cellular division between various cell types
        vi. Analyze how instances of loss of control in cellular regulation processes result in various medical conditions
        vii. Describe processes of osmosis and diffusion and apply concepts to human health
    b. Pathways and Transformations of Energy and Matter
        i. Explain the biochemical pathways of energy flow through biological systems and how they are governed by the laws of thermodynamics.
        ii. Explain the interaction between the processes of photosynthesis, cellular respiration, and fermentation and the variations that exist between taxa.
        iii. Apply effects of diet and exercise on cellular respiration.
        iv. Apply the effects of fermentation on energy production
        v. Explain the role of enzymes in biological systems.
    c. Information flow, Exchange and Storage
        i. Explain Gene Theory and its origins.
        ii. Identify the role of DNA and RNA in biological systems.
        iii. Describe applications of recombinant DNA technology and evaluate social implications that continue to arise as a result of technological developments.
        iv. Explain principles of Mendelian genetics and Heredity Theory
        v. Apply Mendelian genetics to explain inheritance of disease
    d. Evolution
        i. Explain basic assumptions and conclusions of natural selection
        ii. Explain the role of genetic drift in evolution of populations
        iii. Explain how two populations can diverge genetically over generational time
        iv. Apply concepts of evolution to the dynamic problem of antibiotic resistance and vaccine production.
    e. Systems
        i. Identify biodiversity of taxonomic kingdoms and select animal phyla.
        ii. Identify the nature of pathogenic organisms.
        iii. Apply ecological and evolutionary principles to interactions between taxa as related to energy flow.

        iv. Identify various human impacts on the environment and evaluate potential solutions.
2. Synthesize core biological concepts to explain observations of current events in the natural world.
3. Demonstrate an understanding of the nature of science, including:
    a. Explain the role of hypotheses and theories in the scientific method.
    b. Apply knowledge of the scientific method to derive hypotheses and design experiments to test those hypotheses.
    c. Interpret data presented through tables or graphs and apply quantitative reasoning when reading and writing scientific papers.
    d. Communicate conclusions drawn from own experimental data and evaluate those of others.
    e. Explain the nature of science as a human endeavor with its assumptions and limitations.
    f. Explain the self-correcting nature of science.
4. Analyze the significance of technological innovation and its interaction with science on society. Explore potential consequences of technology on society.
5. Demonstrate the ability to work collaboratively.

Appendix C: GE Assessment Plan

Natural Sciences			
ELO 1 Students understand the basic facts, principles, theories and methods of modern science.	• Student achievement will be assessed through embedded questions on quizzes and exams, as well as specific items from lab reports. • PARE report	• Exam and quiz questions will be tied to GE and course outcomes. We will consider a 70% average on objective assessment to be considered mastery of the objective. • On the SALG, we will take a response of 3 or above (out of 5) to reflect student acknowledgment of self-identified gains.	Data from the Student Assessment of Learning Gains survey will be reviewed, in conjunction with data pulled from the scores on line items of the paper rubric criteria. Based on this data, we will discuss what happened, what went well, and what we want to work on. This will allow for a data-driven plan for future offerings.
ELO 2 Students understand key events in the development of science and recognize that science is an evolving body of knowledge.	• Student achievement will be assessed through embedded questions on quizzes and exams, as well as specific items from lab reports.		
ELO 3 Students describe the inter-dependence of scientific and technological developments.	• The final PARE report will require students to address the relationship between science and technology. • Student achievement will be assessed through embedded questions on quizzes and exams.		
ELO 4 Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.	• Students will be assessed on this outcome through the two discussion article summaries and their contribution to the related discussion. • Student achievement will also be assessed through embedded questions on quizzes and exams, as well as specific items from lab reports.		

Appendix E: Sample Syllabus
Biology 1110: Biology for the Health Sciences
Autumn 2017 – 4 credit hours

Lecturer:

Course Coordinator: Adam L. Andrews
Center for Life Sciences Education
255B Jennings Hall
1735 Neil Avenue
Phone: 247-6345
email: andrews.171@osu.edu

Program Assistant: Valerie Gilbert
Center for Life Sciences Education
240A Jennings Hall
1735 Neil Avenue
email: gilbert.578@osu.edu

Assistant Coordinator: Erica Szeyller
Center for Life Sciences Education
255D Jennings Hall
1735 Neil Avenue
Phone: 688-5495
email: szeyller.1@osu.edu

Head Teaching Associate:

Safe Ride Service
Service available from 7:30P-2:40A
614-292-3322
https://dps.osu.edu/safe-ride
Twitter: OhioStateSSS

Class Meeting Schedule

Lecture: 3 hours weekly
Lab: 3 hours, once weekly – *See your BuckeyeLink schedule*

Required Course Materials

Biology: Concepts and Investigations (3rd Edition) by Mariëlle Hoefnagels – ISBN: 978-0-07-352554-9
Biology 1110 Laboratory Manual 2017-2018 Edition; ISBN:
Cell Phone or Internet-connected device (i.e. smart phone, laptop, tablet, etc.)

Internet Access: Your access to Carmen is an integral and necessary part of this course. You must activate your OSU email account to have access to Carmen. The Carmen URL is http://carmen.osu.edu and Biology 1110 should be listed under My Courses on your Carmen homepage. The username to log on is your OSU name.# and the password is the one you use with all OSU email and registration systems. If you have a problem logging in or using Carmen, contact 688-HELP or carmen@osu.edu. IMPORTANT: The CLSE and its course staff will send email ONLY to your official OSU email account.

General Education Natural Science Goals & Objectives

Students who successfully complete this course will fulfill the following GE Natural Science goals and objectives:

Goals/Rationale: Students understand the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

Learning Objectives:

1. Students understand the basic facts, principles, theories and methods of modern science.
2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.
3. Students describe the inter-dependence of scientific and technological developments.
4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

Students in Biology 1110 will be exposed to a survey of the biological world, using foundational knowledge to apply core concepts in biology (evolution; structure and function; information flow, exchange and storage; pathways and transformations of energy and matter; and systems) to a variety of topics of current interest. Themes in the course will include the dynamic nature of scientific discovery and how the fundamental science is translated to applied science through technology. Students will analyze the ethical consequences to and impacts on society that come with technology. The laboratory component of the course will give students the opportunity to experience a hands-on approach to the concepts and technology introduced in lecture, while the assignments throughout will both address core concepts and require reflection on philosophical issues resulting from scientific discovery.

Biology 1110 Learning Outcomes:

Upon successful completion of Biology 1110, students will demonstrate the ability to:

1. Apply core concepts in biology through the study of specific subject areas:
    a. Structure and Function
        i. Identify properties of life
        ii. Identify macromolecules of biological systems and the role diet plays in their acquisition.
        iii. Identify structural differences in prokaryotes, eukaryotes, viruses, retroviruses, and prions and how they relate to treatment of disease.
        iv. Explain processes of cell growth, reproduction, and apoptosis
        v. Explain variation in processes of cellular division between various cell types
        vi. Analyze how instances of loss of control in cellular regulation processes result in various medical conditions
        vii. Describe processes of osmosis and diffusion and apply concepts to human health
    b. Pathways and Transformations of Energy and Matter
        i. Explain the biochemical pathways of energy flow through biological systems and how they are governed by the laws of thermodynamics.
        ii. Explain the interaction between the processes of photosynthesis, cellular respiration, and fermentation and the variations that exist between taxa.
        iii. Apply effects of diet and exercise on cellular respiration.
        iv. Apply the effects of fermentation on energy production
        v. Explain the role of enzymes in biological systems.
    c. Information flow, Exchange and Storage
        i. Explain Gene Theory and its origins.
        ii. Identify the role of DNA and RNA in biological systems.
        iii. Describe applications of recombinant DNA technology and evaluate social implications that continue to arise as a result of technological developments.
        iv. Explain principles of Mendelian genetics and Heredity Theory
        v. Apply Mendelian genetics to explain inheritance of disease
    d. Evolution
        i. Explain basic assumptions and conclusions of natural selection
        ii. Explain the role of genetic drift in evolution of populations
        iii. Explain how two populations can diverge genetically over generational time
        iv. Apply concepts of evolution to the dynamic problem of antibiotic resistance and vaccine production.
    e. Systems
        i. Identify biodiversity of taxonomic kingdoms and select animal phyla.
        ii. Identify the nature of pathogenic organisms.
        iii. Apply ecological and evolutionary principles to interactions between taxa as related to energy flow.
        iv. Identify various human impacts on the environment and evaluate potential solutions.
2. Synthesize core biological concepts to explain observations of current events in the natural world.
3. Demonstrate an understanding of the nature of science, including:

a. Explain the role of hypotheses and theories in the scientific method.
b. Apply knowledge of the scientific method to derive hypotheses and design experiments to test those hypotheses.
c. Interpret data presented through tables or graphs and apply quantitative reasoning when reading and writing scientific papers.
d. Communicate conclusions drawn from own experimental data and evaluate those of others.
e. Explain the nature of science as a human endeavor with its assumptions and limitations.
f. Explain the self-correcting nature of science.

4. Analyze the significance of technological innovation and its interaction with science on society. Explore potential consequences of technology on society.
5. Demonstrate the ability to work collaboratively.

Grading and Evaluation

Your mastery of the course material will be based on seven quizzes administered through Carmen, two midterms, and a comprehensive final exam. Both exams will be administered in class according to the schedule at the end of the syllabus. Material on the quizzes and exams will come from the lectures and labs.

Midterm and Final Exam:

There will be two midterms given during the normal lecture time that will each be worth 100 points. A comprehensive final exam worth 150 points will be given at the time prescribed by the University Registrar. Both exams are listed on the course schedule below. The format for both exams will be multiple choice, true/false, and short answer.

Online Quizzes:

There will be 6 quizzes in this course, worth 15 points each. Use these quizzes to gauge your understanding of course material. Quiz questions will be all multiple choice and administered through the Carmen outside of class. Quizzes **will be open for 72 hours** and you will have until **11:59 pm on the day listed on the syllabus** to complete the quiz. Quizzes will be timed (15 minutes) and you will have **two attempts** at each with the higher score recorded. Questions will be pulled from a pool of questions so that quizzes will not necessarily be the exact same across students. Due to the extended window of time you have to complete the quizzes, extensions and makeup opportunities will not be given except in the most extreme of situations. You are strongly encouraged not to wait until the last minute to complete the quiz as technological issues (i.e. internet or power failures, etc.) will not be grounds to extend the quiz window. Should a technological issue arise, please contact the lecturer immediately. It may be possible to reset a quiz attempt during the quiz window, but deadlines will not be extended if the attempt is not reset or technical problems are not solved before the deadline.

Lecture Participation**:**

We will use TopHat every time we meet in lecture to allow students to become active participants. **No makeup opportunities will be available for missed lectures or non-functioning technology.** For each *correctly answered* question in lecture, you will earn one point. Once you earn 70 points, the next 10 correctly answered questions will be worth 0.5 *bonus* points each. The subsequent 20 correctly answered questions will be worth 0.25 bonus points each, for a total of 10 possible bonus points. It is therefore beneficial for you to come to lecture and participate, even after you have earned the 70 participation points!

**Please note that responding to questions as a proxy for another student will result in BOTH students being reported to the Committee on Academic Misconduct and immediate loss of ALL Lecture Participation points for the course.*

***TopHat Registration:** At the beginning of the semester, we will provide instructions on how to register so that we will be able to link your answers to your OSU name.#; this allows us to know who was in class and to record your answers to the questions. Proper registration is **required** by **Monday, August 28, 2015**. After this deadline, a student will not be eligible to recoup points from previous

lectures***. You must check your grade on Carmen to verify you are earning points.*** Please see announcements on Carmen for further details.

Discussion Articles:
Twice throughout the semester, you will be asked to read an article posted to Carmen. There will be two parts to the assignment associated with each article. First, you must write a one page reaction to the article, consisting of at least two paragraphs (approx. 100-150 words each). The first paragraph is a short summary of the article. The second paragraph is to be your reaction to the article. This page must be typed, and turned in *to the Carmen dropbox* NO LATER than the start of the class period in which the discussion is occurring. You will receive up to 10 points for the summary. During the respective class discussions in lab, all students will be expected to vocally express their comments regarding the article. You will receive 10 points for your **active** participation. No makeup points are available if you are not in class for the discussion, or choose not to say anything. No late summaries will be accepted.

Laboratory: will be assessed on the basis of 290 points:

- Lab Exercises: Each of 9 laboratory exercises will be graded on a 20 point scale. Two points will be for the pre-lab to be completed and turned in *by the start of the lab period*. 18 points will be for completion of the lab report *as a group during lab*.
- PARE: The PARE project will be integrated throughout the lab periods. There will be three pre-lab assignments (2 points each), 3 lab exercises to be completed and turned in (18 points each), technique points worth 20 points, a final report worth 50 points, an oral presentation of results worth 20 points, and a poster worth 50 points.
- Lab Instructor Points: Your participation in lab exercises and cooperative learning opportunities will be monitored by your lab instructor and graded on the basis of 30 points. Your lab instructor will individually specify exactly how these points will be distributed.
- Peer Evaluation: During the last week of the semester you will be asked to evaluate the efforts of your group mates in lab. Your score will be an average of the scores assigned to you by each of the group members and a rating of your own participation, with maximum points of 20. Failure to complete the survey will result in a zero for that student but will not affect group members.

Student Assessment of Learning Gains:
During the last week of the semester you will be asked to complete a survey of the course through Carmen. Completion will be worth 5 points.

LECTURE

2 Midterm Exam (100 pts each)	200
1 Final Exam	150
6 Quizzes (15 pts each)	75
2 Discussion Articles (20 pts each)	40
Lecture Participation	70
SALG	5
	540

LAB

10 Lab Exercises (20 pts each)	200
PARE Project	200
Lab Instructor Points	30
Peer Evaluation	20
	450

Final Grades:
Your final grade will be based on the percentage of the 990 points that you earn during the course of the semester, as indicated below. Please note that we do not grade the course on a curve and *Carmen* does not round scores up to the next nearest percentage point, so 92.11% and 92.97% both earn the grade of A-.

Grade Scale

93-100%:	A	80-82.9%:	B-	67-69.9%:	D+
90-92.9%:	A-	77-79.9%:	C+	60-66.9%:	D
87-89.9%:	B+	73-76.9%:	C	≤59.9%:	E
83-86.9%:	B	70-72.9%:	C-		

Posting Of Grades:
All grades will be posted on Carmen. After grades are posted you have 10 working days to challenge any grade or inquire regarding an unposted or missing grade. **After that time, grades are final as posted or zero if missing.** To challenge or inquire about an in-class activity, contact your TA. To challenge or inquire about exam grades, contact the lecturer to set up an appointment to find your scantron. IMPORTANT: Make sure that all of your grades are properly posted on Carmen as you receive them. Challenges about grades, particularly after the end of the semester, cannot be entertained after the 10-day grace period.

Late Assignments Policy:
No late assignments will be accepted. All assignments will have significant windows in which the assignment can be submitted. Please do not save assignment completion for the 'eleventh hour'. Deadlines will not be extended.

Absences:
If you are unable to take the exam at the regularly scheduled time, you must contact Adam Andrews (andrews.171@osu.edu) within 24 hours to schedule a makeup. If your absence is excused for a university-sanctioned event, if you are ill and have been seen by a medical practitioner on the day of the exam, or have other documentable reasons for missing, you may be offered a makeup exam without penalty. If you have no documentation to support your absence, or your absence from the exam is not for an excused reason, you will still be offered the opportunity for a makeup exam, with a 25% overall deduction on your exam score. Lack of transportation, loss of electricity, travel plans, etc. will not be considered as valid excuses. Arrivals to the exam after the first student has turned in an exam will be considered an unexcused absence, and the policy above will apply. The format for makeup assignments is at the discretion of the instructor.

The final exam is scheduled for TBA. Make sure that this time does not conflict with your future plans. No early exams will be given. The only makeup exam will be held on Friday, December 15 at 9:00am in Jennings Hall 270, and is available only with pre-approval from the course coordinator.

The laboratory portion of this course is an integral part of the learning experience. You are expected to come prepared to all lab sessions. This includes wearing appropriate clothing and footwear, having completed the pre-lab assignment, and having read and understood the lab you will be conducting that day – **this is critical**. (See the schedule below.) Each lab will have a pre-lab that must be submitted in person by the start of the lab period. Once class has begun, no further pre-lab activities will be accepted. Students arriving more than 15 minutes after the beginning of the lab session will not be permitted to stay, nor to earn credit for the missed lab. **Missing more than three labs (*excused or unexcused*) will result in the student being automatically assigned a failing grade for the course.** Students must contact their LAB INSTRUCTOR within two days of the original missed lab. There is no opportunity for a make-up assignment if a student contacts her/his LAB INSTRUCTOR on the third day or later. As part of this goal, makeup opportunities will only be given for circumstances beyond the student's control and must be accompanied by written documentation validating the absence. If you are too ill to attend class, you must receive documentation from a medical practitioner from the day of the absence. Attending a lab section other than your regularly scheduled lab is not permitted.

Section Changes: All section changes and adds are done by the Course Coordinator. Due to the need to keep up-to-minute availability of seats in each recitation, the lecturer and Lab Instructors are unable to sign any permission forms.

Academic Misconduct: It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed, illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/. We will adhere to this policy.

- Unless otherwise specified for a particular assignment, all submitted work should be a student's own unique effort. Collaborative efforts are not permitted unless expressly sanctioned for a particular assignment.
- Using others' verbatim words without the use of quotation marks ***and*** citation is plagiarism. Paraphrased work requires citation to denote the use of others' ideas. Copying other's words without quotation while using citations is still considered plagiarism.
- Use of any technology during a quiz or exam (including but not limited to cell phones, smart watches, headphones, electronic dictionaries, etc.) is strictly prohibited.

Diversity and Inclusion: The Center for Life Sciences Education promotes a welcoming and inclusive environment for all students and staff, regardless of race, age, religion, gender, ethnicity, national origin, disability, or sexual orientation. There is no tolerance for hateful speech or actions. All violations of this policy should be reported to the OSU Bias Assessment and Response Team (BART, www.studentaffairs.osu.edu/bias).

Sexual Harassment: OSU and the CLSE consider sexual harassment to be unacceptable behavior that destroys opportunities for learning. While all members of the staff involved in this course have been trained in the OSU sexual harassment policies and procedures, this is not true for all OSU students. Please report any concerns about questionable or unwanted behavior to the lecturer or Mr. Andrews.

Accommodation of Special Needs: Students with disabilities (including mental health, chronic or temporary medical conditions) that have been certified by the Office of Student Life Disability Services will be appropriately accommodated and should inform the course coordinator as soon as possible of their needs. Please do this within the first week of the semester. Only the course coordinator is authorized to sign ODS forms. Please fill out those parts of the proctor sheet forms that are to be completed by the student before bringing the form for signature. This will help us ensure that your individual needs will be met appropriately and fairly. The Office of Student Life Disability Services is located in 098 Baker Hall, 113 W. 12th Avenue; telephone 292-3307, slds@osu.edu.

Issue Resolution: The CLSE believes that student concerns are usually most effectively addressed by the staff closest to the situation. Therefore, students are ordinarily expected to address issues or concerns with their TAs first. If the issue cannot be resolved by your TA, or for some reason you feel that you absolutely cannot address your concern with your TA, please feel free to contact Adam Andrews, or Assistant Director Matt Misicka.

Copyrighted Class Materials: ©The Instructor's lectures and course materials, including power point presentations, tests, outlines, and similar materials, are protected by copyright. You may take notes and make copies of course materials for your own use. You may not and may not allow others to reproduce or distribute lecture notes and course materials publicly whether or not a fee is charged without the express written consent of the Course Instructor.

Safe Ride Service: Safe Ride (614-292-3322) is a service provided to university students, faculty, and staff who would like safe transportation across campus. Rides are scheduled on a first-come first-serve basis. Phone lines open at 7pm and rides are available until 3am. For more information and service boundaries, please visit https://dps.osu.edu/safe-ride.

AUTUMN 2017 TENTATIVE SCHEDULE

Information in this syllabus is subject to change with as much notice to students as possible.

Week	Date	Lecture Topic	Reading	Laboratory (Week runs Wednesday through Tuesday)	Assignments
1	8/22-25	• Introduction to Biology 1110 • Why ask why? How and why do we do science? Themes in Life	Ch 1	Ex. 1: Nature of Science	
2	8/28-9/1	• Life's chemistry	Ch 2	Ex. 2: Macromolecules and Nutrition	
3	9/4-8	• **NO CLASS 9/4** • Where did cells come from? (Evolution of cells) • What does a cell look like and do?	Ch 3	Ex. 3: Osmosis and Diffusion	**Quiz 1 due**
4	9/11-15	• Biodiversity and microbiology • Viruses and Prions	Ch. 16-17, 18.1,18.6, 19.1, 20.1, 20.7, 21.1, 21.4, 21.7, 21.16	Ex. 4: Cell diversity	
5	9/18-22	• Its all about energy (Metabolism, Energy, Respiration and Photosynthesis)	Ch. 4, 5, 6	Ex. 5: Photosynthesis and cellular respiration	**Quiz 2 due**
6	9/25-9/29	• DNA, gene expression	Ch. 7	PARE I & II	**MIDTERM #1 in lecture** **Discussion #1 in Recitation**
7	10/2-6	• Chromosomes, Cell division	Ch. 8.1-8.5, 9	Ex. 6 Cell division	
8	10/9-13	• Cancer • **NO CLASS 10/12-13**	Ch. 8.6-8.8	**Recitations Only**	**Quiz 3 due**
9	10/16-20	• Genes and Inheritance • Genetic Disease	Ch. 10	PARE III & IV	
10	10/23-27	• Biotechnology	Ch. 11	PARE V & VI	**Quiz 4 due**
11	10/30-11/3	• Evolution and Natural Selection	Ch. 12-13	Ex. 7 Natural Selection	**MIDTERM #2 in lecture** **Discussion #2 in recitation**
12	11/6-10	• Speciation • **NO CLASS 11/10**	Ch. 14	Ex. 8 Speciation	**PARE Draft Report Due**
13	11/13-17	• Populations and Population Dynamics	Ch. 37	Ex. 9 Virulence	**Quiz 5 due**
14	11/20-24	• Ecological Relationships • **NO CLASS 11/22-24**	Ch. 38	**No Labs Sessions Meet**	**PARE Final Report Due**
15	11/27-12/1	• Human Impacts	Ch. 39-40	Ex. 10 Biofuels	**Quiz 6 due**
16	12/4-6	• Global Outlook	Ch. 39-40		
FINALS		**TBA**			

Proposal for Biology 1110
Addendum

Pursuant to the NMS Curriculum Panel's request, we would like to address specific concerns about the Proposal to create Biology 1110, and are filing this Addendum to the original proposal.

The Panel posed the question of whether the CLSE intended Biology 1110 to be for BA or BS students. It is our feeling that the nature of the various labs, and in particular the PARE project would meet the threshold for a BS course. That said, with no prerequisites of Math or Chemistry and the intent that this course will not suffice for students majoring in the Biological Sciences, the BA distinction would be most appropriate within ASC. Other Colleges, such as Nursing, are likely to use the course as a BS requirement.

Regarding the question of space and resources, approximately 200 nursing students currently take Biology 1101 during Autumn semester. In the autumn, the CLSE has typically offered three daytime lecture sections, each enrolling between 180-300 students. The approximately 200 students who will be shifting from 1101 to 1110 will allow us to transition one of the 1101 lecture offerings and its corresponding departmental lab room to 1110, making the addition of Biology 1110 to our catalog space-neutral.

The Panel also requested further evidence to support the General Education Natural Science Assessment Plan. In addition to the *Indirect Methods* outlined in the Assessment Plan (e.g. SALG survey), we will also be categorizing exam questions to GE and course outcomes, and using performance data from those questions to assess student achievement. We have provided examples of such questions, as well as some laboratory exercises to illustrate potential assessment tools that might be used. Please see the following pages for example questions.

GE Outcome	Example Exam Questions	Example Laboratory Exercises
ELO 1 Students understand the basic facts, principles, theories and methods of modern science.	1. Which of the following is a reasonable explanation for why unsaturated fatty acids help keep any membrane more fluid at lower temperatures? a. The double bonds result in shorter fatty acid tails and thinner membranes. b. Unsaturated fatty acids have a higher cholesterol content and therefore more cholesterol in membranes. c. Unsaturated fatty acids are more polar than saturated fatty acids. d. The double bonds block interaction among the hydrophilic head groups of the lipids. e. The double bonds form kinks in the fatty acid tails, preventing adjacent lipids from packing tightly. 2. Gram negative bacteria show a high degree of antibiotic resistance and represent a serious human health concern. Which of the following best describes the mechanism(s) of antibiotic resistance in gram negative bacteria? a. The cell wall of gram negative bacteria is very thick and prevents antibiotics from binding with surface receptors on the surface of the bacterium's cell membrane. b. Some gram negative bacteria have mutated surface receptors. Since they are mutated, the antibiotic can't bind to the receptors and enter the bacterium. c. The outer membrane of gram negative bacteria has a very low permeability to antibiotics. Thus, the antibiotics can't reach the surface receptors on the bacterium's cell membrane. d. B and C are correct e. A and B are correct.	See Appendix A: *PARE Laboratory Manual* See Appendix B: *DNA Structure and Replication*
ELO 2 Students understand key events in the development of science and recognize that science is an evolving body of knowledge.	1. Compare and contrast the accepted views about the world before and after Darwin's *Origin of Species*. 2. What role did Lyell's book, *Principles of Geology*, play in influencing Darwin's thinking?	See Appendix B: *DNA Structure and Replication*

ELO 3 Students describe the inter-dependence of scientific and technological developments.	1. Artificial selection was used on corn to produce a single strain of corn with increased growth rates and greater resistance to a fungus. Although farmers have continued to select for these traits, the productivity of this strain is no longer increasing. This suggests that a. the population size has been decreasing. b. artificial selection is not as strong as natural selection. c. gene migration is a major evolutionary agent in corn. d. all or most of the natural variation for these traits has been eliminated. e. long-term disruptive selection may lead to speciation. 2. You know that smoke from traditional cigarettes contains chemicals that can induce mutations, but what about e-cigarettes? Are they any safer than regular cigarettes? Describe how you would structure a study about electronic cigarettes and their effect on the incidence of lung cancer.	See Appendix A: *PARE Laboratory Manual* See Appendix B: *DNA Structure and Replication*

ELO 4 Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.	1. Fred and Wilma are considering reproduction, but worried about Tay Sachs disease (an autosomal recessive disease). Fred's dad and Wilma's mom are each carriers for Tay Sachs disease. Neither Fred nor Wilma has Tay Sachs. What is the minimum probability that the first child of Fred and Wilma will have Tay Sachs? a. 1/64 b. 1/16 c. 3/16 d. 1/4 e. unless there is a new mutation, their first child will not have Tay Sachs 2. Global warming is a major environmental concern that scientists are trying to find solutions for. Global warming is caused by increased emissions of greenhouse gasses, including carbon dioxide, which act as a 'space blanket' and trap radiant heat. Which of the following would help reduce the overall amount of greenhouse gases in the atmosphere? a. Burning more fossil fuels to release the carbon stored in them b. Genetically modifying organisms to make the process of cellular respiration more efficient c. Practice controlled burning of forests to remove excess oxygen from the atmosphere d. Increase plant biomass by planting trees to replace deforested areas. e. create large mirror systems or artificial ice fields to reflect radiant heat back into the atmosphere. 3. One of the possible concerns about genetically modified foods is that they might kill organisms that we don't want to kill. Which of the following is an example of this phenomenon? A. In the Irish Potato Famine, more than 1 million people died as a result of the lack of genetic diversity in the potato crop. B. The pollen from plants containing insect-killing *Bt* genes can be blown onto other plants. Insects that we don't want to kill, such as monarch butterflies, may be killed by such pollen. C. Featherless chickens look so ridiculous that other barnyard animals have died laughing at them. D. Bears eating genetically modified corn may be poisoned by the *Bt* gene introduced to the corn to act as a pesticide. E. Genetically modified super-sized salmon have been known to kill the bald eagles that generally feed on them.	See Appendix C: *Is Ethanol a Sustainable Solution to Our Energy Needs?*

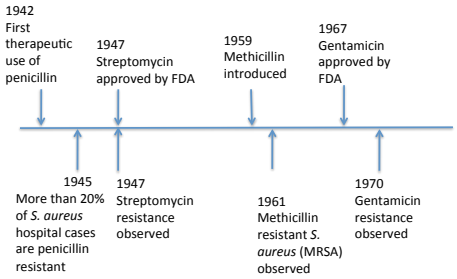
Appendix A:
Prevalence of Antibiotic Resistance in the Environment (PARE) Project

Assessing the Prevalence of Antibiotic-Resistant Bacteria Throughout the Environment

We are currently experiencing a global health crisis in which common infections are becoming difficult or impossible to treat due to the increase in antibiotic-resistant infections. The Centers for Disease Control reports that at least 2 million people in the US become infected each year with bacteria that are resistant to antibiotics, resulting in at least 23,000 deaths. We know that soon after a new class of antibiotic is commercially available, resistant infections are reported rendering the drug ineffective against treatment of those infections.

Why is antibiotic use linked to resistance?
Exposure to the antibiotic kills sensitive bacteria but selects for growth of organisms that may be resistant. Resistance is a trait that is caused by heritable changes in the DNA. We know that resistance spreads not only through rapid division of resistant cells (vertical transmission), but also through the horizontal gene transfer mechanisms that are unique to bacteria. Genes encode products that confer resistance such as enzymes that inactivate antibiotics or pumps that transport the antibiotics out of the cell, lowering the effective concentration inside the bacterial cell. These chunks of DNA can be transferred through conjugation, transduction or transformation to other bacteria of the same or different species. To make matters worse, several antibiotic resistance genes often cluster together such that resistance to multiple antibiotics is acquired through a horizontal transfer event.

Antibiotic use is correlated to the emergence of resistant strains



Adapted from Science (2008) 321:356

The presence of antibiotics will kill bacteria that do not harbor resistance genes or mechanisms; however, it *selects* for survival of those that do. Therefore, any environment with high levels of antibiotics is likely to harbor high levels of antibiotic-resistant bacteria.

Why study dirt?
How can something like soil be interesting and relevant to antibiotic-resistant infections in humans? Individuals generally do not become infected through handling of environmental soil, but soils exposed to high levels of antibiotics tend to harbor high levels of antibiotic-resistant microbes. When antibiotics are used in the home, hospital or farm, the surrounding environment is likely to become exposed due to antibiotics excreted in the feces, discarding of unused prescriptions, and agricultural run-off and spread through waterways. These antibiotic pollutants, in turn, can select for growth of resistant microbes in the affected area. Studies have indicated that people who work or live close to those soils are likely to harbor relatively high levels of resistant microbes on their skin or in their intestinal tracts as part of the population of normal microbes associated with our bodies, yet clinical outbreaks have not been definitively linked to these sites.
In order to determine if the presence of antibiotic-resistant microbes in the environment is linked to clinical infections, detailed surveillance across a broad geographic range is necessary. This

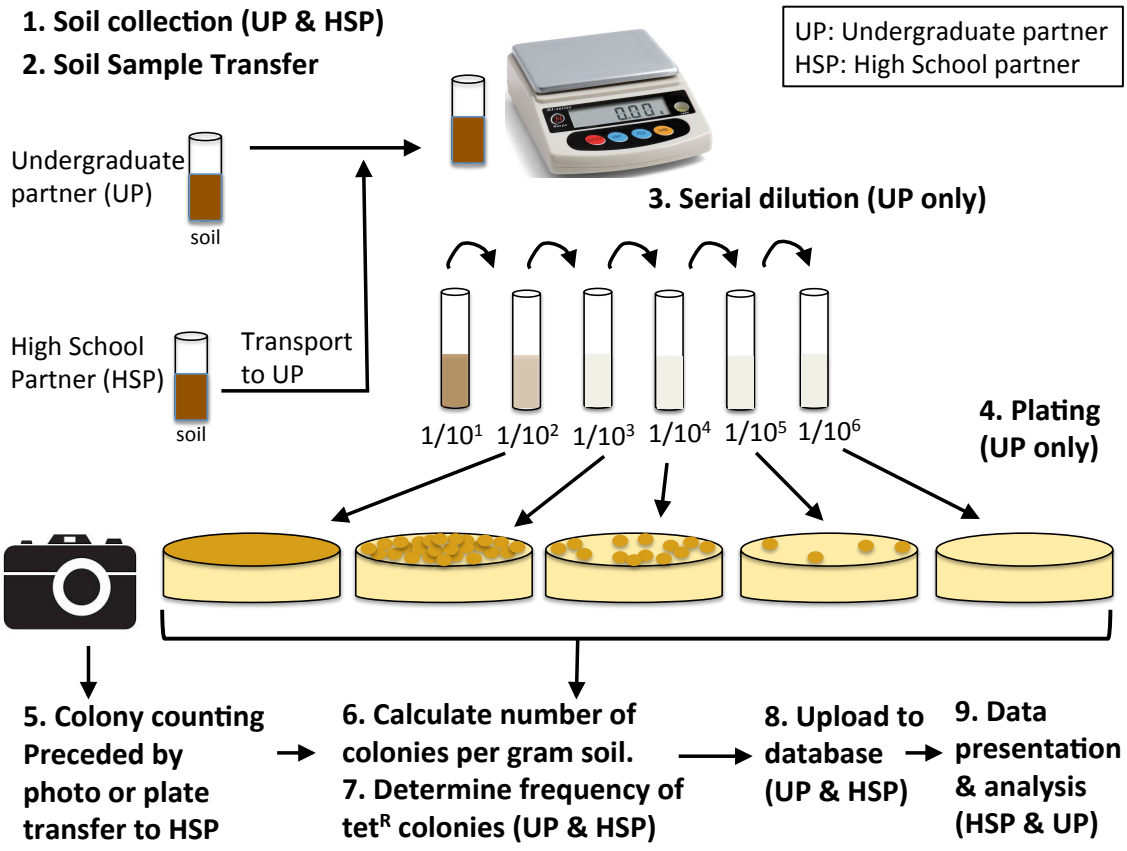
requires reporting at many different sites where all values are determined using the same methodology. You have been invited to participate with other students around the country to coordinate efforts using a "crowd-sourcing approach" to track environmental antibiotic-resistance in a way cannot be accomplished by a single research group.

Experimental Procedure

Overview

1. Collect soil sample and fill out datasheet with soil sample site features.
2. Receive soil sample from high school partners (HSP).
3. Subject soil samples to at least two rounds of systematic dilution (serial dilution).
4. Transfer diluted soil samples to Petri plates containing bacterial growth medium with and without tetracycline.
5.Count and record the number of bacterial colonies observed per plate. Arrange for HSP plates (or photos of plates) to be transferred to high school.
6. Estimate the number of cells present in your soil sample by calculating colony forming units
7. Calculate the frequency of tetracycline resistance in your soil sample.
8. Record soil data and colony count results into national database.
9. Analyze data for your class, present data in graphs and/or tables.

Have fun and get to know a high school student. One of you may make important scientific discoveries and win a Nobel Prize someday.



1. Soil Sample and Data Collection

Each class or collection team will discuss an interesting site for sample collection. Is the site in an urban area, rural, near a factory, or near a waterway? Or would your class like to track changes at the same location over time (each team collects samples from the same general location each year)? Very few studies have been done to monitor the total number of antibiotic-resistant bacteria in soil and those that have been done have demonstrated vastly different frequencies (zero detectable resistant colonies at some sites and up to 80% of total colonies resistant at other sites). Any information obtained will be valuable to help understand the dynamics of antibiotic-resistance.

Materials needed

- One sterile, plastic, sealable tube or bag for each soil collection sample
- A smart phone or device to obtain GPS location information
- Pen, pencil or marker to label collection tube and to fill out Soil Collection Data Sheet
- Soil Collection Data Sheet (1 per student)

Method

1. Each collection team will collect a soil sample from their chosen collection site. These will be labeled with your team name; all data pertaining to your soil sample will later be linked to your team name in the database. Think of a short team name (e.g. “rockets” or “madsci”) and record your team name and all team members’ names on your Soil Collection Data Sheet.

2. Review the Soil Collection Data Sheet at the end of this document (or provided by your instructor) prior to sample collection so that you will know what characteristics must be recorded. Obtain permission for collection from private property.

3. Use a stick or rock at the sample site location (or the plastic collection tube itself, if using one) to loosen a sample of dirt about the size of an ice cream scoop and transfer it into the collection vessel (tube or bag) without touching the dirt (to avoid contaminating with bacteria on your hands).

4. Use a smartphone to capture latitude and longitude coordinates, preferably in decimal degrees format. (for example: lat 41.1509; lon. -73.1415). If latitude and longitude information cannot be captured, record the location information as accurately as possible.

5. Enter information for each indicated data field into data sheet at the collection site. Do not lose this form; this information must be entered into the electronic database at a later date.

6. Label the outside of the tube or bag with the your team name and collection date.

7. Bring your sample to lab/class.

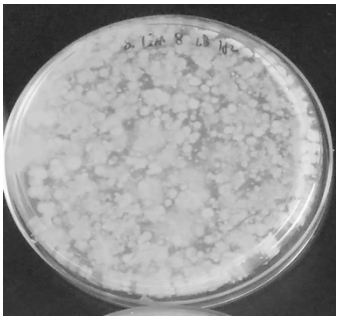
2. Receive Sample From High School Partners

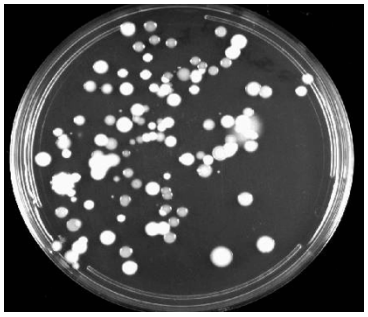
Instructors will arrange for transport of samples. You will need to keep track of the identifying information for your high school partner such as their team name and other factors described later. Your instructor may provide an opportunity for you to mentor your high school partners through visits to the high school or electronic communication with your partner(s).

3. Soil Sample Serial Dilution

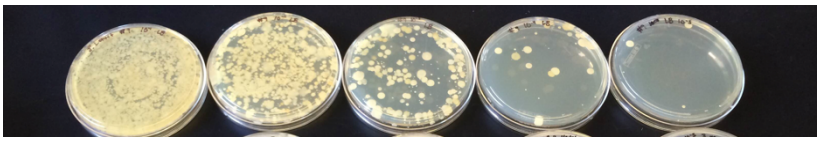
Our goal is to determine the percent tetracycline-resistant bacterial cells in each soil sample. Your team will collectively perform at least two repeat experiments to assess this for your soil sample and for your high school partnering team’s sample. To do this, we need to know the total number of cells present and, of those, how many are resistant to tetracycline. One standard method used for measuring microbes in soil is to assess the number of *colony forming units* (CFUs) per gram of soil. In this project, cell numbers are estimated by spreading a known volume of diluted cells onto plates containing nutrients for growth. When individual bacterial cells land on the growth medium, the cells undergo divisions to produce a colony visible by naked eye. Counting the

number of colonies that grow provides an estimate of the number of cells plated. The values obtained are estimates because cells that were dead or that could not grow under our particular growth conditions will not be detected. For this reason, microbiologists refer to “colony forming units” (CFUs) when estimating cell numbers using this method.





If there are a high number of cells on the plate or if they are clumped together, it becomes impossible to make accurate colony counts. The plate on the left is an example of too many colonies for accurate counting. Mixing the soil in water separates the cells and allows us to perform incremental dilutions. Because there is a high, but unknown concentration of microbes in each soil sample, plating several different dilutions results in at least one plate with colonies separated enough for accurate counting, such as the plate on the right. This process, called serial dilution. An example of a complete plated dilution series is shown below.



Each soil sample will be subjected to at least two rounds of serial dilution and corresponding plating. If the two colony count results are not similar, we can assume that an error took place at some stage in the methods. In the course of a research project, one would repeat with a third dilution and plating series to help to determine which results are accurate, but this may not be possible in your classroom.

Your team will also perform two rounds of serial dilution and plating for your high school team’s sample. The high school students will perform their own colony counting, calculations and database uploads.

Method

Assign members of your team to each required dilution and plating series. For example, a team of four would be assigned as follows:

1. Undergraduate soil sample dilution and plating series #1 (U1)
2. Undergraduate soil sample dilution and plating series #2 (U2)
3. High school soil sample dilution and plating series #1 (H1)
4. High school soil sample dilution and plating series #2 (H2)

1. For each dilution series, label each of the sterile tubes as follows:

$1/10^1$
$1/10^2$
$1/10^3$
$1/10^4$
$1/10^5$
$1/10^6$

2. Use a sterile pipet to transfer 9 ml sterile water into each of the tubes. Measure 1g soil, preferably without rocks or any large debris. If a spatula is used to scoop soil, it should be cleaned with ethanol prior to each use.

3. Add the 1 g of soil to the 9 ml sterile water in the 1/10 dilution tube and seal the cap. This is the 1/10 dilution. The *dilution factor* is 10. Vortex at highest speed for 1 minute.

4. Use a sterile transfer pipet to transfer 1ml of the 1/10 dilution into the tube labeled $1/10^2$. Pipet up and down several times to mix well and without setting the pipet down, transfer 1ml of this dilution to the next tube to create the $1/10^3$ dilution. Mix well and repeat for all of the dilutions using the same pipet. If you set the pipet down, it is no longer sterile and should be replaced for a fresh one.

4. Plate Dilutions onto Growth Medium With and Without Antibiotic

No antibiotic plates
Note: On MA (no antibiotic) plates, you will plate only the $1/10^2$-$1/10^6$ dilutions

1. Label 5 MacConkey agar plates with your team name, the plate type (MA), the series code (U1, U2, H1, or H2) and the dilution for dilutions **$1/10^2$ through $1/10^6$**. Experience indicates that the 1/10 dilution will likely have too many colonies to count. Label along the edge of the plate as shown.

2. Use a sterile pipet to transfer 0.2 ml from the $1/10^6$ dilution onto the $1/10^6$ MA plate. Spread the liquid around evenly on the plate using a sterile spreader or sterile glass beads. Repeat for the other dilutions. Take care not to touch or contaminate the sterile items prior to use.

Antibiotic plates
Note: On the tetracycline plates, you will plate only the 1/10 – $1/10^3$ dilutions

3. Label the three MA3 (3 µg/ml tetracycline) plates with your team name, the plate type, series code (U1, U2, H1, or H2) and the dilution (**1/10 through $1/10^3$**). Repeat for the three MA30 (30 µg/ml tetracycline) plates.

4. Spread 0.2 ml of each dilution onto the corresponding plate as directed in step 2.

5. Wrap all plates with parafilm and incubate at 28°C for 48-72 hours.

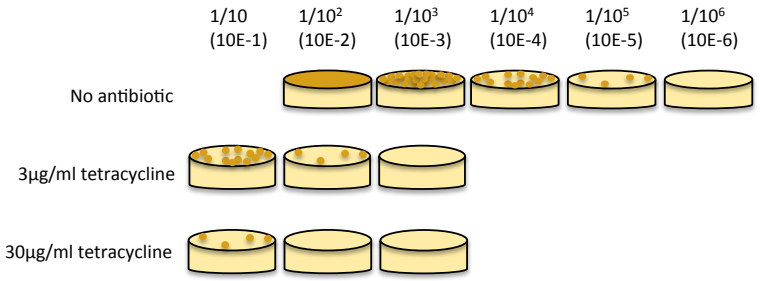
6. Remove plates and record the incubation temperature and the duration of incubation. **This information is required for the database.** Convey this information to your high school partner.

5. Count and Record the Number of Colonies Per Plate

Since the number of cells in each soil sample differs, serial dilutions should provide at least one plate with between 30-300 colonies. This is a number that can be accurately counted and can be considered free of error. Soil contains an enormous diversity of species resulting in many different colony morphologies on the chosen medium. Determining the total number of colonies per plate will be challenging—even the tiniest colonies should be counted. Other colonies will be visible "under" larger colonies. Since each colony is derived from a cell that landed on the plate, each (regardless of size) must be counted to the best of your ability. The challenge of determining an accurate count is one reason that each sample was diluted and plated at least twice. Each member of your team will be responsible for counting the plates that they created, including the high school series. However, for calculations and database upload, you will ignore the high school plates and work together as a team to calculate and record information for your undergraduate team soil sample only. Your high school plate counts will be compared to the high school students' counts to verify their accuracy. You may be asked to volunteer as a mentor in the high school to assist the high school students with their counts and calculations.

Method

1. Arrange plates from your dilution series as shown in the figure below.

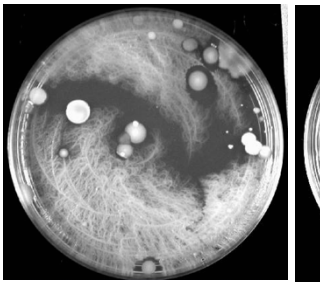


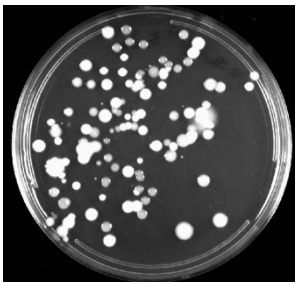
2. Scan the plates in each row to assess whether there are any obvious errors in the dilution or plating technique. Each plate should have about 10-fold fewer colonies than the plate to its immediate left. If this is not the case, record that information in the "notes" section of the database. For each different medium (row), determine the most "countable" plates (plates with 30-300 colonies).

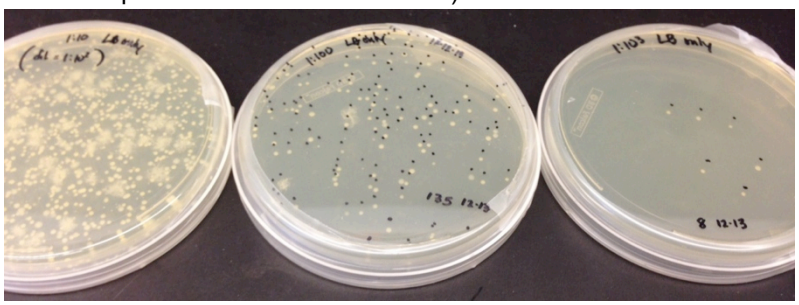
Find out from your instructor if your team will photograph your high school partner's plates prior to counting colonies. If so, refer to the section on Photographs below prior to proceeding.

If you count first, be sure to use a marker that can be removed with ethanol prior to photographing. And be sure that you don't remove the critical labeling information from each plate if using ethanol to remove the counting marks.

3. Count the colonies on the most countable plates and record the values in the appropriate section of Table 1 in the Undergraduate Data Worksheet. Indicate "TM" for plates that have too many colonies to count, "TF" for plates with too few and "OG" for plates that could not be counted due to microbial overgrowth that obscures individual colonies such as a large slimy growth or a fuzzy, fungal growth on the plate (as shown in the figure on the left). The plate on the right is an example of a "countable" plate. As each colony is counted, it is helpful to mark it with a dot using a marker that can be removed with ethanol. This helps to avoid duplicate counting the same colony. Using a marker that can be removed with ethanol facilitates a repeat count if needed. The figure below shows a student sample after counting (the little black dots indicate the position of counted colonies).







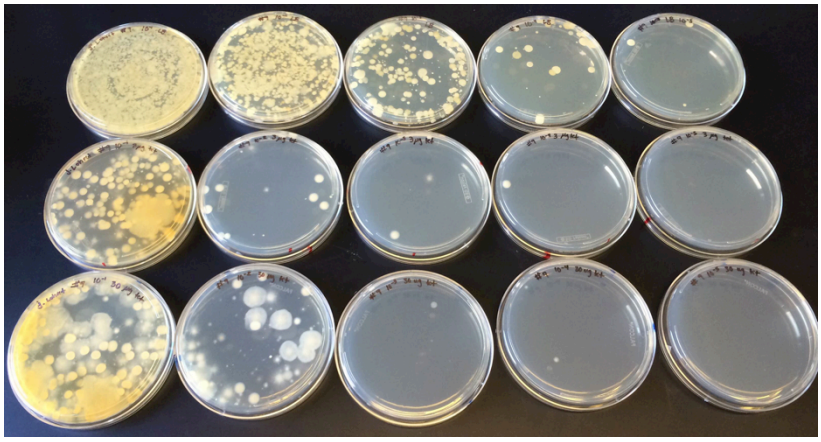
Keep the plates wrapped with parafilm while counting, to avoid personal exposure to the microbes.

4. Communicate with your team members to fill in the remaining sections of Table 1 for all of your team's (undergraduate sample) plating series' counts. You will need all data pertaining to your soil sample for database entry. You do not need to fill out the remaining high school sections.

Photographs

If plates cannot be transported to your high school partner for counting, you will need to send photograph files of the most relevant plates to your partner.

a. Organize your high school partner's plates as in Step 1 (above).
b. Take a photo of the entire high school set. Ensure that the photo is in focus and of best quality possible.



c. Name the photo file with the team name, plating series (e.g. H1 or H2) and indicate that it is a photo of the entire set (as opposed to the single plate photos you will take later). For example:

MadSci_H2_ALL.jpg

Store the document in a place where you can email it later.

d. Refer to the countable (high school) plates (those for which colony numbers were entered into Table 1 in the Data Worksheet) and photograph each of these three individual plates. Use the following nomenclature to name the photo files:
Team name_series code_growth medium type_dilution code

Medium type:
MacConkey: MA
MacConkey with tetracycline at 3 µg/ml: MA3
MacConkey with tetracycline at 30 µg/ml: MA30

Series code:
High school series 1: H1
High school series 2: H2

Because some characters are not allowed in file names, the following naming code has been adopted:
1 = 1/10 dilution
2 = $1/10^2$ dilution
3 = $1/10^3$ dilution
4 = $1/10^4$ dilution
and so on…

Example:
MadSci_H1_MA3_3 would refer to the MadSci team's series 1 sample plated onto MacConkey Agar with 3 µg/ml tetracycline, diluted to $1/10^3$.

e. Transfer the four images to your collaborator partner as instructed by your instructor.
f. Proceed with counting colonies as directed in step 2 above.

6. Calculate the Number of Colony Forming Units Per Gram of Soil

Our goal is to determine what proportion of the total bacterial cells is resistant to tetracycline. We are using CFUs as a measure of total cells present, so determining the ratio of tetracycline-resistant CFUs per gram of soil to the total CFUs per gram soil results in the frequency of tetracycline-resistant cells per gram soil. Some bacterial cells can grow in the presence of low levels of tetracycline but are inhibited at a higher concentration. In addition, a concentration that inhibits growth of one species may not have any detrimental effect on another. We tested, and will report, the frequency of resistance at two different concentrations of tetracycline (3 µg/ml and 30 µg/ml).
Note: The high school students will perform their own calculations on their samples.

Materials needed

- Calculator
- Undergraduate Data Worksheet

Method

1. For each plating series, refer to the number of colonies on the countable MA (no antibiotic) plate (Table 1). Transfer this information to the first row of Table 2.

2. In the second row of Table 2, indicate the volume of cells plated onto each countable plate. If you followed the methods in this handout, you plated 0.2ml onto each plate.

3. Determine the dilution factor for the countable plates. The 1/10 dilution was diluted by a factor of 10, so the dilution factor is 10. The $1/10^2$ dilution was diluted by a factor of 100, so the dilution factor is 100 and so on. If the most countable plate for a series resulted from the 1/100 dilution, the dilution factor for that plate would be 100. Enter this information in Table 2.

4. Use the formula below to calculate the total number of colonies per gram of soil and enter into Table 2. Note, 1g = 1ml. A volume of 0.2 ml was plated, so we need to multiply by 5 (5 x 0.2ml = 1ml) to arrive at the number of cells per ml. The volume plated was also diluted relative to the original soil sample, so we also need to multiply by the dilution factor.

CFUs on plate x 5 x dilution factor

For example, if there are 210 colonies on the $1/10^3$ dilution plate:

$$210 \times 5 \times 10^3 = 1{,}050{,}000 = 1.05 \times 10^6 \text{ CFUs per gram soil}$$

Note: The database does not allow entry of exponential numbers;
1.05×10^6 should be entered as 1,050,000 or 1.05E6

7. Calculate the Frequency of Tetracycline-Resistant Colonies

Materials needed

- Calculator
- Undergraduate Data Worksheet

Method

1. Using the same logic as in Section 6, fill in the appropriate values Table 3 (transfer values for the MA3 and MA30 plates in Table 1 to row 1 of Table 3). If no colonies appear on any of these plates, we can say that there are no detectable tetracycline-resistant colonies under our testing conditions. Tetracycline-resistant bacteria may be present, but perhaps we didn't plate enough cells to detect them (they are present at a relatively low frequency) or they were unable to grow under our chosen growth conditions (perhaps a critical nutrient was missing).

For each concentration of tetracycline, calculate the tet^R CFUs per gram of soil:

CFUs on plate x 5 x dilution factor

For example, if there are 160 colonies on the 1:10^2 dilution of the MA3 plate (3 µg/ml tetracycline), that equates to 8 x 10^4 tet^R cells per gram of soil.

$$160 \times 5x\ 100 = 80{,}000 = 8.0 \times 10^4\ tet3^R\ \text{cells/gram soil}$$

In Table 3, record the results for each concentration of tetracycline for all plating series.

2. Calculate the relative frequency (percent) of resistant cells as a function of the total number of CFUs/gram soil calculated in Section 6.
Divide the total number of tet^R CFUs per gram of soil by the total CFUs per gram of soil (on the non-antibiotic plate) to arrive at the frequency of tet^R colonies. Multiplying by 100 results in the percent resistant cells. For example:

$$\frac{8 \times 10^4\ tet^R\ \text{colonies}}{1.05 \times 10^6\ \text{cells per gram of soil}} = 7.6 \times 10^{-2}$$

$$7.6 \times 10^{-2} \times 100 = 7.6\ \%$$

3. Record percent values in Table 3 of the Data Worksheet.

8. Record Soil Data and Colony Count Results Into National Database

For this project to be of value to other students and to the scientific community, each student must accurately record their results into the database. The collective sum of results provides a rich overview of antibiotic resistance prevalence and provides an opportunity to perform regional comparisons. All database information is available to other PARE researchers for analysis, so please use care to ensure that all calculations are correct and that data are entered correctly.

Materials needed

- Soil Collection Data Sheet responses
- Undergraduate Data Worksheet
- Access to PARE Google Form 'Soil and Microbe data PARE'

Method

You should receive an email from your instructor containing a link to the database entry site (or use the link below). The **database does not allow you to edit entries after submission** so be sure to enter all information as accurately as possible. Contact your instructor if you should need to make a revision at a later date.

1. Access the database by following the link below or by using the link sent from your instructor.

http://goo.gl/forms/Egd1ryo3Jb

2. Begin data entry as directed, taking care to use correct spellings. Each individual student should enter all data for their team's soil sample. Multiple entries of the same data will enable detection of any accidental entry errors. Note that the information will not be recorded until you see the confirmation:

"Your response has been recorded."

3. At the end of the form, you will receive a message indicating that your data have been submitted. You will then have the option to participate in a voluntary, anonymous feedback survey to help drive improvements in the project for future classes. Participation is appreciated.

9. Presentation and Analysis of Data

Your instructor will provide either an Excel spreadsheet of class responses or access to the entire database. Your instructor will provide guidelines on data analysis or presentation requirements.

Soil Collection Data Sheet

Your name_____

Name of collection team (no more than 8 letters) _____

Course instructor (last name only)_____

Which category best describes your school?
_____middle school
_____high school
_____community college
_____technical college
_____liberal arts college
_____state college or university
_____private college or university

Location Information
In order to repeat any interesting results, scientists will need to return to the same sampling site that you've chosen.

Country where soil sample collected _____

State where soil sample collected _____

County where soil collected (check spelling) _____

Closest town or city to soil collection site (check spelling) _____

Latitude of sample site _____
Decimal degree format, e.g. 41.1509)

Longitude of sample site _____
Decimal degree format (e.g. -73.1415)

Address of collection site, if known_____

Additional descriptive information to help identify collection site (*e.g.* along the south bank of the Tomachi River at the canoe launch off of Rt. 66)

_____

Date of collection (MM/DD/YYYY) _____

Days elapsed from collection to plating _____

Which best describes the sample site location?
_____Urban/city (lots of buildings, heavily populated)
_____Rural (farm, countryside, not heavily populated)
_____Suburban (residential, neither rural nor urban)

How far is the nearest body of water to the collection site?
_____0 meters (e.g. sample collected from stream bed, under water, etc.)
_____within 1 meter
_____within 10 meters
_____farther than 10 meters

What best describes the body of water closest to the collection site?
_____Fresh water
_____Salt water
_____Mixed fresh and salt water
_____Not sure what the closest body of water is

Which additional term best describes the body of water?
_____Pond
_____Lake
_____Sea
_____Stream
_____River
_____Estuary
_____Unknown
_____Bog
_____Ocean
_____Sound
_____Bay
_____Reservoir
_____Closest body of water

Name closest body of water, if known _____

Agricultural Features
Was the sample collected on a farm (Y or N)? _____

Are animals reared for food on the farm?
_____yes
_____no
_____unknown

What food animals are reared on the farm (if any)?
_____Chickens or other birds
_____Pigs
_____Cows
_____Buffalo
_____Goats
_____Sheep
_____None
Other _____

Have antibiotics been used on the farm?
_____yes
_____no
_____unknown

Crop Features
Are plant crops grown on the farm?
_____yes
_____no
_____unknown

Have fertilizers and/or pesticides been used?
_____Pesticides
_____fertilizer
_____unknown

What food crops are grown on the farm?
_____Corn
_____Soybeans
_____Hay
_____Grain (e.g. wheat, sorghum, barley, rice)
_____Cotton
_____Vegetable other than corn (e.g. lettuce, squash)
_____Legume other than soybean
_____Alfalfa
_____Fruit tree
_____Non-tree fruit
_____Nuts
_____Unknown
Other _____

Other characteristics of site
Check any of the choices that accurately describe your soil collection site
_____Forest or woodland
_____Desert
_____Tundra
_____Nature reserve
_____Seashore/beach
_____Bog or salt marsh
_____Mountains/high altitude
_____Domestic fruit or vegetable garden
_____Yard, personal home
_____School campus
_____Playground
_____City park
Other _____

Your name_____ Date_____

Name of collection team (no more than 8 letters) _____

Undergraduate Team Members

First Name	Last Name	Plating and dilution series code (*e.g.* U1, H2, *etc.*)

Culture medium_____ Incubation temp. (°C)_____

Number of days incubated_____

Table 1. Number of colonies per plate.

Series U1
YOUR (undergraduate soil sample) plates

	1/10 (10E1)	$1/10^2$ (10E2)	$1/10^3$ (10E3)	$1/10^4$ (10E4)	$1/10^5$ (10E5)	$1/10^6$ (10E6)
No antibiotic (MA)	X					
3ug/ml tetracycline (MA3)				X	X	X
30ug/ml tetracycline (MA30)				X	X	X

Series U2
YOUR (undergraduate soil sample) plates

	1/10 (10E1)	$1/10^2$ (10E2)	$1/10^3$ (10E3)	$1/10^4$ (10E4)	$1/10^5$ (10E5)	$1/10^6$ (10E6)
No antibiotic (MA)	X					
3ug/ml tetracycline (MA3)				X	X	X
30ug/ml tetracycline (MA30)				X	X	X

Series U3 (if applicable)
YOUR (undergraduate soil sample) plates

	1/10 (10E1)	$1/10^2$ (10E2)	$1/10^3$ (10E3)	$1/10^4$ (10E4)	$1/10^5$ (10E5)	$1/10^6$ (10E6)
No antibiotic (MA)	X					
3ug/ml tetracycline (MA3)				X	X	X
30ug/ml tetracycline (MA30)				X	X	X

Series H1
High school soil sample plates

	1/10 (10E1)	$1/10^2$ (10E2)	$1/10^3$ (10E3)	$1/10^4$ (10E4)	$1/10^5$ (10E5)	$1/10^6$ (10E6)
No antibiotic (MA)	X					
3ug/ml tetracycline (MA3)				X	X	X
30ug/ml tetracycline (MA30)				X	X	X

Series H2
High school soil sample plates

	1/10 (10E1)	$1/10^2$ (10E2)	$1/10^3$ (10E3)	$1/10^4$ (10E4)	$1/10^5$ (10E5)	$1/10^6$ (10E6)
No antibiotic (MA)	X					
3ug/ml tetracycline (MA3)				X	X	X
30ug/ml tetracycline (MA30)				X	X	X

Series H3 (if applicable)
High school soil sample plates

	1/10 (10E1)	$1/10^2$ (10E2)	$1/10^3$ (10E3)	$1/10^4$ (10E4)	$1/10^5$ (10E5)	$1/10^6$ (10E6)
No antibiotic (MA)	X					
3ug/ml tetracycline (MA3)				X	X	X
30ug/ml tetracycline (MA30)				X	X	X

Table 2. CFUs per gram soil.

	Plating Series 1	Plating Series 2	Plating Series 3	
Number colonies per plate				
Volume of cells plated				
Dilution factor				
Total CFU per gram soil				←Database entry information

Table 3. Percent tetracycline-resistant cells.

	Plating Series 1		Plating Series 2		
Tetracycline Concentration	**3 µg/ml**	**30 µg/ml**	**3 µg/ml**	**30 µg/ml**	
Number of colonies					
Volume plated					
Dilution factor					
Total tet^R CFUs per gram soil					←Database entry information
Percent tet^R CFUs					←Database entry information

Appendix B:
DNA Structure and Replication

Biology Learning Outcomes: 1a, 3b, 4a

GEC Natural Science Learning Objectives: 1, 2 and 3

Objectives

- To discuss how scientific models are put forth following experimental results and are subsequently tested or refined by further work
- To utilize the scientific process in evaluating information regarding early research on DNA structure
- To recognize how our understanding of DNA has changed over time
- To understand the molecular structure of DNA, and DNA replication

Introduction

The events leading to the discovery of the molecular structure of DNA and the method of replication provide a model for studying the process of science. Researchers generated hypotheses, conducted experiments to collect data, drew conclusions, and presented their results. Others then generated more hypotheses and built upon those results. In this exercise, you will assume the role of an early researcher investigating the molecular structure of DNA. You will use the insights of early research on the molecular basis of genes to generate hypotheses regarding gene structure. You will build models to test your hypotheses. You will also propose hypotheses for the method of replication of the genetic material.

Pre-Laboratory Questions

Please read through the lab manual and answer the following questions. Please record your responses on a separate piece of paper.

Read through the following sequence of events leading to the discovery of the molecular structure of DNA.

Place yourself in the time of the researchers performing the experiments. Forget what you already know about DNA and consider only the information that was available to the scientists at the time of these discoveries.

- **Friedrich Miescher** showed in **1868** that chromosomes could be broken down to elements found in proteins: carbon, nitrogen, oxygen, and hydrogen. However, chromosomes also contained phosphorus, an element not found in proteins. This suggested that a different type of molecule comprised chromosomes that contained not only the elements found in proteins, but also phosphorus. Miescher suggested this molecule be called **nuclein**, named for the nucleus in which chromosomes are found.
- **Walter Sutton** showed in **1903** that Mendel's "factors" were physically located on chromosomes.

1. With this information, generate two hypotheses to address the question, "What type of molecule makes up the genetic material?" Construct your response in this format: H_1: The genetic material is_____.

- In **1927**, **Frederick Griffith** experimented with two strains of pneumonia: smooth, virulent pneumonia, which always caused illness and death in mice; and rough, non-virulent pneumonia, which did not cause illness (**Figure 8.1**). Using heat, Griffith killed the smooth virulent pneumonia and found that when killed, it did not cause illness in mice. He then mixed the heat-killed virulent pneumonia with live, non-virulent pneumonia and injected it into a mouse. To his surprise, this mouse died. Griffith concluded that the virulent strain of pneumonia, even when killed, could somehow pass its deadly characteristics to the non-virulent strain known to be harmless. He called the material that transferred the virulence from one strain to the other the "transforming factor."

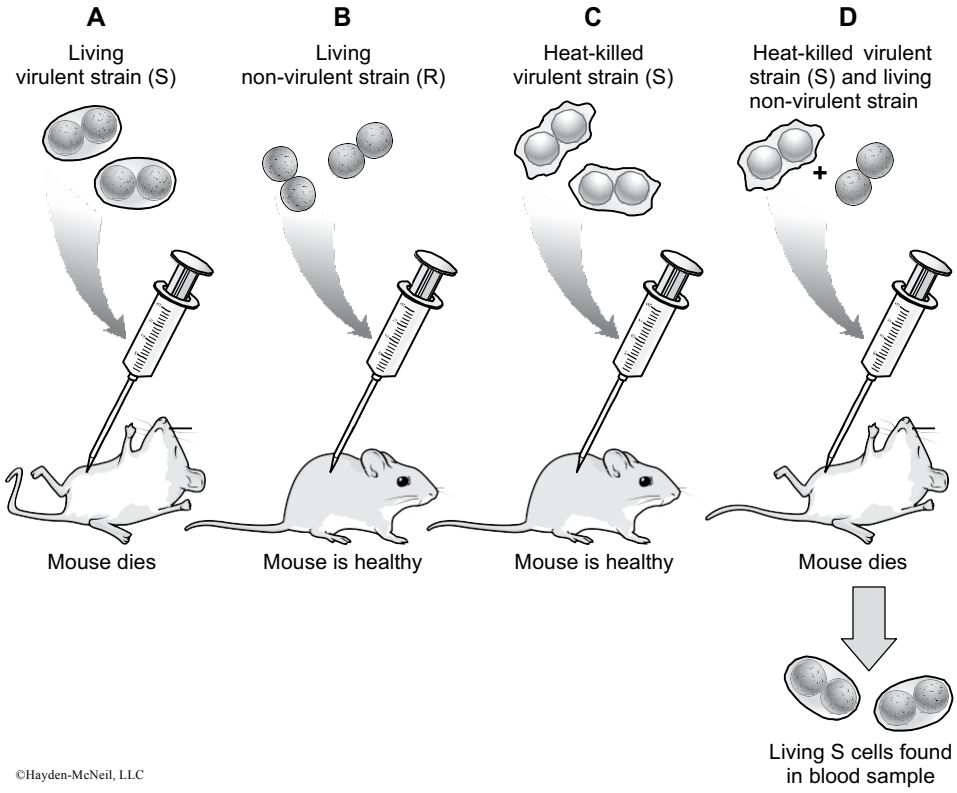


Figure 8.1. Griffith's experiment

- The **Scientific Community** at this time understood that proteins consisted of combinations of 20 different types of amino acid subunits. DNA, on the other hand, consisted of only four types of nitrogen base subunits. (We now know there are 22 amino acids. The 22nd having been discovered here at OSU!)

2. Considering the wide diversity of life forms, which molecule would the majority of the Scientific Community consider to be the more likely candidate for genetic material, despite Griffith's findings regarding the "transforming factor"?

Investigation I: What Is the Nature and Structure of the Genetic Material?

Materials (per lab group)

- Assorted colored beads representing sugar, phosphate, and nitrogen bases

Procedure

In the **1940's, Oswald Avery** noted the following about nuclein:

- Nuclein was determined to be DNA (deoxyribonucleic acid), made up of long chains of nucleotide subunits.
- The quantity of DNA was equal in all cells of an organism, except for the gametes (sperm and egg cells), which had exactly half the amount of DNA as the other cells.
- The amount of DNA in cells of closely related organisms was similar.
- DNA was a remarkably stable molecule.
- None of these points supported the hypothesis that protein was responsible for heritable traits, but rather supported the hypothesis that DNA played this role.

Avery hypothesized that DNA must be the genetic material. He further investigated Griffith's "transforming factor" and tested his hypothesis through experiments involving careful filtration of chemically digested chromosomes (**Figure 8.2**). Avery found that Griffith's "transforming factor" was not affected when proteins were chemically digested (destroyed), but was incapacitated when DNA was digested. He concluded that Griffith's "transforming factor" must be DNA.

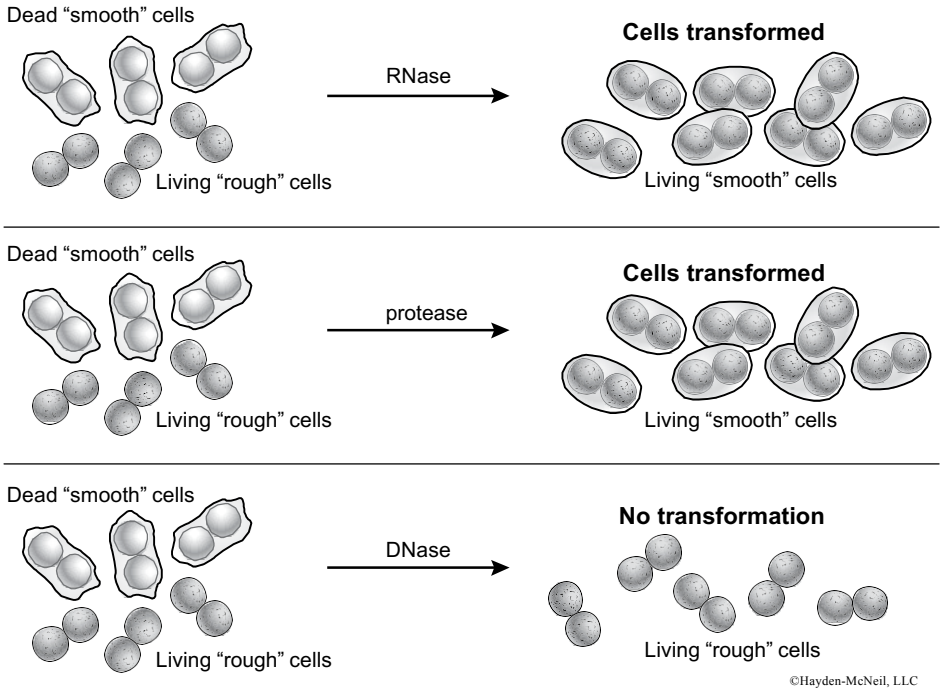


Figure 8.2. Avery's experiment

- Each subunit ("building block") of DNA was found to consist of the following:
  - A simple phosphate molecule containing only phosphorus and oxygen.
  - A somewhat larger sugar molecule containing carbon bonded to hydrogen and oxygen.
  - One of four types of complex nitrogen-containing molecules: adenine, guanine, cytosine, or thymine.
  - Each sugar is always attached to one base and one phosphate, which form a nucleotide, the subunit of DNA. The sugar and phosphate components within the larger DNA molecule are repeating.

How can a molecule with only 4 types of nucleotides account for the tremendous amount of diversity seen in living organisms?

1. Suppose we had a piece of DNA that was only 2 nucleotides long (2 nucleotides linked by a sugar phosphate backbone). With 4 nucleotide options, how many possible 2-nucleotide combinations are there?

   a. Begin answering this question by completing the combinations for C and T below.

Base 1	Base 2	Base 1	Base 2	Base 1	Base 2	Base 1	Base 2
A	A	G	A	C		T	
A	T	G	T	C		T	
A	G	G	G	C		T	
A	C	G	C	C		T	

b. Now, count the total number of different combinations.

Based on the table, for a piece of DNA 2 nucleotides long, there are_____possible 2-nucleotide combinations.

c. Determine how many combinations are possible for different nucleotide lengths in the Results and Analyses section.

2. Obtain beads representing sugar (white beads), phosphate (red beads), and the four nitrogenous bases (blue, green, orange, and yellow beads). Construct one model nucleotide based on the evidence above. **Once you have verified your model with your TA, sketch your model in the space in the Results and Analyses section.**

- In **1949**, **Erwin Chargaff** observed that in DNA, the amount of nucleotides containing the nitrogenous base adenine always equals the amount of nucleotides containing thymine. Further, the amount of nucleotides consisting of the base guanine, always equals the amount of nucleotides consisting of cytosine.

- In **1952**, **Martha Chase** and **Alfred Hershey** experimented with bacteriophage, which are viruses that infect bacteria. Such viruses infect bacteria by attaching to the surface of the bacteria, and then injecting the viral genetic material into the bacteria. The viral genetic material uses the bacteria machinery to replicate more if itself, thus replicating more phage inside the bacteria cell. Hershey and Chase radioactively labeled the phosphorus present in the phage DNA, and also radioactively labeled the sulfur present in the phage protein coat (**Figure 8.3**). Their experiments demonstrated that the phage genetic material injected into bacteria contained phosphorus, which was labeled and present in the DNA, but not present in protein. Likewise, the sulfur labeled in the phage protein coat was not injected into the bacteria.

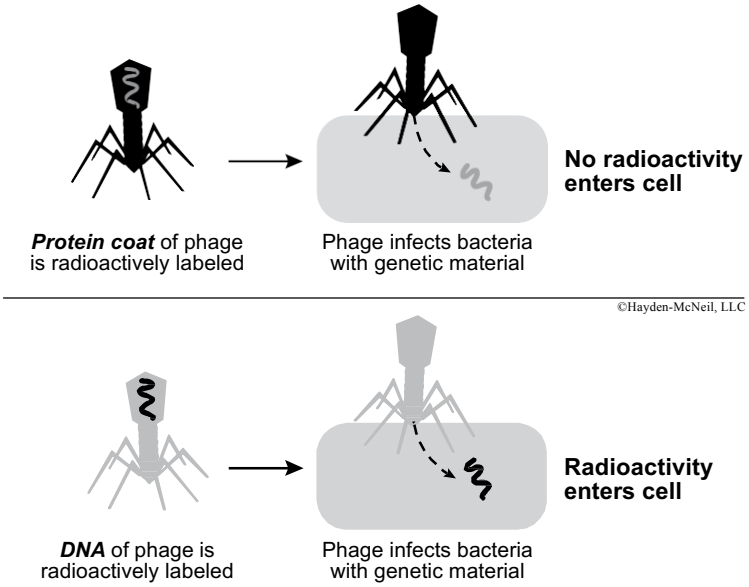


Figure 8.3. Hershey and Chase experiment

3. Return to the original two hypotheses generated in Pre-lab Question 1. In light of these new discoveries, which hypothesis appears to be supported? Record your answer in the Results and Analyses section.

    - At this point, major questions regarding the molecular structure of the genetic material shifted to determining the relative position of the nitrogenous bases with respect to the repeating sugar-phosphate molecules. Model building played a crucial role in understanding and determining the structure of DNA.

4. Using this information, build upon your single nucleotide until it is 6–8 nucleotides in length. **Again, verify your structure with your TA and then sketch your model in the space in the Results and Analyses section.**

    - Several observations were then made in quick succession. **Linus Pauling**, already having won a Nobel Prize for his work on the structure of proteins, hypothesized that DNA must be a twisted helix.

    - In **1953**, **James Watson** and **Francis Crick** realized that nucleotide pairs containing the bases guanine and cytosine were identical in shape to pairs containing the bases thymine and adenine.

5. Considering these observations, the fact that the nitrogenous bases of DNA are very polar, and the nature of hydrogen bonding between polar molecules, would a single stranded model of DNA be sufficient? Using your beads, build a double stranded model of DNA. In the space in the Results and Analyses section, sketch your model using the specified symbols.

    - The Watson-Crick "double-helix" model was supported. In **1962**, **Watson**, **Crick**, and **Maurice Wilkins** received the Nobel Prize for their contributions to science. **Rosalind Franklin** would have been included for her crucial contributions involving measurements of the dimensions of DNA. However, the prize is not awarded posthumously.

Investigation II: How Does the Genetic Material Replicate?

The Watson-Crick model of DNA soon gained the support of the scientific community. Questions then arose about how DNA functions. How does DNA determine genetic traits? How does it replicate itself as an organism grows or makes gametes? **Matthew Meselson** and **Franklin Stahl** recognized that the Watson-Crick model provided three possible hypotheses to explain how the genetic material is replicated when a cell divides.

Conservative Replication: Original double-stranded helix somehow codes for a completely new double helix while still maintaining the original old double helix.

Dispersive Replication: Original double-stranded helix is broken apart into individual nucleotides. Original nucleotides recombine with new nucleotides to make new double helices that are a combination of old and new nucleotides.

Semi-conservative Replication: Original double-stranded helix is split apart lengthwise into single-stranded halves. Each original strand combines with a new strand to make new double helices that are a combination of old and new strands.

Meselson and Stahl realized they could take advantage of recent advances in nuclear physics to test these hypotheses. It was 1953 and the field of research in nuclear physics had made great advances because of World War II, which had ended eight years earlier. It was now possible to modify atoms for research purposes by adding an extra neutron particle to the nuclei of some atoms like nitrogen, one of the elements in the four bases of DNA. These nitrogen atoms with an extra neutron were measurably heavier than normal nitrogen; they referred to them as N^{15} ("heavy"; i.e., containing an added neutron) and N^{14} ("light"; i.e., not containing an added neutron). The difference in mass could be measured by sensitive lab instruments in combination with cesium chloride gradients and a powerful centrifuge (known as an "ultracentrifuge").

A cesium chloride gradient is less dense at the top and progressively increases in density toward the bottom of the tube in which it is contained. This gradient, in combination with the considerable G-force produced by the ultracentrifuge, allows molecules to separate from one another based on molecular weight, with the heavier molecules migrating further into the more dense portions of the gradient. These tools made it possible to measure and distinguish heavy nitrogen (N^{15}) from light nitrogen (N^{14}). In fact, the instruments were so sensitive that DNA double helices made with equal amounts of both heavy and light nitrogen (N^{15}/N^{14}) could be differentiated from helices made using only heavy nitrogen (N^{15}/N^{15}) or only light nitrogen (N^{14}/N^{14}).

Meselson and Stahl began by growing bacteria in a growth medium containing nucleotides made from heavy nitrogen. Thus, they generated a population of bacteria containing pure heavy DNA (N^{15}/N^{15}). They then filtered the bacteria, removed the heavy nucleotides in the growth medium, and re-suspended the bacteria in a new growth medium containing only nucleotides made from normal, light nitrogen. Any "new" DNA made by the bacteria would then contain normal nitrogen (N^{14}), while the "old" DNA would contain heavy nitrogen (N^{15}).

For each of the three replication hypotheses, Meselson and Stahl made predictions about the amounts of each kind of nitrogen that would be present in new DNA molecules made by the bacteria in the new growth medium that contained only normal light nucleotides (N^{14}). The generation time of bacteria, which can be as short as 20 minutes, is easy to control under laboratory conditions, making bacteria ideal organisms for this type of research. Thus, Meselson and Stahl could extend their predictions to multiple generations of bacteria, or successive rounds of replication. Complete the drawings in **Figure 8.5** in the Results and Analyses section by filling in the missing information for all three hypotheses after multiple generations of replication.

Figure 8.4 illustrates their experiment.

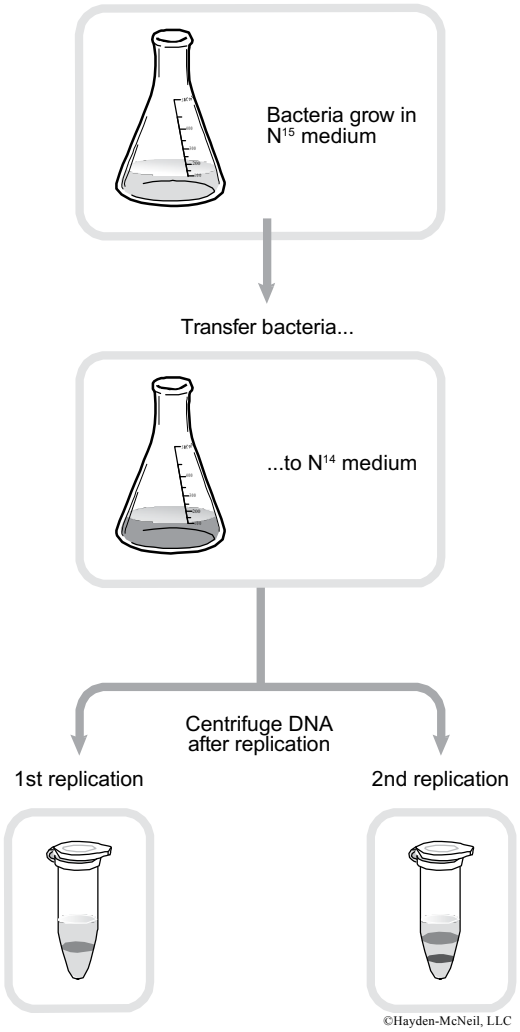


Figure 8.4.

Refer to Figure 4 in Meselson and Stahl's paper. Note that the cesium chloride gradient tubes are vertical, but are pictured horizontally in order to better compare all the data. The figure legend indicates that the gradient increases in density from left to right. Therefore, in **which side of the tube, left or right, would you expect to find bands of heavy molecules of DNA (N^{15}/N^{15})? Intermediate molecules of DNA (N^{15}/N^{14})? Light molecules of DNA (N^{14}/N^{14})?**

Complete Table 8.1 in the Results and Analyses section with the remaining predictions based on your drawings and what you know about the three mechanisms of replication.

Investigation III: DNA Isolation

Every living organism contains DNA. You've spent the lab period developing a model of DNA structure. But what does DNA look like in real life? In this activity you will be extracting the DNA from the nuclei of wheat germ (the plant embryo part of wheat seeds) using items found in most home kitchens.

Before we begin the protocol, let's examine what steps we might take to extract DNA from plant cells. Record your answers in the Results and Analyses section.

1. What are the barriers to getting DNA out of a cell (in particular a plant cell)?
2. Why would wheat germ be a good source of DNA? What properties of its DNA might make it a good source for us to use? You may consult your textbook.
3. Examine the materials listed below. Develop a protocol that uses these supplies to extract the DNA from wheat germ cells. Consider what each supply might be used for in conjunction with the barriers you describe in question 1.
4. Follow your TA's instructions for extracting DNA from wheat germ. How was the provided protocol different from what you developed?

Materials

- Scale
- Non-iodized salt (3.5 g)
- Distilled water (65 mL)
- Wheat germ (7.5 g)
- Blender
- Beaker(s)
- Filter
- Cheesecloth
- Palmolive dish soap (2–3 drops)
- Test tube
- Cold isopropyl alcohol (~1" solution)
- Wooden dowel rod
- Graduated cylinder

Cleanup☑

Your TA will not check you out before the following list is complete:

D Place all thick contents into trash and liquid contents down the sink drain.

D Do not allow excess slurry to sit in the sink.

D Be sure to use a test tube brush on the test tubes.

Exercise 8 Results and Analyses

Group Members

Date Day/Time

TA

Investigation I: What Is the Nature and Structure of the Genetic Material?

1c. Continuing with 4 nucleotide options, determine how many combinations are possible for the nucleotide lengths listed below. Consider using exponents.

a. For 3 nucleotides _____
b. For 5 nucleotides _____
c. For 4 nucleotides _____
d. For 10 nucleotides _____
e. For 1,000 nucleotides _____
f. For 10,000 nucleotides _____

2. **Construct one model nucleotide.** Once you have verified your model with your TA, sketch your model below.

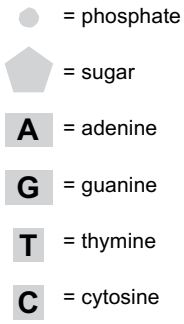
TA initials

3. Return to the original two hypotheses generated in Pre-Lab Question 1. Which hypothesis appears to be supported? Explain.

TA initials

4. Build upon your single nucleotide until it is 6–8 nucleotides in length. Again, verify your structure with your TA and then sketch your model below.

5. Build a double-stranded model of DNA. Sketch your model using the following symbols:



Additional questions from the readings:

6. According to Watson and Crick, what is the novel feature of their model?

7. What comments do these authors make concerning the relation of bases on one strand of the helix as compared to those on the other strand?

8. How might this be suggestive of a possible copying mechanism for the genetic material?

9. From these collective reports, how many bases ("residues") do the authors suggest occur in one turn of the helix?

10. Subsequently, Watson and Crick showed that a molecule of DNA can be broken lengthwise into two linear halves by merely heating it. What does this imply about the strength of the bonds between the two linear halves of DNA? Are the bonds between the two halves likely to be stronger or weaker than the bonds that make up the sugar-phosphate backbone?

Investigation II: How Does the Genetic Material Replicate?

Complete the figure below and Table 8.1 and answer the accompanying questions.

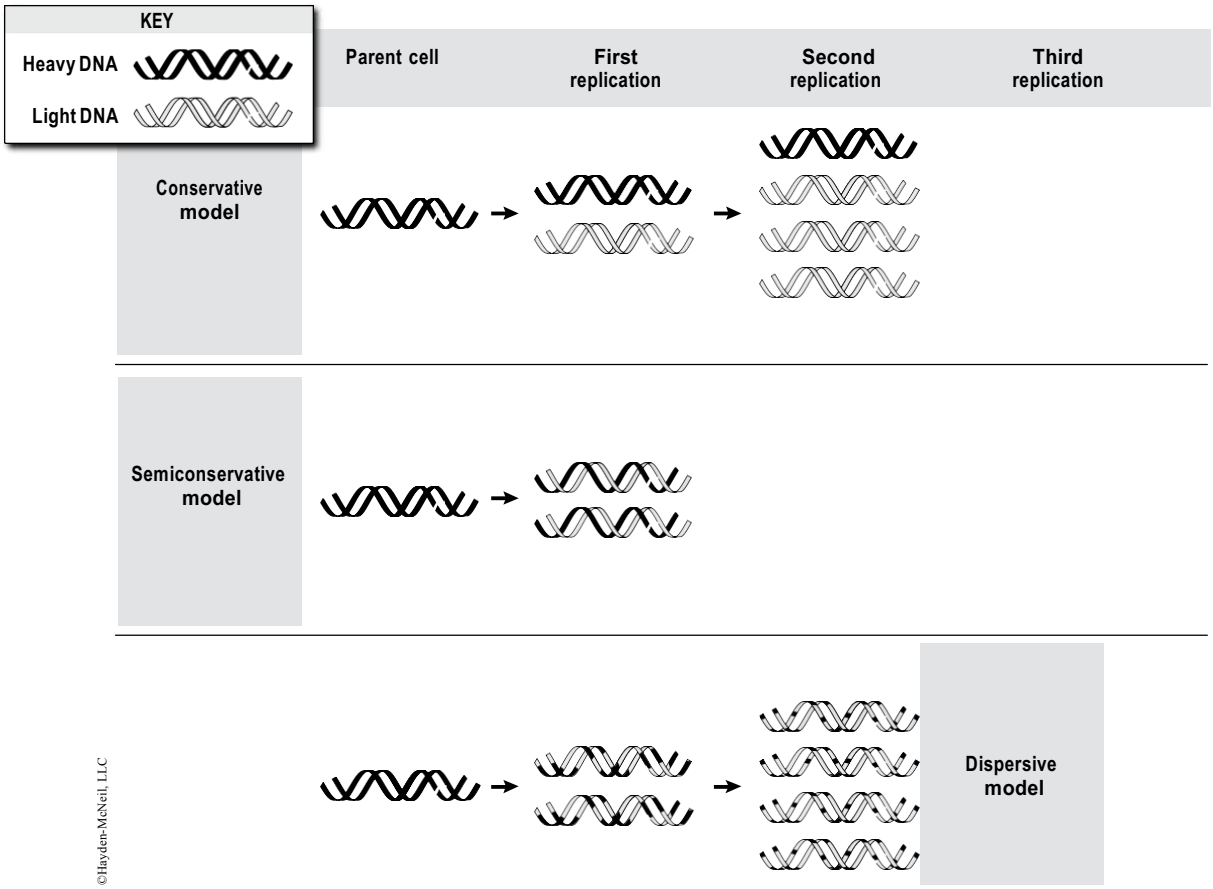


Figure 8.5. Models of DNA replication

Table 8.1: Predicted Amounts of Heavy and Light Nitrogen

Hypothesis	Predicted Result: First Replication	Predicted Result: Second Replication	Predicted Result: Third Replication
Conservative Replication	50% of double helices contain all heavy (N^{15}/ N^{15}) nitrogen, 50% are all light (N^{14}/ N^{14}) nitrogen.		
Semi-conservative Replication			
Dispersive Replication	100% of double helices contain half heavy and half light (N^{15}/N^{14}) nitrogen.		

1. Are the above predictions for the first round of replication mutually exclusive? (In other words, if one of the predictions appears correct, does that exclude all the other predictions from being correct?)

2. After the first round of DNA replication in a growth medium containing nucleotides made with normal nitrogen (N^{14}), Meselson and Stahl chilled some bacteria to stop their growth and analyze the DNA. According to the results in **Figure 4** of Meselson and Stahl's paper, what is the composition of the bacterial DNA after this first round of replication (i.e., does the DNA have heavy (N^{15}/N^{15}), light (N^{14}/N^{14}), or intermediate (N^{15}/N^{14}) composition)?

3. According to the results in **Figure 4** of Meselson and Stahl's paper, after the first round of replication, which hypothesis(es) can be rejected? Which is/are supported?

4. Meselson and Stahl permitted some bacteria cultures to grow two generations before chilling and analyzing the DNA. According to **Figure 4** of Meselson and Stahl's paper, after two rounds of replication, what is the composition of the bacterial DNA? What percentage of the DNA is heavy (N^{15}/N^{15}), light (N^{14}/N^{14}), or intermediate (N^{15}/N^{14})?

5. After the second round of replication, which surviving hypothesis(es) is/are supported? Which is/are rejected?

6. Meselson and Stahl further challenged the hypothesis supported by their first and second generation data by permitting some bacterial cultures to grow to a third generation. According to the surviving hypothesis, what results would they predict after this third round of replication?

7. According to the results in **Figure 4** of Meselson and Stahl's paper, did the composition of DNA double helices after three generations support the surviving hypothesis? Explain.

Investigation III: DNA Isolation

1. What are the barriers to getting DNA out of a cell (in particular a plant cell)?

2. Why is wheat germ a good source? What properties of its DNA might make it a good source for us to use? You may consult your textbook.

3. Examine the materials listed on page 137. Develop a protocol that uses these supplies to extract the DNA from wheat germ cells. Consider what each supply might be used for in conjunction with the barriers you describe in Question 1.

4. Follow your TA's instructions for extracting DNA from wheat germ. How was the provided protocol different from what you developed?

Appendix C:
Is Ethanol a Sustainable Solution to Our Energy Needs?

Pre-Laboratory Questions

To be completed *prior* to lab on a separate sheet of paper. You must properly cite your sources of information.

1. What is the chemical equation for fermentation? *(1 pt.)*
2. How is energy stored in molecules like sugar, gasoline, and alcohol? What is the primary source of this energy? *(1 pt.)*

introduction

Throughout history, humans have discovered numerous ways to actively use other organisms for our own benefit. In fact, it is safe to say that without these other species, the global human population would not be nearly as large as it is today.[1] Many of the organisms that have greatly (positively) impacted human history are obvious (e.g., wheat, rice, cows) and their benefits are obvious too (food sources). However, others are not so conspicuous.

The first *micro*organisms manipulated by humans for their own gains were yeasts.[2] Much like their larger counterparts, yeasts have played a large role in human food systems for millennia, most notably in bread and beverage making. Yeasts are prolific, hardy, and versatile microorganisms—and they love carbohydrates! Yeasts have the ability to process sugars in two ways, employing a different metabolic pathway depending on whether oxygen is present in their environments. In the presence of oxygen, they undergo respiration; in the absence of oxygen, they undergo fermentation. This effervescent reaction is what makes breads rise (CO_2) and "adult beverages" so intoxicating (ethanol).

Yeasts' benefits for humans extend well beyond our gustatory hankerings. Ethanol—the most notable by-product of fermentation—has many uses *besides* its intoxicating effects. Historically, humans have used it as everything from a sterilizing agent to an aphrodisiac (some uses were based on faulty logic). More pertinently, in the last 150 years, humans have developed this resource as a fuel to power internal combustion engines for our transport. In fact, the first Model T Ford ever produced ran on ethanol.

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1 Diamond, Jared. *Guns, Germs, and Steel: The Fates of Human Societies*. New York: Norton, 1999.

2 Goodman, David C. *From Farming to Biotechnology: A Theory of Agro-industrial Development*. Oxford: Blackwell, 1987.

Ethanol production has increased rapidly in the U.S. in the last 25 years in an effort to create cleaner burning gasoline *blends*, and most recently to decrease dependence on fossil fuels for energy. Furthermore, ethanol has been reputed by many to be a better alternative to fossil fuel-based gasoline and diesel by reducing greenhouse gas (especially CO_2) emissions. The acknowledgement of global climate change by the U.S. government has led to an increase in subsidies (money) given to companies producing or harvesting energy sources that reduce greenhouse gas emissions, including ethanol. Together, the above pressures have resulted in an increase in the production of ethanol, and the construction of new ethanol production facilities (distilleries) across the country.

Ethanol can be produced from nearly any digestible carbohydrate, but the sources most efficient for industrial production are those that can be quickly processed by yeast. Two of the best sources are sugarcane and corn. In lab, you will test the fermentation rate of each of these common agricultural products, and calculate the amount of ethanol that can be produced from each. Informed by this, you will be asked to determine which is a better source for mass ethanol production, and whether either is ultimately a good source for our energy needs.

Objectives

- Understand the process of fermentation.
- Compare ethanol production rates using both sugarcane and corn.
- Discuss the sustainability of ethanol production.
- Understand the major components and processes of the carbon cycle.
- Understand the implications of human activities (and decisions) for ecosystems.
- Recognize the connections between biology and society.

Is Corn or Sugarcane a Better Source of Carbohydrates for Ethanol Production?

1 Formulate a hypothesis you can test by fermenting corn and sugarcane. *(0.5 pt.)*

2 Make a prediction for your experiment. *(0.5 pt.)*

Design an experiment to test (compare) the fermentation rates of yeast when given equivalent amounts of sugarcane juice and ground corn. You can determine the relative fermentation rate of each test variable by measuring the rate of CO_2 production. Your TA will show you the apparatuses available to make these measurements.

3 List your materials, and describe your methods. *(1 pt.)*

4 Create a graph to display your results. Remember that the dependent variable should always be on the Y-axis. *(1 pt.)*

5 Draw a conclusion based on your experimental results. *(1 pt.)*

Calculation: Theoretical Yield

6 While the rate at which ethanol can be produced is important, the total *quantity* of ethanol that can be produced from a given crop is also important. Use the information listed below to calculate the theoretical yield of ethanol from a 1 hectare plot of corn and a 1 hectare plot of sugarcane in the U.S. (1 hectare = 2 football fields). Show your calculations. *(0.5 pt. each)*

Corn[3]

- Yield: 138 bushels of seed per hectare
- 1 bushel seed = 2.8 gallons ethanol

Sugarcane[4]

- Yield: 89 tons sugarcane per hectare
- 1 ton sugarcane = 19.5 gallons ethanol

7 Based on your experimental conclusion and the calculations in #6, do you think sugarcane or corn is a better fit for large-scale ethanol production? Why? *(1 pt.)*

8 The primary carbohydrate in sugarcane is *sucrose*, and the primary carbohydrate in corn is corn *starch*. Informed by this information, explain why you think the corn or sugarcane led to faster fermentation. *(1 pt.)*

Many researchers are working to develop strains of yeast, and/or combinations of yeasts and other microorganisms and mechanical processes to produce ethanol from cellulose; cellulose is a by-product of many agriculture and forestry systems, and very plentiful in all plants, but difficult for most organisms to break down (including humans).

9 What cellular structure is made of cellulose? *(0.25 pt.)*

10 What type of macromolecule is cellulose? *(0.25 pt.)*

There is much optimism that if scientists and engineers can create industrial systems to efficiently produce ethanol from cellulose, ethanol will become a more sustainable energy source. While semi-arid climate grasses are the main target of this research, consider the two species you tested. Sugarcane is a very prolific subtropical crop, and produces nearly 10 times as much cellulose by-product as corn. Thus, sugarcane clearly has greater potential for cellulosic ethanol production.

11 Based on this information, and your conclusions from above, why do you think many individuals and organizations in the U.S. are still strong proponents of corn-based ethanol? *(1 pt.)*

3 Bothast, R. J., and M. A. Schlicher. 2005. Biotechnological Processes for Conversion of Corn into Ethanol. *Applications in Microbiology and Biotechnology*, 67: 19–25.

4 Shapouri, H., and M. Salassi. 2006. *The Economic Feasibility of Ethanol Production from Sugar in the United States*. USDA (OEPNU/OCE) and Louisiana State University. URL: www.usda.gov/oce/EthanolSugarFeasibilityReport3.pdf.

Energy drives life on Earth, and can be found in many forms; heat, motion (kinetic), chemical, sound, electrical, and electrochemical energies are all important to biological organisms. Energy is never lost or created, but can be converted from one form to another. For example, mammals convert *chemical* energy stored in the molecules they eat (food) to *heat* energy for maintaining their body temperatures. Similarly, ethanol production involves several energy conversions.

12 Starting with the sun, and finishing with a moving car, create a flow chart (or other diagram) depicting all of the major steps of ethanol production and combustion, and the primary form of energy at each step (e.g., sun and light energy would be step one). *(2 pts.)*

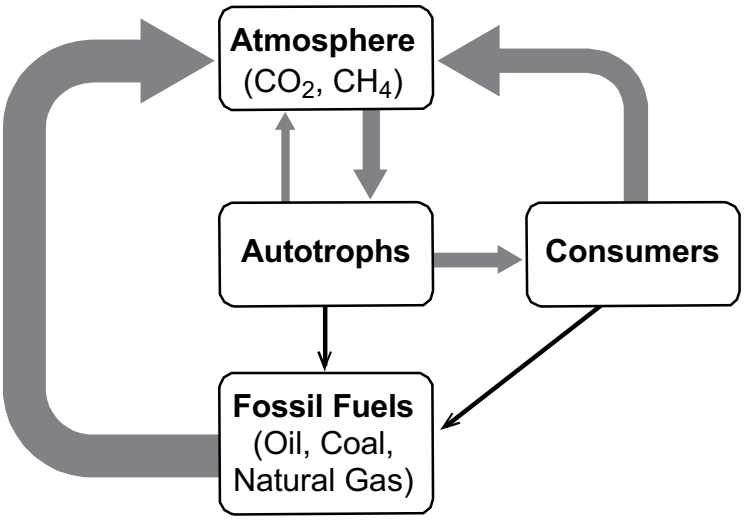
The conversion of energy from one form to another results in a "loss" of approximately 90% of the original quantity of energy to inefficiencies (a.k.a. the "10% rule" of energetics); this occurs each time energy is converted!

13 Starting with sunlight, how many conversions are involved in the *production* of ethanol? *(0.5 pt.)*

14 Informed by the "10% rule," how might we increase the efficiency of acquiring energy and adapting it for our use? Suggest two ideas to improve the efficiency of current energy technology (ethanol related, or otherwise). *(1 pt.)*

Ethanol and Global Climate Change

Global climate change is a major concern for the scientific community and society as a whole; scientists attribute the warming trend of the last century primarily to the by-products of human energy demands. The combustion of gasoline and diesel fuel releases large amounts of carbon dioxide, a "greenhouse gas," into the atmosphere—ultimately increasing the average global air temperature. The release of carbon dioxide via combustion is one major process that comprises the carbon cycle. Examine this relationship and others in the simplified diagram of the carbon cycle below.



15 If ethanol becomes a major source of energy for humans (some would argue it already is), it should be added to the diagram above. Re-draw the carbon cycle on your lab report, adding a new box for ethanol and drawing the correct arrows. *(0.5 pt.)*

16 Label each arrow in ***your*** new diagram with the appropriate process that it represents (e.g., the lower right hand arrow in the diagram provided above should be labeled "decomposition"). *(1 pt.)*

Ethanol has gained support from politicians, agriculture lobbyists, and even a few scientists because it has the potential to reduce the release of greenhouse gases as compared with gasoline and diesel fuels. However, you should see in your carbon cycle that the source of energy/carbon for ethanol and fossil fuels is the same.

17 How will using ethanol in place of gasoline and diesel decrease total greenhouse gases in the atmosphere, comparatively? (Hint: Consider the current location of fossil fuels.) *(1 pt.)*

Despite the theoretical potential for ethanol to provide a better long-term energy source than fossil fuels, *current methods* of ethanol production have been criticized by many. For example, let's examine the most efficient large scale ethanol industry. Brazil is the greatest producer of sugarcane in the world, and is also the only country where vehicles run nearly entirely on ethanol (no coincidence!). When analyzing only the sugarcane to ethanol portion of the process, burning ethanol reduces greenhouse gas emissions over 75% as compared to gasoline. However, Brazil's large scale sugarcane production is possible only by clearing rainforest via slash and burn agriculture.

18 How do you think slash and burn practices contribute to the total greenhouse emissions of sugarcane-based ethanol production? You may find your carbon cycle helpful. *(0.5 pt.)*

19 Do you think Brazil's ethanol production is a good long-term solution to their energy needs? Explain. *(1 pt.)*

Study Questions (1 pt. each)

1. Based on the fermentation equation (from Pre-Lab question 1), what other increasingly valuable resource is needed to produce ethanol? How might this impact the viability of ethanol production in the future (especially if human populations continue to grow)?

2. Some critics of ethanol say the costs of its production are greater than the price at the service pump, and transferred to the consumer in other ways. How do you think this might occur? (Hint: Think about supply and demand.)