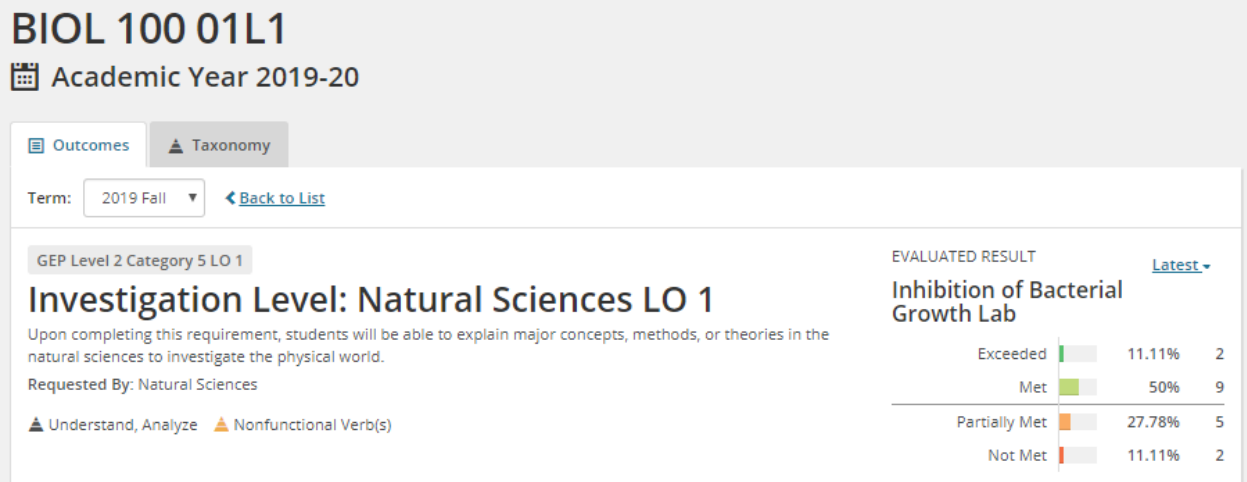


Analysis

Please see the documents attached.

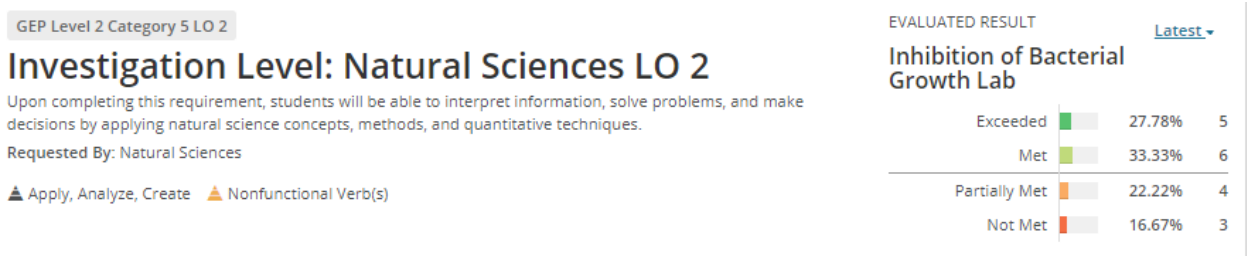
Summary

Please see the documents attached.

Use of Results

- Please see the documents attached.

LO2



Analysis

Please see the documents attached.

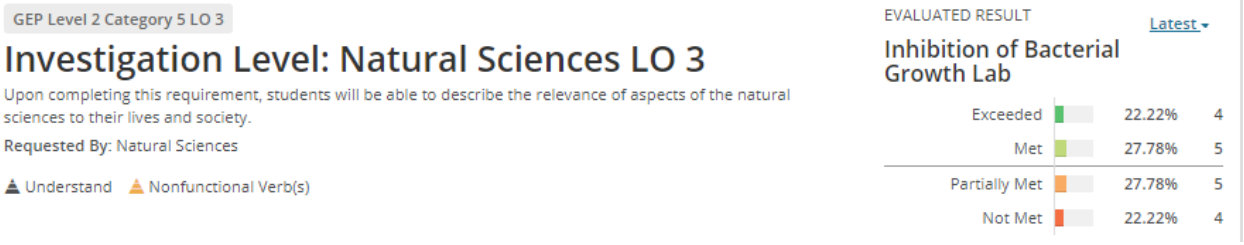
Summary

Please see the documents attached.

Use of Results

- Please see the documents attached.

LO3



Analysis

Please see the documents attached.

Summary

Please see the documents attached.

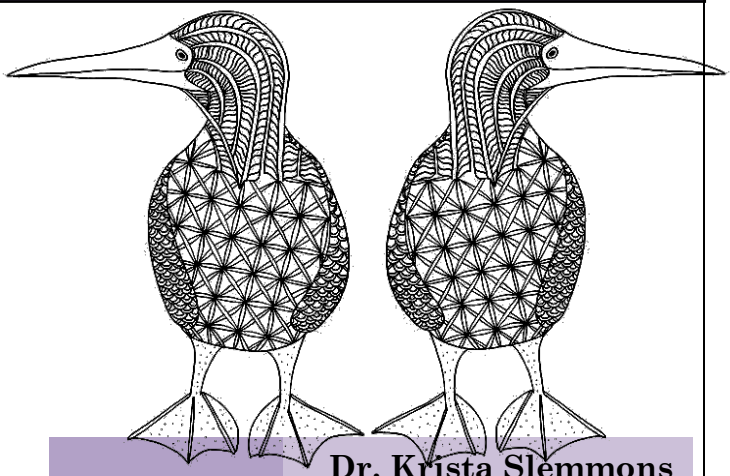
Use of Results

- Please see the documents attached.

1.1 COURSE SYLLABUS AND COURSE ASSIGNMENT SCHEDULE

BIOLOGY 100

Fall 2020



Biological Principles & the Human Environment

Dr. Krista Slemmons
CBB 347
kslemmon@uwsp.edu
http://paleodiatom.com
715-346-2453

Office hours:
Thur 12-2:30

Or by appointment

LECTURE
Tues 11:00-11:50
Online
Thur 11:00-11:50
CBB 101

LAB (CBB 130):

Sect. 1	Thur	8-10:50
Sect. 2	Wed	11-1:50
Sect. 3	Wed	2-4:50

COURSE DESCRIPTION:
Survey of biology emphasizing present and future relationships of humans to their environment.

LEARNING GOALS:

- Students will be exposed to the amazing and diverse world of life by exploring the major themes of biology. Each biological theme will begin with a relevant question or a current problem applicable to everyday life.

- Students will explore, synthesize and evaluate biological concepts through inquiry-based laboratory experiments, a course undergraduate research experience, and exploration of dominant themes in biology. This investigation will begin by focusing on the structure and function of life at the chemical, subcellular and cellular levels, continuing with an examination of genetics and the mechanisms of cellular reproduction. Students will explore biodiversity including the evolutionary factors that have led to the form and function of life, and issues affecting biodiversity.

- Students will be able to critically analyze biological concepts in order to make scientifically literate decisions dealing with environmental and ethical issues related to biology and the human experience.
  ** All of these learning goals will be underscored with the scientific method and based on relevant, inquiry-based science.*

General Education Course:
This is a General Education Course which means that students will explore a broad survey of biological concepts. Specifically, students will:

1) Explain major concepts, methods, or theories in the natural sciences to investigate the physical world.
2) Interpret information, solve problems, and make decisions by applying natural science concepts, methods and quantitative techniques.
3) Describe the relevance of aspects of the natural science to their lives and society.

REQUIRED TEXTBOOK: *Biology for a Changing World*, Second edition, Shuster, Vigna, Tontonoz, Sinha

REQUIRED LAB MANUAL: *Biology 100 Laboratory Manual – online through Canvas*

Put your lab manual in a 3-ring binder and bring it with you to **every** lab meeting.

GEP & OVERALL COURSE STUDENT LEARNING OUTCOMES (C-SLO)

All learning outcomes will be assessed in a variety of ways throughout the semester.
Weekly course student learning outcomes (W-SLO) are listed in the weekly schedule at the end of the syllabus.
Assessments for each W-SLO are listed in abbreviated form. These assessments include but are not limited to:

- SA Summative Assessment (exam)
- FA Formative Assessment (online quiz)
- P Presentation (poster / oral)
- PE Peer evaluation
- SP Scientific Paper
- CS Case Study
- ILQ Inquiry Post Lab Questions'
- TLQ Traditional Post Lab Questions
- D Debate

GEP & COURSE LEARNING OUTCOMES	EXAMPLE CLASS ASSIGNMENT(S):	ACTIVITY
1. Explain major concepts, methods, or theories in the natural science to investigate the physical world. 2. Interpret information, solve problems, and make decisions by applying natural science concepts, methods, and quantitative techniques.	Identify the basic principles of the scientific method in a case study involving childbed fever. Conduct self-designed, long-term experiments (photosynthesis) applying the principles of the scientific method.	Inquiry Lab Case Study Lecture Oral presentation Videos
3. Infer relationships, make predictions and solve problems by **synthesizing** content derived from biological principles including: • Cellular level functions necessary for life • Inheritance & evolutionary change • The diversity of life within an evolutionary context • The basic function of populations, communities and ecosystems.	Infer relationships, make predictions and solve problems based on data dealing with bacterial inhibition and experimental treatments in self-designed experiment	Inquiry Lab Written scientific paper Scientific presentation
4. Describe the relevance of aspects of the natural science to their lives and society.	Evaluate the legitimacy of research in terms of the scientific method and solve problems involved in five different case studies throughout the semester. Case studies involve current, real-life problems and determining solutions to those problems based on course content.	Peer evaluation Case study Independent work Written work

CRITICAL THINKING (CT) AND HONORS (H) LEARNING OUTCOMES (SECTION 3 ONLY):

PARTICIPANTS	OUTCOME	ASSESSMENT
CT & H	Recognize critical thinking as a process of identifying, analyzing, evaluating, and constructing reasoning in deciding what conclusions to draw or actions to take	• Critical Thinking Lesson Module • Assessment Instrument (both found on CANVAS)
CT & H	**Identify**, analyze, evaluate or **construct** reasoning as it is applied to general or discipline-specific questions or issues	• Identify reasoning from a scientific paper • Creation of an argument for labs 1-8
H	Foster intellectually curiosity through engagement in a citizen science research project	• Participation in the project • Poster Presentation

ASSESSMENTS/GRADING:

LECTURE:

3 Lecture exams (100 points each)	= 300 points
15 Online Quizzes (5 points))	= 75 points
20 Lectures w/clicker questions (5 points/lecture)	= 100 points
Subtotal	= 475 points

LAB:

8 Post-labs (20 points each)	= 160 points
3 Labs (15 points each: 5 pre-lab, 10 lab–animal & plant)	= 45 points
14 Pre-labs/Hypotheses (5 points each)	= 70 points
2 Presentations (one poster, one oral, 50 points each)	= 100 points
4 Peer evaluations (5 points each)	= 20 points
1 Lab report, Bacteria	= 50 points
Subtotal	= 390 points

Total	**= 920 points**

CRITICAL THINKING ADDITIONAL GRADES (SECTION 3 ONLY)

Critical Thinking Module/Quiz	=10 points
Scientific Reasoning Paper	=25 points
Total additional points	**= 35 points**

Final grades will be assigned based on the following percentages:

A	= ≥93%	B-	= 80-82%	D+	= 67-69%
A-	= 90-92%	C+	= 77-79%	D	= 60-66%
B+	= 87-89%	C	= 73-76%	F	= < 60%
B	= 83-86%	C-	= 70-72%		

EXAMS: Exams are cumulative but will largely deal with topics covered since the previous exam (80%). Cumulative exams result in longer retention of material (Khanna et al. 2013; Lawrence 2013). Exams will cover assigned textbook readings as well as lecture and lab material. **Make-up exams will be provided only in the case of an acceptable excuse and the discretion of Dr. Slemmons. The final exam must**

be taken during the week of finals unless you are graduating this semester. Graduating seniors must make arrangements with Dr. Slemmons for taking the exam early.

Exam 1 **Oct 3rd**
Exam 2 **Nov 5th**
Final Exam **Thursday Dec 19th 10:15-12:15pm**

LECTURE: Lectures will be held twice a week. I expect you to be prepared, engaged and attentive. Some lectures will involve group or independent work based on videos that you will watch outside of class. While lecture is not mandatory, you will earn clicker points that comprise a part of your grade. If you attend every lecture, there is an opportunity to gain extra clicker points. **Absences from lecture will result in a zero for these clicker points.**

Partial lecture notes will be provided on CANVAS prior to class when deemed necessary (Cornelius and Owen 2008). Providing complete lecture notes decreases student success (Noppe, 2007).

CLICKERS: **This class uses "Turning Point Cloud" to do interactive polling.** You will need to purchase a Turning Technologies code from the bookstore to participate in the class. You will be able to use your own device (a laptop, tablet, or smartphone) to respond to polling.

If you do not have a device, you may check out a clicker from the **UWSP IT Service Desk in room 027 ALB, basement of the UWSP Library free of charge. Returning clickers:** Clickers must be returned to IT Service Desk before the end of finals. Students with unreturned clickers will be billed a late fee and/or may be billed the replacement cost of the clicker.

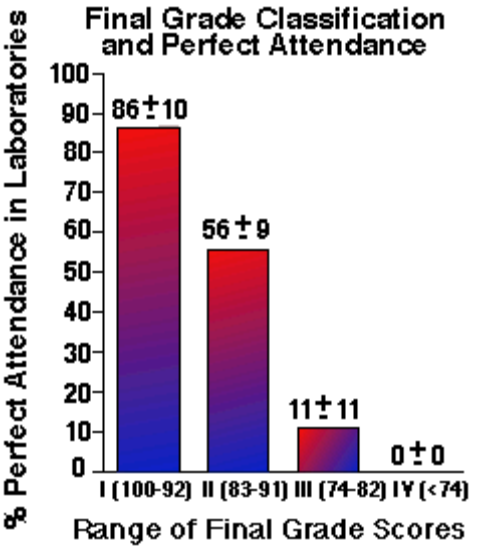
For Service Desk hours: http://www.uwsp.edu/infotech/Pages/HelpDesk/default.aspx

You will need your UWSP Student ID to get your clicker.

Turning Point Account
You will need to create a Turning Technologies account in order to register your device to the class. Please use your UWSP email address to create an account here: https://account.turningtechnologies.com/account/

You can find help with Turning Point Cloud here: https://www.turningtechnologies.com/support/turningpoint-cloud

ONLINE VIDEOS & QUIZZES: Throughout the semester, some material will be presented on CANVAS in a flipped classroom format.
Students will be assessed on their understanding of the content provided in these videos in the form of a CANVAS quiz. If you fail to complete the quiz by the designated deadline, you will not be able to make up the quiz.



Daniloff 1994

CASE STUDIES: There will be seven case studies throughout the semester. Case studies involve a real-world application of some topic that we are covering in class. Case studies may be presented through online videos, a reading or participating in class discussions. Students will answer questions based on these case studies and be assessed based on their ability to apply content knowledge to a real-life scenario. After each case study, students will complete a case study exit slip on CANVAS.

LAB ATTENDANCE: Regular attendance to lab is imperative for success in this course. There is a strong positive correlation between the amount of time a student spends in class and her/his final grade. It is **your** responsibility to get and understand the material covered during a missed lab/lecture.

Lab activities CANNOT be rescheduled. However, your lowest lab grade will be dropped. If you have a valid reason to miss additional labs please contact Dr. Slemmons as soon as possible, otherwise you will receive a zero for the lab. **If you miss a lab and an assignment was due on that day, the assignment is still due at the start of that lab (submitted to CANVAS). If this is not possible, arrangements should be made with Dr. Slemmons to turn in the assignment.**

PRELAB: Each week you are expected to read the assigned lab ahead of time and complete a set of prelab questions that assess your understanding of the lab. These questions are posted in CANVAS under **Quizzes**. Questions are assigned at random and therefore may be different between students. Some pre-labs will have an associated video that should be viewed prior to answering the questions. Proper preparation for lab will ensure your understandings of the concepts and your ability to work cooperatively with your lab partners.

LAB REPORT: Each week a portion of the lab will be graded. Often this is composed of the post-lab questions, a graph, data collected and/or a claim/justification. However, some portions of the lab will be solely graded based on completion. These graded sections are generally outlined in the lab manual. There is one formal lab report due based on the Laboratory 10: Bacteria. The requirements and rubrics for this report are included in the lab manual.

PRESENTATIONS: Students will present in two different formats throughout the semester: 1) a group PowerPoint (or other means of presenting) on lab results from Lab 5: Photosynthesis,

and 2) a Poster presentation on a biological topic of your choosing. Those students that are **elementary education majors** will be required to create a lesson plan on a biological topic and illustrate an activity that demonstrates those learning objectives. Students that are not education majors are encouraged to create a poster that merges their discipline with that of Biology. Students will be constructing a rubric that will be used to evaluate posters. Each student will evaluate the posters of three different peers. You will be assessed on your depth and quality of peer evaluations. Requirements for these assignments are further detailed in the lab manual.

LATE ASSIGNMENTS: Pre-lab questions in CANVAS are due at the **START** of lab each week. Post-lab questions and/or reports are due the following week at the beginning of lab unless otherwise indicated. Post-labs are submitted to CANVAS. Late assignments will not be accepted and will receive a zero. Extensions for CANVAS quizzes will not be granted. If you foresee a problem completing a quiz, please contact Dr. Slemmons prior to the due date.

E-MAIL: UWSP students are expected to check their University e-mail regularly for information from the university and/or instructors. If you are using an e-mail account other than your campus account to contact Dr. Slemmons, be sure your full name is included in the message.

ACADEMIC CONDUCT: All students are expected to follow ethical practices of neither giving nor receiving any unauthorized assistance on their work in this class. Additionally, all students are expected to not divulge the nature or content of any questions or answers on exams to any other student or groups of students. If there are suspected violations of academic misconduct, as defined by the UWSP Chapter 14.03(1) code, then the Chapter 14 policies and procedures will be invoked. See web page at htpp://www.uwsp.edu/admin/stuaffairs rights/rightsChap14.pdf for details. Any student that removes an exam from the classroom may be given a failing grade for the course.

ELECTRONIC DEVICES: Cell phones should be turned **off** and **not** be displayed during labs or exam. Laptops will not be allowed during lecture. Use of laptops decreases student success (Fried 2008; Mueller and Oppenheimer 2014). No other communication or musical devices are allowed. Students needing a foreign language dictionary during exams may use one with permission from me.

INCOMPLETE POLICY Under emergency/special circumstances, students may petition for an incomplete grade. An incomplete will only be assigned at the discretion of Dr. Slemmons All incomplete course assignments must be completed within one month of the completion of the course.

INFORM YOUR INSTRUCTOR OF ANY ACCOMMODATIONS NEEDED:

UWSP is committed to providing reasonable and appropriate accommodations to students with disabilities and temporary impairments. If you have a disability or acquire a condition during the semester where you need assistance, please contact the Disability and Assistive Technology Center on the 6th floor of Albertson Hall (library) as soon as possible. DATC can be reached at 715-346-3365 or DATC@uwsp.edu.

STATEMENT OF POLICY:

UW-Stevens Point will modify academic program requirements as necessary to ensure that they do not discriminate against qualified applicants or students with disabilities. The modifications should not affect the substance of educational programs or compromise academic standards; nor should they intrude upon academic freedom. Examinations or other procedures used for evaluating students' academic achievements may be adapted. The results of such evaluation must demonstrate the student's achievement in the academic activity, rather than describe his/her disability.

If modifications are required due to a disability, please inform the instructor and contact the Disability and Assistive Technology Center in 609 LRC, or (715) 346-3365.

COMMIT TO INTEGRITY:

As a student in this course (and at this university), you are expected to maintain high degrees of professionalism, commitment to active learning and participation in this class and also integrity in your behavior in and out of the classroom.

UWSP ACADEMIC HONESTY POLICY & PROCEDURES
STUDENT ACADEMIC DISCIPLINARY PROCEDURES:

UWSP 14.01 Statement of principles
The board of regents, administrators, faculty, academic staff and students of the university of Wisconsin system believe that academic honesty and integrity are fundamental to the mission of higher education and of the university of Wisconsin system. The university has a responsibility to promote academic honesty and integrity and to develop procedures to deal effectively with instances of academic dishonesty. Students are responsible for the honest completion and representation of their work, for the appropriate citation of sources, and for respect of others' academic endeavors. Students who violate these standards must be confronted and must accept the consequences of their actions.
UWSP 14.03 Academic misconduct subject to disciplinary action.
(1) Academic misconduct is an act in which a student:

(a) Seeks to claim credit for the work or efforts of another without authorization or citation;
(b) Uses unauthorized materials or fabricated data in any academic exercise;
(c) Forges or falsifies academic documents or records;
(d) Intentionally impedes or damages the academic work of others;
(e) Engages in conduct aimed at making false representation of a student's academic performance; or
(f) Assists other students in any of these acts.

(2) Examples of academic misconduct include, but are not limited to: cheating on an examination; collaborating with others in work to be presented, contrary to the stated rules of the course; submitting a paper or assignment as one's own work when a part or all of the paper or assignment is the work of another; submitting a paper or assignment that contains ideas or research of others without appropriately identifying the sources of those ideas; stealing examinations or course materials; submitting, if contrary to the rules of a course, work previously presented in another course; tampering with the laboratory experiment or computer program of another student; knowingly and intentionally assisting another student in any of the above, including assistance in an arrangement whereby any work, classroom performance, examination

or other activity is submitted or performed by a person other than the student under whose name the work is submitted or performed.

Need Help?

Extra Help Resources

Make an appointment with me
Come see Dr. Slemmons during scheduled office hours or make an appointment for extra help.

Form study groups
Find fellow classmates or Biology majors that you form a regular group with and review material and study for exams.

Attend the review sessions at TLC.
Tutors are available to help students with lecture and lab material. Interested students are encouraged to contact the Tutoring-Learning Center.

Contact Disability Services
Students with a disability requiring accommodations should register with the Disability and Assistive Technology Center in the Learning Resource Center (the Library) and contact me at the beginning of the course.

Contact Counseling Center
The counseling center is located on the 3rd floor of Delzell Hall. These counselors can assist you with test anxiety, time management and personal struggles.

Tutoring in Math and Science (TIMS) in the Tutoring-Learning Center (TLC) offers free group and Drop-in Study Table Sessions to support you in your biology classes. In addition, TIMS offers the option for individual biology tutoring sessions. The biology tutors are UWSP students who have done well in their classes and who are here to share their successful study habits and biology content knowledge to help others succeed. Talking about biology and working problem sets together helps to clarify and solidify knowledge, and the tutors in the lab are eager to help. If you have questions about the schedule or would like to make an appointment, please visit room LRC 018 or call (715) 346-3568 for information.

SCIENCE TUTORING – FALL 2018

Name	Day	Time	Location	Cost
Drop-In Tutoring	Mon.–Thurs.	See TLC Website for Drop-In Schedule	Drop-In Tutoring Center, DUC 205	Free
Group Tutoring and Supplemental Instruction (SI)	Mon. –Fri.	See TLC Website	See TLC Website	Free
One-on-One Tutoring	Mon. – Fri.	By appointment	Sign up in TLC, 018 ALB	May have fee

			Mon.-Fri. 9 - 4:30.	

SEVEN PRINCIPLES OF LEARNING (AMBROSE ET AL. 2012)

1. Students' *prior knowledge* can serve to help or hinder learning.
2. Students' *organization of knowledge* impacts how students learn and apply what they know.
3. *Motivation* determines, directs, and sustains what students learn.
4. To develop *mastery*, students must develop the skills, practice integrating them, and know when to apply them.
5. Goal-directed *practice* coupled with targeted *feedback* enhances learning.
6. Level of learner *development* interacts with "course" *climate* to impact learning.
7. To become self-directed, learners must be able to monitor and adjust their approaches to learning.

TEN THINGS PROFESSORS LOVE:

1. Students
2. Students who come to class with an open mind
3. Students who come to class to fulfill a requirement but decide to make the most of the experience
4. Students who give eye contact during lecture (and maybe even smile)
5. Students who aren't afraid to ask questions
6. Students who come to me when they need help
7. Students who tell me not just that they enjoyed my course, but why
8. Students who have their own ideas
9. Students who give me unique and powerful things to say in a letter of recommendation
10. Students who are fully engaged in the learning process

**adapted from Jane E Dmochowski, University of Pennsylvania*

REFERENCES:

Ambrose SA, Bridges MW, DiPietro M, Lovett MC, Norma MK (2010) How Learning Works: Seven Research-based principles for smart teaching. Jossey-Bass

Cornelius TL, Owen-DeSchryver J (2008) Differential Effects of Full and Partial Notes on Learning Outcomes and Attendance. *Teaching of Psychology* 35: 6–12

Fried C (2008) In-class laptop use and its effects on student learning (2008) *Computers & Education* 50 (3): 906–914

Khanna MM, Badura Brack AS, Finken L (2013) Short- and Long-Term effects of cumulative finals on Student learning. *Society for the Teaching of Psychology* 40(3) 175-182.

Lawrence, N. K. (2013). Cumulative exams in the introductory psychology course. *Teaching Psychology* 40 (1), 15–19.

Mueller PA and Oppenheimer DM (2014) The Pen Is Mightier Than the Keyboard Advantages of Longhand Over Laptop Note Taking Psychological Science. DOI: 10.1177/0956797614524581

Noppe IC (2007) PowerPoint Presentation Handouts and College Student Learning Outcomes. *International Journal for the Scholarship of Teaching and Learning* 1(1), Article 9.

NOTE: This is a tentative syllabus. I reserve the right to make amendments to this document. Also, course materials may not be distributed or posted in any online format without permission from Dr. Slemmons.

WEEK 1: NATURE AND CHEMISTRY OF LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the basic characteristics of life (C-SLO: #2; SA, FA)
- Evaluate the characteristics of an "organism" and determine whether it is living or non-living by assessing each characteristic of life (C-SLO: #2; SA, FA)

DATE	LECTURE			ASSIGNMENTS		
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEO	DUE DATE
Tues Jan 21	What is Science?	Intro to Bio Requirements of Life Video Syllabus Is it Alive Demo?		☐ Ch 2: Pages 22-29	☐ Quiz: Syllabus	Sept 5
Thur Jan 23	Nature of Science		Childbed Fever	☐ Ch 1: Pages 1-15	☐ Quiz: Characteristics of Life	Sept 10
Week 1	**LAB**			**ASSIGNMENTS**		
	Procedures/Syllabus Mystery Boxes Lab 1: Scientific Investigation			☐ Pre-Lab 1 & Excel Tutorial (bring copy of two graphs to lab) Critical Thinking Lesson Module & Quiz (section 3 only)		Start of Lab

WEEK 2: THE NATURE OF SCIENCE

WEEKLY STUDENT LEARNING OUTCOMES:

- Identify the main components of the scientific method and apply it to novel situations (C-SLO: #1; ILQ)
- Compare and contrast theory vs. hypothesis (C-SLO: #1; SA, FA)
- Construct testable and falsifiable hypotheses (C-SLO: #1; ILQ, FA, CS)
- Differentiate between scientific processes and other ways of knowing (C-SLO: #3; CS)
-

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	TOPICS & DEMO	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues Jan 28	What is Life & Chemistry of Life	Water – Good conductor of heat Demo	Childbed Fever	☐ Ch 2: Pages 28-39	☐ Quiz: Anatomy of an Experiment	Sept 12

Thur Jan 30	Biomolecules		Start Peanut Butter Project	□ Ch 4: Pages 74-91	□ Quiz: Nature of Science	Sept 17
Week 2	LAB			ASSIGNMENTS		Start of lab
	Lab 2: Biomolecules (DNA Extraction)			□ Post-Lab 1 □ Pre-Lab 2		

WEEK 3: BUILDING BLOCKS OF LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Distinguish between the main biomolecules (C-SLO: #2; CS, SA, FA)
- Define essential nutrients (C-SLO: #2; CS, SA, FA)
- Define enzymes and explain how they work and importance in the cell (C-SLO: #2; ILQ; CS, SA, FA)
- Distinguish between catabolic and anabolic reactions (C-SLO: #2; CS, SA, FA)
- Evaluate the importance of biomolecules to human health (C-SLO: #3; CS, SA, FA)
- Differentiate between plant and animal cells (C-SLO: #2, ILQ, FA, SA)
- Describe the basic structure and function of bacterial, animal and plant cells (C-SLO: #2; TLQ, FA, SA)
- Differentiate between prokaryotic and eukaryotic cells (C-SLO: #2; FA, SA, TLQ)
- Describe a disease that results from a cellular organelle mutation/malfunction (C-SLO: #2; SA, FA)

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues Feb 4	Building Blocks of Life	Biomolecules Demo	Peanut Butter Project	□ Ch 3: Pages 45-60		
Thur Feb 6	Building Blocks of Life	Cells wall vs membrane Demo			□ Biomolecule Video & Quiz: Biomolecules & Cells	Sept 24
Week 3	LAB			ASSIGNMENTS		Start of lab
	3: Diffusion & Cells *(Aquatic Organisms)* 5: Photosynthesis set-up			□ Post-Lab 2 □ Pre-Lab 3		

WEEK 4: ENERGY OF LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Summarize the main steps of cellular respiration and photosynthesis (C-SLO: #2; CS, SA, FA, P, PE, ILQ)
- Demonstrate practical application for understanding cellular respiration and photosynthesis (C-SLO: #2, 3; CS, ILQ)
- Draw connections between cellular respiration and photosynthesis (C-SLO: #2; P, CS, SA, FA)
- Explain the connect between photosynthesis and global climate change (C-SLO: #2, 3; SA, FA)

	LECTURE	ASSIGNMENTS	

Date	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	Due Date
Tues Feb 11	Energy of Life	Cellular Respiration in Yeast Demo	Killer Flea Dip	□ Ch 6: Pages 114-131		Sept 26
Thur Feb 13	Energy of Life	Photosynthesis	Algal Bloom	□ Ch 5: Pages 95-110	□ Quiz: Photosynthesis & Cellular Respiration	Oct 1
Week 4	Lab			Assignments		Start of lab
	4: Properties of Water			□ Pre-Lab 5: Hypothesis & Experimental Design		

WEEK 5: ENERGY OF LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Summarize the main steps of cellular respiration and photosynthesis (C-SLO: #2; CS, SA, FA, P, PE, ILQ)
- Demonstrate practical application for understanding cellular respiration and photosynthesis (C-SLO: #2, 3; CS, ILQ)
- Draw connections between cellular respiration and photosynthesis (C-SLO: #2; P, CS, SA, FA)
- Explain the connect between photosynthesis and global climate change (C-SLO: #2, 3; SA, FA)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings & Guided Questions	Quizzes	
Tues Feb 18	Energy of Life	Review		□ Review Guide		Oct 3
Thur Feb 20	Exam I			□ Ch 7: Pages 136-148, 155-160		Oct 8
Week 5	Lab			Assignments		Start of lab
	6: Enzymes			□ Post-Lab 3 □ Pre-Lab 4		

WEEK 6: CONSTRUCTING LIFE - DNA TO PROTEIN

WEEKLY STUDENT LEARNING OUTCOMES:

- Identify the major players in the discovery of the structure of DNA and describe the experiments that supported their assertions (C-SLO: #2; FA, SA)
- Describe the structure of DNA and explain how it is organized and replicated in cells (C-SLO: #2; SA, FA)
- Explain how DNA can be used in genetic profiling/forensics studies and compare the benefits of using DNA to other forensics means (C-SLO: #3; CS, FA)
- Evaluate the benefits of DNA techniques to society (C-SLO: #3; FA, SA, CS)
- Describe the steps of protein synthesis (C-SLO: #2; FA, SA)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	
Tues Feb 25	Building Blocks of Life	DNA & Replication		□ Ch 8: Pages 163-178	DNA Replication Video □ Quiz: DNA Replication	Oct 10
Thur Feb 27	Building Blocks of Life	Protein Synthesis	Vampire	□ Chapter 9: Pages 193		Oct 15
Week 6	Lab			Assignments		Start of lab
	7: Mitosis 5: Photosynthesis Analysis			□ Pre-Lab 6		

WEEK 7: REPRODUCTION OF LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the process of mitosis and explain how it fits into the cell cycle (C-SLO: #2; ILQ, FA, SA)
- Explain how cell division is related to growth and reproduction (C-SLO: #2; ILQ, FA, SA)
- Identify the connection between mitosis and cancer (C-SLO: #; 2; ILQ, FA, SA, CS)
- Explain the different types of stem cells and how they can be used to cure disease (C-SLO: #2; FA, SA, CS)
- Explain how basic research is important to the discovery of treatments and cures for different cancers (C-SLO: #3; FA, SA, CS, D)
- Evaluate social decision making in light of biological principles, particularly pertaining to aspects of your daily life and societal issues (C-SLO: #2, 3 D)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	
Tues Mar 2	Reproduction of Life	Mitosis Cancer Stem Cells		□ Ch 9: 192207; Ch 10: 215-224 Ch 13 Pages 285-295	Quiz: Mitosis and Stem Cells Quiz	Oct 17
Thur Mar 5	Reproduction of Life	Meiosis Mutations	Sex Determination	□ Ch 11: Pages 228-241	□ Quiz: Meiosis	Oct 22
Week 7	Lab			Assignments		Start of lab
	5: Photosynthesis Presentations			□ Post-Lab 6 □ Pre-Lab 7		

WEEK 8: INHERITING LIFE - GENETICS

WEEKLY STUDENT LEARNING OUTCOMES

- Describe the steps of meiosis and compare these to mitosis (C-SLO: #2; FA, SA)
- Explain how meiosis increases genetic diversity (C-SLO: #2; FA, SA, CS)
- Compare and contrast the process of gamete formation in oogenesis and spermatogenesis (C-SLO: #2; FA, SA)
- Identify different ways in which sex can be determined in humans and compare this to other organisms (C-SLO: #2; FA, SA, CS)
- Explain how crossing over of sex chromosomes can lead to variability in sex determination (C-SLO: #2; FA, SA, CS)
- Identify consequences of mutations can occur through errors in transcription (C-SLO: #2; FA, SA)
- Distinguish between point mutations and chromosomal abnormalities (C-SLO: #2; FA, SA)

- Summarize Mendel's Laws of segregation and independent assortment (C-SLO: #2; TLQ; FA, SA, CS)
- Explain how Mendel's laws relate to meiosis (C-SLO: #2; TLQ; FA, SA)
- Predict the phenotypes and genotypes of offspring from crosses involving one or two genes (C-SLO: #2; TLQ; SA, FA)
- Determine the phenotypic and genotypic probabilities in sex-linked and codominant alleles (C-SLO: #2)

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues Oct 22	Genetics	Mendelian Genetics		□ Ch 12: Pages 258-277	□ Quiz: Non- Mendelian Genetics	Oct 24
Thur Oct 24	Genetics	Genetic Engineering/ Profiling, DNA mutation		□ None		
Week 8	LAB			ASSIGNMENTS		Start of lab
	No Lab			□ Post-Lab 7 □ Pre-Lab 5		

WEEK 9: ENGINEERING LIFE - BIOTECHNOLOGY

WEEKLY STUDENT LEARNING OUTCOMES:

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues Mar 17	Genetics	Biotechnology		□ None		

Thur Mar 19	Genetics	Biotechnology		□ None	□ Quiz: Biotechnology	Nov 5
Week 9	LAB			ASSIGNMENTS		Start of lab
	Spring Break – No Lab			□ Post-Lab 8		

WEEK 10: THE EVOLUTION OF LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the historical importance of Darwin's journey and how these experiences lead to the formation of Natural Selection (C-SLO: #2; SA, FA)
- Explain how the four postulates of natural selection can give rise to evolution (C-SLO: #2; TLQ, SA, FA)
- Explain the four mechanisms of evolution (natural selection, mutation, genetic drift, migration) (C-SLO: #2)
- Explain and provide an example of sexual selection and explain how it fits in with ideas of natural selection (C-SLO: #2; FA, SA)
- Be able to explain how populations evolve through natural selection (C-SLO: #2; TLQ, SA, FA)
- Be able to explain the evidence for the occurrence of evolution (C-SLO: #2; TLQ, SA, FA)
- Compare and contrast the differences in the rates of evolution (punctuated equilibrium vs. gradual evolution) (C-SLO: #2; TLQ, SA, FA)
- Describe an example of evolution in action (C-SLO: #2; TLQ, SA, FA)

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues Mar 24	Exam II			Ch 14: Pages 305-328		Nov 7
Thur Mar 26	Evolution	Darwin & Natural Selection; Candy Dish Demo		Ch 15: Pages 333-	□ Quiz: Natural Selection	Nov 12
Week 10	LAB			ASSIGNMENTS		Start of lab
	8: Meiosis			□ Pre-Lab – Hypothesis Lab 10 □ Pre-Lab 9		

WEEK 11: EVOLUTION & BIODIVERSITY

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the main characteristics and provide examples of the 9 phyla of organisms (C-SLO: #2; TLQ, SA, FA)
- Define biodiversity and distinguish between the three types of biodiversity (species, genetic and ecosystem) (C-SLO: #2; TLQ, SA, FA)
- Describe general patterns in biodiversity (C-SLO: #2; TLQ, SA, FA)
- Explain the Theory of Island Biogeography and apply these concepts to conservation management strategies (C-SLO: #2; SA, FA)

- Explain threats to biodiversity and evaluate the influence of humans on variation in biodiversity (C-SLO: #2, 3; TLQ, SA, FA)
- Draw connections between evolution and biodiversity (C-SLO: #2; TLQ, SA, FA)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	
Tues Mar 31	Evolution	Mechanisms of Evolution		□ Ch 16: Pages 252-267	□ Quiz: Mechanisms of Evolution	Nov 14
Thur Apr 2	Biodiversity	Survey of Life - Domains		□ Ch 17; Pages 372-386		Nov 19
Week 11	Lab			Assignments		Start of lab
	9: Natural Selection 10: Set-up Bacteria Paltes			□ Post-Lab 9 □ Pre-Lab 10		

WEEK 12: THE DIVERSITY OF LIFE - BIODIVERSITY

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the main characteristics and provide examples of the 9 phyla of organisms (C-SLO: #2; TLQ, SA, FA)
- Define biodiversity and distinguish between the three types of biodiversity (species, genetic and ecosystem) (C-SLO: #2; TLQ, SA, FA)
- Describe general patterns in biodiversity (C-SLO: #2; TLQ, SA, FA)
- Explain the Theory of Island Biogeography and apply these concepts to conservation management strategies (C-SLO: #2; SA, FA)
- Explain threats to biodiversity and evaluate the influence of humans on variation in biodiversity (C-SLO: #2, 3; TLQ, SA, FA)
- Draw connections between evolution and biodiversity (C-SLO: #2; TLQ, SA, FA)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	
Tues Apr 7	Biodiversity	Categories		□ Ch 390: Pages 390-404		Nov 21
Thur Apr 9	Biodiversity	Threats		□ Ch 19; Pages 410-423		Nov 26

Week 12	LAB	ASSIGNMENTS	Start of lab
	10: Bacteria & Protists	□ Bacteria Papers Due □ Pre-Lab 11	

WEEK 13: THE INTERACTIONS OF LIFE – POPULATION ECOLOGY

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the main characteristics and provide examples of the 9 phyla of organisms (C-SLO: #2; TLQ, SA, FA)
- Define biodiversity and distinguish between the three types of biodiversity (species, genetic and ecosystem) (C-SLO: #2; TLQ, SA, FA)
- Describe general patterns in biodiversity (C-SLO: #2; TLQ, SA, FA)
- Explain the Theory of Island Biogeography and apply these concepts to conservation management strategies (C-SLO: #2; SA, FA)
- Explain threats to biodiversity and evaluate the influence of humans on variation in biodiversity (C-SLO: #2, 3; TLQ, SA, FA)
- Draw connections between evolution and biodiversity and the environment (C-SLO: #2; TLQ, SA, FA)

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues Apr 14	Population Ecology	Population Demo		□ Ch 21 Pages 448-462		Nov 28
Thur Apr 16		No Class		□ Ch 22: Pages 466-477		Dec 3
Week 13	LAB			ASSIGNMENTS		
	11: Plants					

WEEK 14: THE INTERACTIONS OF LIFE - COMMUNITY ECOLOGY

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the trends and causes of exponential and logistic growth models for populations (C-SLO: #2; SA, FA, TLQ)
- List factors limiting population growth (C-SLO: #2; SA, FA, TLQ)
- Describe human population growth and the implications of this growth (C-SLO: #2; SA, FA)
- Explain sustainability as it relates to resource management and ecological footprints (C-SLO: #2; SA, FA)
- Describe how food web interactions can alter biodiversity (C-SLO: #2; SA, FA, TLQ)
- Explain how energy is transferred from one trophic level to another (C-SLO: #2; SA, FA, TLQ)
- Define niche and compare and contrast fundamental and realized niche (C-SLO: #2; SA, FA, TLQ)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	
Tues Apr 21	Community Ecology		Missing Seal	□ Ch 23: Pages 486+503	□ Quiz: Community Ecology/Population Ecology	Dec 5
Thur Apr 23	Ecosystems	Biogeo-chemical cycles		□ None		
Week 14	Lab			Assignments		Start of lab
	12: Animals			□ Pre-Lab 12 □ Pre-Lab 13		

WEEK 15: CYCLES INFLUENCING LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the trends and causes of exponential and logistic growth models for populations (C-SLO: #2; SA, FA, TLQ)
- List factors limiting population growth (C-SLO: #2; SA, FA, TLQ)
- Describe human population growth and the implications of this growth (C-SLO: #2; SA, FA)
- Explain sustainability as it relates to resource management and ecological footprints (C-SLO: #2; SA, FA)
- Describe how food web interactions can alter biodiversity (C-SLO: #2; SA, FA, TLQ)
- Explain how energy is transferred from one trophic level to another (C-SLO: #2; SA, FA, TLQ)
- Define niche and compare and contrast fundamental and realized niche (C-SLO: #2; SA, FA, TLQ)
- Evaluate social decision making in light of biological principles, particularly pertaining to aspects of your daily life and societal issues (C-SLO: #2, 3 P)

Date	Lecture			Assignments		Due Date
	Theme	Demo & Topics	Case Studies	Readings	Quizzes & Videos	
Tues Apr 28	Ecosystems	Biogeo-chemical Cycles		□ None		
Thur Apr 30	Review	Biogeo-chemical Cycles		□ None	Review Guide	
Week 15	Lab			Assignments		Start of lab
	13" Population Ecology			□ Poster Presentations		

WEEK 16: CYCLES INFLUENCING LIFE

WEEKLY STUDENT LEARNING OUTCOMES:

- Describe the trends and causes of exponential and logistic growth models for populations (C-SLO: #2; SA, FA, TLQ)
- List factors limiting population growth (C-SLO: #2; SA, FA, TLQ)
- Describe human population growth and the implications of this growth (C-SLO: #2; SA, FA)
- Explain sustainability as it relates to resource management and ecological footprints (C-SLO: #2; SA, FA)
- Describe how food web interactions can alter biodiversity (C-SLO: #2; SA, FA, TLQ)
- Explain how energy is transferred from one trophic level to another (C-SLO: #2; SA, FA, TLQ)
- Define niche and compare and contrast fundamental and realized niche (C-SLO: #2; SA, FA, TLQ)
- Evaluate social decision making in light of biological principles, particularly pertaining to aspects of your daily life and societal issues (C-SLO: #2, 3 P)

DATE	LECTURE			ASSIGNMENTS		DUE DATE
	THEME	DEMO & TOPICS	CASE STUDIES	READINGS	QUIZZES & VIDEOS	
Tues May 6	Ecosystems	Biogeo-chemical Cycles		□ None		
Thur May 8	Review	Biogeo-chemical Cycles		□ None	Review Guide	
Week 15	LAB			ASSIGNMENTS		Start of lab
	Poster Presentations			□ Poster Presentations		

WEEK 17: FINAL EXAM

WEEKLY STUDENT LEARNING OUTCOMES:

- Recognize the multiple levels of complexity at which biological systems operate, from molecules to organisms, and explain the emergent properties and processes characteristic for each level.
- Describe mechanisms for continuity of life, including the processes of inheritance, development and evolution.
- Articulate the application of biological science to meeting the needs of society, including basic research, stewardship of biodiversity, human health, and entrepreneurial innovation.

Thursday December 19th 10:15-12:15 CBB 101

1.2 SAMPLES OF STUDENT WORK MEETING EXPECTATIONS

The examples of student work represent a spectrum of understanding of the scientific method, the ability to interpret results and understand the underpinnings of the biological mechanisms at play. Students struggled with the ability to connect their predictions and findings to other scientific work. Students also fell short when if came to understanding the possible biological mechanisms behind their results.

Comments on student samples were made by a peer evaluation by another lab group in the class. The ability to critically analyze another's work was also part of the assessment for this assignment. Students also complete the rubric for another group.

The instructor's evaluation is at the end of sample work.

Student sample 1 represents a higher level understanding of the scientific method and the GEP learning outcomes.

Student sample 2 represents a lower level of understanding of the scientific method and the GEP learning outcomes.

Student Meeting Expectation

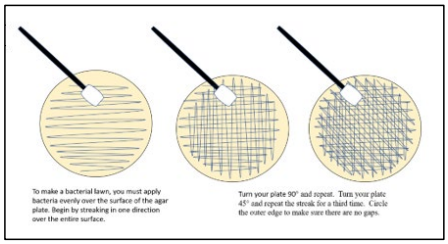
Effect of household cleaners on the diversity and growth rate of phone bacteria

Student Name(s) _____
University of Wisconsin-Stevens Point

Introduction:

Do you know how much bacteria is on your cell phone? Studies show that the average cell phone has more bacteria than the average toilet seat[1]. According to TIMES Magazine, there are more than 17,000 bacterial gene copies on the phones of high school students[1]. The University of Arizona found there are 10 times more bacteria on a cell phone than most toilet seats[1]. We ~~decided to test~~tested the average household cleaners against cell phone bacteria. We had one group as a control to compare the results with our treatments. ~~The active treatments we used were bleach, lysol, and hand soap.~~ Our experiment ~~investigated the question~~tested w~~: W~~hat treatment (lysol, hand soap or bleach) will best kill phone bacteria? ~~Our hypothesis was: If~~We hypothesized that if phone bacteria is treated with bleach, then it will result in the largest zone of inhibition, few bacterial colonies and lower bacterial diversity compared to the other treatments because bleach releases oxygen molecules, through oxidation, which breaks the chromophore bonds[3]. If the other treatments show to inhibit bacterial growth and diversity then we will reject our hypothesis.

Methods:



Commented [SK1]: Nice intro. It is fine to use superscripts for references, but I will tell you based on experience it is a pain. If you ever want to go back and add new references to your work, you have to redo all the numbering (and then you forget which number belongs to which). It is much easier just to state the authors name and year. It is also nicer for the reader (particularly if you are reading a paper where you know many of the researcher) you can immediately see who wrote the paper rather than going back and looking for the number for each citation and finding the author – just a tip.

Commented [SK2]: Consolidate this sentence with the second sentence otherwise it is redundant.

Commented [SK3]: Move to the methods

Commented [SK4]: Good! But expand on this a bit more- what does that mean for the bacteria cell?

Commented [SK5]: Provide more background information that ties in the scientific literature on how these particular items inhibit bacterial growth.

To test our hypothesis, we ~~decided to use~~used a phone as ~~our~~ a source of bacteria and ~~then~~ bleach, lysol, and hand soap as ~~our~~ treatments. ~~To grow the bacteria, we first obtain four nutrient agar plates. Next to apply our~~we created a bacterial lawn ~~we made a bacterial lawn~~ (Figure 1) to allow a uniform growth of bacteria. We infused three small paper disks with the three treatments and then applied them to our bacterial lawn (Figure 2). The three treatments, the independent control, were bleach, lysol and handsoap. The control small paper disk had no treatment. This will create a zone of inhibition, where there will be no apparent bacteria on an area surrounding the disk where the bacteria have been exposed to the treatments. Plates will be grown in a controlled environment with consistent temperate and light. After incubating bacterial plates for a week, we will then measure the zone of inhibition, describe bacterial appearance, measure diversity and count the number of colonies that were formed. These are the dependent variables.

Figure 1. Making a bacterial Lawn.

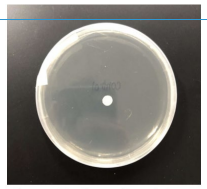


Figure 2. Completed Agar

Results:

~~Based on our experiment~~Our results indicate that, the hand soap ~~results in~~had the lowest number and diversity of phone bacteria. Data was collected after the experiment included the number of different bacteria, zone of inhibition, and qualitative description of the bacteria (Table 1). As determined by measuring the distance from the treatment disc to the first bacteria colony, the hand soap treatment had the greatest zone of inhibition (Table 1). The hand soap had the lowest diversity measured by counting the number of different unique colonies (Table 1). Pictures of each phone bacteria treatment agar were taken at each observation and the number of colonies was recorded by counting each colony (Figure 4, Table 2). The number of colonies increased with time in all samples (Figure 3). The control group had the highest number of colonies (Table 2, Figure 3). The bleach and lysol treatments had the same mid-amount of colonies; the hand soap had the lowest number of colonies (Table 2, Figure 3).

Final Results				
Group #	Treatment	# of Different Colonies	Zone of Inhibition (mm)	Bacteria Qualitative Description
1	Control	3	1.7	punctiform, flat, smooth
2	Bleach	2	1.7	circular, raised, smooth
3	Lysol	2	2.9	circular, flat, smooth
4	Handsoap	1	3.7	circular, raised, smooth

Table 1. Diversity, zone of inhibition, and descriptions of bacteria colonies measured following exposure to household treatments compared to the control at the completion of the experiment.

Number of Colonies				
	Days of Growth			
Treatment	0	4	5	6
Control	0	5	8	17
Bleach	0	5	6	7
Lysol	0	6	6	7
Handsoap	0	0	1	1

Table 2. Bacterial growth, as measured by number of individual colonies of phone bacteria, over the 6-day observation period.

Commented [SK6]: The control should show bacterial growth since there is not treatment to inhibit bacterial growth. Ideally the control would show all the possible bacteria types.

Commented [SK7]: State what these actual results were.

Commented [SK8]: Move to the methods section.

Commented [SK9]: Well done.

Commented [SK10]: Tables should be labeled as Table 1. Table 2 with a table caption and placed above the table.

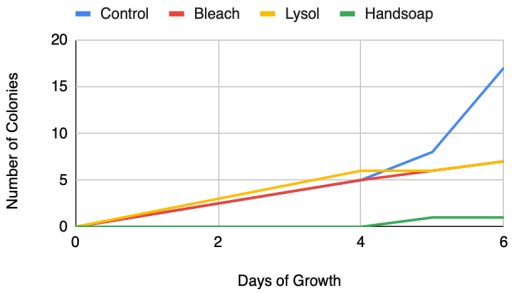


Figure 3. Bacterial growth, as measured by number of individual colonies of phone bacteria, over the 6-day observation period.

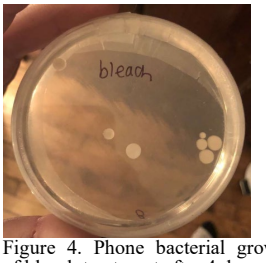


Figure 4. Phone bacterial growth of bleach treatment after 4 days.

Discussion:

The results did not support our hypothesis that if phone bacteria was treated with bleach then it would produce the best results in inhibiting the growth of bacteria, compared to other treatments. The hand soap, in contradiction, had the greatest zone of inhibition, lowest number of colonies, and lowest number of different colonies, which suggests that hand soap is the best treatment to prevent and kill phone bacteria. Hand washing is known to be one of the most effective ways of preventing the spread of illness [2]. So, if people wash their hands more often with hand soap, this will decrease the amount of bacteria on their phones; as a result, this will decrease the likeliness of getting sick. A reason that the results are this way might be because hand soap specifically targets bacteria that people have on their hands [2] while the other treatments kill more bacteria in general. Based on the experimental data, this possible explanation makes sense because phones touch the hands the most. Triclosan, the active ingredient of hand soap, is an antimicrobial agent that interferes with lipid synthesis weakening the cell membrane causing bacterial cell death [2]. In the future, more research should be completed with more treatments to see if other chemicals work better to kill phone bacteria. Also, more research should be done with a larger sample size of each treatment group and using more than one phone as a bacteria source. In this experiment, some of the possible sources of error may have been a different temperature or a different environment than ideal bacteria growing conditions. Another possible source of error could be the amount and type of bacteria were not the same on each agar before treatment. In conclusion, our experiment did not support the hypothesis; the hand soap treatment had the lowest rate of the phone bacteria.

Literature Cited:

[1]Abrams, Abigail. "Your Cell Phone Is 10 Times Dirtier Than a Toilet Seat." *Time*, Time, 23 Aug. 2017, https://time.com/4908654/cell-phone-bacteria/.

[2]Alessio, Faith. "Ingredients in Hand Soap." *Our Everyday Life*, Our Everyday Life, 10 Jan. 2019, oureverydaylife.com/ingredients-in-hand-soap-12259530.html.

[3]"How Does Bleach Work?" *Wonderopolis*, https://www.wonderopolis.org/wonder/how-does-bleach-work.

Commented [SK11]: Nice job with the discussion but expand a bit more into the biological mechanisms – why did you get the results that you did.

– consider breaking this into multiple paragraphs. Also include what have others found who have done similar experiments. Include this as support of your conclusions.

Commented [SK12]: Discuss in depth how your other treatments inhibit bacterial growth – what is the biological mechanism at play, how do those treatments alter the cells of bacteria. Also tie this to antibacterial resistance and overuse of hand sanitizers (cleaners).

Commented [SK13]: You did a great job with this paper. Well done! 49.5/50

Instructor Evaluation Bacteria Lab Report Rubric

CRITERIA	0	Beginning (2-2.8)	Developing (2.8-3.2pts)	Proficient (3.2-3.6)	Mastery at Intro Level (3.6-4 pts)	TOTAL
QUESTION						

Frame Question		☐An attempt is made to pose a question.	☐A question is posed that shows relevance to the topic, misconceptions present.	☒A question is posed that shows understanding of the biological mechanism involved.	☐An insightful question is clearly posed that shows understanding of the biological mechanism.	3.6
Pose hypothesis and predictions		☐An attempt is made to pose a hypothesis and prediction, though incorrectly identified, form is incorrect, prediction does not follow reasoning	☐Both hypothesis and prediction are present and stated in appropriate form, though they may not follow logically from background information.	☐Both hypothesis and prediction are appropriately stated, with the prediction logically flowing from the hypothesis.	☒Hypothesis and prediction well formed, creative, and fluent, showing logical consistency throughout and strong connection to background information.	3.6
Identify variables		☐An attempt is made to identify the variables of the experiment.	☐Some variables are correctly identified, though some may be absent, incorrectly identified, or poorly chosen.	☐Most variables are correctly identified, using accurate terminology.	☒All variables are correctly identified and described in fluent language.	4
Indicate how to falsify		☐An attempt is made to specify the experimental outcome that would falsify the hypothesis, but indicated result would not falsify hypothesis.	☐Falsifying information is identified, but the proposed falsification is either incorrect or is not accompanied by an explanation of how it would falsify the hypothesis.	☒Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided.	☒Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided. Discussion of falsification is fluent.	4.0
BACKGROUND, METHODS						
Background information		☐An attempt is made to introduce relevant background material.	☐Background material is included, but may include inappropriate details or be missing key concepts that should be covered.	☒Background information is appropriate, clearly anticipates and supports the question being asked or hypothesis being posed.	☐Background information is appropriate, clearly anticipates and supports the question being asked, and is fluently rendered. Details anticipate topics covered in the discussion.	3.5
Summary of procedure		☐Experimental procedure is summarized, but is incomplete or poorly designed.	☐Experimental procedure is summarized completely, and experimental design is appropriate for addressing the hypothesis.	☐Experimental procedure is summarized completely, and experimental design is appropriate for addressing the hypothesis. Allows for appropriate	☒Experimental procedure is completely summarized, illustrating optimal experimental design. Expressed in language that skillfully	3.9

				falsification. Summary uses straightforward language that is easy to follow, but may be stilted or lack flow.	communicates meaning to readers with clarity and fluency.	
RESULTS						
Summary of Results		☐An attempt is made to verbally summarize the results of the experiment.	☐The summary of the results is present, but incomplete, lacking key elements, or not adequately summarized.	☐Data are well-summarized, with appropriate generalizations of trends outlined. May lack organization or subtlety.	☒Data are well summarized, and cogently presented. Trends in data identified. Highly organized and fluent reporting of results.	3.9
Graphs		☐Some type of graph illustrating the results of the experiment is submitted.	☐Graphs submitted are properly labeled and show an appropriate set of data.	☐Graphs are appropriately labeled, show appropriate data, and make good use of page space.	☒Graphs are appropriately labeled, show appropriate data, make good use of page space, and are of a type that is well chosen to represent the type of data presented.	3.9
CONCLUSIONS						
Evaluate hypothesis		☐An attempt is made to answer the question and evaluate the proposed hypothesis.	☐Hypothesis is evaluated, though some data may be misinterpreted, or explanation of how the data relate to the hypothesis is unclear.	☐Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is clear.	☒Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is fluent and clear. Discussion shows depth of thought and clear deductive reasoning.	4
Draw conclusions		☐An attempt is made to generalize conclusions from the results of the experiment.	☐Some conclusions are correctly drawn, though some may be spurious, limited, or not reflective.	☐Appropriate conclusions are drawn, and there is an attempt to connect them to introductory background material.	☒Appropriate conclusions are drawn, and are tied to introductory background material and other biological topics.	3.7
RELEVANCE						
Future Questions		☐An attempt is made to indicate how this study may relate to	☐Potential future questions are identified but are not firmly tied	☐Potential future questions are identified and tied to both the	☒Potential future questions are identified and tied to both the	3.9

		other, unanswered, questions.	either to the results of the current study or the introductory background material.	results of the current study and the introductory background material.	results of the current study and the introductory background material. Questions demonstrate insight or integration with other facets of biology.	
Discuss Relevance		☐An attempt is made to identify the relevance of this study to understanding personal health or society.	☐Some relevance of this study to understanding personal health or society is identified and discussed, though discussion may be incomplete or simplistic.	☒Relevance of this study to understanding personal health or society is clearly identified, including discussion of more than one implication of the knowledge gained.	☐Relevance of this study to understanding personal health or society is clearly identified, including discussion of more than one implication of the knowledge gained. Discussion integrates other aspects of biology touched on in the introduction to broaden the overall picture.	3.5
Control of syntax and mechanics		☐Uses language that sometimes impedes meaning because of errors in usage. Multiple typos. Deduct 7-9 points	☐Uses language that generally conveys meaning to readers with clarity, although writing may include some errors. Deduct 4-6 points	☒Uses straightforward language that generally conveys meaning to readers. Few errors are present. Deduct 1-3 points	☐Uses graceful language that skillfully communicates meaning to readers with clarity and fluency and is virtually error-free. No deductions.	3.6
TOTAL						49.1/52

*Total possible points = 52

Additional Instructor Comments:

Provide further detail on the biological mechanism behind the results that you observed. Support these ideas with background research and scientific findings from peer reviewed literature.

Provide further connections to antibiotic resistance in bacteria

Overall nice job fulfilling the requirements of the rubric.

1.3 SAMPLE STUDENT WORK - STUDENT(S) NOT MEETING EXPECTATION

Title?

Student Name(s) _____
University of Wisconsin-Stevens Point

Introduction:

Have you ever wondered what kind of bacteria is on the bottom of your shoe? A shoe on average has four hundred twenty four thousand bacteria on it and over ninety percent of the bacteria can be transferred directly onto the floor on first contact (Brown 2018). We tested the ability of different cleaners (Hand Sanitizers, Hydrogen Peroxide and Mouthwash) on inhibiting bacterial growth.

METHODS

We took the bacteria from the bottom of Tyler's shoe and rubbed it on the petri dish. Then we took a small piece of paper and soaked it one of the treatments and put it in the petri dish with the bacteria. We did the same thing for all the other treatments. We let the bacteria sit for two weeks and then we made final observations.

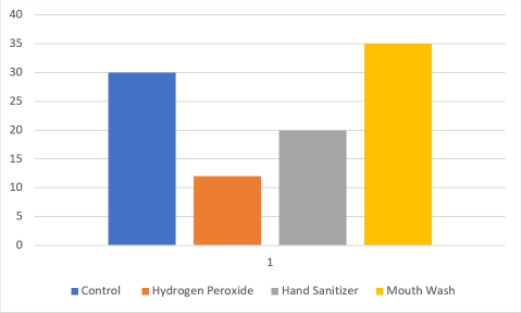
We used a ruler to measure the zone of inhibition along with the percent cover, then just counted the number of colonies and different colonies.

RESULTS

The shoe bacteria combined with the mouthwash grew the most, it had the most amount of colonies, number of different colonies, biggest percent cover and smallest zone of inhibition. This makes sense because mouthwash does not have any antibacterial elements therefore making sense why it grew more than the hand sanitizer and hydrogen peroxide that are antibacterial. In an article written by Alex Silbajoris in 2019 discussing whether or not hydrogen peroxide is effective in killing bacteria. Hydrogen peroxide is used to treat cuts, and is thought to keep the cut from becoming infected with bacteria, This article states that hydrogen peroxide has very limited antibacterial elements but it hinders bacteria reproduction. This is proven through our experiment because the hydrogen peroxide had the smallest growth rate and percent cover because the hydrogen peroxide prevents it from growing or reproducing. The hand sanitizer surprised us because it had a pretty high percent cover, and it is supposed to be antibacterial meaning bacteria should not grow when it is present, so this may not be as effective as companies are claiming.

Table 1. Over a 14 day observation period the number of colonies, zone of inhibition, growth rate, and percent cover

Group #	Treatment	Number of different colonies	Zone of inhibition (mm)	Growth rate (% cover/day)	% Cover
1	Control	6	N/A	0.04	30
2	Hand Sanitizer	3	10 mm	0.02	20
3	Hydrogen Peroxide	4	23 mm	0.017	12
4	Mouth Wash	6	3 mm	0.05	35



Commented [SK1]: Numbers greater than ten should not be written out.

Commented [SK2]: Expand more in the introduction. Discus what your research and hypothesis were. Connect your rationale to already established scientific literature – what have others found to support your ideas. Discuss the biological mechanism at play – why do you think that these particular cleaners might inhibit bacterial growth?

Commented [SK3]: Consider rephrasing along the lines of: "In order to determine the most effective means of inhibiting bacteria growth, we inoculated three nutrient agar plates with bacteria from (source of bacteria)
We treated three discs with (state your treatments) and (state your control) was used as a control. Each disc was placed at the center of the plate. Plates were incubated at room temperature and the following observations were made (state which observations you made) and for how long

Commented [SK4]: This all needs to be reorganized into the appropriate sections.

Commented [SK5]: What is the main finding of the article?

Commented [SK6]: Discussion section?

Commented [SK7]: Units should go in the header not in the individual cell.

Commented [SK8]: Make your figure caption font size smaller, axis titles missing

Figure. 1 The percent growth of a control and three antibacterial treatments over a time span of 14

. The most bacteria was in the control, with all the other ones pretty even. The hand sanitizer, hydrogen peroxide and mouth wash all had little to no bacteria around where the different substances were put. This is all important because this is just a small sample. If this is a bigger sample such as a kitchen at a restaurant we can see and understand. Seeing how fast bacteria can grow when not around something that kills it, and how fast it can grow is frightening. Think about if you ate food from a kitchen that was never cleaned. At the same time it is also scary to think that at some point bacteria will develop to get stronger and change so that they will become resistant to different kinds of cleaners. Also overuse of cleaners and such can cause different problems themselves.

Literature Cited:

Silbajoris, Alex. "Does Hydrogen Peroxide Kill Bacteria?" *Sciencing*, 2 Mar. 2019, https://sciencing.com/hydrogen-peroxide-kill-bacteria-4606163.html.

Brown, Elizabeth. "How Gross Is It to Wear Your Shoes in the House?" *Vice*, 16 May 2018, https://www.vice.com/en_us/article/435ymn/wearing-shoes-inside-house-bacteria.

Bacteria Lab Report Rubric

CRITERIA	0	Beginning (2-2.8)	Developing (2.8-3.2pts)	Proficient (3.2-3.6)	Mastery at Intro Level (3.6-4 pts)	TOTAL
QUESTION						
Frame Question		☐An attempt is made to pose a question.	☐A question is posed that shows relevance to the topic, misconceptions present.	☒A question is posed that shows understanding of the biological mechanism involved.	☐An insightful question is clearly posed that shows understanding of the biological mechanism.	3.2
Pose hypothesis and predictions		☐An attempt is made to pose a hypothesis and prediction, though incorrectly identified, form is incorrect, prediction does not follow reasoning	☒Both hypothesis and prediction are present and stated in appropriate form, though they may not follow logically from background information.	☐Both hypothesis and prediction are appropriately stated, with the prediction logically flowing from the hypothesis.	☐Hypothesis and prediction well formed, creative, and fluent, showing logical consistency throughout and strong connection to background information.	3
Identify variables		☐An attempt is made to identify the variables of the experiment.	☒Some variables are correctly identified, though some may be absent, incorrectly identified, or poorly chosen.	☐Most variables are correctly identified, using accurate terminology.	☐All variables are correctly identified and described in fluent language.	2.9

Commented [SK9]: Make sure you spell check and review the paper for typos

Commented [SK10]: Reword for formality and clarity

Commented [SK11]: Rework discussion to make it more organized and streamlined.

Commented [SK12]: Overall

Commented [SK13]: In the discussion, expand to broader connections or the big pictures. Discuss over use of your treatments and other cleaners in propelling antibiotic resistant bacteria. What were sources of error? What future work could you do to expand your research or what other experiments might be helpful to shed light on your hypothesis? Was your hypothesis supported?

Commented [SK14]: Work on the organization of the paper and streamlining the text to make it formal and more succinct. 42/50

Indicate how to falsify		☒An attempt is made to specify the experimental outcome that would falsify the hypothesis, but indicated result would not falsify hypothesis.	☐Falsifying information is identified, but the proposed falsification is either incorrect or is not accompanied by an explanation of how it would falsify the hypothesis.	☐Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided.	☐Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided. Discussion of falsification is fluent.	2
BACKGROUND, METHODS						
Background information		☐An attempt is made to introduce relevant background material.	☒Background material is included, but may include inappropriate details or be missing key concepts that should be covered.	☐Background information is appropriate, clearly anticipates and supports the question being asked or hypothesis being posed.	☐Background information is appropriate, clearly anticipates and supports the question being asked, and is fluently rendered. Details anticipate topics covered in the discussion.	3.2
Summary of procedure		☐Experimental procedure is summarized, but is incomplete or poorly designed.	☐Experimental procedure is summarized completely, and experimental design is appropriate for addressing the hypothesis.	☒Experimental procedure is summarized completely, and experimental design is appropriate for addressing the hypothesis. Allows for appropriate falsification. Summary uses straightforward language that is easy to follow, but may be stilted or lack flow.	☐Experimental procedure is completely summarized, illustrating optimal experimental design. Expressed in language that skillfully communicates meaning to readers with clarity and fluency.	3.4
RESULTS						
Summary of Results		☐An attempt is made to verbally summarize the results of the experiment.	☐The summary of the results is present, but incomplete, lacking key elements, or not adequately summarized.	☒Data are well-summarized, with appropriate generalizations of trends outlined. May lack organization or subtlety.	☐Data are well summarized, and cogently presented. Trends in data identified. Highly organized and	3.3

					fluent reporting of results.	
Graphs		☐Some type of graph illustrating the results of the experiment is submitted.	☒Graphs submitted are properly labeled and show an appropriate set of data.	☐Graphs are appropriately labeled, show appropriate data, and make good use of page space.	☐Graphs are appropriately labeled, show appropriate data, make good use of page space, and are of a type that is well chosen to represent the type of data presented.	3.2
CONCLUSIONS						
Evaluate hypothesis		☐An attempt is made to answer the question and evaluate the proposed hypothesis.	☒Hypothesis is evaluated, though some data may be misinterpreted, or explanation of how the data relate to the hypothesis is unclear.	☒Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is clear.	☐Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is fluent and clear. Discussion shows depth of thought and clear deductive reasoning.	3.4
Draw conclusions		☐An attempt is made to generalize conclusions from the results of the experiment.	☒Some conclusions are correctly drawn, though some may be spurious, limited, or not reflective.	☐Appropriate conclusions are drawn, and there is an attempt to connect them to introductory background material.	☐Appropriate conclusions are drawn, and are tied to introductory background material and other biological topics.	3.2
RELEVANCE						
Future Questions		☒An attempt is made to indicate how this study may relate to other, unanswered, questions.	☐Potential future questions are identified, but are not firmly tied either to the results of the current study or the introductory background material.	☐Potential future questions are identified and tied to both the results of the current study and the introductory background material.	☐Potential future questions are identified and tied to both the results of the current study and the introductory background material. Questions demonstrate insight or integration with	1.8

					other facets of biology.	
Discuss Relevance		☒An attempt is made to identify the relevance of this study to understanding personal health or society.	☐Some relevance of this study to understanding personal health or society is identified and discussed, though discussion may be incomplete or simplistic.	☐Relevance of this study to understanding personal health or society is clearly identified, including discussion of more than one implication of the knowledge gained.	☐Relevance of this study to understanding personal health or society is clearly identified, including discussion of more than one implication of the knowledge gained. Discussion integrates other aspects of biology touched on in the introduction to broaden the overall picture.	1.8
Control of syntax and mechanics		☐Uses language that sometimes impedes meaning because of errors in usage. Multiple typos. Deduct 7-9 points	☒Uses language that generally conveys meaning to readers with clarity, although writing may include some errors. Deduct 4-6 points	☐Uses straightforward language that generally conveys meaning to readers. Few errors are present. Deduct 1-3 points	☐Uses graceful language that skillfully communicates meaning to readers with clarity and fluency and is virtually error-free. No deductions.	2.6
TOTAL						37.0/52

1.4 Course Portfolio Comments for FLC

1.4.A Explanation of alignment of course Learning Outcomes to GEP Category Learning Outcomes

The Biology 100 course outcomes map directly to the GEP Investigation Level Learning Outcomes as indicated below.

- GEP Learning outcome #1: Explain major concepts, methods, or theories in the natural science to investigate the physical world.
    - Students utilize the scientific method throughout the entire course in lab, lecture and group discussions. For example, students identify the basic principles of the scientific method in an interrupted case study involving childbed fever. Students also conduct two, **self-designed**, long term experiments (photosynthesis, bacterial growth,) explaining major concepts related to biology and applying the principles of the scientific method. Results are analyzed, interpreted and presented in several different formats (e.g. group presentation, scientific, peer-reviewed paper).

- GEP Learning outcome #2: Interpret information, solve problems, and make decisions by applying natural science concepts, methods and quantitative techniques.
    - Students apply scientific concepts, use quantitative techniques and methods to solve problems throughout 10 different inquiry-based laboratories.
    - Students infer relationships, make predictions and solve problems stemming from student, self-generated questions dealing with bacterial inhibition. Students test their questions by designing an experiment and analyzing results. Students then use these results to infer the most appropriate and effective method for inhibiting bacteria. Similar processes are involved in a 3 week long, student designed experiment on photosynthesis in which students present their results to their peers.

- GEP Learning outcome #3: Describe the relevance of aspects of the natural science to their lives and society.
    - Students utilize biological concepts to solve 7 different case studies in a discussion type setting.
    - Students apply scientific concepts to a debate involving National Science Foundation's funding of basic vs applied scientific research.
    - Students solve case studies which involve current, real-life problems and determine solutions to those problems based on course content.
    - Many of the inquiry-based labs have real world connections.

1.4.C Description of Assessment/Assignment

In order to assess the GEP learning outcomes for an investigation level course in Natural Sciences, students in Bio 100 completed an inquiry-based laboratory assignment dealing with bacteria (this is one of 10 of these types of experiments throughout the semester). Students generate question(s) regarding the ability of a treatment to inhibit bacterial

growth and compared the presence and diversity of bacteria in different locations. In small groups, students created a hypothesis and prediction based on their question and designed and conducted an experiment to test this question. Each group collects data over a two-week period, consolidates and interprets their data and then synthesizes this information in the form of a mini scientific paper. Students are given direction regarding several techniques for growing and examining bacteria but the experiment is based on novel questions and experimental designs determined by each student group. Each student is responsible for evaluating another group's paper by using the rubric and is directed to make at least two comments and critiques of the other group's paper. Student groups are also evaluated by the instructor according to the rubric.

Students in this course are largely education majors (specifically elementary education) and non-science majors. Through the semester, I try to make connections to educational settings and describe how the course material relates to different disciplines. This assessment was the first time in the course where they utilized scientific writing and created a lab report.

The requirements for the assignment were outlined in several ways:

1. Description of the assignment and various available laboratory techniques
2. Template for scientific paper
3. Rubric for evaluation

All 3 GEP learning outcomes were assessed in this assignment:

- GEP Learning outcome #1: Explain major concepts, methods, or theories in the natural science to investigate the physical world.
    - Students generated their own questions and hypotheses and designed an experiment to test the hypothesis. Results were gathered, interpreted and assembled into a scientific paper which was peer reviewed and evaluated by other members of the class. Students had to conduct background research to support their hypotheses, prediction and interpretations. Students also identified possible sources of error, changes that would be made if the experiment was repeated and connections to the larger picture of science and society. Each of these steps adheres to the steps of the scientific method.

    - This assignment directed students to question the effectiveness of everyday bacterial inhibiting products. Based on the observations and gathered data, students had to determine the effectiveness of these products and evaluate the accuracy of claims made by the producers of the products. Students also had to infer the relationship between bacterial diversity and the degree of effectiveness of a given product.

- GEP Learning outcome #2: Interpret information, solve problems, and make decisions by applying natural science concepts, methods and quantitative techniques.
    - In designing an experiment, students had to apply a variety of techniques to evaluate bacterial inhibition. Based on the observations and gathered data, students had to determine the effectiveness of these products and evaluate the accuracy of claims made by the producers of the products. Students also had to infer the relationship between bacterial diversity and the degree of

effectiveness of a given product. Further, students had to evaluate whether using a product that kills 99% of all bacteria was a reasonable choice in the light of bacterial resistance and evolution.

- GEP Learning outcome #3: Describe the relevance of aspects of the natural science to their lives and society.
    - Students had to draw connections between this experiment and the persistence of antibiotic resistant bacteria, overuse of antibiotics by the medical and agricultural community, and the prevalence of autoimmune disorders in recent years.

Students were evaluated based on the included rubric. Students were also evaluated based on peer evaluation of another group. This was a means to gauge student's understanding of the scientific method, their ability to be critical of scientific data and methods and to gain an overall understanding of the peer review process.

The lab procedures follow and include a template for the scientific paper, a rubric for evaluation and peer evaluations.

Bacteria

GEP Investigation Level Learning Outcomes:

1. Identify the basic taxonomy and principles of the scientific method as it pertains to the natural and physical world.
2. Infer relationships, make predictions and solve problems based on analysis of evidence or scientific information.

Student Learning Outcomes:

1. Design and conduct an experiment to compare areas where bacteria and fungi can be found.
2. Discuss methods for culturing bacteria.
3. Describe diversity of colony morphologies and cell shapes.
4. Evaluate hypotheses and predictions about bacterial and fungal abundance.
5. Describe diversity within the protists.
6. Identify living protists using a dichotomous key.

Assignments:

1. Pre-Lab Questions
2. Check out (in lab questions

INTRODUCTION

As consumers, we are bombarded constantly with products that make claims regarding their ability to kill germs. We buy antibacterial soaps, cleaners, and hand sanitizers, with the goal of stopping the growth of bacteria on surfaces and our bodies. We go to the doctor when we are sick to obtain prescriptions for antibiotic medications. But what, exactly, do these products do? How can we judge their effectiveness? If not all bacteria are harmful, and many are necessary for the survival of other species, how can we ensure that beneficial bacteria are not harmed by the chemicals we are using to eliminate the destructive bacterial strains?

In order to begin answering some of these questions, an understanding of different sorts of anti-bacterial chemicals is necessary.

In **microbiology**, or the study of microscopic organisms, scientists often take samples for colony forming units. **Colony forming units** or CFUs are used as a measure of the number of viable bacteria or fungi in a given area/sample. In the case of bacteria, a single bacterium is a CFU, and will divide to form an entire colony. For fungi, the CFU is a spore. When spores successfully germinate, they form a fungal mycelium. **Antibiotics** are chemicals that are produced by bacteria or fungi. Under natural conditions, they control the growth of other species of bacteria that might compete with them for resources or might otherwise inhibit their ability to reproduce. As mentioned earlier, antibiotics are generally more effective on Gram-positive bacteria than on Gram-negative bacteria. They function by interfering with the cross-linking of peptidoglycan in bacterial cell wall. This is why humans and other animals can ingest these chemicals without experiencing ill effects to their own cells. Because peptidoglycan is not used in animal cell walls, antibiotics do not have the same destructive effect on them as they have on bacterial cells.

Antiseptics (a word that means "against putrification"), are antimicrobial substances that are safe to be used on living tissues. They either kill bacteria or prevent their growth. The mechanism of action depends on the chemical. Some prey upon the osmotic activity of bacterial cells, such a salt solutions, whereas others work via oxidation of tissues. Antiseptics do not generally result in sterilization of a surface (i.e. killing all of the bacteria), but instead reduce the number that are actively growing.

Disinfectants are chemicals that are used to reduce or eliminate bacteria on inanimate surfaces. Unlike antiseptics, which must not produce excessive damage to the tissues on which they are applied, disinfectants can be quite damaging to living cells other than bacteria. These chemicals may be toxic to humans and domestic animals, as well as to the microbes they are intended to kill. The exact mechanism of action, as with antiseptics, depends on the nature of the specific chemical.

Schedule of Events

Week 1: Set-up (inoculate) culture plates.

Week 1 – 3: Monitor growth and gather data.

Week 3: Collect additional data using a variety of techniques.

Week 4: Compile findings into a lab report

EXERCISE I. COMPARING THE EFFECTIVENESS OF VARIOUS ANTIMICROBIAL

In order to evaluate the effectiveness of various antibacterial agents, you need to expose bacteria to the agent, and you need some means of measuring how effective the agent is in preventing growth. One way to accomplish these ends is to infuse small paper disks with a particular chemical and apply them to a **bacterial lawn** (Figure 9.1). The antibacterial agent will diffuse out of the disk and into the surrounding medium, establishing a concentration gradient, with the highest concentration directly under the disk, and concentration decreasing with distance from the disk.

If the chemical is effective in decreasing bacterial growth, it will produce a **zone of inhibition** in the area surrounding the disk. The zone of inhibition is an area on the lawn where the bacteria have been killed or have been unable to reproduce because of exposure to the chemical and will be visible as an area surrounding the disk where there are no apparent bacteria. The more effective an antibacterial agent is, the larger the zone of inhibition. Because effectiveness is affected by concentration, those agents that are most potently antibacterial will inhibit growth of bacteria at lower concentrations, so they will have larger zones of inhibition. Those agents that are less effective against bacteria will only work at the highest concentrations, so the zone of inhibition will be constrained to the area immediately surrounding the paper disk (Figure 10.2).

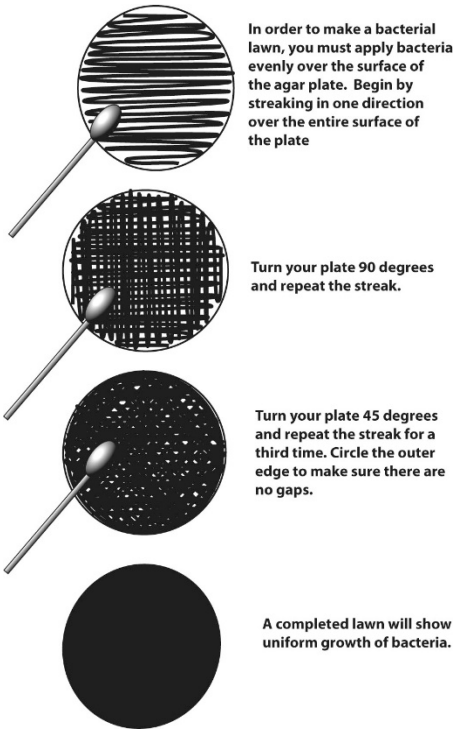


Figure 10.1. Making a bacterial lawn.

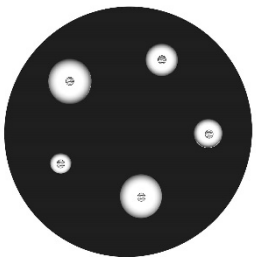


Figure 10.2. Zone of inhibition. The treated paper disks placed on the bacterial lawn have inhibited the growth the bacteria, resulting in an area that appears "clear." This is the zone of inhibition. The size of the zone of inhibition is a good measure of the efficacy of a particular antibacterial agent.

At this time, your lab group will be given four Luria broth plates. You will design an experiment that allows you to address the following a question(s) similar to those listed below:

1. Is a given antibiotic equally effective against different bacterial strains?
2. Do different antiseptics and/or disinfectants have equal antibacterial properties?
3. Do disinfectants and/or antiseptics inhibit growth of bacteria from different sources?

There are many different ways that you could choose to address these questions. You should review your question and your methods for testing that question with your instructor and discuss it with your lab mates. **Record your question and sources below.**

You will be able to examine your plates next week in order to evaluate the results of the experiment.

In today's lab, you will sample an environmental location(s) with swabs, and then wipe the swabs on an agar plate containing nutrients. This will effectively transfer any bacteria and/or fungal spores from the surface onto the plate. We will allow the CFUs to grow and divide. In the next weeks, each individual bacterium or fungal spore will have divided enough to form a pile of cells, or colony, large enough to see with the naked eye. By counting the number of colonies growing on our plates, we can estimate the number of living bacteria or viable fungal spores in the sampled area.

Possible Question:

Possible Bacteria Source(s):

Possible Treatment (s):

Discuss with your group possible sources of bacteria, treatments or possible sample locations. Come to a consensus on what your question will be and how you will test it. Formulating this question and hypothesis requires conducting background research. Once you have decided on a question and **hypothesis**, you should formulate a prediction about your results. Record your information on the next page. Be sure to explain the reason behind your prediction. A list of some available treatments is listed to the right. You are not limited to these treatments and may redesign any aspect of this experimental set-up. You should conduct some background research on how a particular treatment or environment affects bacterium (i.e. what is the biological mechanism). This will be a key component of your grade on your lab report.

Hand sanitizer

Anti-bacterial soap

Hydrogen peroxide

Keep a careful record of your methods on the next page. Make a diagram of your setup and the environmental conditions (both control and experiment).

Table 10.1. EXPERIMENTAL SET UP

Date Plated	
Description of control	
Description of experimental group(s)	
Description of antiseptic and/or disinfectant	

Table 10.2. Diagram of EXPERIMENTAL SET UP

Control	Experimental Group #1	Experimental Group #2	Experimental Group #3

The plate we will be using today contains nutrient agar. **Agar** is a gelatinous substance made from red algae. It is moist enough to encourage the growth of microorganisms. Different nutrients added to the agar will result in selective growth of different types of bacteria or fungi, although the agar we will be using is quite general and does not promote the growth of pathogenic strains of bacteria.

EXERCISE II. MAKING STREAK PLATES OF BACTERIA AND FUNGI

Have you ever wondered what kinds of bacteria are living on the things around you? Do you wonder if some surfaces or objects have greater concentrations of bacteria, or greater variety of bacterial species?

In this exercise, each lab group will isolate bacteria from one or multiple environmental sources of their choosing.

The streak plate technique is used to isolate/separate one bacterial colony or cell from another. Isolating colonies from one another is important, because characteristics like colony size, shape, and margins are only visible in isolated colonies. Figure 1 illustrates how to isolate bacterial colonies using the streak technique.

Aseptic Techniques

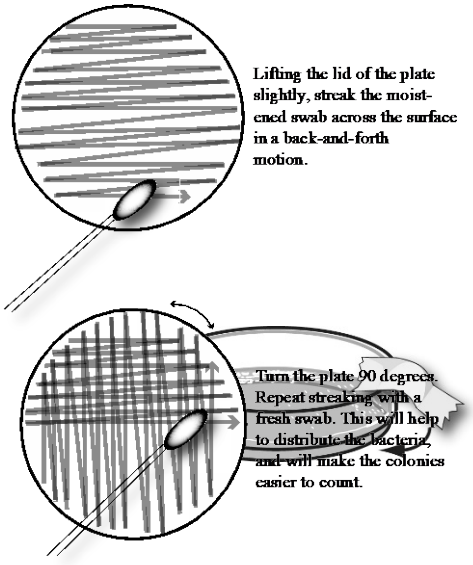
Because we are sampling bacteria of unknown types in this lab, we need to behave as though they are hazardous. Bacteria are microscopic, potentially infectious, and everywhere (hands, house, lab, food, etc.), so it is important when working with them that you take appropriate measures to ensure that unwanted

strains of bacteria are not introduced into your cultures. Similarly, you should take precautions to ensure that the bacteria within the cultures do not "escape" onto the surfaces nearby.

To ensure that your working environment is clean and free from contaminants, the following steps must be taken when working with bacteria. Please:

1. **Wash your hands and put on latex or vinyl gloves before collecting bacteria or handling plates**
2. **Discard swabs in the designated biohazard bag immediately after use!**
3. **Do not place swabs on the table!**
4. **Lift lid of your agar plate ONLY when swabbing it with bacteria. Lift the lid at a slight angle that is wide enough to allow the swab to touch the agar but does not fully uncover the plate. This will help limit the exposure to uninvited bacteria and fungal spores.**
5. **Clean up all spills with paper towels and bleach and discard them in the biohazard bag!**

Obtain a **nutrient agar plate**, and label it with your group name, the source of the sample, and the date. Following the method outlined in Figure 9.3, make a streak plate from your assigned source.



Once you have made your streak plate, turn it upside down. This will help keep condensation from messing up your bacteria. Use two tabs of tape to attach the petri dish to its lid (Figure 9.3). Store your plate on the designated table. You will examine the growth on these plates next week, so be sure to save your lab pages.

Figure 10.3. Method for streaking plate.

EXERCISE III. FINAL BACTERIA DATA COLLECTION AND PROTIST OBSERVATIONS

Most life forms are single celled. In today's lab, we will be examining a number of single-celled organisms, including bacteria and a variety of "protists" In today's lab, you will explore the basic structure of bacteria and learn how scientists identify different types of bacteria. You will review the

basic clades within the “protists,” and explore the use of a dichotomous key in identifying these organisms.

CHARACTERISTICS OF BACTERIA

The most widespread and abundant organisms on our small planet are not visible to the naked eye. They are tiny, unicellular **prokaryotes** (from the Greek “pre-nucleus”) in the domains Bacteria and Archaea. They exist as single cells, and lack membrane-bound organelles, including a nucleus. In spite of their small size and simplicity relative to multicellular eukaryotes like ourselves, these organisms are highly evolved. Each bacterial cell possesses the ability to obtain or produce nutrients, maintain its physical integrity, and reproduce.

Although people typically think of bacteria as harmful, disease-causing microorganisms that we must try to eradicate at all costs, the fact is that bacteria are essential to many forms of life on earth, including humans. They play important roles in the biosphere, acting as decomposers, nutrient fixers, and internal symbionts. The first step toward appreciating the immense diversity among these organisms is to review the basic appearance of bacterial colonies and cells. In the first two exercises of this lab, you will become familiar with describing differences between species of bacteria, using the plates you prepared last week. Be sure to review the aseptic techniques covered last week before beginning.

Colony Morphology

Bacterial colonies are aggregations of millions of bacterial cells that grow from a single parental bacterium. One bacterium divides through **binary fission.** Each of the daughter cells produced then divides, and so on and so on until a mature colony is produced. Growth of the colony continues until the cells use up their resources, or their own metabolic wastes poison them.

Different strains of bacteria produce colonies of different sizes, shapes, and colors. This makes colony **morphology**, or shape and appearance, an important first step in identifying different bacteria. Bacteriologists have a specific vocabulary for describing bacterial colonies. Many of these terms are illustrated in Figure 9.4.

In some instances, bacterial plates may be contaminated with fungi. **Fungal colonies** can easily be distinguished from bacterial colonies. Fungi consist of a **mycelium**, or a mass of filaments called **hyphae**. Fungal colonies appear fuzzy and are often larger than bacterial colonies.

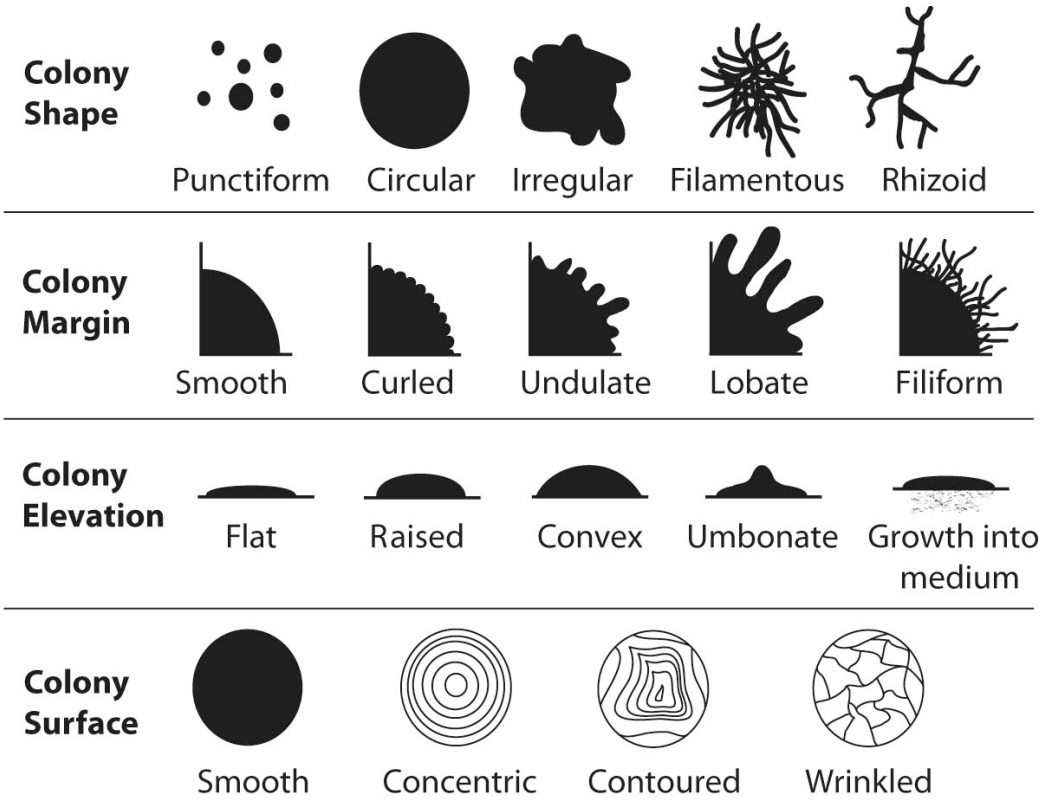


Figure 10.4. Terms used to describe bacterial colonies. A. Shape of colony. B. Colony margins. C. Colony elevation. D. Surface characteristi

EXERCISE IV. IDENTIFY COLONY MORPHOGY

1. Collect your plates from last week.
2. For each plate, identify how many different types of colonies are present. You should list the size, shape, margin, elevation, surface, and color of the colonies present on each plate. In addition, you should count the number of each type of colony.
3. Record your results on Tables 9.1 and 9.2.
4. Use the data collected to evaluate each of your hypotheses about bacterial distribution. Have you supported any hypotheses? Have you falsified any?

Cellular morphology

Just as bacterial colonies vary in appearance, the cells of different types of bacteria also appear different. Most notably, cells differ in shape and size. Three common shapes for bacterial cells are: 1. **cocci** (singular coccus), which are spherical; 2. **bacilli** (singular bacillus), which are rod-shaped; and 3. **spiral** bacteria, which can be tightly coiled or merely twisted into a coma-like shape. The basic cell shape may form part of a bacteria's name. Part of a bacterium's name may also come from how individual cells aggregate together. For example, when we find cells in pairs, we add the prefix **diplo-** to the name, when they are found in chains, we add the prefix **strepto**-. When we find them in clusters, they are given the prefix **staphylo-**. Other arrangements exist, such as tetrads and sarcina (cubes of 8 cells), but these are the most common (Figure 10.5).

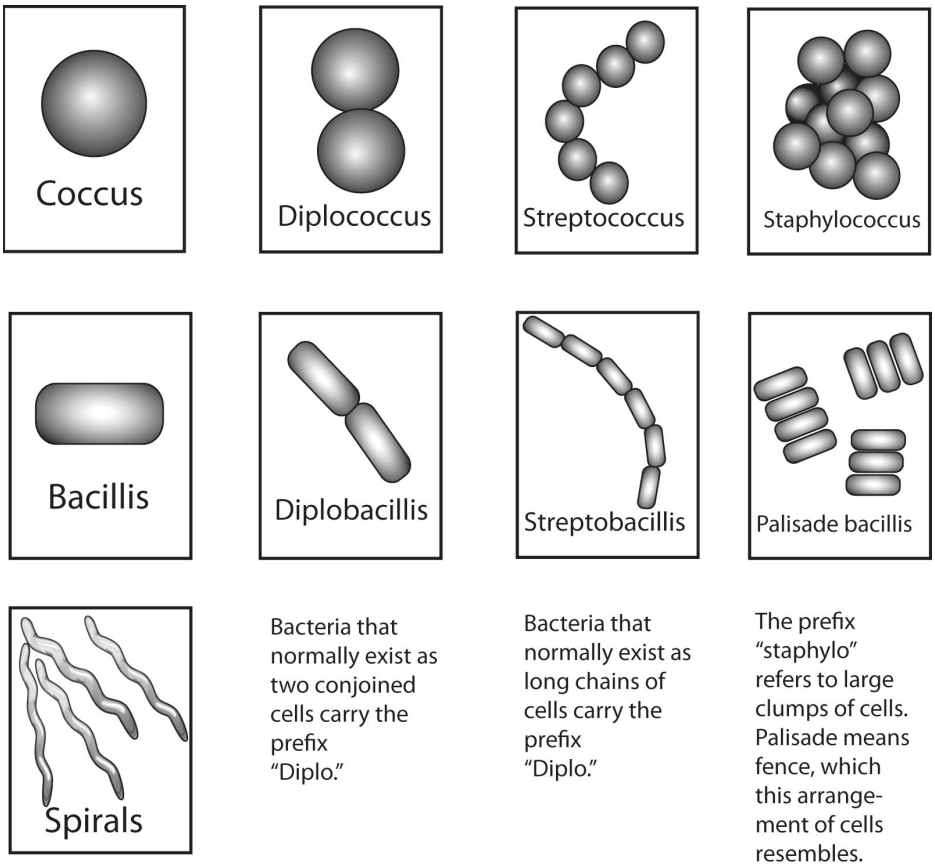


Figure 10.5. Variation in prokaryotic cell shape

EXERCISE V. IDENTIFYING CELLULAR MORPHOLOGY

Examine the cellular morphology of three different types of bacteria available on prepared slides. Practice bringing the cells into focus. Diagram what you see in the spaces provided below and identify the cellular morphology. Remember to clean the microscope lens and the slide when you are don

LAB REPORT

Table 10.2. Observational Data Sheets						
Site data			Number of colonies	Number of different colonies	% cover	Describe any other observations (e.g. zone of inhibition, color, etc.)
Date						
Time		AM				
		PM				
Temp		°F				
		°C				

Site data			Number of colonies	Number of different colonies	% cover	Describe any other observations (e.g. zone of inhibition, color, etc.)
Date						
Time		AM				
		PM				
Temp		°F				
		°C				

Site data			Number of colonies	Number of different colonies	% cover	Describe any other observations (e.g. zone of inhibition, color, etc.)
Date						
Time		AM				
		PM				
Temp		°F				
		°C				

Table 10.4. Results for a variety of observations taken from control and experimental treatments. This table will be filled out once you bring your plates to the next lab.

	Control	Exp. Treatment 1	Exp. Treatment 2	Exp. Treatment 3
Number of colonies				
Number of different colonies				
% cover				
Zone of inhibition (mm)				

Treatment group: _____	For each plate, look at the bacteria characteristics and make a wet mount to examine the type of bacteria under the microscope.				
Species Number	Colony Shape	Colony Margin	Colony Elevation	Colony Surface	Cell shape (e.g. coccus, bacillis, etc.)
Species 1					
Species 2					
Species 3					
Species 4					
Species 5					

COLLECTING DATA ON YOUR BACTERIA & FINISHING YOUR REPORT

Now that you have conducted your experiment and made observations, you will collaborate with your lab mates to compile your and make additional observations regarding your bacterial colonies You will submit a lab report using the format supplied to you on CANVAS and below. Everyone in the group should contribute equally. Remember science is centered on collaboration.

Title: Should be a descriptive sentence
Effect of household cleaners on the diversity and growth rate of buccal cavity bacteria

Group member names
University of Wisconsin-Stevens Point

Introduction:
One paragraph - Overall description and objectives of experiment. Do not include any results in the introduction. A brief literature review should be included describing either the treatment or source of bacteria (or both) and the possible biological mechanisms at play. Use of quotations should rarely be used. If you are using someone else's work, rephrase it and then cite the source.
You should also finish the introduction with your hypothesis and predictions.

Methods:
Includes a description of the steps that were done to test your hypothesis. No results are included in this section. If you include a picture, it should be labeled as Figure #___.

Results:
A concise presentation of the experimental findings in an organized and readable form. Do not use the Results section to interpret or explain the data but concentrate on writing a precise summary of the observations and measurements that were made. You will be most likely to refer the reader to tables or figures in this section. **Introduce the results by discussing what methods were used to analyze the data (e.g. as determined by measuring the distance from the treatment disc to the first bacteria colony, the bleach treatment had the greatest zone of inhibition).**

- Each graph (called a figure) should be numbered and given a title (labeled below the figure).
- Each table (called a table) should be numbered and given a title (labeled above the table).

Table 10.5. Diversity, zone of inhibition, growth rate and % cover of bacteria colonies measured following exposure to household treatments compared to the control at the completion of the experiment.

Group #	Treatment	Number of different colonies	Zone of inhibition (mm)	Growth rate (% cover/day)	% Cover
1	Control	6	0.3	0.8	85
2	Bleach	1	3	0.2	10
3	Vinegar	2	2	0.4	30
4	Listerine	2	1	0.7	45

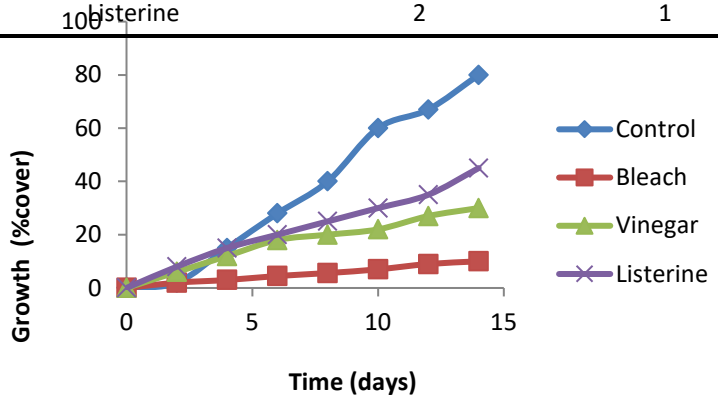


Figure 1. Bacterial growth, as measured by % cover of buccal cavity bacteria, over a 14-day observation period.

Discussion:
The Discussion section is where you demonstrate your understanding of the experiment by interpreting the results, explaining their significance (bigger picture) and describing the possible explanation for your results (i.e. the biological mechanism). This is the most important section of the report and may be as long as the other three sections combined.

Literature Cited:
Include all citations in the proper format (you can choose the format of your major). You may wish to use superscripts[1] in the text and then provide full citations at the end to conserve space.

*1-2 pages in length *50 points *you will be evaluated based on this format as well as the presentation rubric used for photosynthesis

WHAT IS DUE FOR THIS LAB

CHECK:

☐Hypothesis/Experimental Design (5 points)

☐Lab Completion (10 points)

TURN IN:

☐Pre-Lab (5 points)

☐Lab Report (50 points)

☐Peer evaluation (10 poin

Bacteria Lab Report Rubric

Directions:

Using the rubric

1. In your google drive (or CANVAS) you will find a lab report of a group you will be evaluating.
2. Using the rubric below, evaluate the lab report by selecting the appropriate box and assigning a point value to each category.
3. Place this value for each category in the far-right column
4. Tally up the total values for each category to assign a final grade.

Commenting on the lab report:

1. Each lab group member is responsible for commenting on the lab report. Think of this commenting on a discussion thread. You can agree or not agree with your lab partners, but you need to explain why.
2. You will be graded on how well you critique and evaluate the lab report. This may require you to do some background research on why the lab report is inaccurate or inappropriate.
3. You will also be graded on the detail that you provide in your comments.
4. Each lab partner needs to make at least two comments. This can be an original comment or a comment in response to your lab partner.

CRITERIA	0	Beginning (2-2.8)	Developing (2.8-3.2pts)	Proficient (3.2-3.6)	Mastery at Intro Level (3.6-4 pts)	TOTAL
QUESTION						
Frame Question		☐An attempt is made to pose a question.	☐A question is posed that shows relevance to the topic, misconceptions present.	☐A question is posed that shows understanding of the biological mechanism involved.	☐An insightful question is clearly posed that shows understanding of the biological mechanism.	
Pose hypothesis and predictions		☐An attempt is made to pose a hypothesis and prediction, though incorrectly identified, form is incorrect, prediction does not follow reasoning	☐Both hypothesis and prediction are present and stated in appropriate form, though they may not follow logically from background information.	☐Both hypothesis and prediction are appropriately stated, with the prediction logically flowing from the hypothesis.	☐Hypothesis and prediction well formed, creative, and fluent, showing logical consistency throughout and strong connection to background information.	
Identify variables		☐An attempt is made to identify the variables of the experiment.	☐Some variables are correctly identified, though some may be absent, incorrectly identified, or poorly chosen.	☐Most variables are correctly identified, using accurate terminology.	☐All variables are correctly identified and described in fluent language.	
Indicate how to falsify		☐An attempt is made to specify the experimental outcome that would falsify the hypothesis but indicated result would not falsify hypothesis.	☐Falsifying information is identified, but the proposed falsification is either incorrect or is not accompanied by an explanation of how it would falsify the hypothesis.	☐Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided.	☐Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided. Discussion of falsification is fluent.	
BACKGROUND, METHODS						
Background information		☐An attempt is made to introduce relevant background material.	☐Background material is included but may include inappropriate details or be missing key concepts that should be covered.	☐Background information is appropriate, clearly anticipates and supports the question being asked or hypothesis being posed.	☐Background information is appropriate, clearly anticipates and supports the question being asked, and is fluently rendered. Details anticipate topics covered in the discussion.	

Summary of procedure		☐Experimental procedure is summarized but is incomplete or	☐Experimental procedure is summarized completely, and	☐Experimental procedure is summarized completely, and experimental design is appropriate for addressing the	☐Experimental procedure is completely summarized, illustrating optimal experimental design. Expressed	

		poorly designed.	experimental design is appropriate for addressing the hypothesis.	hypothesis. Allows for appropriate falsification. Summary uses straightforward language that is easy to follow but may be stilted or lack flow.	in language that skillfully communicates meaning to readers with clarity and fluency.	
RESULTS						
Summary of Results		☐An attempt is made to verbally summarize the results of the experiment.	☐The summary of the results is present, but incomplete, lacking key elements, or not adequately summarized.	☐Data are well-summarized, with appropriate generalizations of trends outlined. May lack organization or subtlety.	☐Data are well summarized, and cogently presented. Trends in data identified. Highly organized and fluent reporting of results.	
Graphs		☐Some type of graph illustrating the results of the experiment is submitted.	☐Graphs submitted are properly labeled and show an appropriate set of data.	☐Graphs are appropriately labeled, show appropriate data, and make good use of page space.	☐Graphs are appropriately labeled, show appropriate data, make good use of page space, and are of a type that is well chosen to represent the type of data presented.	
CONCLUSIONS						
Evaluate hypothesis		☐An attempt is made to answer the question and evaluate the proposed hypothesis.	☐Hypothesis is evaluated, though some data may be misinterpreted, or explanation of how the data relate to the hypothesis is unclear.	☐Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is clear.	☐Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is fluent and clear. Discussion shows depth of thought and clear deductive reasoning.	
Draw conclusions		☐An attempt is made to generalize conclusions from the results of the experiment.	☐Some conclusions are correctly drawn, though some may be spurious, limited, or not reflective.	☐Appropriate conclusions are drawn, and there is an attempt to connect them to introductory background material.	☐Appropriate conclusions are drawn and are tied to introductory background material and other biological topics.	
RELEVANCE						
Future Questions		☐An attempt is made to indicate how this study may relate to other, unanswered, questions.	☐Potential future questions are identified but are not firmly tied either to the results of the current study or the introductory background material.	☐Potential future questions are identified and tied to both the results of the current study and the introductory background material.	☐Potential future questions are identified and tied to both the results of the current study and the introductory background material. Questions demonstrate insight or integration with other facets of biology.	
Discuss Relevance		☐An attempt is made to identify the relevance of this study to understanding personal health or society.	☐Some relevance of this study to understanding personal health or society is identified and discussed, though discussion may be incomplete or simplistic.	☐Relevance of this study to understanding personal health or society is clearly identified, including discussion of more than one implication of the knowledge gained.	☐Relevance of this study to understanding personal health or society is clearly identified, including discussion of more than one implication of the knowledge gained. Discussion integrates other aspects of biology touched on in the introduction to broaden the overall picture.	
Control of syntax and mechanics		☐Uses language that sometimes impedes meaning because of errors in usage. Multiple typos. Deduct 7-9 points	☐Uses language that generally conveys meaning to readers with clarity, although writing may include some errors. Deduct 4-6 points	☐Uses straightforward language that generally conveys meaning to readers. Few errors are present. Deduct 1-3 points	☐Uses graceful language that skillfully communicates meaning to readers with clarity and fluency and is virtually error-free. No deductions.	
TOTAL						/52

*Total possible points = 52 (this means there is a possibility of two bonus points on this assignment!

1.4.C. Course Learning Activities Targeting the GEP Category

Student achievement in GEP learning outcomes is supported by a variety of learning experiences throughout the semester. Many of these learning experiences are described above. In particular, students are fully immersed in GEP Learning outcome #3: Describe the relevance of aspects of the natural science to their lives and society. This course has been redesigned to fully address the scientific method by revamping the laboratory manual to be focused on an inquiry-based approach. Each lab encourages students explore quantitative techniques and then design an experiment to test their questions. These experimental designs are novel and results are not predetermined by the instructor. As a result, students are conducting science as it is intended to be, not through a cookbook laboratory manual. Refer to the syllabus for direct alignment between course activities, learning outcomes and GEP learning outcomes.

Excerpt from course syllabus:

General Education Course:

This is a General Education Course which means that students will explore a broad survey of biological concepts. Specifically, students will:

1) Explain major concepts, methods, or theories in the natural sciences to investigate the physical world.
2) Interpret information, solve problems, and make decisions by applying natural science concepts, methods and quantitative techniques.
3) Describe the relevance of aspects of the natural science to their lives and society.

GEP & OVERALL COURSE STUDENT LEARNING OUTCOMES (C-SLO)

All learning outcomes will be assessed in a variety of ways throughout the semester.

Weekly course student learning outcomes (W-SLO) are listed in the weekly schedule at the end of the syllabus. Assessments for each W-SLO are listed in abbreviated form. These assessments include but are not limited to:

- SA Summative Assessment (exam)
- FA Formative Assessment (online quiz)
- P Presentation (poster / oral)
- PE Peer evaluation
- SP Scientific Paper
- CS Case Study
- ILQ Inquiry Post Lab Questions'
- TLQ Traditional Post Lab Questions
- D Debat

GEP & Course Learning Outcomes	Example Class Assignment(s):	Activity
1. Explain major concepts, methods, or theories in the natural science to investigate the physical world. 2. Interpret information, solve problems, and make decisions by applying natural science concepts, methods, and quantitative techniques.	Identify the basic principles of the scientific method in a case study involving childbed fever. Conduct self-designed, long-term experiments (photosynthesis) applying the principles of the scientific method.	Inquiry Lab Case Study Lecture Oral presentation Videos
3. Infer relationships, make predictions and solve problems by **synthesizing** content derived from biological principles including: • Cellular level functions necessary for life • Inheritance & evolutionary change • The diversity of life within an evolutionary context • The basic function of populations, communities and ecosystems.	Infer relationships, make predictions and solve problems based on data dealing with bacterial inhibition and experimental treatments in self-designed experiment	Inquiry Lab Written scientific paper Scientific presentation
4. Describe the relevance of aspects of the natural science to their lives and society.	Evaluate the legitimacy of research in terms of the scientific method and solve problems involved in five different case studies throughout the semester. Case studies involve current, real-life problems and determining solutions to those problems based on course content.	Peer evaluation Case study Independent work Written work

2A. Analysis: Briefly describe which assessment instrument was used (such as a rubric) and explain any analysis you performed on the data or information from your input.

The assignment will be assessed using the rubric (below). Each student group received a scored rubric as well as direct instructor comments on the paper. In addition, students were evaluated by two of their peers and provided feedback through the rubric.

The rubric is divided into 5 criteria: Question, Background/Methods, Results, Conclusion and Relevance. This rubric assesses the GEP learning outcomes outlined for a Natural Science GEP course. Relevant GEP learning outcomes are indicated for each criterion (Table 1). Each criterion is assessed based on the following levels of understanding: Beginning (2.0-2.8), Developing (2.8-3.2), Proficient (3.2-3.6) and Mastery (3.6-4). The total value for this assessment was 52 points.

Bacteria Lab Report Rubric

Directions:

Using the rubric

1. In canvas you will find a lab report of a group you will be evaluating.
2. Using the rubric below, evaluate the lab report by selecting the appropriate box and assigning a point value to each category.
3. Place this value for each category in the far-right column
4. Tally up the total values for each category to assign a final grade.

Commenting on the lab report:

1. Each lab group member is responsible for commenting on the lab report. Think of this commenting on a discussion thread. You can agree or not agree with your lab partners, but you need to explain why.
2. You will be graded on how well you critique and evaluate the lab report. This may require you to do some background research on why the lab report is inaccurate or inappropriate.
3. You will also be graded on the detail that you provide in your comments.
4. Each lab partner needs to make at least two comments. This can be an original comment or a comment in response to your lab partner.

Table 1. Rubric to assess GEP Learning outcomes for Bacteria paper assignment in BIOL 100

CRITERIA	0	Beginning (2-2.8)	Developing (2.8-3.2pts)	Proficient (3.2-3.6)	Mastery at Intro Level (3.6-4 pts)	TOTAL
1. QUESTION			**GEP Learning Outcome #1**			
Frame Question		☐An attempt is made to pose a question.	☐A question is posed that shows relevance to the topic, misconceptions present.	☐A question is posed that shows understanding of the biological mechanism involved.	☐An insightful question is clearly posed that shows understanding of the biological mechanism.	
Pose hypothesis and predictions		☐An attempt is made to pose a hypothesis and prediction, though incorrectly	☐Both hypothesis and prediction are present and stated in appropriate form, though they may	☐Both hypothesis and prediction are appropriately stated, with the prediction logically	☐Hypothesis and prediction well formed, creative, and fluent, showing logical consistency throughout	

		identified, form is incorrect, prediction does not follow reasoning	not follow logically from background information.	flowing from the hypothesis.	and strong connection to background information.	
Identify variables		☐An attempt is made to identify the variables of the experiment.	☐Some variables are correctly identified, though some may be absent, incorrectly identified, or poorly chosen.	☐Most variables are correctly identified, using accurate terminology.	☐All variables are correctly identified and described in fluent language.	
Indicate how to falsify		☐An attempt is made to specify the experimental outcome that would falsify the hypothesis but indicated result would not falsify hypothesis.	☐Falsifying information is identified, but the proposed falsification is either incorrect or is not accompanied by an explanation of how it would falsify the hypothesis.	☐Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided.	☐Falsifying information is identified correctly, and a valid explanation of how it falsifies the hypothesis is provided. Discussion of falsification is fluent.	
2. BACKGROUND, METHODS			**GEP Learning Outcome #2**			
Background information		☐An attempt is made to introduce relevant background material.	☐Background material is included but may include inappropriate details or be missing key concepts that should be covered.	☐Background information is appropriate, clearly anticipates and supports the question being asked or hypothesis being posed.	☐Background information is appropriate, clearly anticipates and supports the question being asked, and is fluently rendered. Details anticipate topics covered in the discussion.	
Summary of procedure		☐Experimental procedure is summarized but is incomplete or poorly designed.	☐Experimental procedure is summarized completely, and experimental design is appropriate for addressing the hypothesis.	☐Experimental procedure is summarized completely, and experimental design is appropriate for addressing the hypothesis. Allows for appropriate falsification. Summary uses straightforward language that is easy to follow but may be stilted or lack flow.	☐Experimental procedure is completely summarized, illustrating optimal experimental design. Expressed in language that skillfully communicates meaning to readers with clarity and fluency.	
3. RESULTS			**GEP Learning Outcome #2**			

Summary of Results		☐An attempt is made to verbally summarize the results of the experiment.	☐The summary of the results is present, but incomplete, lacking key elements, or not adequately summarized.	☐Data are well-summarized, with appropriate generalizations of trends outlined. May lack organization or subtlety.	☐Data are well summarized, and cogently presented. Trends in data identified. Highly organized and fluent reporting of results.	
Graphs		☐Some type of graph illustrating the results of the experiment is submitted.	☐Graphs submitted are properly labeled and show an appropriate set of data.	☐Graphs are appropriately labeled, show appropriate data, and make good use of page space.	☐Graphs are appropriately labeled, show appropriate data, make good use of page space, and are of a type that is well chosen to represent the type of data presented.	
4. CONCLUSIONS			**GEP Learning Outcome #3**			
Evaluate hypothesis		☐An attempt is made to answer the question and evaluate the proposed hypothesis.	☐Hypothesis is evaluated, though some data may be misinterpreted, or explanation of how the data relate to the hypothesis is unclear.	☐Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is clear.	☐Hypothesis is correctly evaluated based on data collected, and the explanation of how the data relate to the hypothesis is fluent and clear. Discussion shows depth of thought and clear deductive reasoning.	
Draw conclusions		☐An attempt is made to generalize conclusions from the results of the experiment.	☐Some conclusions are correctly drawn, though some may be spurious, limited, or not reflective.	☐Appropriate conclusions are drawn, and there is an attempt to connect them to introductory background material.	☐Appropriate conclusions are drawn and are tied to introductory background material and other biological topics.	
5. RELEVANCE			**GEP Learning Outcome #3**			
Future Questions		☐An attempt is made to indicate how this study may relate to other, unanswered, questions.	☐Potential future questions are identified but are not firmly tied either to the results of the current study or the introductory background material.	☐Potential future questions are identified and tied to both the results of the current study and the introductory background material.	☐Potential future questions are identified and tied to both the results of the current study and the introductory background material. Questions demonstrate insight or integration with other facets of biology.	
Discuss Relevance		☐An attempt is made to identify the relevance of this study to	☐Some relevance of this study to understanding personal health or	☐Relevance of this study to understanding personal health or society is clearly	☐Relevance of this study to understanding personal health or society is clearly	

		understanding personal health or society.	society is identified and discussed, though discussion may be incomplete or simplistic.	identified, including discussion of more than one implication of the knowledge gained.	identified, including discussion of more than one implication of the knowledge gained. Discussion integrates other aspects of biology touched on in the introduction to broaden the overall picture.	
Control of syntax and mechanics		☐Uses language that sometimes impedes meaning because of errors in usage. Multiple typos. Deduct 7-9 points	☐Uses language that generally conveys meaning to readers with clarity, although writing may include some errors. Deduct 4-6 points	☐Uses straightforward language that generally conveys meaning to readers. Few errors are present. Deduct 1-3 points	☐Uses graceful language that skillfully communicates meaning to readers with clarity and fluency and is virtually error-free. No deductions.	
TOTAL						/52

*Total possible points = 52 (this means there is a possibility of two bonus points on this assignment!

2.B. Summary: In addition to entering your numeric results, please briefly summarize your results/findings. How did the class perform overall?

Assessment results

Overall, students had a good understanding of the process of the scientific method and were able to write a testable hypothesis and design an experiment to test that hypothesis. However, in general many students failed to identify the biological mechanism involved in the results and had some difficulty in critiquing other's work.

In addition, students in this particular semester seemed to be somewhat deficient in their ability to tie results to broader implication, scientific concepts and applicable scenarios. This was illustrated in lower scores in the Conclusion and Relevance section compared to previous years.

The rubric was divided into five main fields: Question, Background/Methods, Results, Conclusions, and Relevance. Under each of these main five fields were more specific criteria that were required in the student's paper. For each criterion, the specific areas where students fell short were identified. Possible courses of action for future courses were also outlined to address these shortcomings.

**See rubric for details on ranking of the criteria.*

Overall results (Figure 1). Overall, students scored at proficient levels for the assignment. There were several areas where most students were lacking and these areas are outlined below.

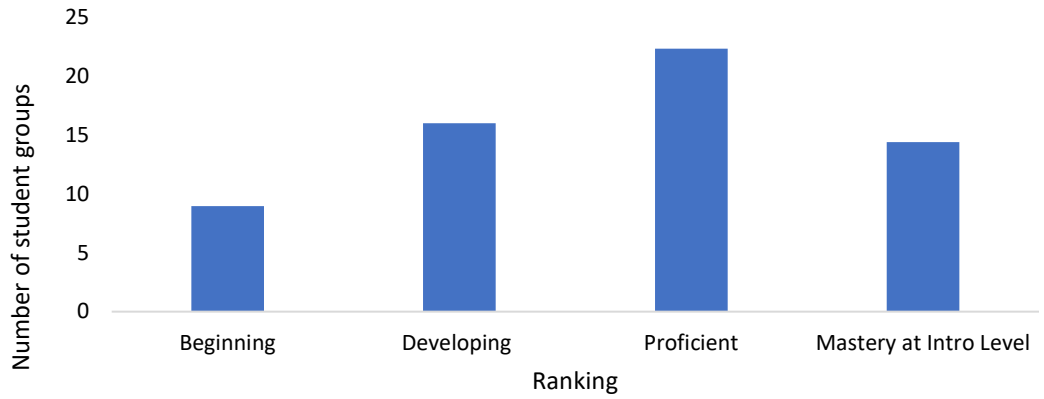


Figure 1. Cumulative date, average ranking for entire assignment - all criteria

Criteria #1 Question (Figure 2). This criterion involved the student's ability to 1) frame a question, 2) pose a hypothesis and prediction, 3) Identify variables, and 4) indicate how to falsify a hypothesis. By in large, students failed to indicate how to falsify a hypothesis. This is a concept that has shown to be a difficult one for students and will be the focus of future discussions in coming semesters. Most students ranked in the developing to proficient level for this criterion.

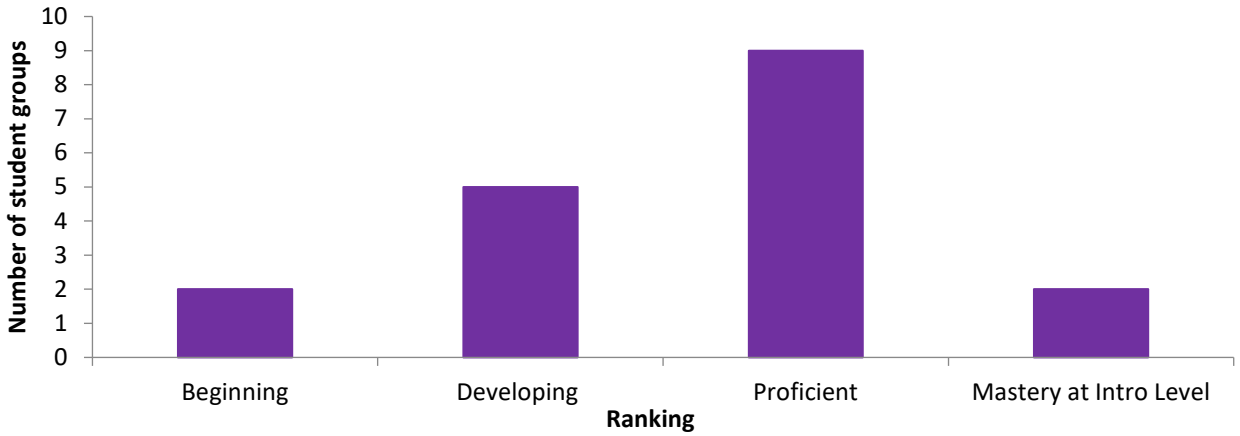


Figure 2. Developing and researching a QUESTION

N= 18 students, from Section 1. This section, Criteria #1 Question, was used as a representative sample of all the sections of this course. The average results from this graph were used as numeric results for LO#1 in Campus Labs.

Criteria #2 Background information (Figure 3). This criterion involved the student's ability to 1) conduct background research, and 2) summarize procedure. Overall students showed proficiency in their ability to conduct literature searches (albeit popular science articles compared to scientific literature) and summarize the procedure. Students seem to struggle with using proper in text citations and appropriate reference formatting. Students also seem to have some difficulties with scientific writing and formality in speech.

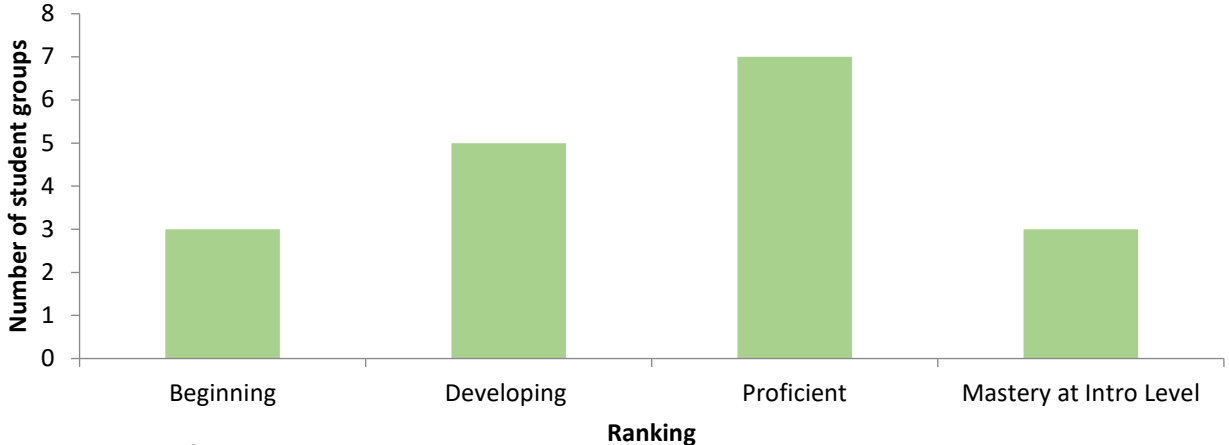


Figure 3. Relevant BACKGROUND INFORMATION

Criteria #3 Results (Figure 4). This criterion involved the student's ability to 1) summarize results, and 2) create graphs. This particular task was one that was scaffolded into different assignments throughout the semesters a result of deficiency in previous semester student performance on graphing and summarizing results. Students were given a template to illustrate their results. Students were proficient at displaying and summarize results in a graphical form.

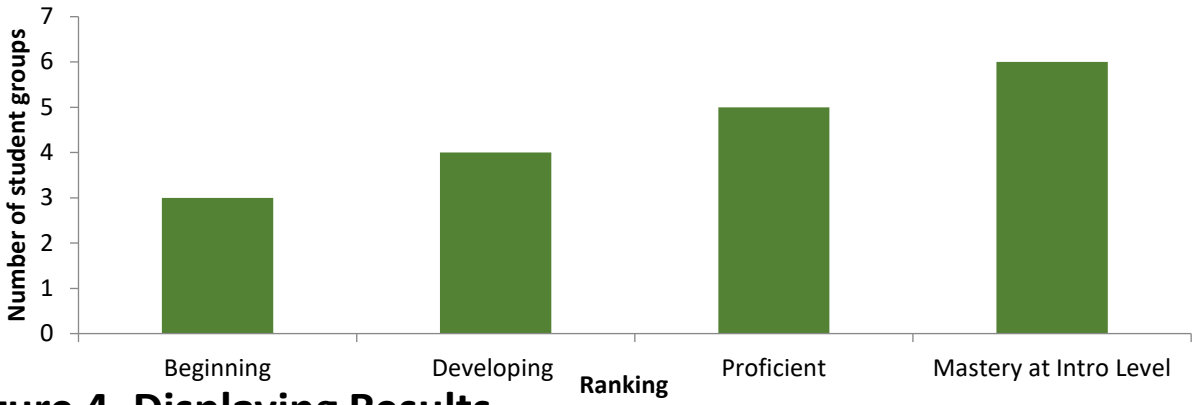


Figure 4. Displaying Results

N= 18 students, from Section 1. These two sections - Criteria #2 Background information and Criteria #3 Results – were used as a representative sample of all the sections of this course. The average results from these two graphs were used as the numeric results for LO#2 in Campus Labs.

Criteria 4: Conclusions (Figure 5). This criterion involved the student's ability to: 1) evaluate hypothesis, and 2) draw conclusions. Students were proficient at evaluating whether their data supported their hypothesis. However, they struggled inferring the possible biological mechanism behind their results and using scientific literature to support their findings.

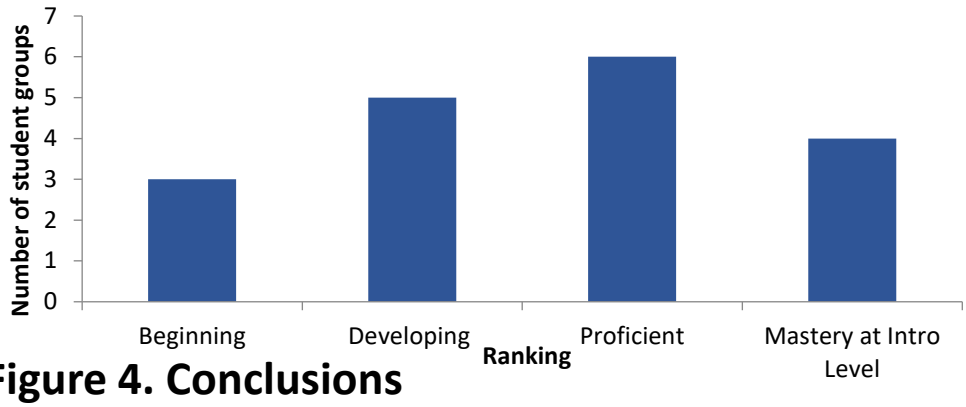


Figure 4. Conclusions

Criteria 5: Relevance (Figure 6). This criterion involved the student's ability to 1) develop future questions, 2) discuss relevance and 3) control of syntax and mechanisms. Students were proficient at discussing possible sources of errors. Few groups mentioned the need for replication and increased sample size. These are two topics will be reinforced in future courses. Students also tended to use informal language in their writing. As a result, a focus on scientific writing procedures will be discussed in future courses. Students struggled with connecting their findings to a broader picture and application of biological concepts to society. In future iterations, I will continue to focus on the importance of applying experimental designs and research questions to real world scenarios.

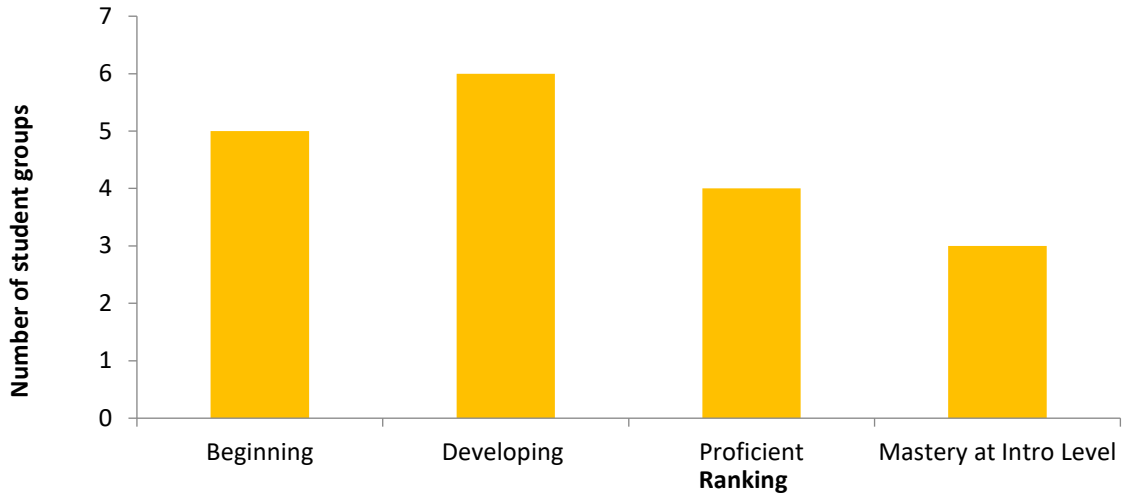


Figure 5. Relevance of findings and application

N= 18 students, from Section 1. These sections - Criteria 4: Conclusions and Criteria 5: Relevance (Figure 6) – **were used as a representative sample of all the sections of this course. The average results from these two graphs were used as the numeric results for LO#3 in Campus Labs.**

2.C. Use of Results – Based on your results/findings, in a bulleted list, record what could be done to improve or maintain student achievement or your assessment process in the future

Improvements

Through the process of assessing this activity in my BIOL 100 course I have made some improvements. These improvements include adding a C-E-R component to the course. Where students draw a conclusion based on the evidence that they gather. They discuss their evidence and how it supports their conclusion and then outline their reasoning for drawing their conclusions. This reasoning must be founded in scientific concepts and backup by cited scientific research. I feel the implementation of this process has greatly improved students' ability to determine if their hypothesis was supported or should be rejected. Students have also made improvements in their ability to tie, to some extent, evidence from their class experiments to that of scientific concepts.

Future course of Action

In the future, I will focus on improving the following areas:

In improving this activity there are several areas where I would like to focus to move more students to a mastery level: These include the following:

- Developing scientific writing skills
- Improve abilities to evaluate and scan through scientific literature (or at least evaluate popular science information). I hope to improve this activity by further expanding more directed instruction on reading and finding scientific literature to support a hypothesis and experimental data.
- I would also like to have students submit drafts for peer/instructor review to focus not only on the scientific procedures but to provide feedback on scientific writing. Furthermore, more time will be spent on developing and evaluating student generated hypotheses. In addition, for students that are education major (about 80%) this assignment will be expanded by having those students rework this assignments to be utilized in their field of education (i.e. writing a lesson plan for different grade levels or incorporating an interdisciplinary aspect for those secondary education non-science majors).

Further, the peer evaluation will be expanded, where, as a class, we will evaluate other scientific work prior to conducting peer evaluations of this assignment.