Say No To Drugs, Unless They Save Your Life

Introduction: This lesson plan is meant for AP Environmental Science classes, but could also be used for Earth/Environmental Science or Biology in parts (or as a whole). It stems from my work with Metrics, Inc. (a pharmaceutical company) and incorporates skills used in the pharmaceutical industry with those of Earth/Environmental sciences.

Medicines are an important part of every day life and are responsible for keeping the human population alive and well. This plan serves to stimulate problem solving skills as students encounter a scenario that involves the appearance of a new disease and the creation of the drugs used to fight it. Students need to learn that drugs aren't just magically created in times of need, but are subject to rigorous testing and trials. The materials needed to make medicines must be found and gathered and the wastes produced by the processes must be handled and/or controlled after the development of said medicines.

Students will learn about the chemistry of creating medicines, how the land is altered in gathering resources and storing wastes, how humans are affected by diseases, and how land and water quality are affected when handling the wastes created as medicines are developed, tested, and used.

Students will be assessed by their creation and analysis of graphical data, participation in blogs, ability to work together to present information, and the creation of a graphic organizer detailing the interaction of the disease and medicine as well as the effects on the environment. Students will also be given a quiz at the end of the lesson to assess understanding of the concepts presented.

Learning Outcomes

1. Students should simulate the effects of a new disease on the global population to understand how diseases spread, how they affect the population, and how treatments/cures are developed.
2. Students should research in order to learn that most medicines are not purely made of the active ingredient, but other substances that aid in their delivery.
3. Students should model the creation of a new medicine and discover that it involves many tests, trials before success. Proper scientific method is imperative for success.
4. Students should classify and categorize the materials used to make medicines and identify how are derived from resources found within the Earth.
5. Students should perform cost-benefit analyses to compare/contrast the costs (financial, environmental, and health-related) and the benefits gained from medicines.
6. Students should practice taking precise measurements that are essential for the reliability of scientific investigations.
7. Students should hypothesize what human activities (creation/disposal of medicines, concentrated population growth) affect the environment.

Curriculum Alignment

*Together the objectives for E/E Science and Biology collectively comprise objectives within the AP Environmental Science curriculum.

Earth/Environmental Science

1. EEn.2.2: Understand how human influences impact the lithosphere.
    -EEn.2.2.1: Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present.
2. EEn.2.4: Evaluate how humans use water.
    -EEn.2.4.2: Evaluate human influences on water quality in North Carolina's river basins wetlands and tidal environments.
3. EEn.2.5: Understand the structure of and processes within our atmosphere.
    -EEn.2.5.5: Explain how human activities affect air quality.

Biology

1. Bio.2.1: Analyze the interdependence of living organisms within their environments.
    -Bio.2.1.1: Analyze the flow of energy and cycling of matter through ecosystems relating to the significance of each to maintaining the health and sustainability of the ecosystem.
2. Bio.2.2: Understand the impact of human activities on the environment (one generation affects the next).
    -Bio.2.2.1: Infer how human activities (including population growth, pollution, global warming, burning of fossil fuels, habitat destruction and introduction of nonnative species) may impact the environment.

AP Environmental Science

APES doesn't have learning objectives, but here are the themes and areas covered by this unit.

1. Science is a process.
2. Humans alter natural systems.
    *Global water resources and use. (Domestic use)
    *Soil and soil dynamics (Mining)
3. Environmental problems have a cultural and social context.
    *Human population (Impacts of Population Growth)
    *Pollution (Land and water pollution)
    *Loss of biodiversity
4. Students should be challenged to:
    *critically observe environmental systems
    * analyze and interpret data, including appropriate statistical and graphical presentations
    * think analytically and apply concepts to the solution of environmental problems
    * make conclusions and evaluate their quality and validity
    * communicate accurately and meaningfully about observations and conclusions

Classroom Time Required
*720 minutes/8 90-minute block periods (in full): If all activities are completed.

Activity #1: Careers in Pharmaceuticals 2 90-minute class periods.

Activity #2: Plague (game, data collection, and discussion) 1 90 minute class period.

Activity #3a: Drug Development (active ingredient v. excipients) 45 minutes

Activity #3b: Measurements and Medicines (lab) 45 minutes

Activity #4: Dissolution/Disintegration (lab) 60-90 minutes

Activity #5a: Source of Drug (environmental impacts of mining or gathering active ingredients and excipients from living things/research before hand/ write blogs in class) 60 minutes

Activity #5b: Evaluating Drug Effectiveness (LD50 graphs) 30 minutes—2 scenarios

---

Activity #6: Newscast (CNN for Meds)—done outside of class; present inside of class. Presented during a class day (90 minutes) If you have time, you could use a day of class for students to work on this. However, it can be worked on throughout the unit to pick up needed footage. This activity should be the culminating project that demonstrates knowledge from all other activities in the unit.

Previous Knowledge
Previous knowledge is not necessary to complete any of the following activities. This unit is all-inclusive and after reading through the instructions and activities, you should have all of the information that you need for answering students questions.

Materials Needed
*This is under the assumption that writing utensils and paper are always needed materials.

During various Activities in this group, students should be able to use smartphones in order to participate in parts of discussions via different apps.

Activity #1:
a. Library
b. Internet/computers, PREZI.com
c. Digital video camera/smartphone
d. Instruction sheet/Rubric

Activity #2:
a. iTouch, iPhone (one or a classroom set, depending on availability) [Note: If 1, then project the screen for the entire class to observe/participate.]
b. Projector/Screen
c. Game: Plague Inc. (99c in App Store for Apple, also available for NonApple platforms)
d. Data Sheet

Activity #3a:
a. Data Sheet
b. Drug Cards

Activity #3b:
a. Data Sheet
b. Powdered chemicals (could be sugar, salt, flour, baking soda, etc…something that mimics a powdered form of a medicine or the API [active pharmacological ingredient])
c. Balances (digital or triple-beam)

Activity #4:
a. Stop watches or Apps. For Stopwatches on smartphones/ipods
b. Three different Aspirin tablets (Walgreens v. Dollar General v. Bayer)
c. Data Sheet/Notebook

Activity #5a:
a. Computer Lab/Computers
b. Notebooks

Activity #5b:
a. Data Sheet
b. Colored Pencils

Activity #6:
a. Video cameras (FlipCam, iPhone cam, etc…)
b. Computers (Windows Movie Maker)

Activities

Activity #1:
Students will have a day of research in the library and a day to present PREZIs concerning "Careers Related to the Pharmaceutical Industry."

This assignment will be an introduction into the unit on pharmaceuticals and also allow students to learn about OTHER careers besides their typical idea of a pharmacist. As students learn just how important (and how dependent) the pharmaceutical industry is to other careers, it will give them a better understanding of the industry as a whole.

Working on a PREZI will also give students the chance to use technology and new applications besides PowerPoint.

Needed for this activity are: library time (approximately one day (90 minutes)), access to computers, and a digital video camera (or smartphone, etc…).

Rubric is included on the back of the instruction handout.

Activity #2:
Teacher will set up Poll Everywhere question for students before they enter the room and project it for them to answer upon arrival. (www.polleverywhere.com)

>Q: What would you do if a pandemic was rapidly spreading across the world?
A1: Gather my family and go somewhere else.
A2: Board up my house and quarantine my family.
A3: Live my life as if nothing was happening.

Students will enter room and be prompted to answer the projected question using their smartphones. If students have no smartphones, allow them to use classroom computer to respond.

Within 5 minutes of the beginning of class, close the polls and analyze the students' answers.

>Compare results in each answer choice.

Introduce **Plague, Inc**. to students. Walk through an example of the program showing them how to use the program and what adaptations they can choose for their disease, with DNA points, etc…

Distribute Data Sheets for use during the game. Students will be responsible for collecting data during the game play. (Note: The game can be paused for collection of data.)

If your school has access to iTouches/iPads, load program on the iTouches/iPads beforehand. Distribute iTouches/iPads in pairs or allow students to work in pairs on smartphones (if they choose to pay 99 cents for the program). If the amount of phones/iPads/iTouches is limited, this activity can be completed using just one iPhone/iTouch/iPad and projected on the screen for the classmates to work together in the decision-making process.

Have students activate Plague, Inc. and go through a simulation using the NORMAL mode and BACTERIA. This should take approximately 15 minutes. As they "play" the game, have them fill out Data Sheets.

Walk around the room as the students play, and formatively assess students at task.

-What decisions are they making?

-What adaptations do they provide to their diseases?

When students finish their respective games, find out whose diseases wiped out the entire planet's populations and whose diseases failed.

-Ask students whose diseases destroyed the population to explain to classmates what adaptations they gave their bacteria to make them so unstoppable.

-For those students whose diseases did not destroy the whole population, inquire what actions from humans stopped their diseases.

-These pieces of information should be written on the Data Sheets.

Next, ask the students what considerations our world takes when pandemics or even epidemics are present that prevent them from spreading.

-Guide the students toward the topic of medicines and their importance in stopping disease causing bacteria.

-Have students develop a KWL chart (on the board, or some large paper) that shows what they know, want to learn, and leave a space for what they will have learned about the importance of medicines later).

<u>Activity #3a:</u>

Before students complete this assignment (like for homework the previous night), students should research the terms listed below. Hopefully, they will pick up an understanding for the terms before the exercises. I would give them the data sheet associated with this assignment so that they could use it for their research.

Students will be provided with various medicine statistics featuring active ingredients and inactive ingredients.

-Show 6 commonly used medicines' ingredients available for students to compare. (Cards attached)

>Look for similarities between medicines…Discuss the following questions: What ingredients do you see many times? What things do you see that seem unique?

-Discuss why ingredients in addition to the active ingredient might be necessary to be included to make a medicine.

>terms of importance: active ingredient, excipients, desiccants, diluents, disintegrants, glidants, lubricants, binders, flavorings, surfactants

*active ingredient: aka active pharmacological ingredient (API): the drug

*excipients: extras added to stabilize drug in a form that can be taken

*dessicants: used to dry out materials in the tablet/capsule

*diluents: aid in making the tablet/capsule a certain weight or making the materials flow smoothly/easily
*disintegrants: chemicals added to help the tablet/capsule break down in the body (instantly or in time-release fashion)
*glidants: aid in flow of drug material
*lubricants: prevent drug from sticking to machinery
*binders: help drug materials stick together
*flavorings: help the drug taste tolerable for oral dosing
*surfactants: such as emulsifiers, help to ensure the mixture is thoroughly mixed

-How do these excipients influence the weight of a drug?
-Do all drugs need every one of these excipients?
-When you buy 500 mg of Tylenol, what does that mean?
-What happens if some of the excipients aren't present?
-Are there any dangers associated with the excipients?

Activity #3b:
This lab is designed to teach students the importance of taking accurate measurements.

For this lab, I recommend having 4 different powders that will be used to simulate making medicines.

I plan to use sugar, flour, kool-aid, and pepper. Label the four powders A, B, C, and D.

Students will follow instructions on the 3A Data Sheet to complete the lab.

Digital balances will be necessary.

Questions following lab should be discussed as a class.

Activity #4:
This lab is designed to allow students to perform just one of the many tests completed by pharmaceutical companies.

A heat bath should be set up to approximately 100 degrees F.

Because real medicines are used, it is very important to be careful and ensure that medicines are not stolen or taken. I would recommend already having the needed amount of tablets counted out and packaged beforehand.

As students complete the lab, walk through to stimulate questions/discussions as they wait for the dissolution to happen. However, be mindful of distracting students from noticing when the tablets have broken apart.

At the culmination of the lab, have students discuss the questions with their table groups and another group. Then, discuss results as an entire class.

Activity #5a:

The creation and implementation of pharmaceuticals is no easy business. Aside from the seemingly endless tests that must be conducted once a drug has been created and stabilized, the "before and after" needs of the drug must also be kept in mind.

The raw materials needed to create a drug must be mined from ore within the earth and/or collected from other living organisms. The wastes produced in the manufacturing process and after the use of the drugs must be managed and minimized if at all possible.

Students will research these "before and after" needs to develop a better understanding of where materials used in drugs are gathered and to acknowledge what happens to the wastes produced by the creation, use, and disposal of leftover drugs.

Questions to Use During Research:

1. What materials are needed to make active ingredient and excipients?
--here, they should learn about ores mined to make drugs/exc., trees/plants whose oils are extracted to make drugs, animals used to obtain drugs
2. How are those materials obtained from the environment?
--see above
3. What effect does obtaining those materials have on the environment?
--destruction of habitats, reduced biodiversity, destruction of rock layers, weathering/erosion
4. What happens to the different wastes produced by the manufacture of drugs?
--many end up in landfills, hazardous waste facilities
5. How do drugs taken by a person return to the environment and how does this recycling of the drugs affect the environment?
--usually end up in waterways after human discharge via urination, over time this makes its way back into drinking water
6. What happens to unused drugs?
--see above

Have students use the information gathered from their research to answer the Blog Post: "How does the pharmaceutical industry affect the environment? Do the risks outweigh the benefits to mankind?" Students will prepare a blog post to answer those questions as well as respond to at least two other students' blog posts.

To prepare a blog, use WordPress.com or Blogspot.com or Blogger.com (they are free!) and have students develop free accounts if they do not already have them in place. You will need to have a blogspace of your own set up on your preferred program so that they can respond on your blog. Instructions for setting up your own blog are available when you sign up! However, if your school system already has blogs set up for students, just use what you have.

Activity #5b:

Once a working formula has been designed for a drug, tests must be conducted to see if the drug is potentially hazardous and/or lethal to those who must take it. Tests called LD50 tests (Lethal Dose 50%) are done on a variety of organisms to ensure the safety and effectiveness of the drug.

Many people are opposed to animal testing, and rightfully so, because who would want to hurt another precious creature? However, animal testing is necessary in the pharmaceutical industry because if a drug does have potential side effects or death, it is thought that other animals' lives are more disposable than human life. (Sorry PETA!)

In conducting these experiments, animals (usually smaller animals at first) are given certain doses of the experimental drug to observe the effects that the drug will have on those animals, and presumably us in the long run. Mice are typically the first to be tested, and if certain thresholds are met, then tests resume on larger mammals (such as dogs and monkeys) in hopes of similar results.

You may want to ask the students what they think about animal testing, but that could be opening a whole can of worms that you may not have the time to discuss. However, other leading questions that could help them to understand the process are:

1) Why do you think other animals are used for testing before humans?
--They are easier to maintain and control. They are cheaper than human testing. There are less restrictions on testing other animals than humans. Their lives are "less valuable" than human lives.

2) Why do you think mammals are typically used when testing the effectiveness of drugs?
--Mammals are most similar to humans, because we, too, are mammals. They have more similar body functions and their circulatory systems (pathway of drug delivery) are more similar to those of humans.

3) Why do you think the progression of mice, to dogs, to monkeys is done when testing?
--Smaller animals will show effects more drastically due to the ratio of body size to dose. They are also cheaper to obtain. As we get to monkeys, we are also more genetically similar to the animals.

After discussion, hand out Data Sheet 5 and allow students to work in groups (3 or 4) to solve the problems presented. After students have completed the data sheet, discuss their answers with them and analyze graphs to ensure student understanding of the issue.

Activity #6:
This activity is meant as an assessment tool to measure what the students have learned throughout the unit on Pharmaceuticals.

Students should work in groups of 3-4 (I use my table groups/pods) to create a "60 Minutes" style broadcast to present to the class. The broadcast should feature an anchor, reporters on the scene, and still images or video footage from each of the covered activities of the unit.

Ideally, the final product should be about 5 minutes long, and will be assessed using the attached rubric.

Depending on your time constraints, students could work together during class time to record, edit, and produce the documentary. I would alert them to this assignment at the beginning of the unit, so that they can obtain pictures and some video footage as they go through the unit. If class time is not available for putting it together, alerting them in advance would also give them plenty of time to get things put together outside of class.

Students, depending on their experience with video-editing software, will most likely use either Windows Movie Maker or iMovie to complete this task, although I wouldn't require either. I try to leave most aspects of the production up to the students to allow their creativity to flourish.

Assessments

√Activity 1 Assessments
PREZI presentation w/rubric

√Activity 2 Assessments
Data Sheet 2
KWL chart (answers can vary)

√Activity 3a Assessments
Identification of excipients from cards

√Activity 3b Assessments
Data Sheet 3b
Class discussion

Activity 4 Assessments
Data sheet 4
Class discussion

Activity 5a Assessments
Blog Post

Activity 5b Assessments
Data sheet 5b

Activity 6 Assessments
Video documentary/presentation
Rubric should be used to assess video documentary of pharmaceuticals.

Author Info
Ryan C. Gardner
South Lenoir High School
Deep Run, NC
AP Environmental Science and Earth/Environmental Science
11 Years Teaching Experience
NBPTS

Activity #1: Careers and Medicine

We often take for granted who is needed in the processes of pharmaceutical research, development, use, and disposal. The objective of this task is to learn about professions that are necessary in the implementation of pharmaceuticals in society.

Your task is **(in groups of 2-3)** to **RESEARCH careers related to the pharmaceutical industry** and **DESIGN** a **PREZI** to **PRESENT** to the class.

Questions to keep in mind as you research are:

1) How does this career choice affect the pharmaceutical industry? In other words, why are these people necessary in the pharmaceutical industry?
2) What do people who work in these fields do (relative to pharmaceuticals)?
3) What education is needed for these careers? What schools are good choices for majors needed in the field?
4) What environmental, economic, or societal concerns are addressed by these careers in relation to the pharmaceutical industry?
5) What technologies are used by people in this field?
6) What salary range is typically available for people in this field?
7) What other occupations work closely with this career to ensure their job is done correctly?
8) What do other people think/know about this career and its relation to the pharmaceutical industry? (Video segment!)

Also, I encourage you to feature any other significant, on-topic information that would help the other students understand the career choice's relationship to pharmaceuticals.

Pictures and other graphics would be beneficial to your presentation grade.

For Question #8, students will be responsible for interviewing at least 3 other people (students, teachers, etc…) I have a flip cam that can be used for this part of the activity.

Also, citations must be included (for information and pictures).

Please do your best to make sure that the PREZI is in your own words—you will need to summarize much of the information that you find. Don't overload PREZI slides with an abundance of information that you just plan to read through. Be familiar with your chosen topic and be prepared for questions to be asked from the class. The ability to answer questions about your career will be a part of your grade.

Have fun, make it interesting, and learn a bunch!

Your rubric is found on the backside of this document.

Rubric for Careers in Pharmaceuticals Project

	0	1	2	3
Career Connection	No career featured.	Career featured but not related to pharmaceuticals.	Career featured and loosely related to pharmaceuticals	Career featured and thoroughly related to pharmaceuticals.
Career Activities in Pharmaceuticals	Career activities in re. of pharm. Not explained	Career activities in re. of pharm. Explained minimally	Career activities in re. of pharm. Explained sufficiently	Career activities in re. of pharm. Explained thoroughly
Education Requirements	Education not addressed.	Education needs addressed, but without potential schools	Education needs and potential schools addressed minimally	Education needs and potential schools addressed.
Environmental, Economical, Societal Connections	No connections made between concerns and career.	1 of 3 areas connected to pharm. Industry/career	Two of 3 areas connected to pharm. Industry/career	All three areas connected to pharmaceutical industry/career.
Technology	Technology not addressed in relation to career	Technology vaguely addressed	Technology used is minimally explained.	Technology explained in relation to career
Salary discussed	No mention of salary.	Salary discussed.		Salary thoroughly explained and described.
Other Occupations Connection	No other occupations mentioned.	Other occupations mentioned, not explained.		Occupations explained and described in relation to chosen career and pharm. industry
Video Interviews	No interview included.	Interview is present, but barely to the point.	Interview is sufficient with 1-2 subjects interviewed.	3+ people interviewed about career/pharm. industry.
Presentation	No presentation given.	Presentation has problems with accuracy, but complete.	Presentation accurate and complete.	Presentation accurate, complete, and professionally done.
Citations	No citations given.			Citations complete.

Activity #2: Plague, Inc. Data Sheet

1. Write the name of your disease: _____.

2. Where did you choose to start your disease? _____
   *Why did you choose this location for the emergence of your disease? In other words, what abiotic or biotic factors might make the disease more likely to spread from this place?

3. How long did it take for your plague to affect 100 people? 1,000 people? 10,000 people? 100,000 people? 1,000,000 people? What do you notice about the time it takes to spread between these intervals? Why do you think this occurs?

4. How long did it take for your disease to spread to another country? Why did it take so long?

5. What is the first mutation you used to alter your disease's method of transmission and why did you choose that one?

6. What is the first mutation you used to alter the symptoms of your disease? How does it affect the transmission of the disease?

7. What is the first mutation you used to alter the abilities of your disease? How does it make the disease more likely to survive?

8. Did any symptoms spontaneously mutate? What were they? How do you think that occurred?

9. When did the first death occur due to your disease? Why did death take so long?

10. Did any social problems emerge due to the outbreak of the disease?

11. When was work on the cure started?

12. Did your disease destroy the human race? If not, how long did it last before a cure was created and your disease was eradicated? Why do you think it took so long?

    *Did you employ any mutations in order to slow down the production of the cure?

    *How did that mutation affect cure development?

13. What strategy did you use to attack the human race?
    a. Focus on simple, mundane symptoms over time
    b. Focus on complex, deadly symptoms quickly

    *How did your strategy work? Which seems like the better idea and why?

14. What strategies were employed by the world to try and stop your disease? Why was each strategy you list used?

Activity #3a2: Excipients Data Sheet

*What is the difference between the API (active pharmacological ingredient) and excipients?

Common Excipients:

Excipients:	**Function:**	**Examples:**
Dessicants		
Diluents:		
Disintegrants:		
Glidants:		
Lubricants:		
Binders:		
Flavorings:		
Colorings/Dyes:		
Surfactants:		

What do these medicines need?

a) When making capsules, researchers discovered that the mixture is sticking to the metal framework of the capsule maker
b) People testing the drug cannot tolerate the bitterness of the drug
c) Tablets made for a drug company do not stay together once they have been made
d) Machinery is constantly stopped at the plant because the powder is sticking together in clumps
e) One trial of the tablets has been tested, and the tablets do not dissolve as fast as they should

Use the data below to calculate percentages of each part of a tablet. Then, draw a pie graph depicting the proportion of each part of the tablet.

Listed below are some (but not all) of the ingredients found in Tylenol-Extra Strength.
©Tylenol (www.tylenol.com)

Acetaminophen (API): 500 mg
Magnesium stearate (Lubricant): 200 mg
Polysorbate 80 Powdered cellulose (Surfactant): 700 mg
Titanium dioxide (Coating): 100 mg
Editate calcium sodium (Preservative): 300 mg
Blue no. 1 (Coloring): 100 mg
Corn starch (Disintegrant/Binder): 500 mg
Polyethylene glycol (Time Release): 100 mg

A common misconception about medicines is that you are buying just that—the active ingredient.

How did this activity change your understanding of what you are buying when you fill a prescription or buy over the counter medications?

Cards for Use with Activity #3a1

Advil 200 mg Ibuprofen Acetylated monoglycerides, colloidal silicon dioxide, cornstarch, croscarmellose sodium, methylparaben, microcrystalline cellulose, pharmaceutical glaze, pharmaceutical ink, povidone, pregelatinized starch, propylparaben, sodium benzoate, sodium lauryl sulfate, stearic acid, sucrose, synthetic iron oxide, titanium dioxide and white wax	**Benadryl** 25 mg Diphenhydromine hydrochloride candelilla wax, colloidal silicone dioxide, crospovidone, hypromellose, microcrystalline cellulose, polyethylene glycol, providone, pregelatinized starch, starch, stearic acid, titanium dioxide, and talc
Motrin 400-800 mg Ibuprofen carnauba wax, colloidal silicon dioxide, croscarmellose sodium, hypromellose, lactose, magnesium stearate, microcrystalline cellulose, propylene glycol, titanium dioxide	**Pepto Bismol** 252 mg Bismuth subsalicylate calcium carbonate, flavor, magnesium stearate, mannitol, povidone, red 27 aluminum lake, saccharin sodium, talc
Pepcid AC 10 mg Famotidine hydroxypropyl cellulose, hypromellose, magnesium stearate, microcrystalline cellulose, red iron oxide, starch, talc, titanium dioxide	**Aleve** 200 mg Naproxen sodium FD&C blue #2 lake, hypromellose, magnesium stearate, microcrystalline cellulose, polyethylene glycol, povidone, talc, titanium dioxide

Activity #3b: Taking Accurate Measurements

Goals for the Lab:
1. Accurately measure the parts necessary to make a theoretical tablet.
2. Gather the materials needed to make 5 tablets.
3. Calculate the percent error between your 5 tablets.

Materials:
For this lab, you will need to use a digital balance and samples from 4 different powders.

Procedure:
1. Make 5 solutions of powders that fit the following requirements:
    *100 mg Powder A
    *200 mg Powder B
    *400 mg Powder C
    *100 mg Powder D

2. How much total mass should your tablets have? _____

3. Calculate the percent error for each of your tablets.
    (to do this, divide your measured mass by the goal mass and multiply by 100)

	Tablet 1	**Tablet 2**	**Tablet 3**	**Tablet 4**	**Tablet 5**
Measured mass					
Ideal mass					
Percent error					

*If your percent error is off by more than 2%, then you must prepare another powder.

Questions for Understanding:

A. Why might companies want the least percent error possible?

B. What precautions might be necessary to make if you were actually making powders that were going into medicines? Why?

C. How might this experiment have been changed to make it more accurate?

Activity #4: Dissolution Lab

Objectives:
1. Determine the amount of time it takes two different versions of the same medicine to dissolve under "body-like" conditions.
2. Analyze the dissolution of the two different brands of tablets.

Materials:
5 tablets of Bayer Brand Aspirin
5 tablets of Walgreens Brand Aspirin
5 tablets of Dollar General Brand Aspirin
Beakers
Hotplate/Bath (warmed to approximately 100 degrees)
Stopwatches
Water (I used tap water.)

Students should be in table groups or groups of around 4.

Procedure:
1. Place a tablet of each brand in separate beakers and pour approximately 100 mL into the jars before placing jars into the bath. Begin timing the pill as it sits in a solution of water. Have students watch jars for signs of disintegration.

2. Record time required for tablets to dissolve.

3. Repeat procedure 4 more times.

	Walgreens Aspirin	**Dollar General Aspirin**	**Bayer Aspirin**
1			
2			
3			
4			
5			
Average Time			

4. Calculate the average time it took Bayer tablets, Walgreens tablets, and Dollar General tablets to dissolve and record your data in the chart.

Questions:

A. Was there a noticeable difference between the times it took for each of Walgreen tablets to dissolve? If yes, why do you think there was?

B. Was there a noticeable difference between the times it took for each of Dollar General tablets to dissolve? If yes, why do you think there was?

C. Was there a noticeable difference between the times it took for each of Bayers tablets to dissolve? If yes, why do you think there was?

D. Was there a noticeable difference between the times it took for the Walgreens tablets, Dollar General tablets, and Bayer tablets to dissolve? If there was, why do you think there was?

E. Why do you think it is important for pharmaceutical companies to test for the time it takes for tablets to dissolve in the body?

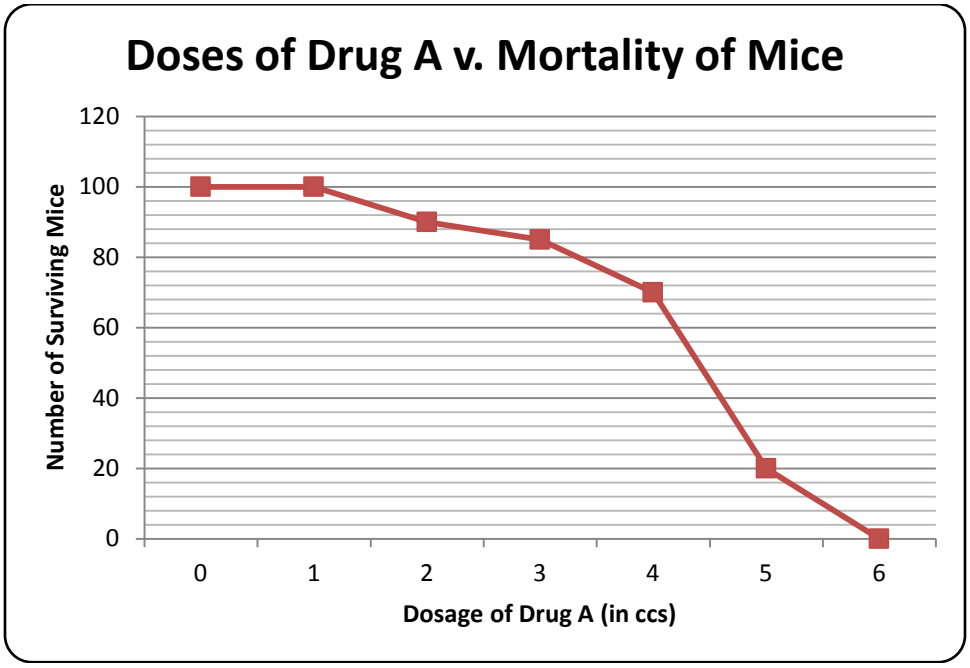
F. What could be done to make this experiment more accurate? How do you think it would be done differently if it was performed in a pharmaceutical laboratory?

G. How do you think the experimental results would change if 100 tablets were used, or 1,000? Explain your rationale.

Activity #5b: LD50 in Drug Trials

Background: LD50 is the common name for a host of tests comparing the dosage or amount of exposure of a certain chemical to the number of surviving organisms after contact.

Drug A:
Drug A, designed to treat hair loss, has been tested on 100 mice. The results of the test were as follows:



Questions:

1. What is the independent variable of this test? The dependent variable? How do you know?

2. What is the LD50 of this drug (in mice)? How do you know?

3. What is the LD90 of this drug (in mice)?

4. What is the difference in concentration between LD50 and LD90?

5. If chemists hypothesized that the drug was safe enough to test on humans at this point, would you agree? Why or why not?

Suppose Drug A was indeed passed and tested on a larger animal (dogs). Another test was run with 100 dogs and yielded the following data:

Concentration of Drug A (cc)	Number of Surviving Dogs
0	100
1	100
2	100
3	100
4	95
5	90
6	75
7	60
8	40
9	5
10	0

Draw a line graph showing the relationship between drug concentration and number of surviving dogs. Make sure to label your axes. Place an "X" on the line that shows the LD50 for the dogs.

1. What is the LD50 for the dogs?

2. Explain whether or not you would recommend going to human trials with this drug.

Activity #5a Instructions:

The creation and implementation of pharmaceuticals is no easy business. Aside from the seemingly endless tests that must be conducted once a drug has been created and stabilized, the "before and after" needs of the drug must also be kept in mind.

You will research the "before and after" needs to develop a better understanding of where materials used in drugs are gathered and to acknowledge what happens to the wastes produced by the creation, use, and disposal of leftover drugs.

Questions to Use During Research:

1. What materials are needed to make active ingredient and excipients?
2. How are those materials obtained from the environment?
3. What effect does obtaining those materials have on the environment?
4. What happens to the different wastes produced by the manufacture of drugs?
5. How do drugs taken by a person return to the environment and how does this recycling of the drugs affect the environment?
6. What happens to unused drugs?

Once you have the answers to these questions, develop a response to the following questions:

"How does the pharmaceutical industry affect the environment? Do the risks outweigh the benefits to mankind?"

You must answer this question in a BLOG post. Once you have made your post to my blog, you must then respond to the ideas of at least two other classmates.

Activity #6 Rubric

	3	2	1	0
Content:				
Careers in Pharm.	Thoroughly covered in broadcast.	Substantially covered in broadcast.	Minimally covered in broadcast.	Not covered in broadcast.
Epidemics/Disease	Thoroughly covered in broadcast.	Substantially covered in broadcast.	Minimally covered in broadcast.	Not covered in broadcast.
Research/Development	Thoroughly covered in broadcast.	Substantially covered in broadcast.	Minimally covered in broadcast.	Not covered in broadcast.
Testing	Thoroughly covered in broadcast.	Substantially covered in broadcast.	Minimally covered in broadcast.	Not covered in broadcast.
Environmental Impact	Thoroughly covered in broadcast.	Substantially covered in broadcast.	Minimally covered in broadcast.	Not covered in broadcast.
Delivery:				
Professionalism	Serious, professional broadcast	Casual, but mature broadcast	Immature, playful broadcast	Total lack of commitment to broadcast
Accuracy	All information accurate.	Most information accurate.	Some information accurate.	Little/no information accurate.
Presentation:				
Creativity	Broadcast very creative and interesting.	Broadcast creative and interesting.	Broadcast minimally creative and somewhat interesting.	Broadcast is neither creative, nor interesting.
Proofing/Evidence	Several examples of Still images/video footage used to support story.	Few examples of still images/video footage used to support story.	Minimal use of still images/video footage used to support story.	No still images/video footage used to support story.
Group dynamic:				
Teamwork	All participants had substantial influence and participation in production.	Most participants had substantial influence and participation in the production.	Little evidence of teamwork, although all members participated.	No teamwork evident.

Total Score: _____

Comments:

KEY

Activity #2: Plague, Inc. Data Sheet

1. Write the name of your disease: Gpox: 44.

2. Where did you choose to start your disease? Central Africa
   *Why did you choose this location for the emergence of your disease? In other words, what abiotic or biotic factors might make the disease more likely to spread from this place?
   Central Africa is an area with little development. I don't think people are wealthy, so they probably have little access to doctors + medicines. Also, the climate of central Africa is tropical which might allow the disease to spread faster.

3. How long did it take for your plague to affect 100 people? 1,000 people? 10,000 people? 100,000 people? 1,000,000 people? What do you notice about the time it takes to spread between these intervals? Why do you think this occurs?
   From start: 100 – 3 mos.
   1,000 – 5 mos.
   10,000 – 6 mos.
   100,000 – 7 mos.
   1 mil – 8 mos.
   Once the disease began to spread through small communities, it seemed to explode outward as people moved from place to place. It seemed to spread exponentially.

4. How long did it take for your disease to spread to another country? Why did it take so long?
   7 mos. It was no big deal – a very minor disease at first. I think it stayed "under the radar" for a while until it affected a very large number of people

5. What is the first mutation you used to alter your disease's method of transmission and why did you choose that one?
   Transmission by insects – Mosquitoes run rampant in this area – it's often associated with malaria, which is spread by mosquitoes so I thought they would help to spread the disease.

6. What is the first mutation you used to alter the symptoms of your disease? How does it affect the transmission of the disease?
   Coughing – I figured it would help spread the disease, a bacteria, by the air

7. What is the first mutation you used to alter the abilities of your disease? How does it make the disease more likely to survive?
   Heat Resistance – it's hot in central Africa, so I wanted the disease to survive extremely warm temps.

8. Did any symptoms spontaneously mutate? What were they? How do you think that occurred?
   Cysts – as the disease was spread to more and more people the DNA was more likely to be corrupted as it was copied more and more.
   Insomnia – people suffer so much they cannot sleep – weakens immunity

9. When did the first death occur due to your disease? Why did death take so long?
14 mos – at first, the disease was minor and not life threatening - the mutations made it more dangerous

10. Did any social problems emerge due to the outbreak of the disease?
Countries began central corpse disposals – people were getting infected from dead bodies
Countries shut down airports to try to stop the spread of disease.
Brazil's goverment falls India in anarchy US president taken ill.

11. When was work on the cure started?
11 mos. later – Jan 2014 – in Japan

12. Did your disease destroy the human race? If not, how long did it last before a cure was created and your disease was eradicated? Why do you think it took so long?
No – it took a little more than 2 years to develop a cure for my disease. It took that long just to be noticed and then it was funneled in to research and development.

*Did you employ any mutations in order to slow down the production of the cure?
Drug Resistance

*How did that mutation affect cure development?
It slowed down the cure development because of the new strain that no longer responded.

13. What strategy did you use to attack the human race?
(a.) Focus on simple, mundane symptoms over time
b. Focus on complex, deadly symptoms quickly

*How did your strategy work? Which seems like the better idea and why?
I feel like I had the right strategy because if it's too severe too quickly, then they will already start working on a cure. I got overzealous and added too many severe symptoms too quickly.

14. What strategies were employed by the world to try and stop your disease? Why was each strategy you list used?
Closing airports – stop spread from country to another country.
Distribution of free masks – stop spread of airborne microbes.
Central corpse disposal, Use of mass graves } reduce worry of people getting sick from dead bodies
Curfews – stop human contact and illicit activities that might spread disease

Cards for Use with Activity #3a1

Advil
200 mg Ibuprofen
Acetylated monoglycerides, colloidal silicon dioxide, cornstarch, croscarmellose sodium, methylparaben, microcrystalline cellulose, pharmaceutical glaze, pharmaceutical ink, povidone, pregelatinized starch, propylparaben, sodium benzoate, sodium lauryl sulfate, stearic acid, sucrose, synthetic iron oxide, titanium dioxide and white wax

Benadryl
25 mg Diphenhydromine hydrochloride
candelilla wax, colloidal silicone dioxide, crospovidone, hypromellose, microcrystalline cellulose, polyethylene glycol, providone, pregelatinized starch, starch, stearic acid, titanium dioxide, and talc

Motrin
400-800 mg Ibuprofen
carnauba wax, colloidal silicon dioxide, croscarmellose sodium, hypromellose, lactose, magnesium stearate, microcrystalline cellulose, propylene glycol, titanium dioxide

Pepto Bismol
252 mg Bismuth subsalicylate
calcium carbonate, flavor, magnesium stearate, mannitol, povidone, red 27 aluminum lake, saccharin sodium, talc

Pepcid AC
10 mg Famotidine
hydroxypropyl cellulose, hypromellose, magnesium stearate, microcrystalline cellulose, red iron oxide, starch, talc, titanium dioxide

Aleve
200 mg Naproxen sodium
FD&C blue #2 lake, hypromellose, magnesium stearate, microcrystalline cellulose, polyethylene glycol, povidone, talc, titanium dioxide

DIS = Disintegrant
DS = Dessicant
DL = Diluent
G = Glidant
L = lubricant
B = binder

F = flavoring
C = coloring/dye
S = surfactant

KEY

Activity #3a2: Excipients Data Sheet

*What is the difference between the API (active pharmacological ingredient) and excipients?

The API is there to actually fight the pain, bacteria/microbes, disease, etc... and the excipients are there to help the API last long enough in the body to do its job.

Common Excipients:

Excipients:	Function:	Examples:
Dessicants	to absorb water/keep meds dry	Tyvek, polyethylene, viscose, silica
Diluents:	filler for weight	mannitol, lactose, sorbitol
Disintegrants:	to help tablet break down inside the body	starch, microcrystalline cellulose, explotab, PGS
Glidants:	aid in flow of powders inside tablet	talc, starch, sodium chloride magnesium stearate
Lubricants:	prevents drugs from sticking to machinery	talc, magnesium stearate, calcium stearate
Binders:	helps powders that make tablet stick together	starch, ~~microcrystalline~~ ethylcellulose, PVP, ~~explotab~~ gelatin
Flavorings:	make meds taste good	oils – cinnamon, coriander, artificial flavorings
Colorings/Dyes:	to change the appearance of the product	FD+C dyes and Lake dyes
Surfactants:	aid in keeping powders thoroughly mixed (when making tablets)	sodium lauryl sulphate

What do these medicines need?

a) When making capsules, researchers discovered that the mixture is sticking to the metal framework of the capsule maker LUBRICANTS

b) People testing the drug cannot tolerate the bitterness of the drug FLAVORINGS

c) Tablets made for a drug company do not stay together once they have been made BINDERS

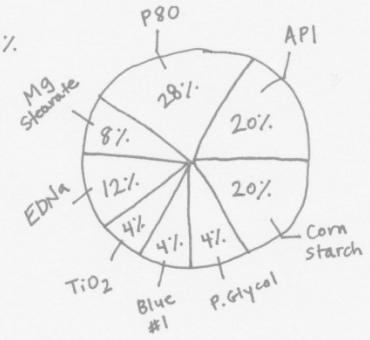
d) Machinery is constantly stopped at the plant because the powder is sticking together in clumps GLIDANTS

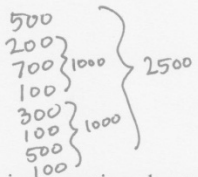
e) One trial of the tablets has been tested, and the tablets do not dissolve as fast as they should DISINTEGRANTS

Use the data below to calculate percentages of each part of a tablet. Then, draw a pie graph depicting the proportion of each part of the tablet.

Listed below are some (but not all) of the ingredients found in Tylenol-Extra Strength.
©Tylenol (www.tylenol.com)

Acetaminophen (API): 500 mg 20%.
Magnesium stearate (Lubricant): 200 mg 8%.
Polysorbate 80 Powdered cellulose (Surfactant): 700 mg 28%.
Titanium dioxide (Coating): 100 mg 4%.
Editate calcium sodium (Preservative): 300 mg 12%.
Blue no. 1 (Coloring): 100 mg 4%.
Corn starch (Disintegrant/Binder): 500 mg 20%.
Polyethylene glycol (Time Release): 100 mg 4%.





A common misconception about medicines is that you are buying just that—the active ingredient.

How did this activity change your understanding of what you are buying when you fill a prescription or buy over the counter medications?

Very little of the tablet you ingest is actually the medicine you have bought!

KEY

Activity #3b: Taking Accurate Measurements

Goals for the Lab:
1. Accurately measure the parts necessary to make a theoretical tablet.
2. Gather the materials needed to make 5 tablets.
3. Calculate the percent error between your 5 tablets.

Materials:
For this lab, you will need to use a digital balance and samples from 4 different powders.

Procedure:
1. Make 5 solutions of powders that fit the following requirements:
    *100 mg Powder A
    *200 mg Powder B
    *400 mg Powder C
    *100 mg Powder D

2. How much total mass should your tablets have? 800 mg

3. Calculate the percent error for each of your tablets.
    (to do this, divide your measured mass by the goal mass and multiply by 100)

	Tablet 1	Tablet 2	Tablet 3	Tablet 4	Tablet 5
Measured mass	799 mg	798 mg	795 mg	801 mg	800 mg
Ideal mass	800 mg	800 mg	800 mg	800 mg	800 mg
Percent error	-0.125%	-0.25%	-0.625%	+0.125%	0%

*If your percent error is off by more than 2%, then you must prepare another powder.

Questions for Understanding:

A. Why might companies want the least percent error possible?
If the API is too far off (even in mg) it could cause health problems or poisoning.
If the exc. are off the tablet could break down, or fail to disintegrate

B. What precautions might be necessary to make if you were actually making powders that were going into medicines? Why?
Gloves - avoid contamination and to prevent yourself from potentially absorbing chemicals
Hairnets - preventing contaminants from getting into the mix

C. How might this experiment have been changed to make it more accurate?
- We could have a more accurate balance.
- We need to have tools that ensure all of the powder makes it into the tablets.
- other Answers depending on your set-up.

KEY

Activity #4: Dissolution Lab

Objectives:
1. Determine the amount of time it takes two different versions of the same medicine to dissolve under "body-like" conditions.
2. Analyze the dissolution of the two different brands of tablets.

Materials:
5 tablets of Bayer Brand Aspirin
5 tablets of Walgreens Brand Aspirin
5 tablets of Dollar General Brand Aspirin
Beakers
Hotplate/Bath (warmed to approximately 100 degrees)
Stopwatches
Water (I used tap water.)

Students should be in table groups or groups of around 4.

Procedure:
1. Place a tablet of each brand in separate beakers and pour approximately 100 mL into the jars before placing jars into the bath. Begin timing the pill as it sits in a solution of water. Have students watch jars for signs of disintegration.

2. Record time required for tablets to dissolve.

3. Repeat procedure 4 more times.

	Walgreens Aspirin	Dollar General Aspirin	Bayer Aspirin
1	20 s	21 s	19 s
2	18 s	20 s	16 s
3	15 s	20 s	15 s
4	21 s	15 s	20 s
5	16 s	18 s	21 s
Average Time	18 s	18.8 s	18.2 s

SAMPLE DATA

✓ 4. Calculate the average time it took Bayer tablets, Walgreens tablets, and Dollar General tablets to dissolve and record your data in the chart.

Questions:

A. Was there a noticeable difference between the times it took for each of Walgreen tablets to dissolve? If yes, why do you think there was?

Tablet 3 took less time than the others – it may have already been cracked/damaged in bottle

B. Was there a noticeable difference between the times it took for each of Dollar General tablets to dissolve? If yes, why do you think there was?

Tablet 4 took less time than the others – once again, it may have been minorly damaged in bottle.

C. Was there a noticeable difference between the times it took for each of Bayers tablets to dissolve? If yes, why do you think there was?

There was a variety of times, with Tabs 2,3 taking less time to dissolve. Maybe

D. Was there a noticeable difference between the times it took for the Walgreens tablets, Dollar General tablets, and Bayer tablets to dissolve? If there was, why do you think there was?

No – the average times for dissolution/disintegration was fairly comparable.

E. Why do you think it is important for pharmaceutical companies to test for the time it takes for tablets to dissolve in the body?

They can see if effects will be instantaneous or take time and advertise as such. Also, they can test other caplets that have been coated for time release properties to see if they will stand the test of time.

F. What could be done to make this experiment more accurate? How do you think it would be done differently if it was performed in a pharmaceutical laboratory?

- More accurate machinery/equipment
- Using liquids that were close to body pH
- Simulating motion that would exist in stomach

G. How do you think the experimental results would change if 100 tablets were used, or 1,000? Explain your rationale.

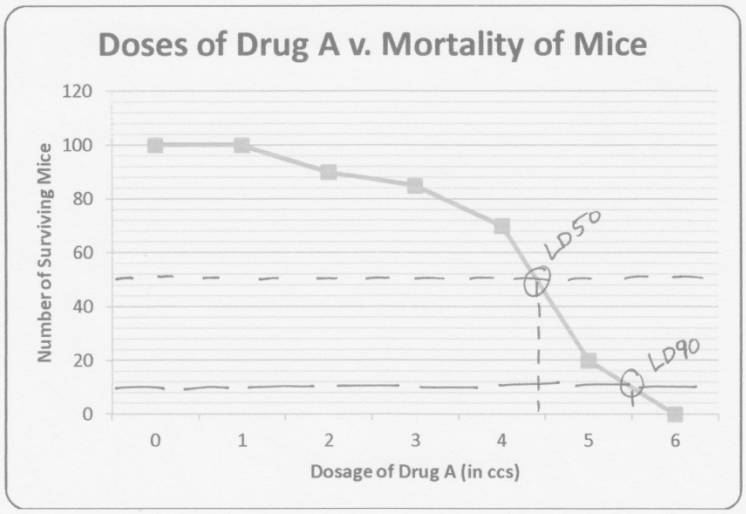
Results would be more reliable. More samples = greater accuracy

KEY

Activity #5: LD50 in Drug Trials

Background: LD50 is the common name for a host of tests comparing the dosage or amount of exposure of a certain chemical to the number of surviving organisms after contact.

Drug A:
Drug A, designed to treat hair loss, has been tested on 100 mice. The results of the test were as follows:



Questions:

1. What is the independent variable of this test? The dependent variable? How do you know?

IV = Drug Dosage
DV = Surviving Mice #
DOSAGE affects MICE survivors.

2. What is the LD50 of this drug (in mice)? How do you know?

100 mice → ½ = 50 mice
4.5 cc of Drug A.

3. What is the LD90 of this drug (in mice)?

100 mice → 90% = 90 dead mice
5.5 cc of Drug A.

4. What is the difference in concentration between LD50 and LD90?

5.5 cc − 4.5 cc = 1.0 cc between 50% dead and 90% dead.

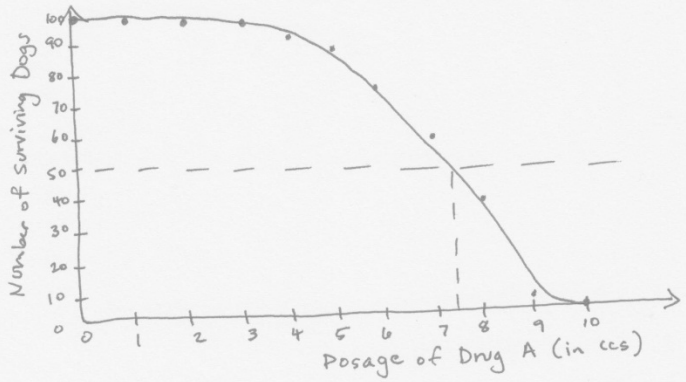
5. If chemists hypothesized that the drug was safe enough to test on humans at this point, would you agree? Why or why not?

- Depends on the dosage (< 1 cc seems okay)
- Either way, I wouldn't test on humans until it was tested on a larger animal.

Suppose Drug A was indeed passed and tested on a larger animal (dogs). Another test was run with 100 dogs and yielded the following data:

Concentration of Drug A (cc)	Number of Surviving Dogs
0	100
1	100
2	100
3	100
4	95
5	90
6	75
7	60
8	40
9	5
10	0

Draw a line graph showing the relationship between drug concentration and number of surviving dogs. Make sure to label your axes. Place an "X" on the line that shows the LD50 for the dogs.



1. What is the LD50 for the dogs? $\frac{50 \text{ sur.}}{100 \text{ total}} = 50\%$. Around 7.5 ccs

2. Explain whether or not you would recommend going to human trials with this drug.

These results seem to look better than in the rats. Doses of (< 3 ccs) seems safe. I'd run one more series of tests on monkeys before taking to human trials.