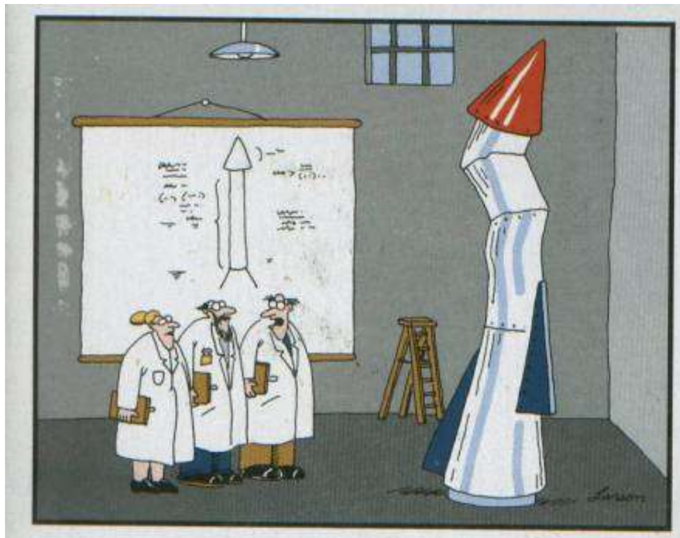
Name:____________________________Date:_______________Block:____

The Scientific Method: BACTERIA!

The scientific method is a problem solving technique used by scientists. Many parts of this method are used by every day people to solve problems.

1. State the problem or ask a question.
2. Make observations of the problem.
3. Create a hypothesis based on observations.
4. Design an experiment to test your hypothesis.
5. Conduct the experiment and collect data.
6. Analyze the data.
7. Form a conclusion based on the results, and determine whether the hypothesis was true or false.
8. Form a new hypothesis if necessary.



"It's time we face reality, my friends. … We're not exactly rocket scientists."

In the paragraph story, please identify which step of the scientific method was being used by putting a number in the space before the sentence.

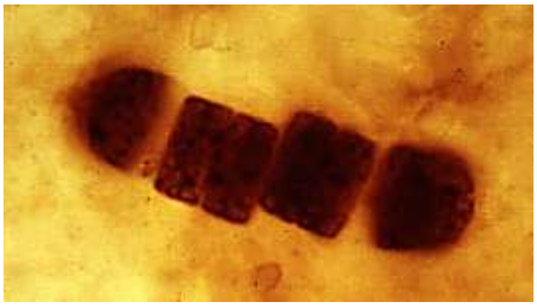
___There was a small town in Vermont, north of Brattleboro, called Connecticutville, that had an outbreak of a disease called Gotcha. ___Suddenly people all over Connecticutville, people were complaining of symptoms of swollen feet, forgetfulness and a low fever. ___In extreme cases, patients needed to be hospitalized and suffered with permanent memory loss. ___Many were seen limping around aimlessly. ___Over the course of three months, the number of cases increased from two to forty seven in this town that only had a population of three hundred! ___Blood samples from patients showed very high white blood cell counts, which was evidence that their immune system was trying to fight an infection. ___There was no known cure. ___The students at Compass School conducted tests on mice which revealed that when a spoonful of cod liver oil was taken twice daily, swelling in the feet and fever were both reduced. ___Cod liver oil seemed to cure the Gotcha disease altogether in mice. ___The students decided to see if they could cure the people from Connecticutville by giving them cod liver oil. ___They gave ten patients (five men and five women) the cod liver oil over a period of one week, and they gave ten other patients (also five men and five women) corn oil over the same week (as a control group). ___After analyzing the patient's conditions after the ten week treatment, students found that 8 of 10 people given cod liver oil were cured, while only 2 of 10 who got the corn oil showed signs of improvement. ___The Compass School students concluded that cod liver oil cures the Gotcha disease.

Your Turn!

As "budding" biologists you now get to practice your scientific skills and actually *do* science. As we are learning about A Brief History of Nearly Everything, we've decided to experiment with the growth of some of the simplest organisms found on our planet: BACTERIA! As you know, Eubacteria and Archaebacteria are the oldest forms of life.

Some History

Bacteria are grouped into two general categories. **Archaeabacteria** (from Greek word meaning, 'old') are a diverse group of bacteria as they are prokaryotes that do not have a nucleus and are considered a major group unto themselves. The more 'modern' bacteria are called **eubacteria**.



How are we sure of this 'old' bacteria? It may seem surprising that bacteria can leave traces of their existence in fossils! However, one particular group of bacteria, the cyanobacteria or "blue-green algae," have left a fossil record that extends far back into the Precambrian Era. The oldest cyanobacteria-like fossils known are nearly 3.5 billion years old, indeed the oldest fossils that scientists have yet found. Cyanobacteria are larger than most bacteria, and may secrete a thick cell wall.

Why did they make such a nice fossil imprint once upon a time, long, long ago? Cyanobacteria have large layered structures which form as a mat as they grow, trapping sediment and sometimes secreting calcium carbonate in their ocean environment.

The picture above is a short chain of cyanobacterial cells, from the Bitter Springs Chert of northern Australia (about 1 billion years old). Very similar cyanobacteria are alive today; in fact, most fossil cyanobacteria can almost be referred to living descendents.

When most people think of bacteria, they think of disease-causing organisms, like the *Streptococcus* bacteria growing in culture in this picture, which were isolated from a man with strep throat. While **pathogenic** bacteria are notorious for such diseases as cholera, tuberculosis, and gonorrhea, such disease-causing species are a comparatively tiny fraction of the bacteria as a whole.

Bacteria are everywhere! They may be found on the tops of mountains, the bottom of the deepest oceans, in the guts of animals, and even in the frozen rocks and ice of Antarctica. One feature that has enabled them to spread so far, and last so long is their ability to go dormant for an extended period.

Most bacteria may be placed into one of three groups based on their response to gaseous oxygen.

- **Aerobic** bacteria thrive in the presence of oxygen and require it for their continued growth and existence.

- Other bacteria are **anaerobic**, and cannot tolerate gaseous oxygen, such as those bacteria which live in deep underwater sediments, or those which cause bacterial food poisoning.
- The third group are the **facultative anaerobes**, which prefer growing in the presence of oxygen, but can continue to grow without it.

Now are you beginning to see why they're so cool and so successful! Bacteria may also be classified both by the mode by which they obtain their energy. Classified by the source of their energy, bacteria fall into two categories: heterotrophs and autotrophs.

- **Heterotrophs** derive energy from breaking down complex organic compounds that they must take in from the environment -- this includes saprobic bacteria found in decaying material, as well as those that rely on **fermentation** or **respiration**.
- The other group, the **autotrophs**, fix carbon dioxide to make their own food source; this may be fueled by light energy (**photoautotrophic**), or by oxidation of nitrogen, sulfur, or other elements (**chemoautotrophic**). While chemoautotrophs are uncommon, photoautotrophs are common and quite diverse. They include the cyanobacteria, green sulfur bacteria, purple sulfur bacteria, and purple nonsulfur bacteria. The sulfur bacteria are particularly interesting, since they use hydrogen sulfide as hydrogen donor, instead of water like most other photosynthetic organisms, including cyanobacteria.

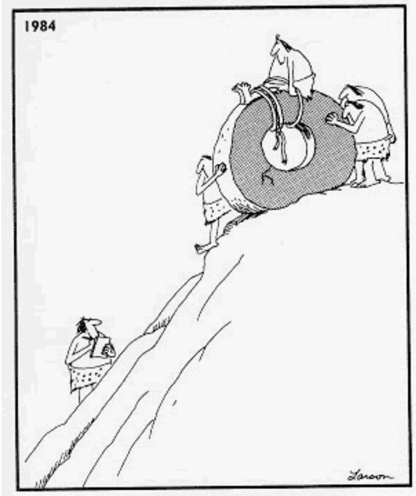
We are going to use our knowledge of bacteria in this lab to help us understand, observe, and investigate evolution!

<u>Materials Available</u>

- 1 petry dish with agar (a sterile Petri dish that contains a growth medium used to culture microorganisms)
- Any bacteria you can find in the school
- Sterile swabs
- One disk of each of the following **anti**biotics: tetracycline, chloramphenicol, and penicillin
- Cultures of the following bacteria:
    - *Enterobacter aerogenes (*Found in soil, water, and sewage, as well as serves as food for protozoans. Normal intestinal flora. Motile. Rods. Gram negative reaction. Aerobic. Incubation temperature 37°C. Tryptic soy agar growth medium.)*,*
    - *Bacillus cereus (*Central elliptical spores. Rhizoid colonies differ from *B. cereus*. Nonmotile. Rods. Gram positive reaction. Aerobic. Incubation temperature 30°C. Tryptic soy agar growth medium.)*,* and
    - *Sarcina aurantiaca* (Produces orange pigments. Nonmotile. Cocci; tetrads and packets. Gram positive reaction. Aerobic. Incubation temperature 25°C. Tryptic soy agar growth medium.)

Today you have class time to design your experiment. Please complete the following to prepare your experiment design.

Design an Experiment!
Spring 2008



Early experiments in transportation

Project Overview

1. State the problem or ask a question.
2. Make observations of the problem.
3. Create a hypothesis based on observations.
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1. Brainstorm below all the potential topics you could design an experiment using the materials above. (E.g. PART 1: Is there bacteria on this door handle—and would it be more apt to grow in my petry dish if it were swabbed with a dry or wet swab? PART 2: If I do get some bacteria to grow, what affect with the antibiotic tetracycline have on the growth of my colony?)

1a. Circle the topic you will explore and OK it with your teacher.

2: Brainstorm a list of testable questions/observations that are related to your topic. To stimulate your thinking, use the following question starters: Who? What? Where? Why? When? Will? Which? How? Do? What if? What bugs me? Record and title your brainstorm of ideas. (E.g. What does grow really mean? How would I measure "growth"? How will I be able to tell if the antiobiotic prevents or stops the growth of my bacteria? What does a 'wet' swab mean? What else might I want to test?)

3. Create a hypothesis based on your observations. Guess a solution. **"I predict**…because…" What do you predict will be the answer to your question and why? (I predict there is bacteria on the door handle and that the dry swab will transfer them to my plate and they will grow more significantly than those transferred by the wet swab because…)

4. Design an experiment to test your hypothesis. This is a very involved step. Let's break it down.

4a. ***Brainstorm Variables and control:***

DEFINE control:____

DEFINE variable:____

In the space below, brainstorm all of the variables that might affect the answer to your question. Create a title for your brainstorm. (E.g. Amount of water on the swab, amount of time left to incubate, amount of bacteria I get, etc.)

4b. ***Choose a Variable:*** What is the ONE only variable you will change during your experiment and how do you plan to change it? In order for this experiment to work successfully, it's important that we have only ONE VARIABLE. In the space below, please list what we are going to control and what the one variable will be:

Controls—must stay the same	Variable—the thing that will change
	(E.g. the wet vs. dry swab)

4c. ***Plan Observations:*** Describe what kinds of observations you plan to record by using recording methods like: drawings, photos, charts, graphs, and written descriptions. (Look for changes in what you see, hear, smell, taste, feel, and intuit[1])

4d. ***Create any observation tools*** that will help you RECORD your research on a separate piece of graph paper. Make careful observations over the next days, recording the data as you planned. Your data will be very important to show the results of your experiment and make conclusions.

4e. ***Create Materials List:*** Create a "Materials List" on a separate sheet with the type and number of each of the materials you need to implement your experiment.

4f. ***Critique your experiment by identifying weaknesses.*** What are some of the weaknesses of your experiment and how would you avoid them if you repeated your study? Where are there potential areas of human error? (E.g. I didn't necessarily control for temperature as well as I would have liked.)

4g. ***Share what you learn.*** Share your design with a classmate. Ask him/her to predict your findings. Ask your classmate if s/he sees problems with your design, findings, or interpretations. Share your own concerns.

Congratulations! You are well on your way to a creative scientific study!

[1] Intuit: To know by perception of the truth or fact, independent of any reasoning process.