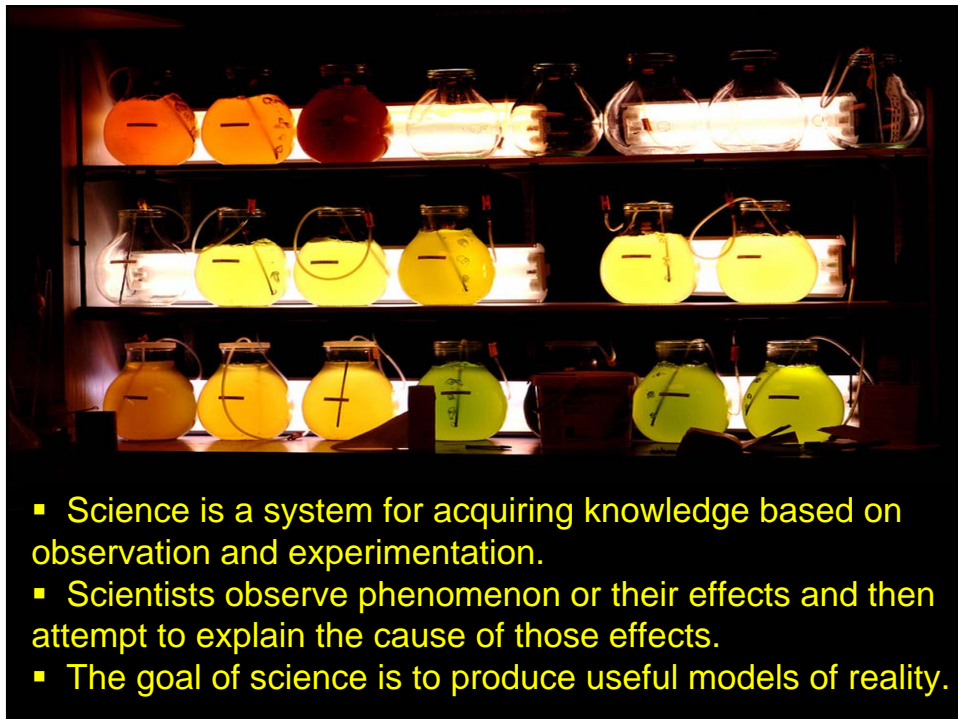


Chapter 2: Biology as a Science

Methods of science, laws & theories
Tools of the Trade: Microscopes



Etymology

The word science comes from the Latin word scientia-for knowledge, which in turn comes from scio - I know.

Despite having “I Know” as part of their job title. Scientists never claim to possess absolute knowledge. Unlike a mathematical proof, a proven scientific theory is always open to falsification, if new evidence is presented.

Even the most fundamental theory may turn out to be imperfect if new observations are inconsistent with them.

Isaac Newton's law of gravity is an example of an established law that was later found not to be universally true (by Einstein) as it does not hold in experiments involving motion at speeds close to the speed of light or in close proximity of strong gravitational fields.

The Sun Revolves Around the Earth

- For over 10,000 years, people believed the sun rotated around the earth
- It wasn't until Copernicus proposed his heliocentric in the early 1500s universe that people began to think otherwise.
- Throughout history, people have sought ways to understand nature





"Astronomer Copernicus: Conversation with God" painted by Jan Matejko (1872).

The Scientific Method

- **Science** - an organized process of learning about the world.
- A process is...

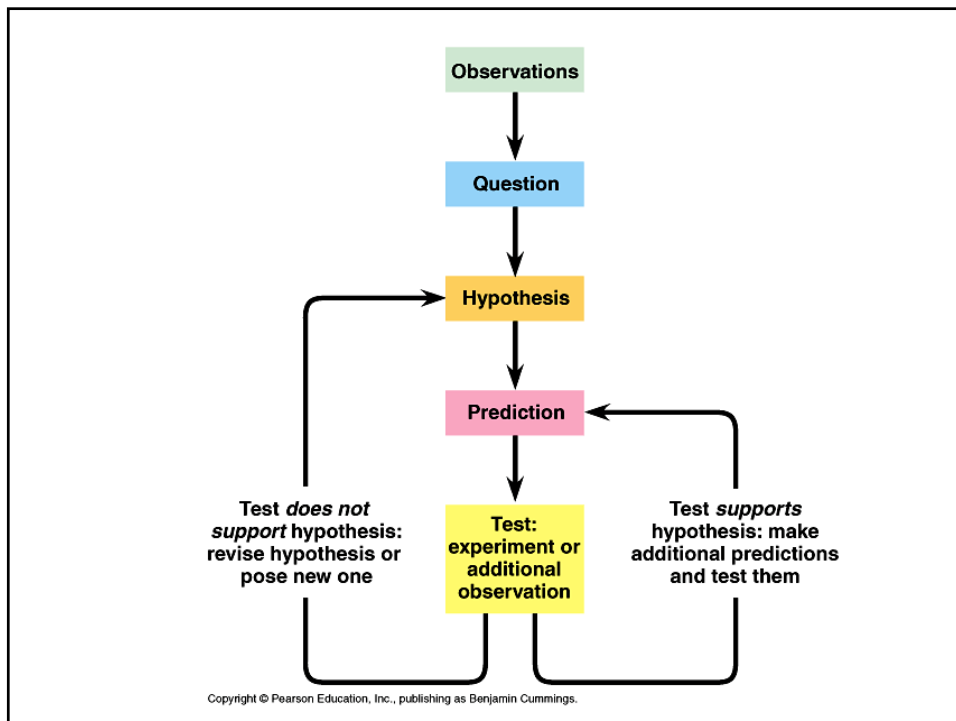
A goal-directed, interrelated series of actions, events, mechanisms, or steps

The Scientific Method

Starts with

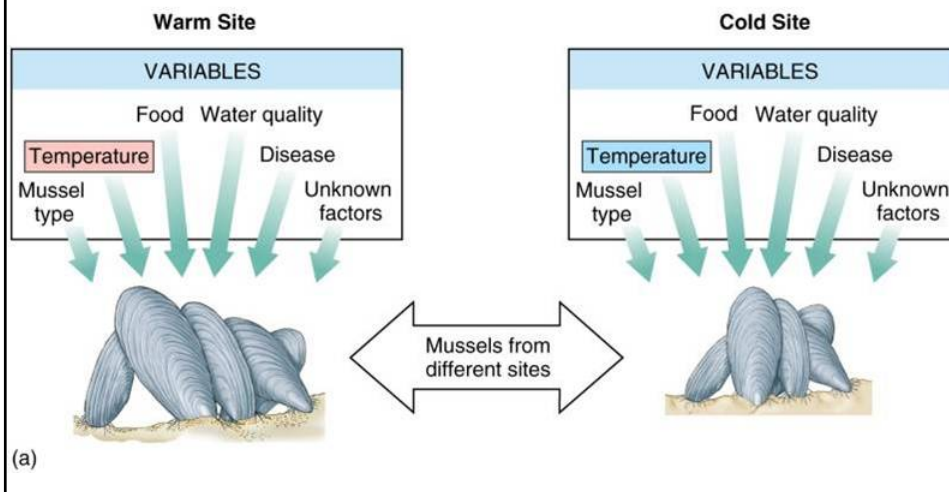
- **Observations**

- Are the “heart” of science because they may lead to questions, new discoveries
- Can be informal or formal
- Can lead to the development of a **question** or **problem** to be investigated



In this experiment the Marine Biologist wants to test the effect of water temperature on mussel growth.

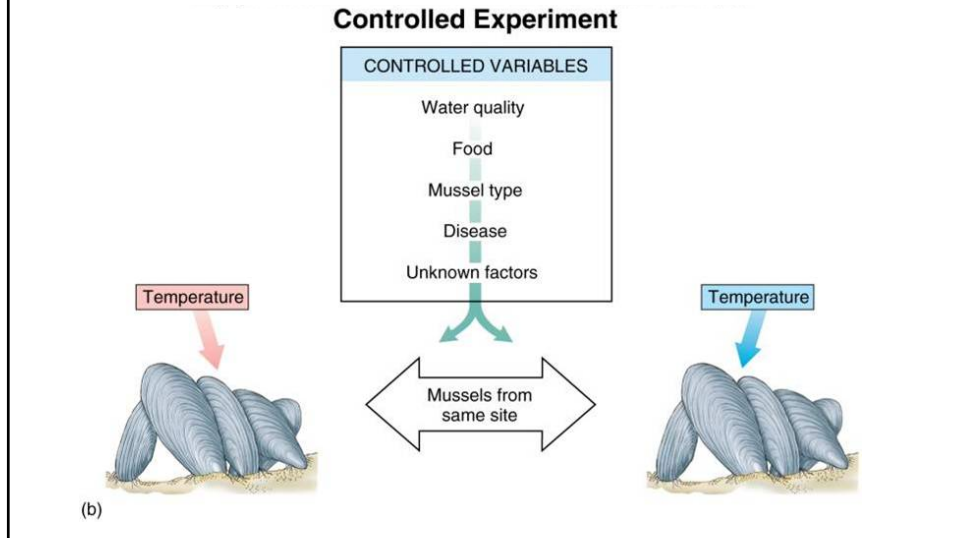
Field Observations



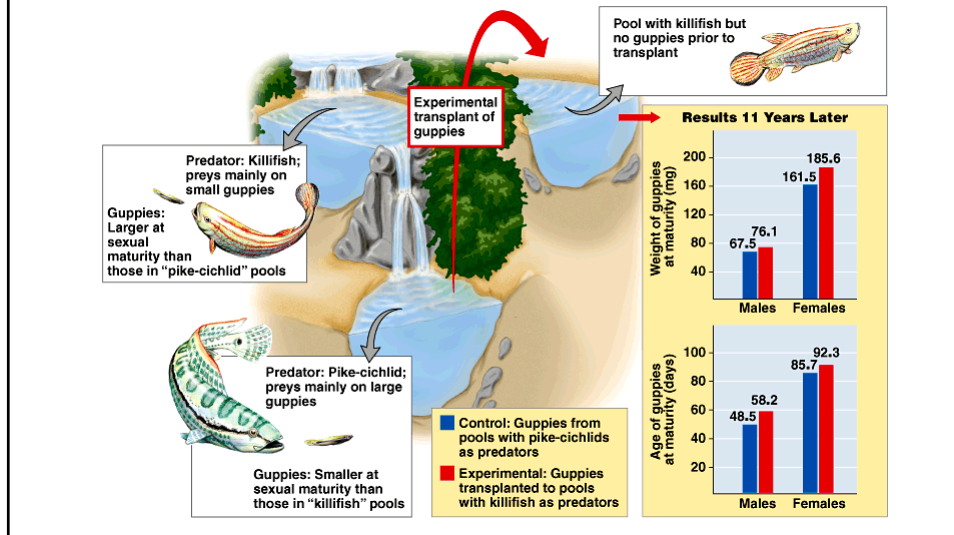
Relating data and the hypothesis

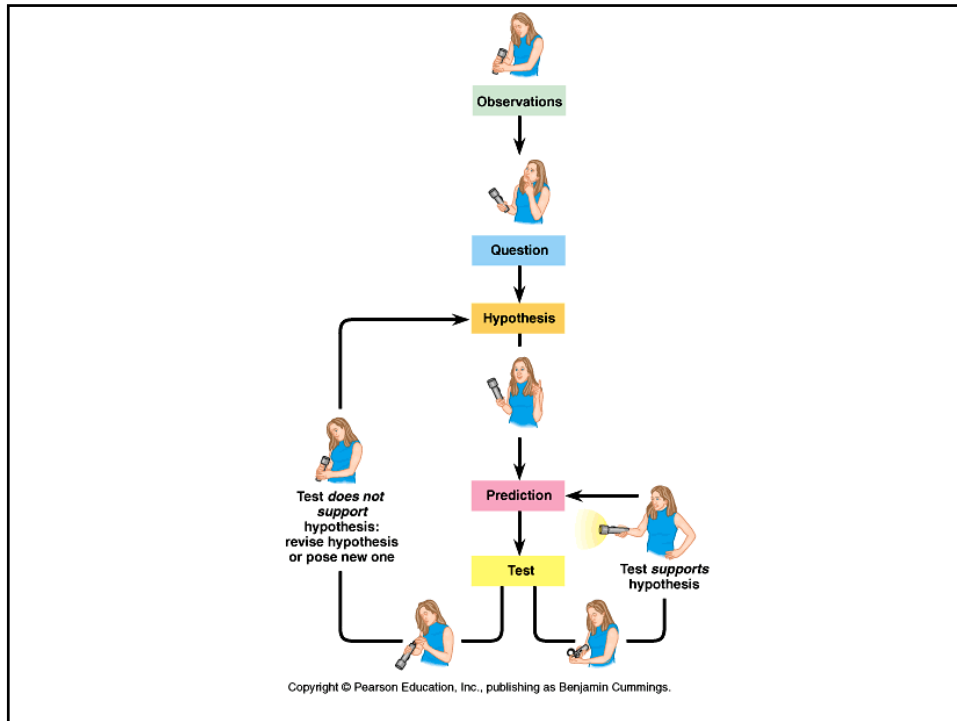
- **Hypothesis** predicts possible outcome, identifies variables and the control, and relates to the data
- **Data** is collected from observations and experiments
- **Conclusions** are made after scientists interpret data and use reasoning.

A Controlled experiment only changes 1 variable...the variable being tested is the independent variable i.e. Temp.



Experimental groups must keep all variables the same as a control group...except 1-the independent variable. The dependent variable is the change that results from changing that 1.



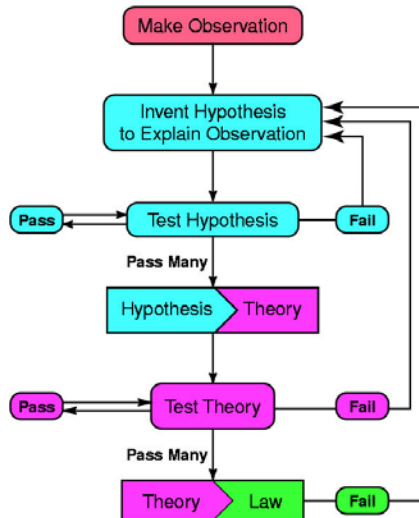


Hypothesis vs. Theory vs. Law

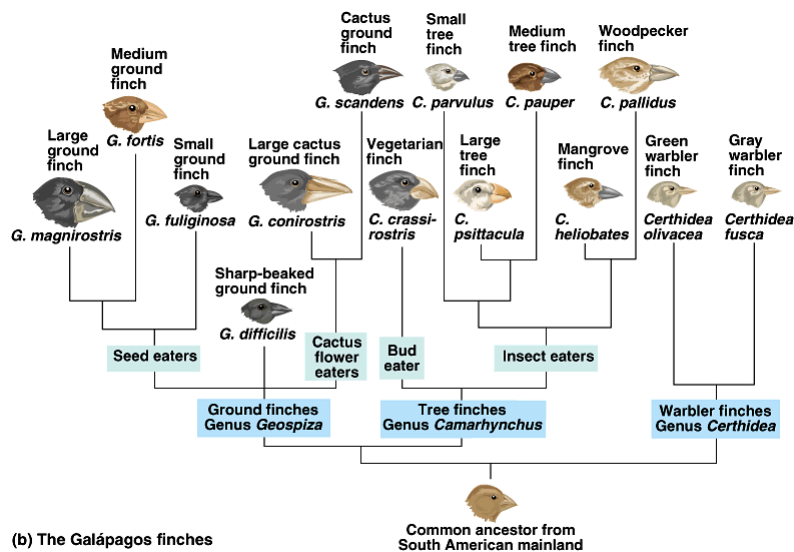
- A hypothesis often has **short-term** results
- A theory has lasted for **many** years
 - Example: Evolution, relativity
- **Laws** describe events that happen in nature –
- Scientists use **theories** to explain **laws**

Theories & Laws

Scientific Method



The Galapagos finches are an example of his theory of evolution through natural selection.

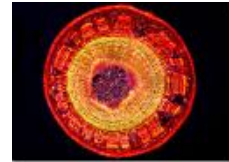
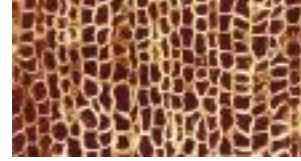


(b) The Galápagos finches

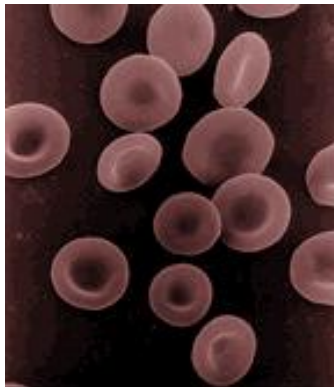
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What are all living things made of?

- **All living things are made of CELLS,** according to Robert Hooke (1635-1703) He used a crude microscope to discover that cork was made of small building blocks he called **cells**



Modern Biology Begins (1800s)



CELL THEORY:

1. All organisms are made of cells
2. All cells come from other cells
3. The CELL is the basic unit of life

Chemical composition of cells

- **Living cells contain from 65-90% water by weight**
- **What is the formula for water?
What do you know about the weight of each element?**
- **C, H, O, N, P and Ca make up about 99% of a body's mass**

Life: A unique series of chemical reactions

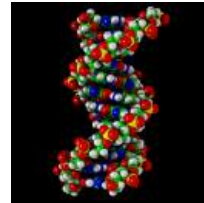
- **Living things are filled with continuous chemical reactions**



What are some of the chemical reactions going on inside your body right now?

What we can see

- Cells can be visible using the compound light microscopes we have at school
- Very large **macromolecules** are made up of billions of molecules. They can be seen with special electron microscopes. One example of a macromolecule is DNA.



Microscopes

- The main function of a microscope is to magnify small objects.
- However, the clarity of what you see is just as important...the resolving power of a microscope is its ability to distinguish 2 objects as being separate.



Microscopes were 1st introduced in the 1600's by Galileo. Shown here is Robert Hooke's simple microscope

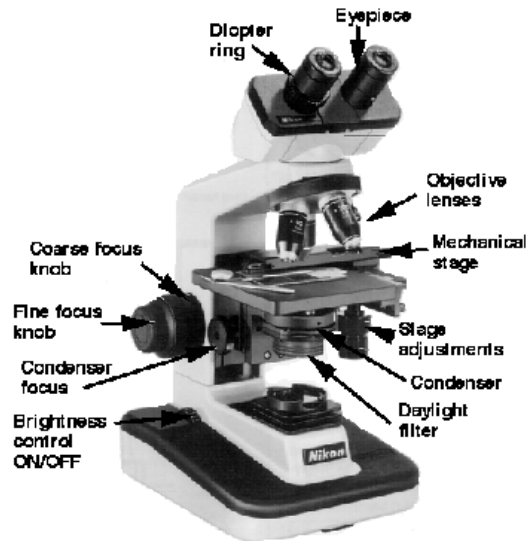


Compound Light Microscopes

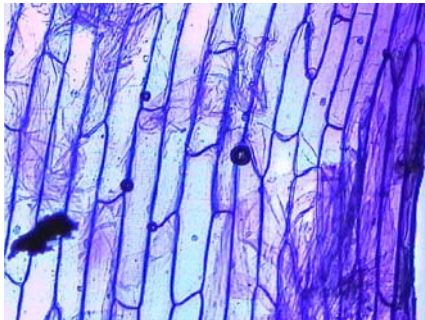
- As the name implies, these scopes use light as their energy source and 2 or more lenses to focus light.
- The binocular microscope & monocular can magnify to a max of 2,000X



Microscope parts



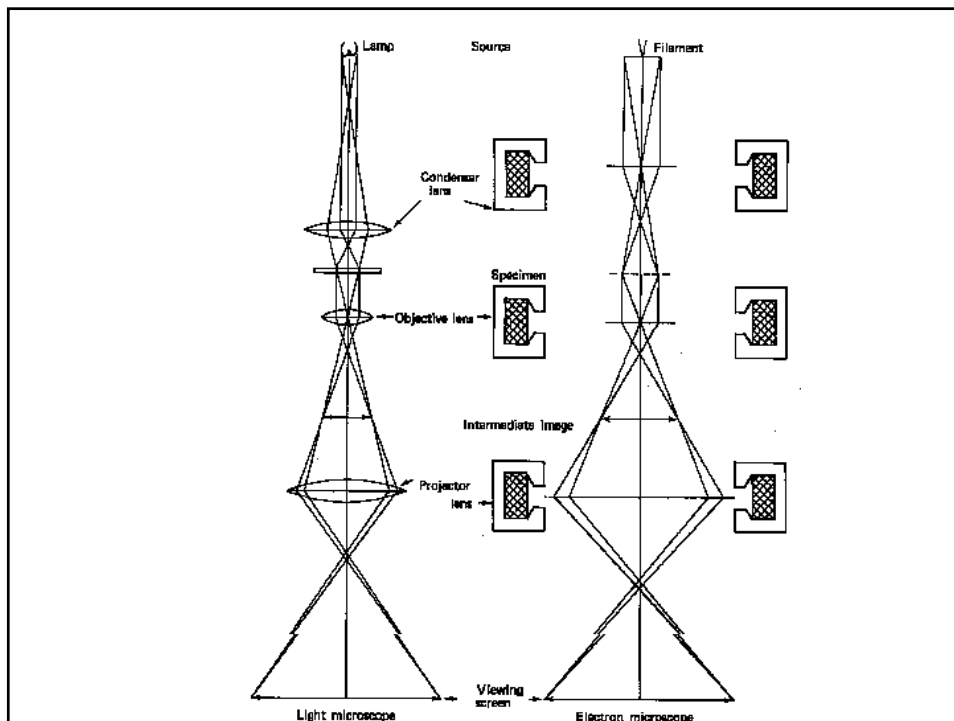
Light Microscopes



- Specimens can be viewed alive and in color.
- Shown here is an image of an Amoeba and Onion cells.

Electron Microscopes

- Developed in the 1960's Electron microscopes use a beam of electrons to produce a image of the object being viewed.
- They have much greater resolving power than light scopes.

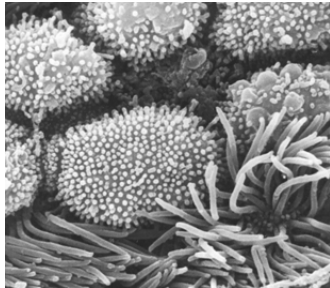


Transmission Electron Microscope



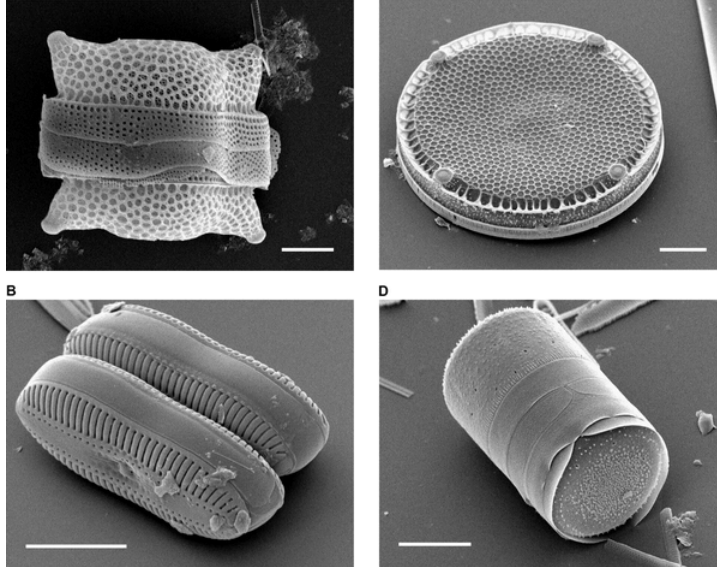
- Electrons are beamed through a frozen thin specimen.
- A black & white 2D image is then produced on an electron sensitive plate.

Scanning Electron Microscopes

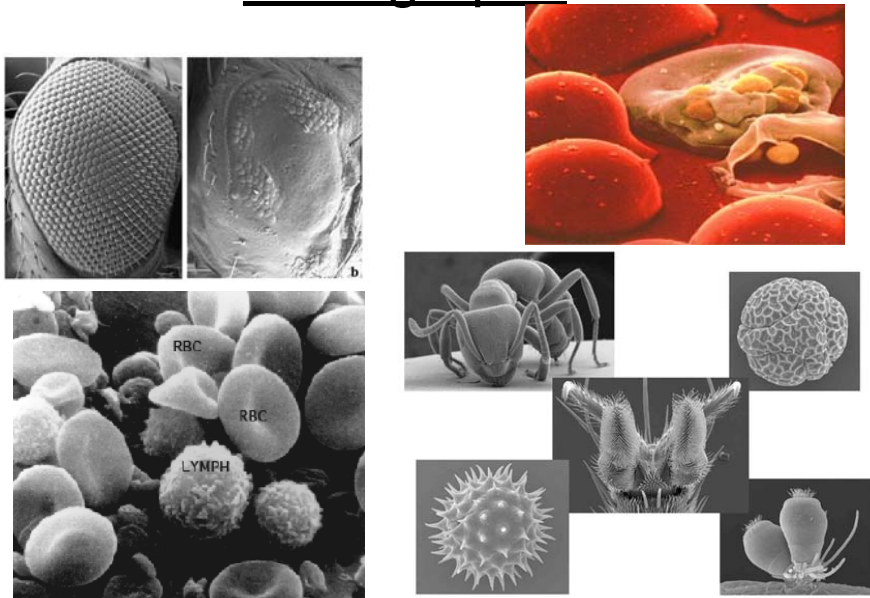


- SEM has a lower magnification, but produces a 3D image as electrons bounce off of the specimen.
- Micrographs are black & white, unless enhanced by a computer program.

SEM Micrographs



Micrographs

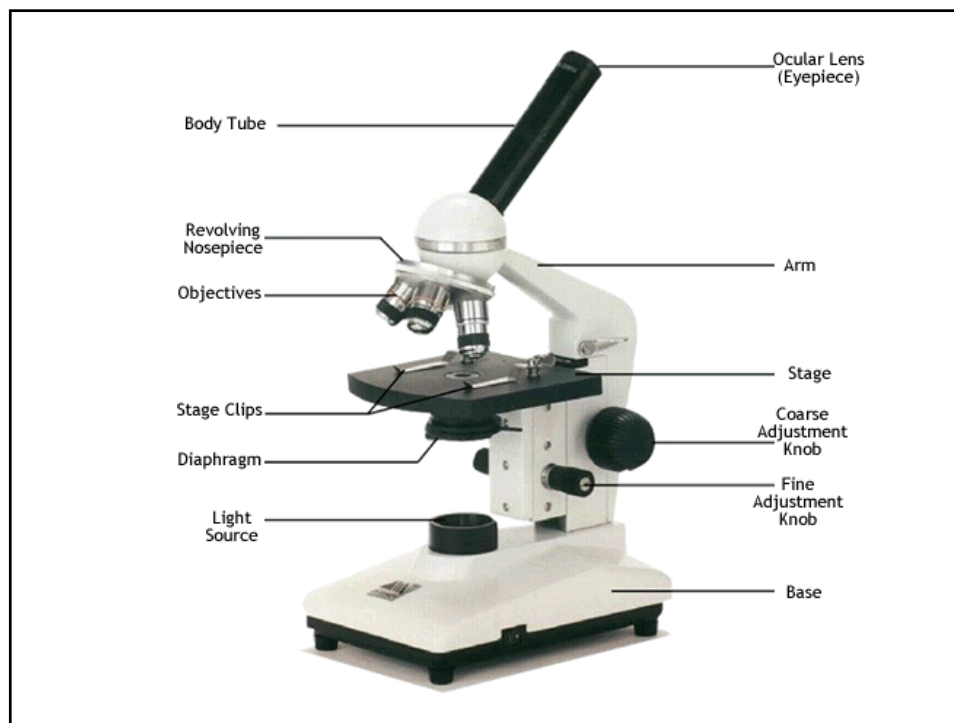


Compound light microsc



Common lab microscopes use light passing through an object to produce a larger image

1. Simple microscope – only 1 lens
2. Compound – 2 or more lenses
 - Eyepiece: magnifies by 10 times
 - Objectives: magnify by 4, 10 or even 40 times (what we use)

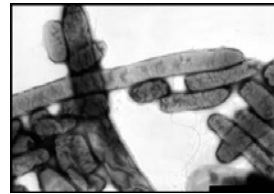


Electron microscopes

- Uses beams of electrons to produce enlarged images
 - Used to view greater details about an object that are possible with a light microscope
 - 3 Types

1. Transmission Electron Microscope TEM

- Uses electrons as its light source
- Material viewed must be very thin for the beams to pass through.
- Magnifies up to 200,000 times.
- Developer won a Nobel Prize in Physics in 1986



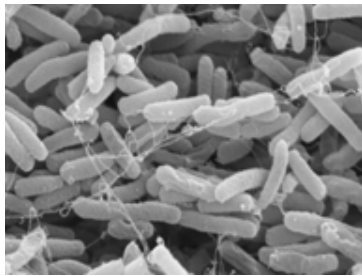
Bacteria
TEM Image

2. Scanning Electron Microscopes (SEM)

Scans the surface of a specimen

» Can provide 3-D images

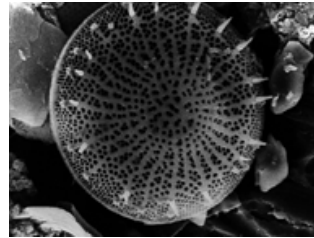
» Up to 50,000 times magnification



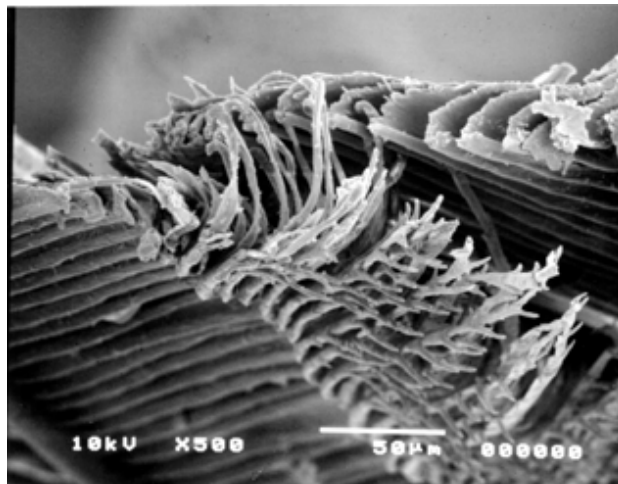
E coli bacteria



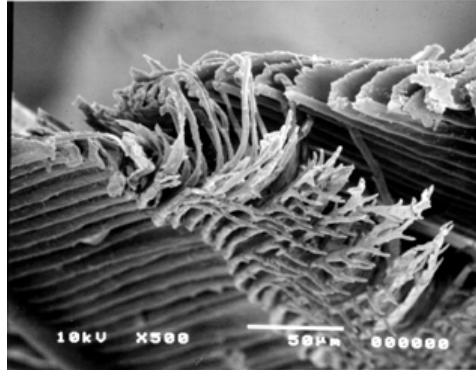
Diatom →



Can you guess what this is?
Animal? Plant? Mineral?



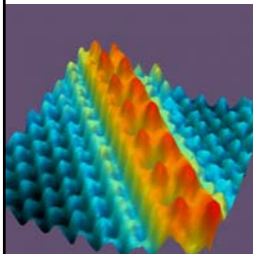
- The vane of a bird's feather consists of a series of barbs that connect together by hooked barbules. Like a zipper, each barb is connected to the adjacent one, creating a solid vane.

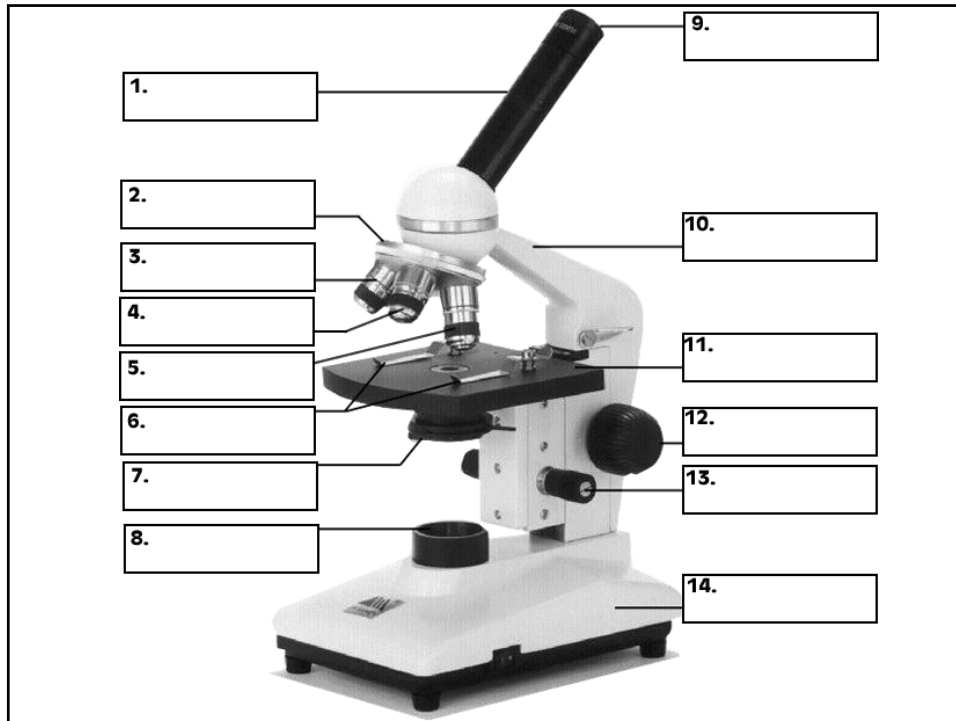


3. Scanning Tunneling

Advantage: can be used to view living things

Widely used in both industry and research to obtain atomic-scale 3-D images of surfaces.





Abiogenesis theories

- Lack of proper experimentation lead early scientist to believe in abiogenesis
- Controlled exp. Like F. Redis Maggots from meat experiment disproved this theory.

