BIOLOGY

Biology: **the study of life**
Organisms: **all living things**
There have been different views of life throughout history.

1. **<u>vitalism:</u> living things exist because they have been filled with special forces, called ethers, which bring nonliving things to life**
   Vitalism was the main view of life for about 2000 years until the Dark Ages, when the idea of spontaneous generation came around.

2. **<u>spontaneous generation:</u> a theory stating that living organisms are produced from nonliving matter and ethers**
   examples: maggots from rotting meat
   mice from old rags
   geese from river banks

1668 – Francesco Redi tests spontaneous generation. Redi thought that maggots came from flies, not from ethers. So he put some rotting meat in jars.

1. **When the jars were left open → maggots appeared**
   (Both flies and ethers could get into the jar. What does this show?)
2. **When the jars were sealed → no maggots**
   (Neither the ethers nor the flies could get into the jar. What does this show?)

3. **When the jars were covered with cloth → no maggots**
   (Ethers could get in but flies could not. What does this show?)

Redi's experiment supported another theory that eventually replaced spontaneous generation → biogenesis.

3. **<u>biogenesis:</u> principle that life comes only from life**
   "bio" = life "gen" = to make, produce
   → Each type of living organism produces more of its own kind.

But it wasn't as if everyone let go of spontaneous generation and immediately embraced biogenesis. In fact, Redi's work and conclusions were questioned and tested for the next 200 years.

Background info: Microorganisms (bacteria, protists, etc.) were first observed around the same time as Redi was completing his maggot experiments.

John Needham – mid 1700's – English scientist

- **claimed that spontaneous generation could occur under the right conditions**
- **Needham sealed a bottle of gravy and heated it. He claimed that the heat would kill any living things in the gravy. After several days, the gravy was teeming with microorganisms.**
- **Needham's (incorrect) conclusion: The micro-organisms only could have come from the gravy itself.**

Rebuttal of Needham's Work:

Lazzaro Spallanzani – Italian scientist

- **He thought that Needham had not heated his samples of gravy to a temperature high enough.**
- **Spallanzani <u>boiled</u> 2 flasks of gravy. He assumed that boiling would be enough to kill any micro-organisms already in the gravy.**
- **Immediately after boiling, he sealed one of the flasks of gravy. The other was left open.**
- **After a few days, the open jar was full of micro-organisms. The sealed jar had none.**
- **Spallanzani's Conclusion: Gravy did not produce microorganisms. The microorganisms in the open jar had come from microorganisms in the air that had multiplied in the gravy.**

Despite Spallanzani's work, some scientists still continued to support spontaneous generation well into the 1800's. They argued that <u>air</u> contained a "life force" necessary for generating life, and therefore Spallanzani's work was not conclusive.

Louis Pasteur – 1864 – French scientist

- **Designed a flask to settle the argument.**
- **The flask had a long curved neck. Air could get in, but microorganisms from the air could not make their way through the neck into the flask.**
- **Broth was boiled in this flask and without being sealed, it remained free of microorganisms for an entire year. As long as it was protected from**

microorganisms, the broth remained free of living organisms.

- **After one year, Pasteur broke off the curved neck of the flask, and the broth quickly filled with micro-organisms.**
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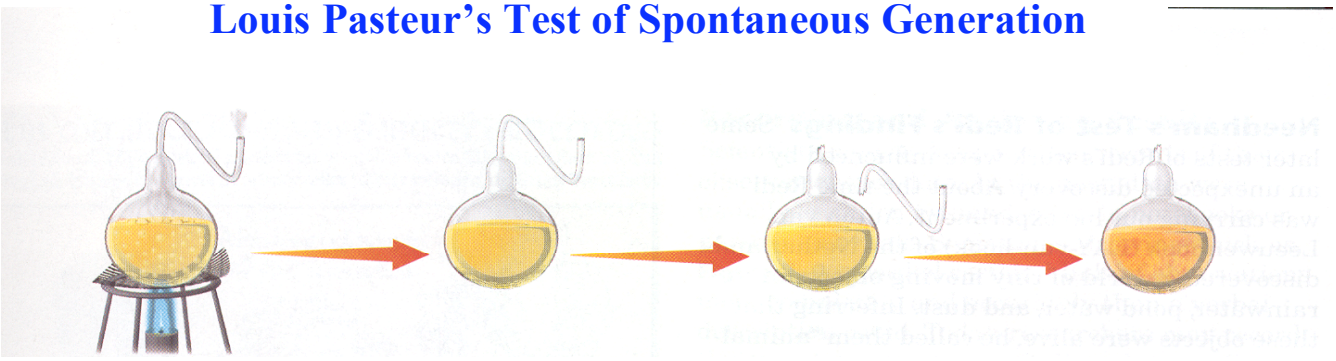
Pasteur's experiment finally convinced other scientists that spontaneous generation was incorrect. It also provided very strong support for biogenesis.

Louis Pasteur's Test of Spontaneous Generation



Broth is boiled.

Broth is free of microorganisms for one full year.

Curved neck is is removed.

Broth is teeming with microorganisms.

Side Note: We've been talking about hypotheses and theories. The word "theory" has a different meaning in science than in other areas. In science, a theory is a well tested explanation that unifies a broad range of observations. Theories are extremely well supported by vast amounts of experimentation, data collection, and scrutiny. It is not an "educated guess" like a hypothesis.

As more information is gained with advances in technology and further research, a theory is constantly analyzed, reviewed, and if necessary, revised.

Properties of Life

I. Living things are made up of units called cells.
II. Living things reproduce.
III. Living things are based on a universal genetic code.
IV. Living things grow and develop.
V. Living things obtain and use materials and energy.
VI. Living things respond to their environment.
VII. Living things maintain a stable internal environment.
VIII. Taken as a group, living things change over time.

We're going to take a brief look at each one of these properties and later in the course, take a much deeper look at some of them. Remember, every textbook you pick up could have a different list. There is no set list of properties that is universally accepted.

I. Living things are made up of cells.
Cell – collection of living matter enclosed by a barrier that separates the cell from its surroundings; basic unit of all forms of life
A. Cells can grow, respond to the environment, and reproduce; they are complex and highly organized.
B. Organisms can be made of one cell or many cells.
1. unicellular – "single celled" – organisms consisting of only one cell

2. **multicellular – "many celled" – organisms consisting of hundreds, even trillions of cells**
    a. **often has a diversity of cells with different functions**
    b. **sizes and shapes of cells differ also within the organism**

II. Reproduction

A. All organisms produce new organisms through reproduction.

B. Two basic kinds of reproduction:

1. **sexual reproduction:**
    a. **cells from 2 different parents unite to produce the first cell of the new organism**
    b. **the majority of multicellular organisms use sexual reproduction**
2. **asexual reproduction:**
    a. **a single parent reproduces by itself**
    b. **there are many different ways that asexual reproduction can happen**
        - **a single celled organism divides in half to form 2 new organisms**
        - **a portion of an organism splits off to form a new organism**

III. Based on a Genetic Code

A. Traits are inherited from parent to offspring. In asexual reproduction, parents and offspring have the same traits. In sexual reproduction, offspring are different from their parents, within limits.

B. DNA, or deoxyribonucleic acid, is the molecule that holds the directions for these patterns of inheritance.
C. Every single living organism has DNA, the genetic code.

IV. Growth and Development
A. All living things grow during at least part of their lives.
<u>growth</u> – increase in size
B. Multicellular organisms also go through a process called development.
1. As cells divide in early stages of life, they change in shape and structure to form cells such as liver cells, brain cells, lung cells, etc.
2. This process is called <u>differentiation</u> (also called <u>cell specialization</u>) – process in which cells become specialized in structure and function

V. Need for Materials and Energy
A. To grow, develop, reproduce, and just to stay alive, living things need energy and materials.
1. <u>metabolism</u>: set of chemical reactions through which an organism builds up or breaks down materials as it carries out life processes
2. Organisms have many different ways of obtaining energy from their environments.
a. plants, some bacteria, most algae – photosynthesis

b. other organisms eat those organisms that use photosynthesis
c. There are other chemical ways besides photosynthesis to get energy from the environment, but they are not very common. e.g. chemoautotrophs

VI. Response to the Environment

A. Organisms detect and respond to stimuli in the environment.
1. <u>stimulus</u> (plural stimuli) – a signal to which an organism responds
2. <u>internal stimulus</u> – comes from within the organism
e.g. hungry feeling when sugar levels are low
3. <u>external stimulus</u> – environment outside the organism gives a signal
e.g. sunlight amounts, temperatures, gravity

VII. Maintaining an Internal Balance

A. Though conditions in the environment can vary widely, internal conditions for organisms must be kept fairly constant e.g. temperature, hydration.
1. <u>homeostasis</u> – process by which organisms maintain a relatively stable internal environment
2. often involves internal feedback systems
e.g. too hot – body sweats to cool itself
too cold – body shivers to produce heat

VIII. Evolution

A. Although individual organisms go through changes, the basic traits they inherited from their parents do not - eye color, skin color, etc.

1. **However, as a GROUP, any given kind of organism can evolve, or change over time.**
2. **It takes a very long time for change to appear, hundreds, thousands, even millions of years.**

B. The ability for a group of organisms to change over time is invaluable for survival in a world that is always changing.

How might global warming affect evolution?

Branches of Biology and the Organization of Life

Life has many different levels of organization. All of them are open to study and have different specialties associated with them. The following section is a hierarchy, or arrangement, of these levels of life.

1. **atoms & molecules: Atoms are the smallest parts of ALL MATTER, living or nonliving. Molecules are groups of atoms and have different properties than the atoms by themselves.**

2. **cell: made up of groups of atoms and molecules; smallest unit of life**

3. **tissue: group of similar cells that perform a specific function; examples – muscle, bone, blood**

4. **<u>organ:</u> group of tissues that work together to perform closely related functions ex. – heart, leaves, kidneys**

5. **<u>organ system:</u> group of organs working together to perform a specific function; ex. digestive, circulatory**

6. **<u>organism:</u> an individual living thing**

7. **<u>population:</u> group of organisms of one type that live in a particular area**
   ex. snapping turtles in Farmer Smith's pond
   Yellow bellied sapsuckers living in Raccoon Creek State Park

8. **<u>communities:</u> all of the populations that live together in a defined area**
   ex. the lawn in your front yard – worms, ants, beetles, grass, fungi (BUT NOT the water, soil, minerals, sunlight, and rain)
9. **<u>ecosystem:</u> the community and its nonliving surroundings**

10. **<u>biosphere</u> – the parts of the Earth that contain all ecosystems**

Chemistry of Life

Inorganic and organic compounds – life needs some of each.

Organic: includes most compounds that contain carbon; usually associated with living things

example: calcium carbonate $CaCO_3$

Inorganic: compounds that generally don't contain carbon

example: salt (sodium chloride) NaCl

Organisms are composed of 4 major classes of macromolecules (big molecules) plus water.

1. **Proteins:** made of amino acids
   → functions: give structure to the body; speed up chemical reactions
   Note: Proteins that speed up chemical reactions are called enzymes. Not all proteins are enzymes.

2. **Lipids:** fats, waxes, steroids
   → functions: store energy; make up a part of membranes; act as hormones

3. **Carbohydrates:** sugars, starches
   → function: source of energy

4. **Nucleic Acids:** DNA and RNA
   → functions: contain genetic information help to make proteins

Other chemistry affecting life: pH

Solutions may be acidic, basic, or neutral. It depends on how many hydrogen ions (H^+) there are compared to how many hydroxide ions (OH^-) there are.

<u>Ion:</u> an atom with an electrical charge due to a loss or gain of electrons

<u>pH scale:</u> standard measurement of concentration of H^+ ions in solution

The pH scale ranges from 0 to 14.

0 up to 7 is acidic 7.0 = neutral above 7 to 14.0 is basic

pH is important because it affects the rates of chemical reactions, often making them happen very fast or very slow depending on the reaction and how the pH changes.

***Be sure to study the diagram pages about ions and atoms!**

I. Microscopes

A. Two main types

1. **light microscope: produces magnified images by focusing visible light rays**
2. **electron microscope: produce magnified images by focusing beams of electrons**

B. Two main problems in making microscopes

1. **What is the instrument's magnification?**
   a. **how much larger can it make an object appear than its real size?**
2. **How sharp an image can the microscope produce?**

C. Light Microscopes

1. **most commonly used**
2. **magnification is about 1000x**
3. **compound light microscope: allows light to pass through the specimen (what you're looking at) and uses 2 lenses to form an image**
    a. **can view dead organism and their parts**
    b. **can view some tiny organisms and cells while living**
4. **Methods to improve using a light microscope**
    a. **chemical stains to show specific structures in cells and other specimens**
    b. **using video cameras and computer processing to produce moving 3D images**
5. **Main advantages:**
    a. **very affordable**
    b. **easy to use**
6. **Main disadvantages:**
    a. **magnification is very limited**
    b. **images can often be grainy, poor quality**

D. Electron Microscopes

1. **primarily used to see extremely tiny objects**
2. **magnification is vastly greater than light microscopes**
3. **two main types of electron microscopes**
    a. **transmission electron microscopes (TEMs) - shine a beam of electrons through a thin specimen**
    - **can reveal lots of detail inside the cell**

- **samples must be preserved and dehydrated (nothing living)**

b. scanning electron microscope (SEMs) – scans a narrow beam of electrons back and forth across the surface of a specimen

- **produce realistic and detailed 3D images of the surfaces of objects**
- **the images are often quite surprising in their details**
- **like TEMs, samples must be preserved and dehydrated**

4. Main Advantages

a. pictures are spectacular

b. the magnification is fantastic

5. Main Disadvantages

a. extremely expensive

b. need extensive training to use

E. In the 1990's, scientists perfected a new type of microscope, the scanning probe microscope.

1. produces images by tracing the surfaces of samples with a fine probe

2. now possible to view single atoms

3. can operate in ordinary air (SEMs and TEMs need a vacuum) and can show samples in solution

4. revolutionizing what and how we study many small particles