Scientific Fundamentals
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Science is fundamentally different from religion. While religion includes belief based on faith in the absence of evidence, scientific beliefs are based on evidence. When evidence changes, scientific beliefs must be adjusted accordingly.

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Chemistry is the science dealing with matter, its properties, and changes that occur to things made of matter. Chemical changes occur because of interactions between atoms, resulting in rearrangements of electrons. Biology is the study of living things and of interactions between living things and between living things and their dead and non-living surroundings. Biotechnology is a branch of biology. Biotechnology can be broadly defined as any use of technology involving living things to produce some sort of product.

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Any chemical reaction involves some number of reactants that are transformed into some number of products. As a reaction proceeds, some chemical bonds are broken, and some new chemical bonds are formed. The result is that reactants are consumed and products are produced. No matter is created or destroyed in this process, but a rearrangement of electrons results in products that have different properties compared to the reactants from which they are produced.

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All material things are made up of tiny subunits called atoms, which in turn are made up of even smaller subatomic particles. There are three primary types of subatomic particles:

- Protons are found only in the nucleus of an atom. Each proton has a +1 electrostatic charge. The number of protons in an atomic nucleus determines which kind of element that atom represents.
- Neutrons are found only in the nucleus, along with some number of protons. While every atom has at least one proton in its nucleus, not every atom includes neutrons. A neutron is nearly identical in mass to a proton, but it has no electrostatic charge.
- Electrons are much smaller that protons and neutrons, and they are not part of the nucleus. Instead, electrons are found orbiting the nucleus. Each electron has a -1 electrostatic charge. Despite the drastic difference in size between an electron and a proton, the negative charge of an electron is just as big as the positive charge of a proton.

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A chemical reaction is represented by a chemical equation, using an arrow to separate reactants (on the left) from products (on the right). Reactants and products can be represented in various ways, including names, pictures, structural diagrams, and chemical formulae.

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Organisms, like all material things, are made of atoms. Though there are more than a hundred different elements, organisms are made mostly of a small number of the smallest of these elements. Most of the human body, for instance, is made up of just four kinds of atoms: carbon, hydrogen, nitrogen, and oxygen.

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Though it is difficult to provide a rigorous definition of "living thing", all living things share some important characteristics:

- A living thing responds to the environment in which it lives.
- A living thing is capable of reproduction, whether alone (asexually) or with the cooperation of a mate (sexually).
- Though unicellular organisms undergo little growth, a multicellular organism undergoes extensive growth (by adding more cells) and development (by changing form and function during some part of the lifetime).
- A living thing must process energy to supply the needs of life. Life is a large set of chemical reactions occurring in the cell or cells of an organism.
- The large set of chemical reactions occurring within an organism must be regulated; otherwise the organism will die. Regulation is achieved through feedback, which allows for homeostasis.
- A living thing possesses a high degree of order compared to most non-living things.
- Over the course of many generations, species become more and more adapted to their environments. This adaptation is driven by evolution, whereby an accidental mutation that happens to be beneficial to the organism will provide that mutant organism a greater chance of surviving long enough to reproduce. By reproducing, the mutant organism passes on the new and beneficial trait to the next generation, whereas harmful mutations (resulting in reduced chance of reproduction) will less likely be passed on.

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Biology can be studied at many different levels, reflecting a hierarchical arrangement of biotic and abiotic entities.

- At the small end of the hierarchy are atoms, of which all material things are made.
- Atoms combine to form larger structures called molecules.
- Molecules combine to form structures called organelles. These function as "tiny organs" within
- cells.
- Organelles of different types make up a cell, which is the fundamental unit of organisms.
- In multicellular organisms, collections of cells form tissues.
- In multicellular organisms, different tissues make up an organ.
- In multicellular organisms, a collection of functionally related organs make up an organ system.
- In multicellular organisms, all of the different organ systems constitute the organism. For a
- unicellular organism, the Cell level and the Organism level are the same thing, and the levels in
- between the two are not applicable.
- Multiple individuals of the same species living in a specific space make up a population.
- Multiple populations (different species) living in the same space make up a community. A
- community includes only the living things in that space.
- An ecosystem includes a community (the biotic entities) as well as the non-living (abiotic)
- entities in that space.
- The biosphere is the collection of all known ecosystems.

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An organism is something that consists of at least one cell. Cells can be classified into two types:

- A prokaryotic cell does not contain a true nucleus, and it does not contain any other membrane-bounded organelles.
- A eukaryotic cell contains a true (membrane-bounded) nucleus as well as other membrane-bounded organelles.

Any cell possesses a plasma membrane that separates the intracellular fluid from the extracellular fluid. With its single membrane, a prokaryotic cell contains only one compartment. The materials within that compartment are collectively called the cytoplasm. A eukaryotic cell contains two major compartments (one outside the nucleus and one inside the nucleus). The cytoplasm includes all the cell contents that are outside the nucleus. The contents of the nucleus are called the nucleoplasm

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Evolution operates, because organisms pass on traits to their offspring. The passing of traits to offspring occurs because DNA is transferred from parent cell to offspring cell, and because DNA indirectly determines traits. DNA (deoxyribonucleic acid) is a type of biological macromolecule that serves as a set of codes for how to indirectly construct proteins within a cell. Those proteins directly give the organism its traits. In a eukaryotic cell, DNA is found in the nucleus. DNA in a prokaryotic cell is found in a region of the cytoplasm called the nucleoid.

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Organisms produce four classes of macromolecules:

- Lipids include fats, oils, sterols, and other molecules. Lipids are hydrophobic, because they are non-polar; they therefore do not interact readily with water or other polar molecules.
- Polysaccharides are carbohydrate polymers made of small carbohydrate monomers called monosaccharides. Monosaccharides are simple sugars; therefore polysaccharides are also called complex sugars.
- Proteins are polymers made up of monomers called amino acids. Proteins perform a hugely diverse set of functions in cells.
- Nucleic acids include ribonucleic acid (RNA) and deoxyribonucleic acid (DNA). They are polymers made up of monomers called nucleotides. The sequence of nucleotides in a DNA molecule serves as an instruction code for how to produce proteins.

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A centrifuge is a device for separating different kinds of particles based on their different weights. A collection of particles (a sample) is put into a tube and spun by the centrifuge at very high speed. This subjects the sample to force many times that of gravity, and the heavier particles quickly precipitate to the bottom of the tube, while the lighter particles float at the top, forming the supernatant.

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A vortexer is a device that spins bottom of a test tube while it is held. This stirs the contents of the tube very efficiently.

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Gel trays are also known as electrophoresis chambers. Electrophoresis is a separation technique in which particles that have been deposited into a gel are separated based on electric charge, size of particle, and shape of particle. Voltage applied across the gel forces negatively charged particles to migrate through the gel toward the positive electrode and forces positively charged particles to migrate toward the negative electrode.

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Pipettes are slender tubes that are used to accurately measure the volume of liquids to be transferred from one container to another. The narrower the pipette, the greater the precision with which volume can be measured.

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Pipettors are devices that provide suction to pipettes for drawing volumes of liquid into the pipette. They range in complexity, but they all operate for the same purpose.

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Heat blocks are heated racks designed to hold tubes and keep them within a narrow range of a prescribed temperature.