A note by Anton "Tony" Lawson: My definition of a theory is an explanation for a broad class of related phenomena. A model is defined as some sort of representation of phenomena. So they are not they same thing. In reality what I listed are all models as they are representations (i.e., lists of words and sentences that represent the thoughts, which are the theories). Theories exist only in people's minds. Models exist in the external world. The models represent the theories. But this is a bit technical so I call the lists theories.

Basic Theories.doc

Basic Theories for Introductory Biology

theory A collection of statements (conditions, components, claims, postulates, propositions) that when taken together attempt to explain a broad class of related phenomena.

I. THE NATURE OF THEORIES

Greek Four-Material Theory

1. Everything in the world consists of four fundamental materials either in pure form or in various combinations.
2. The fundamental materials are earth, water, air and fire.
3. Each material has its own "natural" location.
4. Nature locates earth below water, water below air, and air below fire.
5. Living things differ from nonliving because they contain a special life-giving *vital force*.

Combustion Theory

1. Matter consists of atoms and combinations of atoms called molecules.
2. Atoms can combine with and separate from other atoms.
3. Combustion (burning) is a process in which oxygen atoms from the air combine with the atoms of the burning material.
4. Combustion stops when a sufficient supply of oxygen atoms is gone.

Spontaneous Generation Theory

1. Living things are generated spontaneously from nonliving materials when an unseen life-giving vital force enters the nonliving material.
2. Different kinds of nonliving materials give rise to different kinds of living things. For example, rotting meat gives rise to flies while old rags give rise to mice.
3. Spontaneous generation has occurred in the past and still occurs today.

Biogenesis Theory

1. New life arises only from prior life.
2. The kind of new life that arises depends on the kind of life that preceded it, that is, there is a continuity of life forms from one generation to the next.

II. BASIC THEORIES OF INHERITANCE, DEVELOPMENT, AND GROWTH

Cell Theory

1. Cells are the structural and functional units of all living things.
2. Growth occurs primarily when new cells arise by cell division, a complex process in which the parts of the parent cell duplicate themselves and then separate into two sets.

Cell Division Theory

1. Cell division involves mitosis and cytokinesis.
2. Long, thin nuclear chromosomes, which occur in pairs, duplicate themselves before mitosis begins.
3. At the start of mitosis, the duplicated chromosomes coil up and the nuclear membrane disintegrates.
4. Next, the duplicated, coiled chromosomes move to either side of the cell's equator across from like chromosomes.
5. The two sets of duplicated chromosomes then move to opposite sides of the cell.
6. When the chromosomes arrive at opposite sides, they uncoil and a nuclear membrane forms around each set of uncoiled chromosomes.
7. Cell parts outside the nucleus duplicate (cytokinesis) and a new cell membrane forms (and in plants a new cell wall) beginning along the old equator.

Meiosis Theory

1. Meiosis begins after the paternal and maternal chromosomes duplicate.
2. The duplicated paternal chromosomes and their matched pair of duplicated maternal chromosomes coil up, move, and end up next to each other. This results in groups of four identical chromosomes.
3. Each group of four chromosomes then moves to the cell's equator so that two chromosomes of each group are on each side.
4. Two chromosomes of each group of four now move away from the equator in one direction, while the other two move in the opposite direction.
5. A new cell membrane forms to produce two new cells, each with two chromosomes from the initial group of four.
6. Each of these two new cells undergoes another cell division such that each of the four resulting cells, the gametes, receives just one chromosome from each initial group of four, consequently, when one type of gamete (e.g., a sperm) combines with the other type (e.g., an egg), the original number of chromosomes is restored.

Chromosome Theory of Inheritance

1. Chromosomes contain the hereditary instructions.
2. Transmission of the hereditary instructions from one "parent" body cell to its "offspring" cells takes place during mitosis when the dividing cell duplicates its chromosomes and passes one complete set to each new cell.
3. The sperm and eggs of sexually reproducing organisms are produced by meiosis; hence they contain only half of the normal number of chromosomes.
4. Transmission of the hereditary instructions from adult sexually reproducing organisms takes place when a sperm enters an egg (fertilization) to produce a zygote with one complete set of chromosomes.

Mendel's Theory of Inheritance

1. Tiny "particles" called genes serve as "instructions" that guide the development of heritable characteristics.
2. Genes are passed unchanged from parent to offspring in sperm and egg cells.
3. In all cells, except sperm and eggs, individuals have at least one pair of genes for each observable characteristic.
4. During sperm and egg cell formation, paired genes separate. Each sperm or egg cell receives one gene of each pair. There is an equal chance that a sperm or egg cell will receive one or the other of the paired genes.
5. During sperm and egg production, the paired genes assort independently.
6. Paired genes that separate during sperm and egg production recombine randomly during fertilization.

7. One gene of a pair dominates the other so that it alone guides development of the observable characteristic (dominant/recessive).

Cell Differentiation Theory

1. The hereditary instructions in the cell's nucleus guide embryonic development.
2. The hereditary instructions initiate a series of changes in the newly fertilized egg to produce differentiated cytoplasm (i.e., cytoplasm that differs from one region to another).
3. The degree of cytoplasmic differentiation varies from species to species.
4. As cell division occurs, the hereditary instructions duplicate so that identical instructions pass from a parent cell to each offspring cell.
5. Each cell division splits the parent cell's cytoplasm into two regions, each with its own differentiated cytoplasm.
6. The differentiated cytoplasm of each offspring cell somehow modifies, but does not destroy, the hereditary instructions.
7. The modified hereditary instructions produce cells with different characteristics in different embryonic regions (i.e., cell differentiation occurs).

Atomic Molecular Theory

1. Matter consists of small particles called atoms.
2. Atoms consist of three types of subatomic particles called protons, neutrons, and electrons.
3. Positively charged protons and uncharged neutrons are located in the atomic nucleus, while much smaller and negatively charged electrons rapidly orbit the nucleus.
4. Kinds of atoms differ from one another depending on their numbers of protons, neutrons and electrons.
5. An atom or molecule with excess electrons is called a negative ion. A positive ion has lost one or more electrons.
6. Atoms of a particular kind with varying numbers of neutrons are called isotopes.
7. Atoms may form connections (i.e., bonds) with other atoms due to forces of attraction. Bonded atoms are called molecules.
8. Whether a material is a solid, liquid, or gas depends primarily on the distances separating its atoms or molecules and the rate at which the atoms/molecules move relative to one another.

III. BASIC THEORIES OF EVOLUTION AND SPECIATION

Darwin's Evolution Theory

1. All life evolved from one relatively simple kind of organism.
2. Each kind of organism (each species), past or present, arose from another kind that preceded it in time.
3. Evolutionary changes occur gradually and over long periods of time.
4. Each species originated in a single area.
5. Over long periods of time, more and more related groups of organisms arose by a continuation of the same evolutionary process.
6. The greater the similarity between two groups of organisms, the closer is their relationship and the more recent is their common ancestral group.
7. Elimination of old kinds occurs due to competition with new kinds or due to environmental change.

The Darwin/Wallace Theory of Natural Selection

1. Populations have the potential to rapidly increase in numbers from one generation to the next.
2. In the short run, the number of individuals within populations remains fairly constant because the environment limits population growth.

3. Individuals within populations are not all the same; they exhibit variations in their characteristics.
4. There is a struggle for survival so that individuals having favorable variations will survive to produce more offspring than those with unfavorable variations.
5. Some of the variations responsible for differential survival and reproduction are passed from parent to offspring (i.e., are heritable).
6. The environments of many organisms have been changing throughout geologic time.
7. Natural selection causes the accumulation of favorable variations and the loss of unfavorable variations.

Synthetic Evolution Theory

1. Each species has an isolated set of genes (a gene pool).
2. Evolution is defined as the change of gene frequencies in the gene pool of a species or sub-species.
3. Individuals contain only a portion of the genes in its species gene pool and the portion is different for each individual.
4. The particular combination of genes in a sexually reproducing individual is the result of the combination of genes from its parents, recombination of its own genes, and genetic mutation.
5. Initial separation that restricts gene exchange between sub-populations is essential for the sub-populations to begin evolving into new species.
6. Changes in gene frequency are the result of natural selection, migration, and non-directional changes such as genetic drift and mutation.
7. Evolution may involve the change of a particular species across time (phyletic speciation), or an increase in the number of species (divergent speciation, adaptive radiation).
8. Speciation is complete when variations among the evolving populations are large enough so that gene exchange cannot occur even if individuals of the populations meet.

Recapitulation Theory

1. Embryos of different species from a taxonomic group resemble one another because they are related evolutionarily.
2. The more closely related two species are in terms of their evolutionary history, the more closely their embryos resemble each other.
3. Embryos resemble one another more closely in early development than in later development because the embryos of later species pass through stages that "retrace" their ancestor's evolution. For example, embryos of evolutionarily later mammals pass through stages that resemble the embryos of evolutionarily earlier species (i.e., fish, amphibians, reptiles, in that ascending order).

Biological Classification Theory

1. A species is a kind of organism defined as a group of organisms that share enough characteristics so that they can mate and produce fertile offspring.
2. Classification schemes represent the evolutionary history of the species considered.
3. The more characteristics shared by two groups the more closely they are related to each other and to a common ancestor.
4. Organisms can be subdivided into increasingly smaller and smaller groups with more and more characteristics in common. The larger groups are called kingdoms, and the smallest groups are called species.

Chemosynthesis Theory

1. The primitive Earth's atmosphere consisted of small inorganic molecules such as H_2O, CO_2, CO, N_2, N_2S, NH_3, H_2, HCN and CH_4, but not O_2.
2. Energy inputs from solar radiation, lightning, and the Earth's heat caused the small molecules to spontaneously combine to form larger, more-complex "building block" molecules such as amino acids, monosaccharides, fatty acids, and nitrogenous bases, which then accumulated in the early oceans.
3. Sunlight shining on small bodies of water caused water evaporation and further concentration and linkage of the building block molecules into long chains-like molecules (i.e., proteins, carbohydrates, lipids, and nucleic acids).
4. Small coacervate spheres made of complex molecular aggregates formed and absorbed still more molecules, thus increased in size and eventually broke apart to form additional spheres.
5. The small, replicating coacervate spheres increased in complexity to become the first living cells.

A Theory of Life

1. Living and nonliving things alike are composed of atoms and molecules that are controlled by physical forces.
2. Living things (organisms) are distinguished from nonliving things by: a) their ability to grow, develop, reproduce, and die, b) their molecularly complexity and need for energy to sustain that complexity, c) their ability to change across generations; d) their sets of instructions (i.e., genes) that guide their activities, e) their responsiveness to environmental stimuli, and f) their organization into one or more normally tiny compartments called cells.
3. Intermediate entities, such as viruses, exist that possess some, but not all, of the characteristics of living things.

Infectious Disease Theory

1. An infectious disease is any condition that adversely affects the normal structure and function of an organism caused by some kind of microorganism.
2. Each infectious disease is caused by a specific kind of microorganism.
3. The diseased organism's symptoms are due to the growth of the microorganism's population or other activities of that population inside the diseased organism's body (e.g., the production of poisons).
4. Infectious diseases are transmitted directly from one organism to another or indirectly by ingesting spores (dormant resting cells) that the microorganism has deposited in the environment.

Biological Decomposition Theory

1. Several kinds of eubacteria (and molds and fungi) produce spores that exist inside living organisms and in the environment.
2. When organisms die, the spores (or the eubacteria themselves) come in contact with the dead body and become active, thus begin to absorb the organic molecules of the dead body.
3. Given favorable environmental conditions, the eubacteria begin to reproduce and their populations grow.
4. The result of this process, known as biological decomposition, is that the larger organic molecules in the dead bodies are broken down into smaller inorganic molecules, which are then deposited in the environment. These inorganic molecules can then support a new generation of plants.

A Theory of the Origin of Eukaryotic Cells

1. As prokaryotic cells increased in size over time, their cell membranes folded inward to increase cell surface area.

2. An increase in surface area was necessary to allow continued effective molecular exchange with the surroundings.
3. Eventually infolding and pinching off resulted in a number of internal membrane-bound structures (i.e., organelles) and membrane-filled regions that became sites for specific cellular functions (e.g., digesting food, collecting wastes, holding genetic material).
4. Some organelles, such as chloroplasts and mitochondria, arose when larger prokaryotic cells engulfed tiny bacteria (i.e., cyanobacteria, eubacteria). The engulfed bacteria were not digested. Instead, to the evolutionary benefit of both the smaller and larger cells, the smaller prokaryotic cells became organelles within the larger cells.

IV. BEHAVIORAL AND ECOLOGICAL THEORIES

Ecosystem Theory

1. Biological communities consist of interacting populations in which energy enters and exits the community and inorganic molecules are cycled between the community and its abiotic environment.
2. An *ecosystem* consists of the biological community, its abiotic environment, and all their interactions in the particular area being considered.
3. The communities' producers absorb relatively small inorganic molecules from the environment and with the use of solar energy synthesize complex organic molecules that are then used as a food energy source during plant respiration.
4. Food energy is distributed to other populations in the community (the consumers and decomposers) through many links in food chains and food webs.
5. Respiration of individuals at each feeding level converts useable food energy into non-useable heat energy, thus less and less useable food energy is available at progressively higher levels limiting the length of food chains.
6. Excretion and decomposition return inorganic molecules to the environment for absorption and reuse by producers.

Population Growth Theory

1. Environments present populations with a range of environmental conditions.
2. Generally too little or too much of an abiotic environmental factor (e.g., too cold/too hot, too dry/too wet, too little salt/too much salt) adversely affects individual survival, and hence limits population growth. Optimum ranges of abiotic environmental factors exist.
3. Small populations in favorable environments grow rapidly and soon reach their natural rate of increase (biotic potential).
4. Growth continues until competition for resources and/or some effect of the environment, such as disease, reduces birth rate and increases death rate.
5. Population growth stops when birth rate equals death rate.
6. Population growth in a limited environment constantly changes that environment.
7. If environments adversely change and/or necessary raw materials and energy are not available, populations will crash.

Competitive Exclusion Theory

1. When direct competition between individuals occurs to fill a particular niche, one of the species will have an advantage.
2. The species with the advantage will eventually win and fill the niche.
3. The loser will either have to change (via natural selection) to fill another niche or it will become extinct, i.e., competition leads one way or the other to the "exclusion" of the competitors.
4. Thus, natural selection reduces direct competition by producing distinct species that fill distinctly different niches. When direct competition between individuals of two species occurs to fill a particular niche, one of the species
5. As a result, stable communities contain one species per niche with little or no direct competition between species.

Cropping Theory

1. Predation limits prey population sizes, thus reduces competition among prey species.
2. Reduced competition among prey species (i.e., inter-specific competitions) reduces competitive exclusions, thus increases the number of prey species living in a biological community.
3. Increased prey species diversity produces greater predator specialization and predator diversity.
4. Greater predator diversity in turn keeps prey species numbers down, and so on in a “feedback loop” that increases community diversity.

Succession Theory

1. Species with the proper migratory and adaptive characteristics colonize a new or disturbed area and begin to modify the environment.
2. Some succession changes occur because species alter the environment in ways that make it less favorable to themselves and more favorable for other species.
3. Competition among species and existing abiotic conditions may also determine which species persist and which decline or disappear.
4. Competition and stable climatic conditions favor certain species that do not modify the environment and reproduce in such a way that a climax community ultimately forms.
5. In general, as succession progresses food web complexity, species diversity, primary productivity increase up to a point, until the ratio of primary productivity to community respiration decreases to approximately one.
6. Food web complexity, species diversity, and primary productivity drop in later succession stages as relatively few plant types dominate the community, crowd out others and lock up nutrients.
7. General climate and local environmental conditions determine the nature of the climax community (e.g., desert, grassland, forest) in any particular area.

V. THEORIES OF PLANT STRUCTURE AND FUNCTION

Osmosis-Pull Theory of Water Rise in Vascular Plants

1. Water molecules evaporate from leaf cells and escape to the outside though tiny holes called stomata. This process called transpiration increases the osmotic concentration inside leaf cells.
2. Due to this increased osmotic concentration, water molecules from the leaf xylem move into the leaf cells via osmosis.
3. The tension created then pulls on the water column in the leaf xylem.
4. The leaf water column then pulls upward on the stem water column, which then pulls on the root column.
5. Water moves into the roots and root xylem primarily due to osmosis.

Theory of Stomata Opening and Closing

1. Land plants regulate water loss by opening and closing their stomata, through which water and gases pass.
2. Due to thickened inner walls of guard cells, stomata open when the guard cells take in water and expand.
3. Guard cells actively pump in potassium ions. This increase in potassium ion concentration then causes water to move in, via osmosis, and the cells to expand.
4. To close a stoma, the guard cells stop pumping in potassium ions. Thus, the ions passively diffuse out lowering internal osmotic pressure. Water then flows out via osmosis, the guard cells contract and the stoma closes.
5. Negatively charged chloride ions also move in and out of the guard cells due to their attraction to the positively charged potassium ions The changing chloride ion concentration also contributes to osmotic concentration changes, to guard cell expansion and contraction, and to stoma opening and closing.

Phototropism Theory

1. Unidirectional light causes a movement of auxin molecules from tip cells to the shaded side of growing plants.
2. The auxin molecules then move down the shaded side of the plant stem.
3. When the auxin molecules reach specific target cells, they stimulate the cells to elongate, possibly by weakening the cellulose fibers in their cell walls, thus the plant bends towards the light.

Flowering Theory
1. Flowering plants synchronize flowering with others of their species to encourage cross-fertilization and insure that seeds are produced at environmentally appropriate times.
2. Flowering in many plants is triggered by changes in photoperiod.
3. Leaf cells contain phytochrome molecules that respond to changes in photoperiod to somehow cause release of a flower-inducing hormone called florigen.
4. Once released, florigen diffuses throughout the plant.
5. When florigen reaches specific target cells, it stimulates the cells to divide, grow, and differentiate into flowers.

VI. THEORIES OF ANIMAL STRUCTURE AND FUNCTION

Harvey's Circulation Theory
1. Blood moves in circular patterns (i.e., circulates) continuously due to contractions (pumping) of the heart.
2. The heart contains one-way valves. Thus, circulating blood passes from the heart's lower-right chamber (**right ventricle**) to the lungs (via the pulmonary **arteries**), then back to the heart's upper-left chamber (**left atrium**), via the pulmonary **veins**, and then into the heart's lower-left chamber (**left ventricle**).
3. From the left ventricle, blood is forced into the **aorta** and through its branches and sub-branches to all parts of the body except the lungs.
4. From the arteries' smallest branches, blood flows through tiny unseen vessels (**capillaries)** into the smallest veins.
5. The veins contain one-way valves to prevent backward blood flow. Thus, due to contractions of nearby muscles, blood is squeezed from the smallest veins into larger and larger veins into the largest veins (the superior vena cava and inferior vena cava) and then into the heart's upper-right chamber (**right atrium**).
6. The heart's right atrium then periodically forces blood into the right ventricle.

Theory of Animal Heat
1. Blood carries oxygen molecules from the lungs and food molecules from the digestive tract to body cells.
2. The oxygen and food molecules enter the body cells where they interact in ways that cause the carbon, hydrogen and oxygen atoms in food to separate and produce carbon dioxide and water molecules - a process known as combustion.
3. During the combustion process, motion is somehow released from the interacting molecules.
4. The released motion is then used in ways that keep the molecules, the cells, the tissues, the organs and the whole organism itself moving, alive and warm.

Digestion Theory
1. Food consists of relatively large molecules that must be broken apart into molecules small enough to enter the blood stream for distribution to the body cells.
2. Food breakdown occurs due to both mechanical processes (i.e., chewing by teeth, churning and mixing by digestive tract muscles) and chemical processes (i.e., chemicals from stomach, liver, and pancreas).
3. Mechanical movements and the production and release of digestive chemicals are under both nerve and hormone control.

4. Absorption of food molecules takes place primarily in the small intestine; the large intestine absorbs water prior to the elimination of non-digestible feces.
5. Once the food molecules arrive at the body cells, they enter the cells, as does oxygen delivered from the lungs.
6. When food and oxygen molecules enter body cells they interact in a way that further breaks them apart. This combustion (i.e., cellular respiration/oxidation) process produces waste molecules, such as carbon dioxide and water, and to "release" motion/energy.
7. Waste molecules enter the blood stream for eventual elimination; while the body cells use the "released" motion/energy to carry out their activities and remain alive.

Excretion Theory

1. The combustion/oxidation of food molecules inside living cells supplies the body with needed motion/energy, but also produces wastes (carbon dioxide, water, and toxic nitrogen-containing molecules).
2. Carbon dioxide molecules diffuse out of cells into blood vessels that carry them to the lungs where the molecules then diffuse from the vessels to the air for elimination as the animal exhales.
3. The wastewater and nitrogen-containing molecules diffuse into blood vessels, which then carry them to capillaries inside Bowman's capsules, inside kidneys.
4. The nitrogen-containing molecules diffuse from the capillaries into the Bowman's capsules, through the loops of Henle and eventually to the urinary bladder for temporary storage prior to periodic elimination as urine.
5. Blood pressure forces water and other relatively small materials (e.g., NaCl, glucose, amino acids) to pass from the capillaries into Bowman's capsules.
6. Diffusion, osmosis and active transport act so that most of these materials are not excreted. Instead they are reabsorbed into the blood stream as they pass through loops of Henle.

Theory of Heart-Rate Regulation

1. Increased muscle activity increases the amount of CO_2 in muscle cells.
2. CO_2 passes out of muscle cells and increases the amount of CO_2 in the blood stream.
3. CO_2 combines with H_2O in the blood to produce carbonic acid (H_2CO_3), which splits to form hydrogen ions (H^+) and bicarbonate ions (HCO_3^-).
4. Increased numbers of hydrogen ions are sensed by cells in the aorta arch and carotid sinus, which in turn send electrical signals to the cardio-accelerator center in the brain stem.
5. The center then sends signals to the heart, which causes it to beat more rapidly and pump more blood to the lungs where CO_2 escapes.
6. The resulting drop in blood CO_2 level causes a drop in hydrogen ion concentration, which has an opposite effect on heart rate via a cardio-inhibitory center in the brain stem.

Nerve Impulse Theory

1. A non-conducting neuron actively maintains an uneven distribution of electrical charge across its membrane, thus is like a set mousetrap.
2. The uneven charge is due to active pumping of sodium ions out of the axon and potassium ions in. The membrane's potassium channels are left open so the potassium ions diffuse out while large negatively charged molecules remain in.
3. When stimulated, the membrane opens its sodium channels in one area allowing sodium ions to rush in - the set mouse trap snaps shut. This initiates the impulse.
4. The impulse travels down a neuron fiber due to the successive openings of sodium channels.
5. The sodium channels close behind the impulse allowing the cell to restore its initial uneven distribution of charges.

Synaptic Transmission Theory

1. Neural impulses pass from cell to cell across both electrical and chemical synapses.
2. Impulses pass directly across electrical synapses through tiny channels called gap junctions.
3. When an impulse stimulates a chemical synapse, its enlarged end (a synaptic knob) releases small packets (vesicles) of chemicals (neurotransmitters).
4. The neurotransmitters diffuse across the synapse and stimulate the post-synaptic cell to initiate an impulse.

Sliding-Filament Theory

1. Muscles contract due to shortening of their cells.
2. Muscle cells contain bundle upon bundle of overlapping thick and thin filaments. The thin filaments are connected to tiny "walls."
3. When stimulated, motion in the thick filaments causes the thin filaments to slid past pulling the "walls" behind them and shortening the cells.
4. Motion of the thick filaments comes from breaking apart molecules of ATP in a complex and not yet completely understood way. Note: A contracted muscle lengthens due to the contraction of its opposing muscle, which is attached to the opposite side of its bone.

Sensory-Processing Theory

1. External stimuli cause sense receptors (e.g., eyes, ears, taste buds) to initiate impulses that pass along neurons to the brain and/or spinal cord.
2. Upon reaching the brain, neural impulses travel to specific areas of the brain where they stimulate specific neurons to fire.
3. Different brain areas respond to different sorts of stimuli, some to specific features, some to larger patterns of features, and some to spatial relationships among the patterns.
4. Thus, perception of an entire scene requires the coordination of inputs to several brain areas to allow the "construction" of the scene.

Cellular-Level Learning Theory

1. Impulses traveling down axons stimulate the release of neurotransmitter molecules from their synaptic knobs, which then diffuse across synapses.
2. Post-synaptic neurons fire if and only if a sufficient amount of neurotransmitter is released.
3. When impulses reach a synapse where the post-synaptic neuron is already firing, the pre-synaptic knob is stimulated to increase its production and release of neurotransmitter.
4. The increase in neurotransmitter produced and released might be enough to cause subsequent impulses to stimulate an otherwise non-firing post-synaptic neuron to fire, hence create a new functional connection, that is the network learns and forms a new "memory."

VII. ATOMIC AND MOLECULAR LEVEL THEORIES

Kinetic-Molecular Theory

1. Matter consists of small particles (atoms and combinations of bonded atoms called molecules) and light, which appears at times to consist of still smaller weightless particles called photons.
2. Moving matter can strike other pieces of matter and transfer some/all of its motion (kinetic energy) to the other pieces.
3. Photons can interact with electrons and cause them to move more rapidly. Photons may also be "released" from electrons, which results in a reduction in the motion of the electrons.
4. Atoms and molecules contain several forms of stored motion (potential energy) such as nuclear, electrical, chemical and radiant energy.
5. Given enough activation energy, forms of potential energy may be released, e.g., molecular bonds that store potential chemical energy can be broken causing the atoms to move apart, which in turn can cause collisions and the breaking of more molecular bonds, or perhaps the formation of new molecular bonds.

6. Energy can neither be created nor destroyed, thus energy transfers do not result in changes in energy amounts.

Photosynthesis Theory

1. Photosynthesis consists of two sets of reactions - one set requires light, the light-dependent reactions; the other set does not, the light-independent reactions.
2. The light-dependent reactions occur in the thylakoids in chloroplasts when photons interact with electrons of chlorophyll molecules and cause them to move more rapidly, jump to higher atomic orbits and the escape into nearby molecules.
3. Electron transfers result in the splitting of H_2O molecules to produce O_2 molecules and H^+ ions. In the process, ADP is converted to ATP and NADP to NADPH.
4. The light-independent reactions (including the Calvin cycle), which occur in the chloroplasts outside the thylakoids, combine several CO_2 molecules and several H^+ ions to produce large molecules such as glucose ($C_6H_{12}O_6$), and in the process reconvert ATP to ADP and NADPH to NADP.
5. Most of the CO_2 used during the light-independent reactions comes from air, but some comes from cellular respiration inside the plant cell.
6. Most of the O_2 produced during the light-dependent reactions diffuses to the air, but some is used inside the plant cell in cellular respiration.

Theory of Fermentation and Cellular Respiration

1. Fermentation and cellular respiration are processes that take place inside cells and involve the breakdown of "food" molecules such as glucose, in which the chemical energy stored in their molecular bonds is released to provide the kinetic energy needed to produce adenosine tri-phosphate (ATP) molecules.
2. When oxygen is not present, the breakdown of glucose results in two 3-carbon pyruvic acid molecules and then either alcohol or lactic acid molecules - a process called fermentation. Two ATP molecules are produced for every one glucose molecule broken down.
3. When oxygen molecules are present, the two pyruvic acid molecules enter mitochondria where they are broken down further in a series of steps (the Krebs cycle and electron transport chain) that result in the formation of some 21 to 36 ATP molecules, six CO_2 molecules and six H_2O molecules.
4. Excess CO_2, H_2O, alcohol, lactic acid, and nitrogen-containing molecules produced during fermentation or cellular respiration diffuse out of cells as waste products.
5. ATP molecules produced during fermentation and cellular respiration diffuse to cell locations where they become an energy source for various jobs (e.g., muscle contraction).

Watson and Crick's Theory of DNA Structure and Replication

1. Deoxyribonucleic acid (DNA) consists of a two-stranded spiral helix (i.e., a twisted ladder) in which the strands consist of alternating deoxyribose and phosphate parts.
2. The ladder's rungs consist of adenine-thymine pairs (A-T) and guanine-cytosine pairs (G-C). These pairs link to the deoxyribose parts of the two strands.
3. The rungs may be in any sequence along the two-stranded spiral helix and may be positioned A-T, T-A, C-G, or G-C.
4. When DNA replicates, the A-T pair and the G-C pair separate, permitting the two strands to uncoil and separate.
5. As the strands separate, new parts (i.e., new nucleotides) containing T's, A's, C's and G's bond sequentially with the exposed A's, T's, G's and C's in each strand.
6. As the bonding continues, deoxyriboses attach to phosphates, thus form two new strands; each new strand then coils with its original strand to produce two two-stranded DNA molecules.

Protein Synthesis Theory

1. Instructions for synthesizing proteins are contained in sequences of A's, T's, G's and C's in DNA.

2. A strand of messenger ribonucleic acid (mRNA) forms in a nucleus complementary to an unwound DNA strand.
3. The mRNA strand diffuses to the cytoplasm where it bonds to one or more ribosomes.
4. Transfer RNAs, one or more for each kind of amino acid, form in the nucleus and also diffuse to the cytoplasm.
5. Amino acids in the cytoplasm bond to specific tRNAs.
6. Transfer RNAs and their bonded amino acids then move to ribosomes (which are bonded to the mRNA strand) and bond to the mRNA.
7. While in this position, each amino acid bonds to the preceding amino acid.
8. As the ribosome moves along the mRNA strand, tRNAs bring in additional amino acids, so protein synthesis is a sequential, linear process.

Scientific “Habits of Mind”

1. When someone claims that A causes B, or when something puzzling occurs for some unknown reason, be certain that you understand what is claimed or what has occurred that needs to be explained. In other words, clearly identify and state the *causal question.*

2. Brainstorm, by talking to yourself and with others, one or more possible explanations (i.e., *hypotheses or theories*) - the more the better, as the "correct" explanation may not easily come to mind. Also keep in mind that the puzzling observation in question may have multiple causes or may occur only given specific combinations of potential causes.

3. Before accepting or rejecting any of the alternative explanations, seek evidence to test them. The evidence may be circumstantial, correlational or experimental in nature.

4. To test the alternatives, first rank them in order of most likely to least likely and try to test them in that order. Keep in mind that testing requires assuming for the time being that the alternative is correct and trying to derive some specific test condition that leads to one or more specific *predictions* (expected results).

5. Talk to others and do some further reading to see if such predictions have in fact been found. You may even need to conduct your own test and gather its *observed results* to compare with the predictions.

6. Draw *conclusion(s)* about the relative truth of falsity of the tested alternative explanations in terms how well the observed results match your predictions and the adequacy of the test conditions (e.g., was the sample sufficiently large and representative? Were important independent variables controlled in the experiment so that alternative explanations can be ruled out?)

7. Recycle the above procedure until all of the reasonable alternatives and combinations of alternatives have been tested. Also keep in mind that causal claims are not proven true or false beyond any doubt - only beyond a reasonable doubt.