Biology 20 Exam Review – Units 1 and 2

1. Define an open and a closed system.
2. What are the components of the biosphere?
3. What gases make up the atmosphere? Their percentages?
4. Describe three factors that affect the amount of heat found on different parts of the world.
5. What are the formulas for cellular respiration and photosynthesis?
6. What is acid rain and how is it caused? How can we reduce the damage and the amounts of acid rain?
7. Name the biogeochemical cycles and draw a diagram of each.
8. How have people modified the carbon cycle? Describe in terms of sinks, and fast/slow cycling.
9. Describe three natural ways to get nitrates and nitrites into the soil. Describe one negative method that removes nitrates and nitrites.
10. What is an algae bloom? What do they lead to?
11. Why is water the universal solvent? Be specific.
12. What is hydrogen bonding?
13. What biogeochemical cycles do bacteria play a role in?
14. Identify three ways phosphorus is used in plants and animals?
15. Explain why energy is said to 'flow' and matter is said to 'cycle' on Earth.
16. What is an ecosystem?
17. What is productivity?
18. How are stromatolites used in understanding our world?
19. Describe the Gaia Hypothesis.
20. How does phytoremediation work?
21. Define heterotroph and autotroph.
22. Between individuals and biomes there are other terms to describe levels of organization of the natural world. List them in order.
23. Why are decomposers important?
24. What is the difference between a food chain and a food web?
25. Draw a simple food chain. Label consumer levels, trophic levels, and the types of consumers.
26. Describe the energy differences between the different levels.
27. What are the two laws of thermodynamics? How do they affect the shape of a food pyramid?
28. List and describe the three different types of ecological pyramids.
29. List and describe three ways that we have significantly interfered with ecological pyramids.
30. Respond to the following statement: 'The processes of photosynthesis and cellular respiration maintain a balance in the biosphere.' Do you agree? Disagree?
31. Describe chemosynthesis and state its equation.
32. Describe the three different types of adaptations and give several examples of each.
33. In order, describe Darwin's theory of Natural Selection.
34. Discuss the difference between Darwin's beliefs and Lamarck's beliefs. Use an example to help explain each theory.
35. What is the difference between homologous and analogous structures. Give several examples of each.
36. What is Pangaea? Give three forms of evidence to support the existence of Pangaea. (Think lines of evidence for evolution).
37. What is a definition for adaptation?
38. List in order the classification scheme we use today. Identify the six kingdoms.
39. What are the domains? Which kingdoms fit under each domain?

40. For each of the six kingdoms, identify: prokaryotic or eukaryotic, # of cells, method of reproduction, method of energy/food intake (auto- or heterotrophs?), mobility, and a few examples of organisms.
41. What is a limiting factor in an environment? Give examples.
42. What contributions did Lyell, Cuvier and Buffon make to evolutionary theory?

Photosynthesis Review

1. What is the primary function of photosynthesis?
2. Draw the electromagnetic radiation spectrum.
3. State the formula for photosynthesis.
4. What types of organisms can photosynthesize?
5. Define chlorophyll and describe its' location in a plant.
6. What is an absorption spectra? What wavelengths are absorbed by which pigments?
7. Draw and label a chloroplast.
8. Identify and describe the function of other cell organelles found in plants.
9. Identify and describe the function of other cell organelles found only in animals.
10. List in order the reactions of photosynthesis.
11. Where do the different reactions of photosynthesis take place? Be specific.
12. Draw a summary diagram linking the products and reactants of the two major cycles in photosynthesis. (hint, use a chloroplast as the boundary)
13. What is phosphorylation? Dephosphorylation?
14. Diagram and/or describe the steps in the light dependent stage of photosynthesis.
15. Diagram and/or describe the steps in the light independent stage of photosynthesis.
16. Explain the process of the electron transport chain and ATP synthesis/chemiosmosis.
17. What is oxidation? Reduction? How are these reactions important in photosynthesis?
18. What factors would affect photosynthesis? Can you describe a way to speed it up/slow it down?
19. What is the primary function of photosynthesis?
20. How many molecules of carbon dioxide must enter the Calvin cycle for a glucose molecule to be produced?

Cellular Respiration Review

1. What is the primary function of cellular respiration?
2. What types of cellular activities require energy?
3. How does a cell transport material across it's' membrane? (there are four ways)
4. What type of energy is stored in glucose and other compounds?
5. Identify the two types of cellular respiration.
6. List, in order, the steps of each type of cellular respiration (hint: first step is same).
7. Summarize glycolysis using a diagram.
8. What organelle does cell respiration occur in? Draw and label a diagram.
9. Show the pyruvate oxidation reaction, including the role of coenzyme A.
10. Draw the Krebs cycle. Summarize the key features of the cycle.
11. Explain the process of the electron transport chain and ATP synthesis/chemiosmosis.
12. How could you interfere with cellular respiration?

13. Draw an aerobic respiration energy tally → how many ATP are used/produced and at what stages.
14. What is fermentation? How do we use this in our daily lives?
15. What is the difference between lactic acid fermentation and alcohol fermentation?
16. Draw a summarizing diagram that shows the major steps in photosynthesis and cellular respiration and the molecules that link these two processes.

Human Systems Review

Digestive System

1. Provide an example of each level of cellular organization: cell, tissue, organ, organism.
2. What are the essential nutrients (macromolecules) that must be in very diet?
3. Complete the following table:

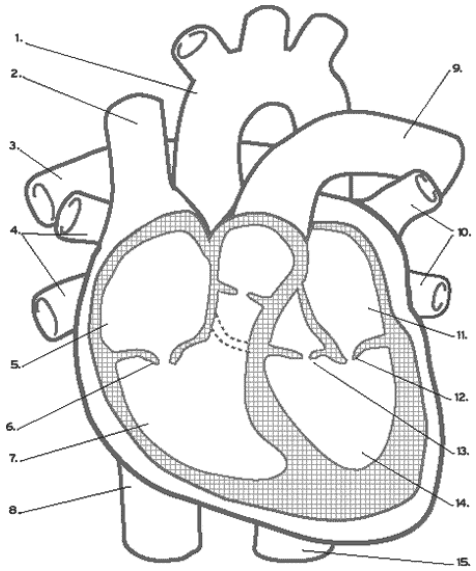
Nutrient	Components after Digestion	Use by the body
protein		
		coenzymes: assist enzymes to bind substrates
	fatty acid + glycerol	
di- and polysaccharides		
		genetic material that directs cell activity
water		

4. What are the factors that affect enzymes? How do you speed up or slow down an enzymes function?
5. Describe and draw the formation of an enzyme with its substrate → ES complex → products and enzyme.
6. What is the difference between a coenzyme and a cofactor?
7. How is enzyme functioning regulated?
8. What is hydrolysis?
9. What is a polymer?
10. What happens to carbohydrates that are not immediately used by the body?
11. Describe lipids
    a. their structure,
    b. the difference between saturated and unsaturated
    c. their function in your body (including membranes)
12. Describe proteins
    a. The basic amino acid structure
    b. Structure of peptides, polypeptides, and proteins
    c. Role in the body
    d. Type of bonding
    e. Denaturation and coagulation
13. State the four components of the digestive process/
14. Sketch a diagram of the human digestive system, including the accessory organs.
    a. Salivary glands
    b. Teeth
    c. Oesophagus
    d. Stomach
    e. Small intestine
    f. Pancreas
    g. Liver
    h. Gallbladder
    i. Large intestine
    j. Rectum & anus

15. For each of the above organs, describe the role they play in digestion. Be specific, including what types of nutrients they digest and any enzymes or secretions they produce.
16. Explain where bile is produced and how it's released.
17. Are nutrients absorbed passively or actively in the digestive tract? Where are the carbs, amino acids and fats absorbed?
18. How do hormones help regulate digestion?
19. What are some disorders of the digestive system? What are the symptoms?

<u>The Heart, Blood, Lymph and Circulation</u>

1. Name four key functions of the circulatory system?
2. List the types of blood vessels found in the circulatory system. For each:
    a. Write a definition
    b. Describe the thickness/thinness of the vessel
    c. Rank based on diameter
3. Describe the following terms:
    a. Vasoconstriction (provide an example)
    b. Vasodilation (provide an example)
    c. Atherosclerosis
    d. Aneurysm
4. What causes a pulse?
5. Fluid pressure is very low in veins. Explain how blood gets back to the heart.
6. What are the functions of capillaries?
7. Label the diagram of the heart.
8. Name the primary function of each of the three circulatory systems in the human body.
9. Describe key structural features of the following:
    a. septum
    b. atria (plural)
    c. ventricles
    d. atrioventricular valves
    e. semilunar valves
    f. superior and inferior vena cava
    g. pulmonary arteries
    h. pulmonary veins
    i. aorta
    j. coronary arteries



10. What is angina and what causes it?
11. What is a coronary bypass and why is it performed?
12. Describe the role of the following in a heart beat:
    a. Sinoatrial node
    b. Atrioventricular node
    c. Purkinje fibres
    d. Myogenic muscle
13. What is the difference between the sympathetic and para-sympathetic nervous systems? How do they affect your heart rate?
14. Describe how the *lubb-dubb* sound of your heart is made.
15. Explain what the terms diastole and systole mean. Indicate what the average values are.
16. Explain the relationship between cardiac output, stroke volume and heart health.
17. What is the name of the instrument used to measure blood pressure? What instrument is used to graph a heart beat?
18. Rank in order from most to least the pressure found in the different types of blood vessels. (Hint, there are 5 types of vessels)
19. How is blood pressure regulated? What happens when you exercise?

20. All cells exist in a bath of extracellular fluid (a.k.a.: ECF, ECM, interstitial fluid…). Describe how the pressure differences between blood and the ECM facilitates capillary fluid exchange. Use diagrams if that helps.
21. What is lymph?
22. What are lymph vessels and how are they related to the circulatory system?
23. What are lymph nodes and lymphocytes?
24. Blood is made up of plasma, erythrocytes, leukocytes and platelets. State the approximate percentage of each as well as any distinguishing features of the components.
25. What is anaemia?
26. Describe the process of blood clotting in detail, including the different plasma proteins.
27. What is the difference between a thrombus and an embolus?
28. Define:
    a. Antibody
    b. Antigen
    c. Agglutination
29. Fill in the following table:

Blood Group	**Antigen on Erythrocyte**	**Antibody in Serum**	**Can donate to?**	**Can receive from?**
O				
A				
B				
AB				

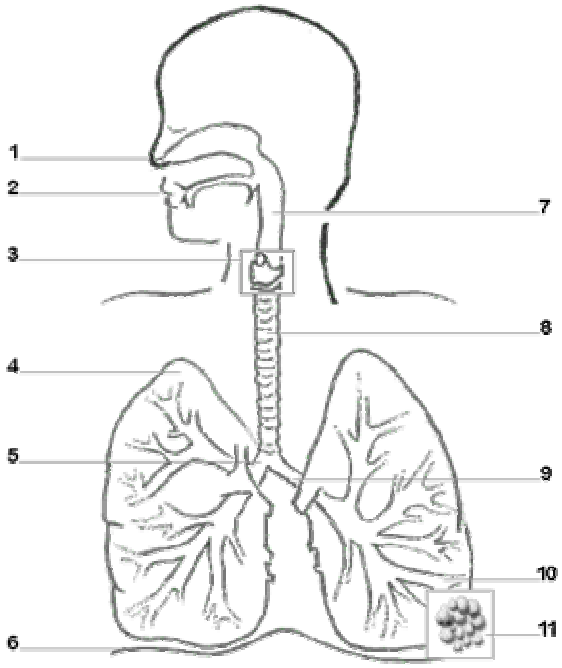
30. What is the rhesus factor? Why is it important for pregnant women to know their type?
31. The skin is the body's first line of defence against invading micro-organisms. The second line of defence is non-specific and involves macrophages and the inflammatory response. Describe how they help the body defend itself.
32. The third line of defence is the immune response. Describe the different types of lymphocytes and how they recognize and fight off invading micro-organisms.
33. How does the immune systems' memory work?
34. How are allergies and organ transplants connected to the immune system?
35. Identify what each of the waves indicates on an ECG. Make a sketch to illustrate.

<u>Muscles</u>

1. Describe the structure of skeletal muscle from the smallest unit (hint: the myofilaments) to the largest (the muscle itself).
2. Compare the size of the actin and myosin myofilaments.
3. Which myofilaments 'slide' in the sliding filament model of muscle contraction?
4. Describe the role of Ca^{2+} in muscle contraction.
5. Identify the role of the following:
    a. Sarcolemma
    b. Sarcoplasm
    c. Sarcoplasmic reticulum
6. What triggers a muscle to contract?
7. Can muscles push? Why or why not?

The Respiratory System

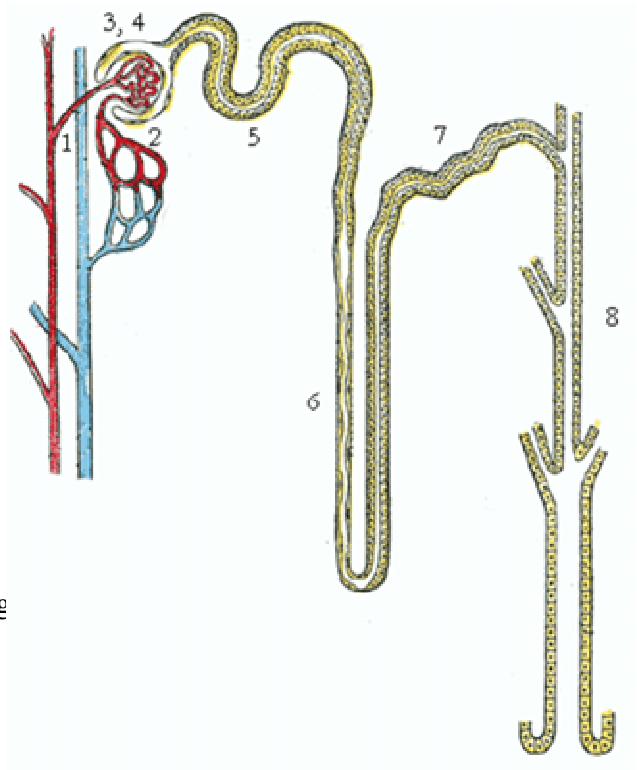
1. What gases make up the air we breathe? What percentage of the air is oxygen?
2. Define and distinguish between breathing and respiration.
3. Label the diagram of the respiratory system.
4. Describe key structural features of the following, and how they are suited to their purpose:
    a. Nasal cavity
    b. Trachea
    c. Cilia
    d. Epiglottis
    e. Larynx
    f. Pharynx
    g. Bronchi (plural)
    h. Bronchioles
    i. Alveoli (plural)
    j. Pleural membrane
    k. Lung
    l. Rib cage
    m. Diaphragm
    n. Intercostal muscles



5. Explain how and why oxygen and carbon dioxide diffuse between the alveoli and the air in the lungs.
6. Describe the changes that occur in the chest during:
    a. Inspiration
    b. Expiration
7. What is bronchitis? Pneumonia? TB? Emphysema? Asthma? Lung cancer? Pneumothorax?
8. Nicotine in cigarette smoke causes blood vessels to narrow. What problems would this cause for the cells of the body?
9. Where is the partial pressure of oxygen the highest? Lowest?
10. Where is the partial pressure of CO_2 the highest? Lowest?
11. How do the answers to 9 and 10 help explain gas exchange in our body?
12. Define and describe the role of haemoglobin in our blood.
13. How is carbon dioxide transported through our blood?
14. How does haemoglobin act as a buffer?
15. What is the function of carbonic anhydrase?
16. What are chemoreceptors and how do they work to regulate breathing?
17. How does the body respond to exercise?
18. Draw a graph showing the tidal volume, inspiratory reserve volume, vital capacity and total lung capacity.
19. Which receptors are more sensitive Oxygen or carbon dioxide receptors?

The Excretory System

1. Many of compounds the body gains energy from are converted into simpler compounds that are toxic to life. Wastes are eliminated by breathing, through the liver, the large intestine and the kidneys. When proteins are broken down deamination occurs. Answer the following:
    a. What is it?
    b. What is the deadly product?
    c. How do we convert it to a safe form?
2. What is uric acid and how is it formed?
3. Draw a diagram of the excretory system and include the following:
    a. Ureters
    b. Urethra
    c. Bladder
    d. Cortex
    e. Medulla
    f. Renal pelvis
4. Label the nephron with the following:
    a. Glomerulus
    b. Peritubular capillaries
    c. Bowman's capsule
    d. Proximal tubule
    e. Loop of Henle
    f. Distal tubule
    g. Collecting ducts
    h. Renal artery
    i. Renal vein
5. State the three stages of urine formation. For each:
    a. Describe in detail how the process works,
    b. including the solutes that are moved across at each stage. (Hint: water only is reabsorbed in the descending loop and salt passively follows up the ascending loop).
6. What is meant by a 'threshold level' of a substance?
7. How does the kidney regulate the body's pH balance?
8. Describe key features of each of the following kidney dysfunctions/treatments:
    a. Diabetes mellitus
    b. Nephritis
    c. Kidney stones
    d. Dialysis
    e. Transplants
9. Draw and label a diagram of the excretory system, including the major blood vessel, tubes and organs involved.
10. Compare the differences and similarities between antidiuretic hormone and aldosterone. Draw a negative feedback loop for each.



The Biology 20–30 program emphasizes the science themes: *change, diversity, energy, equilibrium*, *matter* and *systems* as they relate to biology.

Biology 20 consists of four units of study:
Unit 1: The Biosphere
Unit 2: Energy Flows and Cellular Matter
Unit 3: Energy and Matter Exchange in Ecosystems
Unit 4: Energy and Matter Exchange by the Human Organism.

Unit 1 The Biosphere

Concept 1

The biosphere is maintained by a constant flow of *energy*.

- most of the energy used in the biosphere comes from the Sun and is either stored or reradiated back into space
- explaining how energy storage in the biosphere, as a system, can be visualized as a balance between photosynthetic and cellular respiratory activities
- describing how stored biological energy in the biosphere, as a system, is eventually lost as heat; e.g., muscle heat generation, decomposition, etc.
- measuring the amount of solar radiation in the local area, and comparing this with solar radiation data of other areas of the province and/or the country.
- evaluating the evidence for the influence of ice and snow on the storage of solar energy; i.e., albedo effect, hypothesizing about consequences of fluctuations for biological systems

Concept 2

The cycling of *matter* through the biosphere perpetuates its steady state *equilibrium*.

- specific chemical elements are cycled through the biotic and abiotic components of the biosphere
- summarizing and explaining the biogeochemical cycles for carbon, nitrogen and phosphorous
- explaining how water is cycled through the biosphere along characteristic pathways
- identifying the properties of water and explaining their relevance to the hydrologic cycle; e.g., freezing point, hydrogen bonding, specific heat, density.
- predicting disruptions in nitrogen and phosphorous cycles caused by human activities
- hypothesizing how alterations in the carbon cycle, as a result of the burning of fossil fuels, might influence other cycling phenomena
- discussing the influence of agricultural products or processes on the biogeochemical cycle of phosphorous and nitrogen; e.g., feedlot operations, composting, commercial fertilizer applications

Concept 3

The balance of *energy* and *matter* exchange in the biosphere, as an open *system*, maintains its steady state *equilibrium*.

- air composition is influenced by the activities of organisms
- explaining how the equilibrium between gas exchanges in photosynthesis and cellular respiration influences atmospheric composition
- describing how human activities can have a disrupting influence on the balance, in the biosphere, of photosynthetic and cellular respiratory activities; e.g., fossil fuel combustion, forest destruction.
- predicting the effect of changes in carbon dioxide and oxygen concentration on the atmospheric equilibrium by a significant reduction of photosynthetic organisms through human activities

- designing a model of a closed biological system in equilibrium with respect to carbon dioxide, water and oxygen exchange; e.g., space station, Biosphere II.
- examining the influence of changes to atmospheric ozone levels on society, agriculture, plants and animals

Unit 2 Energy Flows and Cellular Matter

Concept 1

Photosynthesis stores energy in chemical compounds.

- light energy is stored in plants when photosynthesis uses light energy to synthesize carbohydrates
- explaining, in general terms, how pigments absorb light, transfer that energy as reducing power in nicotinamide adenine dinucleotide, reduced form (NADH), and to chemical potential in ATP by chemiosmosis, describing where those processes occur
- explaining, in general terms, how the products of the light reactions, NADH and ATP, are used to reduce carbon in the Calvin–Benson cycle, describing where the process occurs in the cell.
- using chromatography techniques to demonstrate that plant leaves contain a range of pigments
- drawing analogies between the storage of energy by photosynthesis and the storage of energy by active solar generating systems.
- researching and analyzing the effects of herbicides on the biochemistry of photosynthesis

Concept 2

Respiration releases potential *energy* from organic compounds.

- cellular respiration involves the release of stored energy from carbohydrates, as well as other organic molecules,
- explaining, in general terms, how carbohydrates are oxidized by glycolysis and Krebs cycle to produce reducing power in NADH and flavin adenine dinucleotide, reduced form (FADH), and chemical potential in ATP, describing where in the cell those processes occur;
- explaining, in general terms, how chemiosmosis converts the reducing power of NADH and FADH to the chemical potential of ATP, describing where in the cell the process occurs;
- explaining the role of oxygen in cellular respiration; e.g., aerobic, anaerobic
- summarizing and explaining the role of ATP in metabolism; e.g., synthesis, movement, active transport
- explaining how environmental pollutants, like cyanide or hydrogen sulfide, inhibit cellular respiration.
- demonstrating that respiration causes oxidation and an exchange of gases
- drawing analogies between the role of ATP in a cell and money in an economic system
- investigating the action of metabolic toxins, such as hydrogen sulfide, on cellular respiration.
- understanding that potential energy stored in organic compounds is released by cellular metabolic processes, the role of oxygen and ATP, and environmental influences on these processes;
- demonstrating heterotroph gas exchange;
- discussing how specific compounds released into the environment, by society, may have precise metabolic effects on humans, plants and animals, and the desirability of regulating such releases

Unit 3: Energy and Matter Exchange in Ecosystems

Concept 1

The biosphere is composed of a *diversity* of biomes, each with distinctive biotic and abiotic factors.

- the biosphere is composed of biomes, each with many different ecosystems, characterized by physiographic, climatic, edaphic (soil) and biotic factors by:
- describing how energy and matter exchange contribute to the existence of the biosphere's major biomes; e.g., tundra, taiga, deciduous forest, rain forest
- identifying ecosystem biotic and abiotic factors and explaining their influence in an aquatic and a terrestrial ecosystem in a local region; e.g., stream or lake, prairie, boreal forest, vacant lot, sports field.
- performing a field study and measuring, quantitatively, appropriate abiotic factors, such as temperature, precipitation, snow depth, ice thickness, light intensity, pH, hardness and oxygen content in an aquatic and a terrestrial ecosystem; and presenting the data in a form, such as graphs, tables or charts, that describe, in general terms, the abiotic structure of the ecosystem chosen
- performing a field study and gathering and analyzing both quantitative and qualitative data on the diversity of plant, animal and decomposer species in the ecosystem chosen; and presenting the data in a form that describe, in general terms, the biotic structure of the ecosystem chosen
- hypothesizing the ecological role of biotic and abiotic factors; e.g., albedo effect, competition
- evaluating the dependability of resources, including technologies, used for measurement, assessment or analysis; and identifying the degree of bias in a field study.
- evaluating the impact that human activity has had, or could have, on the ecosystems chosen
- analyzing the needs and interests of society that may influence the natural quality of water used for human consumption

Concept 2

Ecosystems have characteristic structures determined by their *energy* and *matter* exchange.

- the structure of ecosystems can be described, by extending from Biology 20, Unit 2, the relationshipbetween photosynthesis and respiration, and by:
- explaining, quantitatively, the structure of ecosystem trophic levels, using models, such as food chains and webs
- explaining, quantitatively, the energy and matter exchange in ecosystems, using models, such as pyramids.
- collecting information and building a model depicting the food web of a chosen ecosystem
- evaluating, quantitatively, the energy and matter exchange in a chosen ecosystem, using a pyramid of mass or numbers
- analyzing data on the diversity of plants, animals and decomposers that make up the biotic component of a specific endangered ecosystem; and predicting the future outcome
- of that ecosystem.
- researching the effect single-crop monoculture has on food webs and species diversity in the ecosystem, and the influence of the needs and interests of society on this practice

Concept 3

Populations are basic components of *ecosystem* structure.

- there is a great deal of variation within populations, by:
- describing, in general terms, the nature of variation within populations; e.g., inherited versus acquired, continuous versus discontinuous

- explaining how populations are adapted to their environment; e.g., drug resistance, cold tolerance
- explaining, in general terms, how a great range of variation exists within individual populations; e.g., blood groups, enzymes
- summarizing and describing lines of evidence to support the evolution of modern species from ancestral forms; e.g., hominids, horses
- describing natural selection and explaining its action on future populations leading to evolutionary change.
- designing and performing an experiment to measure inherited variation in a plant or animal population
- formulating hypotheses about the adaptive significance of the variations in a range of homologous structures in extant (still existing) and extinct organisms
- gathering and analyzing data, actual or simulated, on plants or animals to demonstrate how morphology evolves over time; e.g., corn, Darwin's finches, pepper moths
- understanding that populations are the basic component of ecosystem structure, including range of variation, environmental adaptation
- discussing the nature of science as a way of knowing, compared with other ways of knowing; e.g., origin of life
- describing how paleontology and the role of evidence in the accumulation of knowledge has provided invaluable data for theories explaining observable variations in organisms over time

Unit 4 Energy and Matter Exchange by the Human Organism.

Concept 1

The human organism's digestive and respiratory *systems* exchange *energy* and *matter* with the environment.

- human organisms, like other organisms, must exchange energy and matter
- describing the intake of matter from the environment, its chemical and physical processing through the digestive system into the blood stream and the return of the remaining material to the environment
- explaining how gases and heat are exchanged between the human organism and its environment.
- designing and performing experiments to investigate the mechanics of breathing; e.g., lung volume, breathing rate.
- investigate the influence of enzyme concentration, temperature and pH on the activity of enzymes; e.g., pepsin, pancreatin
- observing the principal features of the digestive and respiratory systems of a mammal, using models, computer simulations or dissected organisms; and identifying the structures from drawings of those systems; e.g., villi, alveoli
- explaining the biological basis of nutritional deficiencies; and evaluating how diet can adversely affect the equilibrium of other body systems; e.g., anorexia nervosa
- assessing the physiological effect of such legal drugs as alcohol and nicotine on digestive and respiratory functions

Concept 2

The human organism's excretory *system* exchanges *energy* and *matter* with the environment.

- human organisms, like other organisms, must maintain an equilibrium with respect to their internal environment, by:
- explaining the role of the kidney in excreting metabolic wastes from the body and expelling them into the environment
- explaining how the excretory system maintains internal equilibrium with respect to water, pH and ions.

- researching the human excretory system and designing a flow chart model to describe how the human organism maintains homeostasis with respect to water and ions in a situation where either the water intake was high; e.g., tea, coffee, soda pop, or where the sodium ion intake was excessive; e.g., anchovy pizza, cheese
- making analogies between kidney function and renal and peritoneal dialysis.
- identifying specific pathologies of the digestive, excretory, respiratory and circulatory systems, and the technology used to ease or cure the problems
- examining the relationships that exist among lifestyles, hypertension and kidney function

Concept 3

The human organism's circulatory *system* transports *energy* and *matter* to maintain *equilibrium a*mong the body *systems* as well as between the organism and its external environment.

- human organisms must maintain an internal equilibrium with respect to organs and organ systems, as well as equilibrium with their external environment, by:
- explaining the role of the circulatory system in aiding the digestive, excretory and respiratory systems' exchange of energy and matter with the environment
- explaining the role of the body surface in maintenance of organism equilibrium; e.g., temperature regulation, protection from pathogens
- describing the main components of blood and their role in transport, and their role in resisting the influence of pathogens; e.g., erythrocytes, leucocytes, platelets, plasma
- listing main cellular and noncellular components of the human immune system and describing their role; e.g., macrophage, helper T cell, B cell, killer T cell, suppressor T cell, memory T cell.
- observing the principal features of the circulatory and excretory systems of a mammal, using models, computer simulations or dissected organisms; and identifying the structures from drawings of those systems
- summarizing, from models, computer simulations or a dissected organ, the structures and direction of blood flow through a mammalian heart
- evaluating the needs, interest and financial support society has on preventing the spread of disease-causing organisms, like *Staphylococcus*, smallpox virus and the human immunodeficiency virus (HIV)