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STUDY OUTLINES, WORKSHEETS, EXERCISES, STUDY TECHNIQUES, AND A STUDY MODULE ON CD!

Pass the TExES Science 8-12

First Edition

FOR TEXAS TEACHERS.
A test prep manual for the TExES Science exam #136 for grades 8-12. SEMINAR/TUTORING AVAILABLE!

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1. Safety and Procedures

Key Descriptors:

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NOTE: Refer to the bullet points under each Competency in the ETS/SBEC study guide. On the lines above paraphrase each bullet point using a short phrase that is meaningful to you.

Key Words:

Lab Safety

Managing Safety Hazards

Safe Practices for a Safe Learning Environment

Equipment and Technology Usage for:

- Data accumulation
- Presentation
- Analysis

Measuring Devices

Measurement Systems

D E S C R I P T O R   H I G H L I G H T S

- Promote procedures for safety and responsibility in the lab and field. Use resources wisely and ensure ethical treatment of lab resources.
- Use the right tools for the right job—use equipment and technology correctly and with precision to gather and present data.
- Promote critical thinking and emphasize the importance of making connections between science and technology.
- Know how to use calibration and measurement techniques to ensure precise measurements while recording data.
- Understand measurement systems and conversions across systems.

1. Safety and Procedures

Competency 1:

The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment, and technologies.

A. Safety in the Laboratory and Field

Demonstrate safe practices and implement procedures to promote responsibility in the use of resources and the learning environment.

- Prepare for lab safety, clearly explain and repeat procedures and use of safety equipment.
- Clearly post lab safety rules.
- Insist on proper attire—no loose clothing or open footwear.
- Explain the importance of proper Bunsen burner usage.
- Safety with glassware, chemicals and dissecting specimens.
- Proper disposal techniques and handling of reusable resources.
- Blood-borne pathogen safety.

B. Proper Usage of Tools, Technology and Techniques

Use/select the correct tools and equipment at your disposal to collect, organize, and present data, with precision. Be very aware of the current scientific trends and research.

- Knowledge of meniscus and viewing the meniscus at the correct angle to give accurate results.
- Names and proper usage of different kinds of graduated cylinders.
- Using different kinds of balances accurately to measure mass. Mass is the amount of matter in an object.

C. The Scientific Method

The scientific method essentially involves identifying the problem, researching it, forming a hypothesis, testing it and finally drawing a conclusion from the data you have collected. The process will involve the following steps:

- Preparing the lab - Safety procedures should be repeated; insist on written lab report plans detailing a question and a possible answer to the question being asked. Encourage research on the planned topic/experiment.
- Planning the experiment - You must think it through and do it yourself first.
- Lab-station cleanup ensures a safe working environment and helps maintain the equipment.

D. Data - Collection, Presentation and Analysis

- Construct graphs, tables, and charts to organize, examine, and evaluate information.

E. Charts

A chart is a diagram, pictorial representation, or list of information. This can include numbers that are not represented in columns or rows.

Graphs: A graph contains an “x” and “y” axis showing the relationship between two variables.

F. Tables

A table is a numerical display made up of columns and rows.

- Promote scientific methods. Encourage critical thinking via data analysis and promote problem solving to make predictions based on student understanding of data. Review and critique existing scientific theories to encourage thinking “out-of-the-box.”

Continued

1. Safety and Procedures, cont'd.

5. Using Measurement Systems

Know the International System of Units, SI, which is commonly called the metric system. All science measurements are made using this system. Be aware of the guidelines for correct usage and the common mistakes. The SI is founded on seven SI base units for seven base quantities assumed to be mutually independent. All other SI units are derived by simply multiplying or dividing these base units in various ways. Know your SI units and their conversions across different systems.

SI base units:
Length in meters, m
Mass in kilograms, kg
Time in seconds, s
Electric current in amperes, A
Thermodynamic temperature Kelvin, K
Amount of substance in moles, mol
Luminous intensity in candela, cd

Domain II:

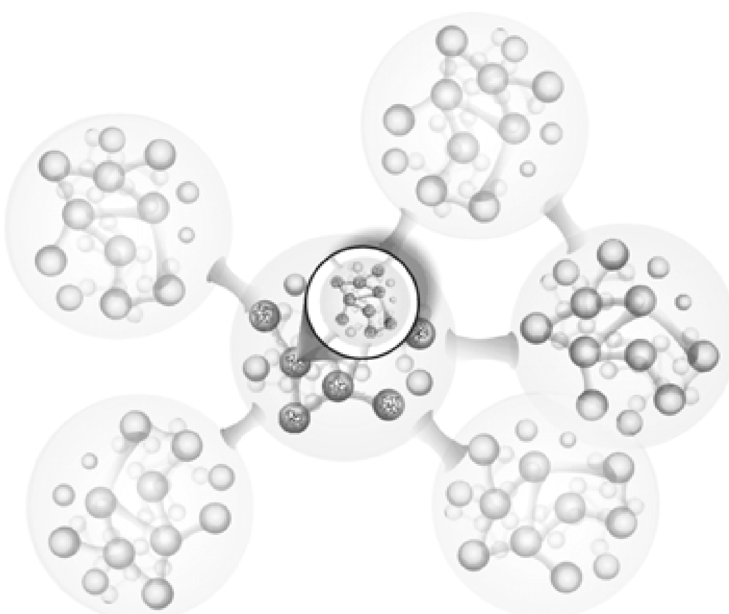
Physics

Competencies 4-11

(20% of the test)

Science 8-12 Standard VIII:

The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in physical science.



4. Motion - An Introduction

Key Descriptors:

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NOTE: Refer to the bullet points under each Competency in the ETS/SBEC study guide. On the lines above paraphrase each bullet point using a short phrase that is meaningful to you.

Key Words:

Vectors and Scalars
Displacement, Velocity Acceleration
Uniform and Accelerated Motion
Projectile Motion
Circular and Rotary Motion
Frames of Reference
Special Relativity

D E S C R I P T O R   H I G H L I G H T S

- Graphs describing the motion.
- Vectors in displacement, velocity and acceleration.
- Understand uniform and accelerated motion, projectile, uniform circular and rotary motion, and solve problems.
- Motion of fluids.
- Motion relative to different frames of reference.

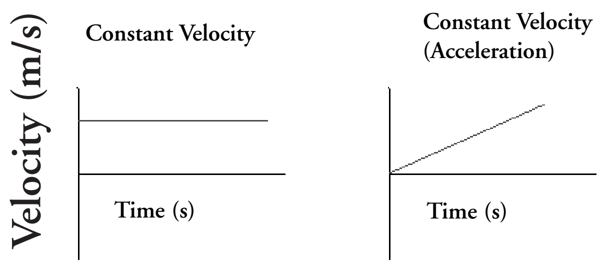
4. Motion - An Introduction

Competency 4:

The teacher understands the description of motion in one and two dimensions.

1. Generate and interpret graphs describing motion

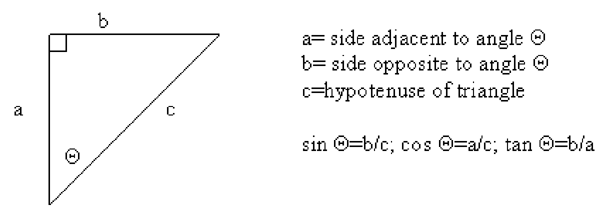
- The specific features of the motion of objects are demonstrated by the shape and the slope of the lines on a velocity vs. time graph.



- If the acceleration is zero, then the velocity-time graph is a horizontal line (i.e., the slope is zero).
- If the acceleration is positive, then the line is an upward sloping line (i.e., the slope is positive).
- If the acceleration is negative, then the velocity-time graph is a downward sloping line (i.e., the slope is negative).
- The ***slope*** is determined by the slope equation Slope, $m = (y-y_1)/x-x_1)$
  (x_1,y_1) is a point on the line

2. Displacement, Velocity and Acceleration

- ***Displacement*** is the most basic of all vectors and simply defined, it is the object's change in position. In other words, it is the distance and direction from some starting point.
- ***Velocity*** is a vector quantity which refers to the rate at which an object changes its position. They can be added by the same mathematical rules that apply to displacement vectors.
- ***Acceleration*** is the rate of chance of velocity. Simply put, average acceleration is the change in velocity divided by the length of time required to make that change.
- ***Vectors*** are physical quantities that have direction. For example, velocity is a vector. Velocity tells you "which way" you are going. Vectors have both magnitude and direction and can be added geometrically. The Pythagorean Theorem can be used to determine the resultant (i.e., the hypotenuse of the right triangle).



- ***Speed*** on the other hand is a "scalar," a quantity that has no directional property. Your speedometer tells you nothing of where you are going, only how fast you will get there. Time, temperature and volume are all scalars.

3. Uniform and Accelerated Motion

- ***Uniform motion*** is motion in which no forces are acting—for example, motion at a constant velocity. The state of rest is a special case of uniform motion.
- ***Uniform acceleration*** occurs when the speed of an object changes at a constant rate. The acceleration is the same over time. Constant acceleration means velocity increases or decreases at the same rate throughout the motion. For example, an object falling near the earth's surface (neglecting air resistance).

Continued

4. Motion - An Introduction, cont'd.

Domain II: Competencies 4-11

When an object is accelerating at a constant rate its motion can be modeled by two simple equations,

$a = (v_f - v_4) / t$ and

$s = 1/2\ (v_f + v_i) \times t$

Combining these two helps us relate speeds to the acceleration and distance:

$v_f^2 = v_i^2 + 2as$

Using these equations gives you the ability to discover information about the motion while lacking a variable. The equations can be rearranged and substituted into each other to compensate for the lack of the distance, initial speed, final speed, acceleration or the time variable.

4. Projectile Motion

- The path of a projectile in free fall is called its ***"trajectory."*** Trajectories are calculated by dealing separately with the accelerated vertical motion and the steady horizontal motion.

5. Uniform Circular and Rotary Motion

- When acceleration has constant magnitude and is always kept perpendicular to velocity, motion is in a circle at constant speed and the centripetal acceleration (ca) can be calculated:

  $a_c = v^2/r$

  r is the radius of the circle and v is the speed or tangential velocity.
- ***Rotary motion*** is the motion of a body about an internal axis. Examples are a spinning bicycle wheel, the spinning crankshaft of a car, and a cheerleader doing a cartwheel.
- ***Uniform circular motion*** is the motion of objects as they travel in a circle; twirling a rock on the end of a string, a car going around a race track, riding a ferris wheel, and the earth orbiting the sun.

6. Motion of Fluids

A fluid, unlike a solid, is a substance that can flow. Fluids can be either liquids or gases. The difference between a liquid and a gas is the positioning of the molecules. In gases the molecules are much farther apart than a liquid. This does not prevent either substance from flowing. Unlike solids where mass and the amount of force exerted on the mass controls the motion, fluids move in response to density and pressure.

Some of the fundamental principles are:

Pascal's Principle. A change in the pressure applied to an enclosed container is transmitted without change throughout the fluid and acts in all directions. For example, a hydraulic pump.

Archimedes' Principle. A body immersed in a fluid will be buoyed up by a force equal to the weight of the fluid that it displaces. For example, getting in a bathtub full of water.

Bernoulli's Principle. The pressure in a fluid decreases with increased velocity of the fluid. (The faster the liquid moves, the lesser is the pressure in that liquid.) Example, how air moves around the wings on airplane providing "lift."

- Use examples to illustrate these principles.
- Often there is a combination of principles at work.
- Pressure within the fluid helps move it.

7. Identify and describe motion relative to different frames of reference

- A "***frame of reference*** *is a system for describing the location of objects.*" It is used to specify the positions and relative motions of objects. Velocities transform from one frame of reference to another, while accelerations do not.
- The cornerstone of the theory of special relativity is the ***Principle of Relativity:*** "The Laws of Physics are the same in all inertial frames of reference." Special relativity is usually concerned with the behavior of objects and observers which remain at rest or are moving at a constant velocity. In this case, the observer is said to be in an inertial frame of reference or simply inertial.

11. Quantum Physics

Key Descriptors:

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Key Words:

Wave-Particle Duality
Uncertainity Principle
Quanta
Photons
Electrons
Quantum Theory
Absorption and Emission Spectra
Laser
Photoelectric Sensor

D E S C R I P T O R   H I G H L I G H T S

- The teacher understands the concept of wave-particle duality and the fundamentals of quantum physics.
- The teacher understands and applies knowledge of the Uncertainty Principle.
- The teacher understands and explains the photoelectric effect.
- The teacher understands the quantum model of the atom and applies this knowledge to explain absorption and emission spectra.
- The teacher knows and understands real world applications of quantum phenomena.

11. Quantum Physics

Competency 11:

The teacher understands the fundamental concepts of quantum physics.

Quantum physics describes how electrons surround the nucleus of the atom and other subatomic actions. It is a branch of science that deals with discrete, indivisible units of energy called quanta as described by the ***Quantum Theory***. Light and matter waves are waves of probability.

- Energy is not continuous, but comes in small but discrete units.
- The elementary particles behave both like particles and like waves.
- The movement of these particles is inherently random.
- It is physically impossible to know both the position and the momentum of a particle at the same time. The more precisely one is known, the less precise the measurement of the other is.
- The quantum theory predicts only probabilities of single events.

1. Wave Particle Duality

- In physics, wave-particle duality holds that light and matter simultaneously exhibit properties of waves nd of particles (or photons). Thus, objects (light, electrons, etc.) can at times appear to us as waves, and at other times as particles. In this sense they are neither particles nor waves, in an absolute sense, but only exhibit wave or particle properties, depending on the experiment being performed.

2. The Uncertainty Principle

- Heisenberg's Uncertainty Principle set limits on the accuracy of measurements. It said that physical quantities come in pairs. Momentum and position make a Heisenberg pair, as do energy and time. There is always some uncertainty in measuring either member of a pair, and when both are measured, the product of the uncertainties can never be less than $h/2\pi$, where h is Planck's constant.
- The Heisenberg uncertainty principle applies only to the subatomic world.
- Suppose you have a time-varying signal such as a sound wave, and you want to know the exact frequencies in your signal at an exact moment in time. This is impossible; since in order to determine the frequencies accurately, you need to sample the signal for some time and you thereby lose time precision. (In other words, a sound cannot have both a precise time, as in a short pulse, and a precise frequency, as in a continuous pure tone.) The time and frequency of a wave in time are analogous to the position and momentum of a wave in space.

3. Photoelectric Effect

- Another experiment which provides compelling proof for the photon nature of light is the ***photoelectric effect.*** In this effect light is shone at a metal plate, and it is found that electrons are ejected. These electrons then get accelerated to a nearby plate by an external potential difference, and a photoelectric current is established.
- The photon hits an electron in the metal, giving up its energy, This is enough to free the electron from the attractive forces holding it in the metal, and it is accelerated towards the other side, causing a flow of charges and hence a current. This effect, which is used in devices such as automatic door openers, burglar alarms, light detectors, and photocopiers, cannot be explained using a wave picture of light.
- Photons have no mass, but they have momentum and they have an energy given by:
  Energy of a photon, $E = hf$
- A high-energy "violet" photon can knock a single electron out of its atom.

Continued

11. Quantum Physics, cont'd.

- A low-energy "red" photon cannot.
- This can be explained only if light is made up of particles.

4. Quantum Model of the Atom

- The wave function of each electron can be described as a set of four quantum numbers: **Principal number (n)** - describes the energy level.
- **Angular momentum quantum number (l)** - how fast the electron moves in its orbit (angular momentum); like how fast a CD spins (rpm). This is related to the shape of the orbital.
- **Orbital magnetic quantum number (m)** - its orientation in space.
- **Spin magnetic quantum number** - is related to the direction that the electron spins while it is moving in its orbit (i.e., clockwise, counterclockwise). Only two electrons could share the same orbital, one spinning clockwise and the other spinning counterclockwise.
- The orbitals had different shapes and maximum numbers at any level:
  - s (sharp) - spherical (max = 1)
  - p (principal) - dumb-bell shaped (max = 3)
  - d (diffuse) - four-lobe-shaped (max = 5)
  - f (fundamental) - six-lobe shaped (max = 7)
- The names of the orbitals came from names of atomic spectral features before quantum mechanics was formally invented. Each orbital can hold only two electrons. Also, the orbitals have a specific order of filling, generally: s, p, d, f.

5. Absorption and Emission Spectra

- Electrons can only be in specific energy levels in an atom, thus transitions from one level to another can only be achieved by absorbing or emitting the exact difference in energy between levels. This needs to be done instantaneously and is most easily accomplished by the electron absorbing or emitting a photon of the correct energy.
- Suppose there is a source of electromagnetic radiation which contains all wavelengths. If that radiation passes through a gas under low pressure and is examined certain wavelengths would then be found missing from the resultant spectrum. This phenomenon is known as ***absorption spectra.***
- Heating up a gas results in the electrons of its constituent atoms entering excited states (higher energy levels). Instead of absorbing photons, these energized electrons emit photons as they drop down to lower energy levels. Visualization of these photons results in an ***emission*** or line spectra.

6. Real World Applications

- **Lasers (Light Amplification by Stimulated Emission of Radiation)** - Light is emitted due to quantum transitions in gases, liquids, or solids. These sources are characterized by high coherence and directionality over an extremely narrow spectrum. Lasers harness atoms to store and emit light in a coherent fashion.
- The electrons in the atoms of a laser medium are first pumped, or energized, to an excited state by an energy source. They are then "stimulated" by external photons to emit the stored energy in the form of photons, a process known as stimulated emission. The photons emitted have a frequency characteristic of the atoms and travel in step with the stimulating photons. These photons, in turn, impinge on other excited atoms to release more photons. Light amplification is achieved as the photons move back and forth between two parallel mirrors, triggering further stimulated emissions. The intense, directional, and monochromatic laser light finally leaves through one of the mirrors, which is only partially silvered.
- **Semiconductor Structures** - Incident photons are converted by semiconductor struc-

11. Quantum Physics, cont'd.

tures into usable electrons. Solar cells convert light to electrical power. Common devices for imaging and information detection are CCDs (charge coupled devices), photodiodes, and avalanche photodiodes. *Photodiodes will produce an electrical current proportional to the irradiance of light absorbed.* The design of semiconductor photo detectors depends on the wavelength sensitivity of the materials.

- The most compact of lasers, the semiconductor laser usually consists of a junction between layers of semionductors with different electrical conducting properties. The laser cavity is confined to the junction region by means of two reflective boundaries.
- Photoelectric sensors in smoke detectors: Smoke can block a light beam. In this case, the reduction in light reaching a photocell sets off the alarm. In the most common type of photoelectric unit, however, light is scattered by smoke particles onto a photocell, initiating an alarm.
- This detector has a T-shaped chamber with a light-emitting diode (LED) that shoots a beam of light across the horizontal bar of the T. A photocell, positioned at the bottom of the vertical base of the T, generates a current when it is exposed to light. Under smoke-free conditions, the light beam crosses the top of the T in an uninterrupted straight line. When smoke is present, the light is scattered by smoke particles, and some of the light is directed down the vertical part of the T to strike the photocell. When sufficient light hits the cell, the current triggers the alarm.

Domain III:

Chemistry

Competencies 12-20

(20% of the test)

Science 8-12 Standard VIII:

The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in physical science.

12. Atomic Structure

Key Descriptors:

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Key Words:

Matter	Mixtures
Mass	Protons
Weight	Neutrons Electrons
Inertia	Electron Configuration
Density	Atomic Orbitals
Solids	Atomic Number
Liquids	Atomic Mass
Gases	Periodic Table
Elements	Groups
Compounds	Periods

D E S C R I P T O R   H I G H L I G H T S

- The teacher understands properties and changes of matter.
- The teacher explains the differences between solids liquids and gases.
- The teacher can compare elements compounds and mixtures.
- The teacher understands the structure of the atom and uses this knowledge to explain concepts of atomic orbitals and electronic configuration.
- The teacher identifies elements and isotopes using mass number and atomic number.
- The teacher knows the history of the periodic table and how elements are placed in it.

12. Atomic Structure

Competency 12:

The teacher understands the characteristics of matter and atomic structure.

1. Properties of Matter

Matter is defined as anything that has mass and occupies space. Mass is the quantity of matter a substance possesses and has a unit of *weight* assigned to it.

- *Mass* is constant, while weight can vary. Mass can also be defined as a measure of the inertia of an object. The SI unit of mass is the gram (g) or kilogram (kg).
- *Weight* is a measure of the pull of gravity on an object. The SI unit of weight is the Newton (N). One Newton = 1 kg m / s^2
- *Inertia* is the resistance of a substance to changes in motion.
- Since matter occupies space, different types of matter can be identified in terms of density, which is the mass per unit volume of the substance. Volume is the amount of space a substance occupies.

  $D=m/V$

  The unit of mass (m) is gram (g) and volume (V) is cubic centimeter (cm^3).

2. Changes of Matter

- Changes of matter may be classified as either physical or chemical. *Physical changes* alter the physical properties of matter, but the composition is not affected. *Chemical changes* are changes to the composition and structure of a substance.
- Chemical changes are always accompanied by energy changes, in the form of heat, light or both.
- ***Exothermic reactions*** result in energy being released during the process of the reaction.
- ***Endothermic reactions*** absorb energy to complete the reaction.
- In chemical reactions, matter can neither be created nor destroyed; it can only change from one form to another. This statement is called the *Law of Conservation of Matter.*

3. Solids, Liquids and Gases - Structure and Properties

- All matter exists in three states: solid, liquids and gases.
- A solid has both size and shape.
- Liquids have a definite volume, but take the shape of the container they are in.
- Gases have neither a definite shape nor a definite volume.

4. Elements, Compounds and Mixtures

- ***Elements*** are the basic substances of which all matter is composed, and an element is made up of only one kind of atom.
- Elements are completely homogenous.
- ***Compounds*** are made up of elements combined chemically in definite proportions by mass (the law of constant composition) to form pure compounds, and have two or more atoms.
- ***Molecules*** are the building blocks of compounds and all molecules of a particular compound react the same way.
- The elements in a chemical compound can only be separated by destroying the compound.
- The properties of compounds are different from the elements that they were made from.
- Composition is homogenous.
- ***Mixtures*** are usually heterogeneous and vary in composition.
- They are usually mixed together but not chemically joined.
- The individual components of a mixture can be physically separated from each other and retain their properties.

Continued

5. **Model of the Atom**

History

In 1803 **John Dalton** published his atomic theory. He said that everything is made up of atoms, and that different elements have different kinds of atoms. He thought that atoms were solid spheres -- like a bunch of marbles all stacked together. What made elements different was the size, shape, and mass of their atoms.

J. J. Thomson discovered the electron, and figured out that it was part of an atom. He decided that an atom was a positively-charged ball with lots of negatively-charged electrons stuck into it.

In 1911 **Ernest Rutherford** performed the gold foil experiment which had major implications for atomic structure. He suggested that most of a gold atom (or any other atom; he experimented with other metal foils, too) is empty space. Since some of the alpha particles did bounce off, he knew that in the middle of each atom was a small, positively-charged nucleus. The electrons, he figured, were grouped around it.

In **Neils Bohr's** model, the negatively charged electrons orbit about the positively charged atomic nucleus because of the attractive electrostatic force according to Coulomb's law. Only certain orbits were permitted and in these permitted orbits, the electrons would not radiate (would not create radio waves). He also showed that light of certain colors (and wavelengths) would be created when the electron (of its own power) changed orbits.

Model of the Atom

- All matter consists of protons, neutrons, and electrons.
- Protons and neutrons are in the nucleus of the atom and electrons orbit the nucleus in a cloud.
- Protons and neutrons have the same mass (weigh the same), but electrons are much lighter
- Protons are positively charged and electrons are negatively charged.
  - Like charges repel, so protons repel one another as do electrons.
  - Opposite charges attract which causes the electrons to be attracted to the protons.
  - As the electrons and protons grow farther apart, the forces they exert on each other decrease.
- There are equal numbers of protons and electrons in an atom.
- Atoms bond to other atoms to form molecules when positive nuclei share electrons
- Molecules bond to other molecules in the same way.
  - These bonds can be quite strong and this keeps keeps solids rigid.

6. **Elements and Isotopes**

All elements are ordered by their **atomic number.** The atomic number is the number of protons per atom. In an atom with a neutral charge, the number of electrons equals the number of protons. The periodic table represents neutral atoms.

The atomic number is typically located above the element symbol. Beneath the **atomic number** is the atomic mass number. Atomic mass is measured in Atomic Mass Units where 1amu = (1/12) mass of carbon measured in grams. The atomic mass number is equal to the number of protons plus neutrons. This number is typically found beneath the element symbol.

Isotopes are atoms of the same element that contain different numbers of neutrons and thus have different masses. They have the same atomic number, but different mass numbers.

In other words,

- An element's or isotope's atomic number tells how many protons are in its atoms.
- An element's or isotope's mass number tells how many protons and neutrons are in its atoms.
- The atomic number is always the smaller number and is written above the element symbol on the periodic table.

7. **Electron Configuration and Atomic Orbital**

A wave function for an electron in an atom is called an **atomic orbital;** this atomic orbital describes a region of space in which there is a high probability of finding the electron. The atomic orbitals of the hydrogen atom can be visualized as a cloud around the nucleus.

- Atoms that have 1, 2 or 3 electrons in their outer levels will tend to lose them in interactions with atoms that have 5, 6 or 7 electrons in their outer levels.
- Atoms that have 5, 6 or 7 electrons in their outer levels will tend to gain electrons from atoms with 1, 2 or 3 electrons in their outer levels.
- Atoms that have 4 electrons in the outer most energy level will not tend to totally lose or totally gain electrons during interactions.

The distribution of electrons among the orbitals of an atom is called the electron **configuration.** The electrons are filled in according to a scheme known as the Aufbau principle ("building-up"), electrons must always enter the first available orbital of lowest energy. Orbitals are filled in order of increasing energy, with no more than two electrons per orbital.

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d
5p 6s 4f 5d 6p 7s 5f 6d 7p

The type of sublevel (*s, p, d,* or *f*) is determined from the block in which the atomic number is found. The number for the principal energy level (for example, the 3 in 3p) is determined from the row in which the element is found and the knowledge that the s sublevels start on the first principal energy level, the *p* sublevels start on the second principal energy level, the *d* sublevels start on the third principal energy level, and the *f* sublevels start on the fourth principal energy level.

8. The Periodic Table

Mendeleyev, a Russian scientist, is known as the father of the periodic table of the elements. He arranged all the known elements in order of increasing mass of the atoms. He found that the properties of elements repeated themselves at regular intervals and arranged the elements in the form of a table so that the elements with similar properties would fall into a vertical column. Because the properties of elements repeated themselves at regular intervals or periods the table is called the Periodic table of elements. He even predicted elements for as yet unoccupied places in the table

Mendeleyev's statement of periodicity read:

"The properties of the elements, as well as the forms and properties of their compounds, are in periodic dependence on, or (expressing ourselves algebraically) form a periodic function of, the atomic weights of the elements."

Modern Statement of the Law of Periodicity is as follows:

"The properties of the elements, as well as the forms and properties of their compounds, are in periodic dependence on, or (expressing ourselves algebraically) form a periodic function of, the ***atomic number*** *of the elements."*

9. Periodic Table - Physical and Chemical properties of Elements

The periodic table is arranged according to increasing atomic number. The periodic table can be used to predict general trends in many chemical and physical properties, as given here:

- ***Atomic Radius:*** The atomic radius increases from top to bottom down a group and decreases from left to right across a period.
- ***Ionization Potential:*** The first ionization potential decreases from top to bottom down a group and increases from left to right across a period, with a few exceptions.
- ***Electron Affinity:*** The first electron affinity generally becomes more exothermic (electron gain is more favored) from left to right across a given period, with a few exceptions. There is generally no well-defined trend for electron affinities down a group.

Continued

12. Atomic Structure, cont'd

Features of the Periodic Table:

- *Periods* are the horizontal rows that contain elements with the same value for the largest principal quantum number, *n*. Going from left to right on the periodic table, you will find metals, then metalloids, and finally non-metals. The 4th, 5th, and 6th periods are called the transition metals.
- *Groups* are the vertical columns which include elements with similar chemical and physical properties. These vertical arrangements consist of elements with the same number of electrons in the same types of subshells.

Domain III: Competencies 12-20

Group 1A	Known as Alkali Metals Very reactive Never found free in nature React readily with water
Group 2A	Known as Alkaline earth elements All are metals Occur only in compounds React with oxygen in the general formula EO (where O is oxygen and E is Group 2A element)
Group 3A	Metalloids Includes Aluminum (the most abundant metal in the earth) Forms oxygen compounds with a X2O3 formula
Group 4A	Includes metals and nonmetals Go from nonmetals at the top of the column to metals at the bottom All oxygen form compounds with a XO2 formula
Group 5A	All elements form an oxygen or sulfur compound with E2O3 or E2S3 formulas
Group 6A	Includes oxygen, one of the most abundant elements. Generally, oxygen compound formulas within this group are EO2 and EO3
Group 7A	Elements combine violently with alkali metals to form salts Called halogens meaning "salt forming" Are all highly reactive
Group 8A	Least reactive group All elements are gases Not very abundant on earth Given the name noble gas because they are not very reactive

Domain IV:

Cell Structure and Processes

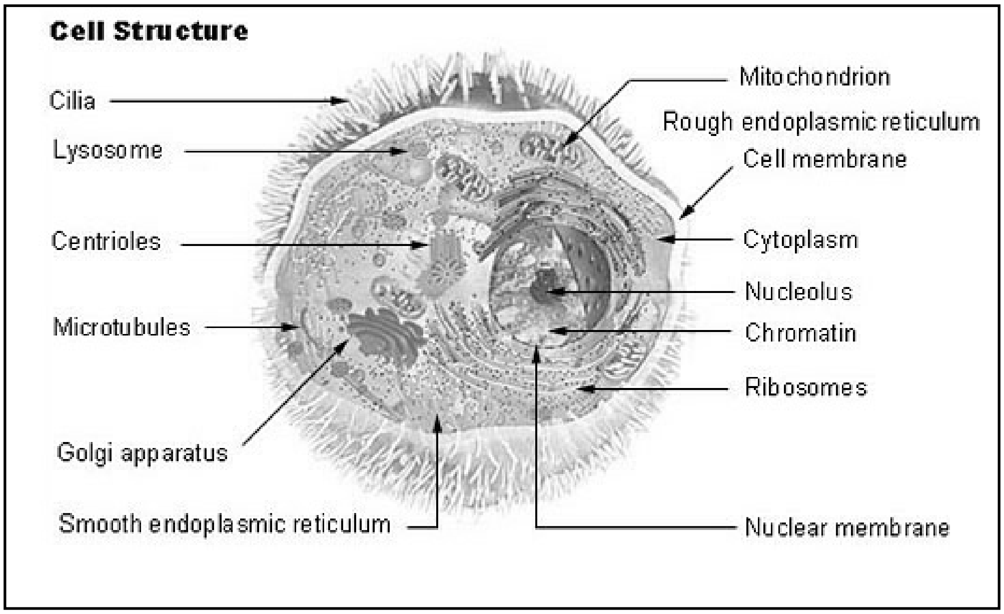
Competencies 21-24

(8% of the test)

Domain IV: Competencies 21-24

Science 8-12 Standard IX:

The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in life science.



21. Biomolecules

Key Descriptors:

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NOTE: Refer to the bullet points under each Competency in the ETS/SBEC study guide. On the lines above paraphrase each bullet point using a short phrase that is meaningful to you.

Key Words:

Organic
Inorganic
Hydrophobic
Hydrophilic
Hydrocarbon
Isomers
Polymers
Monomers
Phospholipids
Lipids
Carbohydrates
Proteins
Enzymes
Coenzymes
Substrate
Active Site
Amino Acids
Polypeptides
Nucleic Acids
Hydrolysis
Dehydration Synthesis

D E S C R I P T O R   H I G H L I G H T S

The teacher...

- Demonstrates knowledge of characteristics and uses of primary and secondary sources.
- Assesses multiple points of view relating to a social studies issue.
- Organizes and interprets information.
- Knows how to use maps and other graphics to present information and relationships.
- Evaluates the validity of sources.

21. Biomolecules

Competency 21:

The teacher understands the structure and function of biomolecules.

1. Chemical Elements in Biology

- The elements Hydrogen (H), Carbon (C), Oxygen (O), and Nitrogen (N) are extremely important to biology. These four elements make up 96% of living matter. A few other elements: phosphorus (P), sulfur (S), calcium (Ca) and potassium (K) make up most of the remaining 4%.
- Chemical elements join together in different ways to form a range of molecules, from simple monomers to larger more complex polymers. These polymers and other large molecules make up the structures that eventually form living cells.
- Cells are made up of small molecules like water; ions such as sodium and magnesium, and large organic molecules.
- Many interactions important to cells involve bonds that are weaker than covalent bonds. The most important of these is the hydrogen bond. For example, in living things the weak forces contributed by *hydrogen bonds* stabilize the structure of large molecules such as DNA and proteins.
- *Inorganic compounds* present in cells include water, mineral salts inorganic acids and bases. These are compounds that have no chemically combined carbon and hydrogen.
- *Organic compounds* have carbon and hydrogen combined chemically. Examples of organic compounds present in cells include carbohydrates, lipids, proteins and nucleic acids.

2. Significance of Water and Carbon in Life Processes

Properties of Water

- Water is the most common inorganic compound in living things. It makes up about 80-95% of living organisms.
- The ability of ions and other molecules to dissolve in water is due to *polarity.* The tetrahedral shape of water and structure of its bonds makes water a polar molecule
- It has unique *hydration properties* towards biological macromolecules (particularly proteins and nucleic acids) that determine their three dimensional structures, and hence their functions, in solution.
- Water is a very important transport medium for living organisms because of its solvent properties.
- This hydration forms gels that can reversibly undergo the gel-sol phase transitions that underlie many cellular mechanisms.
- Water ionizes and allows easy proton exchange between molecules, so contributing to the richness of the ionic interactions in biology.
- The hydrophobic effect, or the exclusion of compounds containing carbon and hydrogen (non-polar compounds), is another unique property of water caused by the hydrogen bonds. The *hydrophobic effect* is particularly important in the formation of cell membranes.
- Water is a very thermally stable medium which helps living organisms resist changes in their environment. Compared to molecules of similar size and properties water has a very high melting point and boiling point.

Properties of Carbon

- Because carbon has four valence electrons and makes covalent bonds, it can form molecules that are long chains and rings that serve as the backbones of organic molecules.
- It has the ability to form large, complex and diverse molecules. The cells and tissues of virtually all organisms are made up of the same basic molecules: carbohydrates, lipids, proteins and the nucleic acids which are based on carbon.

Continued

Domain IV: Competencies 21-24

21. Biomolecules, cont'd.

- Carbon bonds covalently with other carbon atoms, as well as a number of other atoms, notably hydrogen, oxygen and nitrogen. In fact, the basic carbon compound is a *hydrocarbon,* formed from carbon and hydrogen.
- Hydrocarbon skeletons vary in length (number of carbons).
- Living systems make a variety of new chemicals by adding functional groups to hydrocarbon skeletons
- Hydrocarbons vary in structure. Different structures with same chemical formula are *isomers.*
- Polymers are the chains that living systems assemble subunits into. *Monomers* are the subunits of polymers.

3. **Biomolecules - How Shape Relates to Function**

The structure of each type of macromolecules is what determines how the molecules function in our bodies.

- ***Receptor.*** It is a specialized molecule of a cell's membrane that receives information from the environment and conveys it to other parts of the cell. The information is transmitted in the form of a specific chemical, ***neurotransmitter,*** which must fit the receptor like a key in a lock.
- ***Receptor Binding.*** Neurotransmitters will bind only to specific receptors on the postsynaptic membrane that recognize them.
- Neurotransmitters are made in the cell body of the neuron and then transported down the axon to the axon terminal.
- Communication of information between neurons is accomplished by movement of neurotransmitters across a small gap called the synapse.
- ***Lipids*** or fats can be considered to be biological molecules which are soluble in organic solvents.
- ***Phospholipids*** are a variation on the triacylglycerol theme in which one fatty acid is replaced with a phosphate group, which in turn is bound to additional functional groups
- Structurally and functionally, the important thing about phospholipids is that these molecules are simultaneously hydrophobic (at one end, the fatty acid end) and hydrophilic (at the other end, the phosphate end)
- ***Protein*** structure is critical for its function. Each protein has a unique shape or **conformation.** However, all proteins are composed exclusively of subunits of amino acids, which join together in long chains called *polypeptides* that fold or coil into the unique shape of the functional protein.
- The function of many proteins depends on a specific region of the protein that binds to another molecule. An ***enzyme*** binds to the substrate (the reactants) at a specific active site on the enzyme.
- ***Nucleic acids*** (polynucleotides) are formed when covalent linkages are made between the 3 carbons of one nucleotide's sugar and the phosphate of the next nucleotide to form long chains. DNA forms double chains while RNA forms single chains.

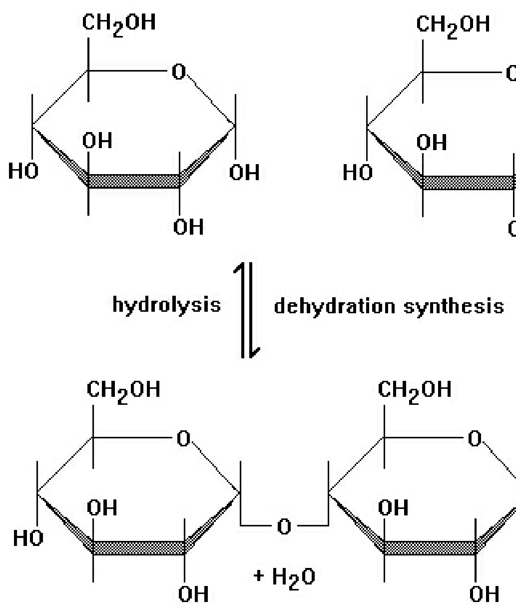
4. **Chemistry of Biomolecules**

Cells use the following reactions to assemble and disassemble polymers. The reactions involve water. The methods of hooking the amino acids together, the sugars together, the nucleotides together, and the method of attaching each of the 3 fatty acids to the glycerol molecule are all the same.

- ***Dehydration synthesis*** is an exchange reaction in which two substances are joined such that a water molecule is lost. In other words, a reaction in which "Polymer + Monomer" yields "Longer Polymer + Water," where monomers combine to form larger molecules. For example:

  A-OH + H-B ➔ AB + HOH
- Dehydration synthesis allows for close packaging of complex molecules. An example is the process in which two single sugars combine to make the double sugar maltose.
- ***Hydrolysis*** is an exchange reaction in which water is added to a molecule thus effecting its decomposition. It is a reaction in which "Polymer + Water" yields "Shorter Polymer +

Monomer." This is the way large macromolecules in food are digested into monomers small enough to enter our cells. For example: AB + HOH ➔ A-OH + H-B.



5. Types of Biomolecules

Carbohydrates

- A carbohydrate is an organic compound that is composed of atoms of carbon, hydrogen and oxygen in a ratio of 1 carbon atom, 2 hydrogen atoms, and 1 oxygen atom.
- $C_6H_6O_{12}$, glucose, which is a monosaccharide, is the basic unit of all sugars and starches.
- The primary function of carbohydrates is for short-term energy storage. A secondary function is intermediate-term energy storage.
- Other carbohydrates are involved as structural components in cells, such as cellulose which is found in the cell walls of plants.
- Hooking two *monosaccharides* together forms more complex sugars called disaccharides (two sugars). Both monosaccharides and disaccharides are soluble in water.
- *Polysaccharides* are more complex carbohydrates that are formed by linking many shorter units together. Because of their size, these are often times not soluble in water. Many biologically important compounds such as starches and cellulose are Polysaccharides.

Lipids

- Each type of lipid has a slightly different structure, but they all possess a large number of **C—H bonds** which makes them a primarily non-polar group of molecules.
- There are three different functions for lipids in our bodies:
  - Energy storage
  - Forming the membranes around our cells.
  - Hormones and vitamins
- Lipids are made up of two basic units; an alcohol (usually glycerol) and fatty acids.
- Fatty acids are composed of a chain of methylene groups with a Carboxyl functional group at one end. The methyl chain is the fatty part, the Carboxyl, the acid.
- In *triglycerides,* a fatty acid is joined to each of the three carbons of glycerol by dehydration synthesis to form a molecule which stores a lot of calories in a small space. Triglycerides are energy-storage molecules.
- **Phospholipids** serve an extremely important function in our bodies, they form the cell membrane. Phospholipids are very much like triglycerides but with one important difference. A phosphate functional group is substituted for one of the three fatty acids.
- The polar heads of the P-lipids turn toward the water molecules (***Hydrophilic***) while the non-polar tails hide from water molecules (***Hydrophobic***). When exposed to an aqueous (water) environment, phospholipids form unique assemblies called "bilayers."
- The plasma or cell membrane is formed from a ***phospholipid bilayer.*** This structure is an important barrier and defines the boundaries of living and non-living portions of a cell.

Continued

21. Biomolecules, cont'd.

Proteins

- All proteins contain carbon, hydrogen, oxygen and nitrogen. Amino acids form the building blocks of a protein molecule.
- An amino acid is composed of a central asymmetrical carbon singly bonded to a hydrogen atom, a carboxyl group, an amino group, and a variable side chain that gives amino acids their unique properties.
- There are twenty different amino acids, each with a different side group.
- The carboxyl and amino groups of adjacent amino acids link together in a peptide bond, forming long polymers.
- Proteins function as enzymes or as structural units in cells. They do most of the work in the cells.
- The structure of a protein determines its function, and the order of amino acids determines the protein's structure. The sequence of amino acids in a protein is known as its ***Primary Structure.***
- ***Secondary structure*** describes how the primary is folded into particular, localized configurations, the alpha helix and beta pleated sheets, which result from hydrogen bonding between peptide linkages.
- ***Tertiary structure*** describes the additional, less regular contortions of the molecule caused by the involvement of side groups in hydrophobic interactions, hydrogen bonds, ionic bonds, and covalent bonds called disulfide bridges.
- When a protein is subjected to very high temperature or extremes of pH, the well ordered tertiary structure is destroyed. When a protein loses its structural organization, it is said to be ***denatured.*** Most denatured proteins lose their function, and their properties can also change, they sometimes become insoluble or change their color.

Nucleic Acids

- Nucleic acids are polymers consisting of nucleotides, complex monomers consisting of a pentose (five-carbon sugar) covalently bonded to a phosphate group and to one of five different kinds of nitrogenous bases.
- The two kinds of nucleic acids, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are named on the basis of their characteristic pentoses: deoxyribose in DNA, and ribose in RNA.
- The five nitrogenous bases are members of two families, the *purines* and the *pyrimidines,* distinctive ring skeletons of carbon and nitrogen with various attached groups.
- The pyrimidines consist of *cytosine* (C) *thymine* (T) and *uracil* (U); the purines consist of *adenine* (A) and *guanine* (G).
- RNA is a single-stranded nucleotide polymer containing the bases A, G, C, and U.
- DNA is a helical, double-stranded polymer with bases A, G, C, and T projecting into the interior of the molecule. Since A always hydrogen bonds to T, and C to G, the nucleotide sequence of the two strands is complementary, and one strand can serve as a template for the formation of the other.
- The property of complementary strands gives DNA its unique ability to replicate itself and provides a mechanism for the continuity of life.
- Once replicated specific nucleotide segments of the DNA (genes) program the manufacture of an organism's characteristic proteins. RNA functions in protein synthesis.

6. Enzymes and Biomolecules

Enzymes are reusable and are not consumed in a reaction. They act as organic catalysts for the thousands of biochemical reactions in our bodies. Living cells neither synthesize nor breakdown more material than is required for normal metabolism and growth. All of this necessitates precise *control mechanisms* for turning metabolic reactions on and off.

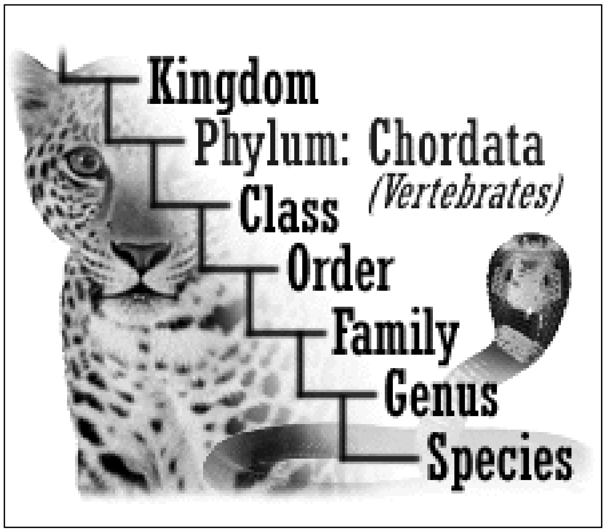
- Most biological enzymes are proteins. Some may have non-protein parts known as coenzymes. Vitamins frequently function as *coenzymes.*

21. Biomolecules, cont'd.

- Enzymes have a definite three-dimensional shape which is complementary to the material that the enzyme acts on, the *substrate.* A change in the shape of the enzyme can also prevent it from catalyzing reactions.
- The first step in any enzyme-catalyzed reaction is the formation of an enzyme-substrate complex.
- The substrate attaches to the region of the enzyme known as *active site,* where a reaction takes place, resulting in the formation of products.
- The enzyme is then free to react again with any available substrate.
- Three important characteristics of enzymes are important to the chemistry of cells:
  - Enzymes are deactivated by heat.
  - The action of enzymes can be blocked by certain compounds.
  - Enzymes are specific in their activity.
- Digestion of food is a disassembly process in which complex biopolymers are degraded to their simple monomer building blocks by *hydrolytic* (bond-breaking) *enzymes.*
- Genetic makeup can be analyzed using a technique called restriction mapping. In this process, strands of genetic material are first attacked by enzymes that cleave the DNA at specific sites. Restriction enzymes can be isolated and used in the laboratory to manipulate fragments of DNA. This makes them indispensable tools of recombinant DNA technology, or genetic engineering.
- Enzymes may be classified into 6 general groups.
  1. *Oxidoreductases* - catalyze oxidation - reduction reactions.
  2. *Transferases* - catalyze group-transfer reactions.
  3. *Hydrolases* - catalyze hydrolytic reactions.
  4. *Lyases* - catalyze addition groups to double bonds.
  5. *Isomerases* - catalyze isomerization reactions.
  6. *Ligases* - catalyze condensation of two molecules (coupled with cleavage of ATP, GTP etc.)

Domain VI:
Diversity of Life
Competencies 29-32
(8% of the test)

Science 8-12 Standard IX:
The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in life science.



29. Living Organisms and Taxonomic Systems

Key Descriptors:

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NOTE: Refer to the bullet points under each Competency in the ETS/SBEC study guide. On the lines above paraphrase each bullet point using a short phrase that is meaningful to you.

Key Words:

Adaptation
Ecosystem
Biomes
Ecology
Classification
Taxonomy
Homologous Trait
Convergence
Dichotomous Keys
Kingdoms, Phylum, Class, Order, Family, Genus, Species
Monera, Protista, Fungi, Plantae and Animalia

DESCRIPTOR HIGHLIGHTS

- The teacher compares adaptations of organisms in various biomes.
- The teacher explains interrelationships between ecosystems and environmental changes (natural and man-made).
- The teacher knows the uses and limitations of classification schemes.
- The teacher understands the evolutionary basis of taxonomy and distinguishes between and homologous and convergent traits.
- The teacher knows the characteristic features of the five kingdoms.

29. Living Organisms and Taxonomic Systems

Competency 29:

The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

1. **Plant and Animal Adaptations in Various Environments**
   - An ***adaptation*** refers to any structural, functional, or behavioral characteristic of an organism that helps it to better survive in its environment.
   - An ***ecosystem*** consists of the biological community that occurs in some locale, and the physical and chemical factors that make up its non-living or abiotic environment. This variety of biotic and abiotic components functions in an interrelated fashion.
   - ***Biomes*** are major groupings of ecosystems that cover a substantial area of the earth's surface. They may be broadly classified as aquatic, terrestrial, or a mixture of both.
   - *Terrestrial biomes* are generally less stable as compared to the more stable aquatic biomes, due to the lower rates of temperature fluctuations in water.
   - Terrestrial biomes include the *tundra, desert, forests* and *grasslands.*
   - Because weather conditions in the arctic and alpine tundra are unpredictable, plants need to adapt to all sorts of weather. One of the survival strategies of plants is their cool growing temperature. Tundra plants can grow at temperatures 15°C to 20°C (27°F to 36°F) which is cooler than any other plant in the world.
   - Small and low growing plants are also a characteristic of tundra plants. This is because of the lack of nutrients found in the soil. Also being close to the dark, warmth, absorbent soil helps to keep plants from freezing.
   - Most *deserts* are very hot, with very limited or scarce water supply. The can get cold during the night, because hot air dissipates very quickly once the sun goes down.
   - To prevent over-heating, both reptiles and animals make burrows to escape the heat. Burrows can remain at a much cooler temperature during the day and a much warmer temperature during the night.
   - *Aquatic biomes* include marine (i.e., oceans and estuaries) and freshwater biomes (i.e., ponds and rivers).
   - Freshwater is defined as having a low salt concentration—usually less than 1%. Plants and animals in freshwater regions are adjusted to the low salt content and would not be able to survive in areas of high salt concentration.
   - Rivers and streams are bodies of freshwater that flow continuously in one direction. Plants and algae in streams typically are attached firmly to rocks or other substrates at the bottoms or sides of streams. Aquatic invertebrates also attach to, or hide underneath, these stationary objects. The animals living in streams must also anchor themselves or fight the flow of water.
   - Because the nutrients in rivers and streams are always flowing downstream, animals in these biomes must grab what they can from the water as it passes by. Many stream-dwelling animals are *filter-feeders,* sifting through the water for small particles of plant or animal matter to eat.
   - The marine biome contains 99.9 percent of the earth's surface water. Three life forms exist here, *plankton* (tiny animals and algae that float on the top), *nekton* (cod and sharks) and *benthos* (bottom dwellers like sponges and oysters).
   - Since water absorbs light, sunlight penetrates only the upper few hundred meters of the ocean, greatly affecting ocean life.

Continued

Domain VI: Competencies 29-32

- *Photic zone* - The part of the ocean that receives sunlight.
- *Aphotic zone* - The part of the ocean where sunlight cannot penetrate.

- The *abyssal zone* lies at the bottom of the ocean, and is also called the *benthic zone.* The abyssal zone is actually home to an assortment of highly specialized animals. Many of them congregate around deep sea hydrothermal vents. Unlike all other biomes, life in the deepest abyssal zone is supported not from photosynthesis, but chemosynthesis.
- The benthos feed off the dead organisms that sink to the bottom of the ocean floor.

2. Adaptive Changes of Organisms to Environmental Changes in Their Ecosystems

Ecology is the study of interactions of organisms with one another and with their physical surroundings.

- Natural and human-induced changes in the environment interact to affect the structure, functioning, and services of ecosystems.
- Observed ecological responses to recent climate change and variability include the shifting of geographic ranges of plant and animal species, lengthening of plant growing seasons, and increased mortality of tropical corals.
- Animals and plants in New England adapt to the environmental changes that accompany the transition from summer to fall.
- When winter comes, some animals hibernate and others migrate. The arctic hare has adapted to winter snowfall by shedding its brown summer coat for a white winter one. This gives it camouflage throughout the year.
- Giant tortoises are found in two varieties: domed or saddlebacked. Their “creation” depended on the food that was available to them. If the tortoises had to raise their heads to eat from trees or bushes, they became saddlebacked. If they had to eat off the ground, they became domed.
- The plants associated with a tall grass prairie are those which have evolved features suited to a combination of elements. Deep roots, for instance allow plants to tap ground water in times of drought. Rhizomes allow plants to survive the periodic fires, which prevent trees from taking over. As the season progresses and the grasses grow taller, different forbs come into flower at heights parallel to the height of the grass.
- Climate warming may enhance the growth of some trees by extending the growing seasons, but pathogens able to better survive winters because of milder conditions might at the same time decrease forest productivity.
- Subtle changes in the salinity or temperature of ocean currents may alter the ranges and population sizes of fish species, affecting catches for better or worse.
- Small changes in environmental conditions might alter plant and animal species mixes in ecosystems, resulting in long-term changes in ecosystem functioning.
- For a given ecosystem, functionally diverse communities are more likely to adapt to climate change and climate variability than impoverished ones.. In addition, high genetic diversity within species appears to increase their long-term persistence.

3. Classification Schemes

- In biological terminology, *classification* is the process of defining and naming classes of organisms. Classification schemes provide us with a system that helps us organize and name living organisms.
- Classifications systems assign a single universally accepted name to each organism.
- Good biological classification systems place organisms into groups that have real biological meaning, thus helping researchers to see that members of a group share similar characteristics.
- A requirement of an effective classification system is a set of universally accepted rules for grouping organisms.

29. Living Organisms and Taxonomic Systems, cont'd.

- One problem that lies in listing distinguishing characteristics is the rigidity it implies as far as attributes of a species are concerned. We must keep in mind the evolutionary processes that defined them and that they might change yet again.
- Another problem in classifying a newly discovered organism is in determining the specific characteristics that actually distinguish it from all other types of organisms.
- Another important factor to keep in mind is that most species are genetically diverse, which might create problems when generalizing based on specific traits.

4. Taxonomic Classification and Evolutionary History

- The Linnaean scheme for classification of living things puts organisms together based on presumed homologies. The assumption is that the more homologies two organisms share, the closer they must be in terms of evolutionary distance.
- On discovering an unknown organism, researchers begin their classification by looking for anatomical features that appear to have the same function as those found on other species.
- The next step is determining whether or not the similarities are due to an independent evolutionary development or to descent from a common ancestor. If the latter is the case, then the two species are probably closely related and should be classified into the same or near biological categories.
- Early embryos of many different vertebrate species look remarkably similar. These similarities in early embryological development of vertebrates can be taken as another indication that vertebrates may share a common ancestry.
- ***Homologies*** are anatomical features of different organisms that have a similar appearance or function because they were inherited from a common ancestor that also had the feature. The more homologies two organisms possess, the more likely it is that they have a close genetic relationship.
- Homologous traits are traits found in different species that have a common origin but may have different functions.
- For instance, the forelimb of a bear, the wing of a bird, and your arm have the same functional types of bones as did our shared reptilian ancestor—these bones are homologous structures.
- ***Convergence,*** or convergent evolution, is the development of a similar anatomical feature or trait in distinct species lines after divergence from a common ancestor that did not have the initial trait that led to it.
- The similar appearance and predatory behavior of North American wolves and Tasmanian wolves is an example. The former is a placental mammal and the latter is an Australian marsupial. Their common ancestor lived during the age of the dinosaurs more than 100 million years ago and was very different from these descendants today.

5. Hierarchical Classification System

- Carl Linnaeus published *Systema Naturae,* in 1758. This marked the beginning of the modern classification of plants and animals.
- He assigned organisms sharing the same characteristics into groups called *taxa* (singular: taxon), and the science of naming these organism and assigning them to groups was called ***taxonomy.***
- His system looked like this:
  - Kingdom
    - Phylum
      - Class
        - Order
          - Family
            - Genus
              - Species
- The smallest taxon is the species and the largest is called kingdom.
- The higher the category, the more inclusive it is.
- Members of a kingdom share general characters; members of a species share quite specific characters.

Continued

29. Living Organisms and Taxonomic Systems, cond'd.

- Characters are any structural, chromosomal, or molecular feature that distinguishes groups.
- Additional levels of classification can be added by adding super-, sub-, or infra- (e.g., suborder, subspecies).
- The identification of biological organisms can be greatly simplified using tools such as *dichotomous keys.*
- A dichotomous key is an organized set of couplets of mutually exclusive characteristics of biological organisms.
- Compare the characteristics of an unknown organism against an appropriate dichotomous key. These keys will begin with general characteristics and lead to couplets indicating progressively specific characteristics.
- If the organism falls into one category, go to the next indicated couplet. By following the key and making the correct choices, it is to identify a specimen to the indicated taxonomic level.
- Simple photographs and drawings can be of assistance, but carefully constructed, keys based on unambiguous taxonomic characteristics are more accurate and systematic.
- Some basic ideas in dichotomous key construction:
  - Use constant characteristics rather than ones that disappear or vary with the season or other environmental factor.
  - Use characteristics which can be directly observed.
  - Use quantitative measurements with an amount or dimension rather than vague terms like "big" and "small."
  - The name of the anatomical part should precede the descriptive terms with to which it applies.

6. Characteristics of Kingdoms

- The classification system used today is that of Whittaker (1959), and contains five kingdoms: Monera, Protista, Fungi, Plantae and Animalia.
- The greatest division now recognized is not between plants and animals (which are relatively similar), but between the prokaryotes (cells without nuclei) and eukaryotes (cells with nuclei).
- ***Monera:*** Have a primitive cell structure, lack a nuclear membrane.
- ***Protists:*** Are predominantly unicellular organisms with plant-like and/or animal-like characteristics.
- ***Fungi:*** Cells are usually organized into branched, multinucleated filaments that absorb digested food from their environment.
- ***Plants:*** They are multicellular photosynthetic organisms.

  Bryophytes - lack vascular tissue; have no true roots, stems or leaves.

  Tracheophytes - Possess vascular tissue; have true roots stems and leaves.
- ***Animals:*** Are muliticellular, heterotrophic organisms.

  Coelenterates - Have two cell layers, hollow body cavity.

  Annelids - Have segmented body walls.

  Arthropods - Have jointed appendages, exoskeleton.

  Chordates - Possess dorsal nerve cord, internal skeleton.

Domain VIII:

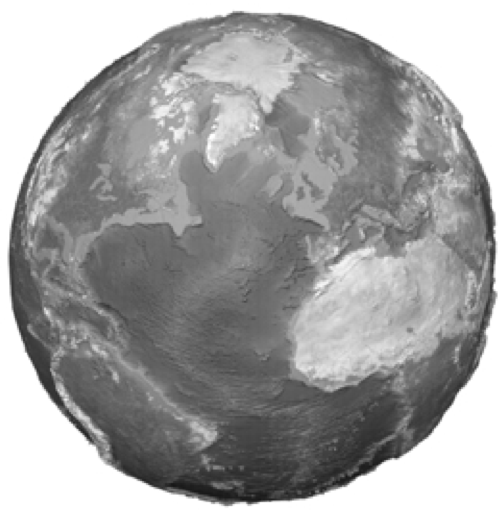
Earth's History and the Structure and Function of Earth Systems

Competencies 36-41

(9% of the test)

Science 8-12 Standard X:

The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in Earth and space science.



Domain VIII: Competencies 36-41

36. Geosphere

Key Descriptors:

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NOTE: Refer to the bullet points under each Competency in the ETS/SBEC study guide. On the lines above paraphrase each bullet point using a short phrase that is meaningful to you.

Key Words:

Geosphere
Seismic Waves
Rock Cycle
Density
Hardness
Streak
Cleavage
Minerals
Sedimentary Rocks
Igneous Rocks
Metamorphic Rocks
Rock Cycle
Landforms
Topography
Renewable and Non-renewable Resources
Fossil Fuels
Mantle Convection

DESCRIPTOR HIGHLIGHTS

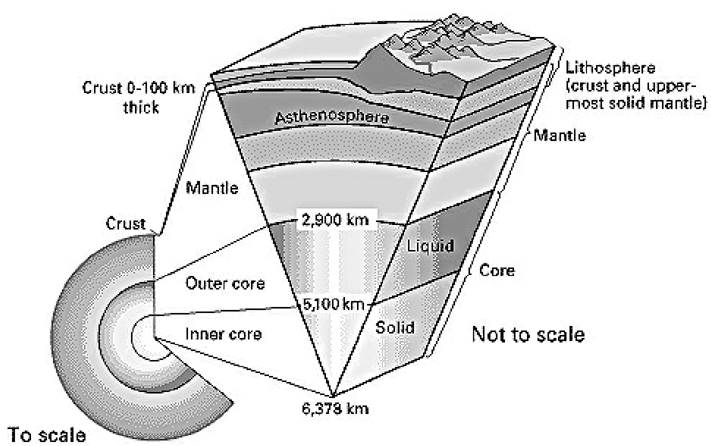
- The teacher understands the structure of the Earth's interior and the processes used to investigate it.
- The teacher knows how to classify and identify rocks and minerals and their economic uses.
- The teacher understands the processes involved in the formation of rocks and minerals.
- The teacher knows the topography and different landforms on the Earth's surface.
- The teacher knows the different types and uses of Earth's renewable and non-renewable resources.
- The teacher explains the source of matter and energy and its cycles and transformations in the geosphere.
- The teacher explains the relationship between the principles of conservation of mass and energy to processes in the geosphere.

36. Geosphere

Competency 36:

The teacher understands structure and function of the geosphere.

1. **Earth Structure and Investigative Methods**
   - The Earth is made up of three main layers: *crust, mantle,* and *core.* This layered structure can be compared to that of a boiled egg.



   - The crust, the outermost layer, is rigid and very thin and brittle compared with the other two. The crust is composed mainly of alumino silicates.
   - Beneath the oceans, the crust varies little in thickness, generally extending only to about 5 km. The thickness of the crust beneath continents is much more variable but averages about 30 km. Under large mountain ranges, the base of the crust can be as deep as 100 km.
   - Below the crust is the *mantle,* a dense, hot layer of semi-solid rock approximately 2,900 km thick. The mantle, which contains more iron, magnesium, and calcium than the crust, is hotter and denser because temperature and pressure inside the Earth increase with depth.
   - At the center of the Earth lies the *core,* which is nearly twice as dense as the mantle because its composition is metallic (iron-nickel alloy) rather than stony.
   - The Earth's core is actually made up of two distinct parts: a 2,200 km thick *liquid* outer core and a 1,250 km-thick *solid* inner core. As the Earth rotates, the liquid outer core spins, creating the Earth's magnetic field.
   - The behavior of seismic waves indicates the presence of several layers and the Earth is separated into layers based on mechanical or physical properties in addition to its composition.
   - The topmost layer is the ***lithosphere,*** which is comprised of the crust and solid portion of the upper mantle. The lithosphere is divided into many plates that move in relation to each other due to tectonic forces.
   - Temperature and pressure at these depths are relatively low; therefore the rock in this region is quite brittle. Most earthquakes originate here.
   - The lithosphere essentially floats atop a semi-liquid layer known as the ***asthenosphere.*** This layer allows the solid lithosphere to move around since the asthenosphere is much weaker than the lithosphere.
   - Heat and pressure cause a small amount of melting to occur in the asthenosphere and the rock exists in a semi-liquid state. While still solid, the asthenosphere is able to flow. This ability of a solid to flow is called ***plasticity.***
   - Heat supplied from beneath the asthenosphere contributes to the melting process, and liquid basalt flows up through the spreading ridges.
   - The Earth's layers are studied by looking at recordings of seismic waves generated by earthquakes. When an earthquake occurs, seismic waves travel throughout the earth. Sensitive seismic instruments record them.
   - There are two types of seismic waves:
     - *P-waves* which are longitudinal pressure waves and can propagate in both solids and liquids.
     - *S-waves* which are transverse waves that can propagate in solids but not in liquids
   - Since seismic waves have their direction of motion changed (refracted) by variations in

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Domain VIII: Competencies 36-41

the interior density; studying the way such waves propagate in the Earth tells us about density variations. Additionally, the fact that P-waves propagate in liquids but S-waves do not allows us to determine if portions of the interior are liquid.

2. Types of Rocks and Minerals and Their Uses

- Rocks may be classified into three main groups according to their method of formation. Rocks which form from the cooling and crystallization of magma are called ***igneous rocks.*** Rocks that are composed of fragments or sediments of other rocks are called ***sedimentary rocks.*** Rocks that form from the alteration of existing rocks by heat, pressure, and chemical change are metamorphic rocks.
- The concept of a ***rock cycle*** was proposed by James Hutton in the late 1700's. It shows how rocks of one rock class may be recycled by geologic processes to become the raw material for other rock classes. The interrelationship among the rock types is referred to as the rock cycle.
- The rock cycle works something like this.
  1. Liquid (molten) rock material solidifies either at or below the surface of the earth to form *igneous rocks.* Uplifting occurs forming mountains made of rock.
  2. The exposure of rocks to weathering and erosion at the earth's surface breaks them down into smaller grains producing soil.
  3. The grains are transported by wind, water and gravity and eventually deposited as sediments. This process is referred to as *erosion.* The sediments are deposited in layers and become compacted and cemented forming *sedimentary rocks.*
  4. Variation in temperature, pressure, and/or the chemistry of the rock can cause chemical and/or physical changes in igneous and sedimentary rocks to form *metamorphic rocks.*
  5. When exposed to higher temperatures, metamorphic rocks (or any other rock type for that matter) may be partially melted resulting in the creation once again of igneous rocks starting the cycle all over again.
- Rocks are made up of one or more minerals. They have been an integral part of the history of mankind, first being used as tools for hunting and defense, and then as building materials to construct shelters and monuments.
- Minerals are homogeneous, naturally occurring, inorganic solids. Each mineral has a definite chemical composition and a characteristic crystalline structure. A mineral may be a single element such as copper (Cu) or gold (Au), or it may be a compound made up of a number of elements. About 2,500 different minerals have been described.
- Minerals are important in many ways. First, many minerals are useful. Salt is used to flavor food, graphite is used in pencils, and gemstones and precious metals are used to make jewelry and other items. Minerals also combine as the basic building blocks of all common rocks.

3. Rocks and Minerals - Identification and Processes

- Igneous rocks that form on or near the earth's surface are termed *extrusive* (or *volcanic*). These rocks have small crystals with a fine grained texture (e.g., *basalt,* the most common rock of the seafloor). If the magma cooled so quickly that no crystals formed, the rock has a glassy texture and is *obsidian.* Volcanic rocks that have holes where the bubbles of gas escaped from the lava are *pumice* and *scoria.*
- Igneous rocks that form deep below the earth's surface are *intrusive (*or *plutonic*). They cool slowly developing large crystals. *Granite* with its coarse-grained texture is a plutonic rock. It is the most common rock underlying the continents.
- Sedimentary rocks are usually classified according to the origin of the sediments. Cemented or compressed rock fragments are *clastic* sedimentary rocks. Minerals precipitat-

ed or evaporated from a solution are chemical sedimentary rocks (e.g., *salt* or *crystalline limestone*). *Organic* sedimentary rocks form from plant and animal remains (e.g., *coal* or *fossil limestone*).

- Wind or running water deposit clastic sediments by size. As these sediments become cemented together, the gravel and pebbles form *conglomerate,* the sands form *sandstone,* and the clays form *shale.* The change from sediment to solid rock is called *lithification.* Lithification takes place with the help of *cementation, compaction,* and *crystallization.*
- Metamorphic rocks are formed from other rocks that have been subjected to heat, pressure, and chemical alteration. Metamorphic rocks are usually harder and more crystalline than the original rock.
- Metamorphism occurs when rocks are deeply buried during mountain building. Metamorphic rocks often show evidence of being squeezed. Squeezed rocks such as *slate, schist,* and *gneiss* have their minerals reoriented and realigned at right angles to the pressure. These rocks are foliated.

  Rocks that have recrystallized without showing any parallel alignment are non-foliated. *Marble* is a metamorphic rock formed from recrystallized limestone.
- Within the earth's molten liquid rock, minute particles called *atoms* dance wildly in every direction. As this molten mass cools, the movement of atoms slows down and similar atoms begin bonding themselves together in an orderly fashion. This process is called *crystallization* and results in the formation of solid minerals.
- You can identify minerals using some of the following tests:
  - The true color of a specimen can be determined by a *streak test.*
  - A *luster test* evaluates the shine or reflective characteristics of a mineral.
  - Mineral hardness tests determine how scratch-resistant or abrasive a mineral is.
  - *Mineral cleavage* is another test that determines how a mineral breaks apart. This can provide valuable information about its structure.

4. Landforms and Topography

- *Topography* is the surface configuration of Earth. Landforms are individual topographic or natural physical features of the earth's surface, for example, valleys, plateaus, mountains, plains, hills, loess, or glaciers
- A *valley i*s a hollow or surface depression of the earth bounded by hills or mountains, a natural trough in the earth's surface that slopes down to a stream, lake or the ocean, formed by water and/or ice erosion.
- A *mountain* is a landform that rises prominently above its surroundings, generally exhibiting steep slopes, a relatively confined summit area, and considerable local relief.
- *Hills* are elevations of the earth's surface that have distinct summits, but are lower in elevation than mountains. Hills may be formed by a buildup of rock debris or sand deposited by glaciers and wind. They can also be created by faults.
- Major features of the ocean floor include the oceanic ridge system, transform faults and fracture zones, island arcs and trenches, abyssal plains, oceanic plateaus, seamounts and island chains.
- The flat floors of the ocean are the *abyssal plains* and they have an average depth about 4 to 6 km. The abyssal plains are covered by a thin layer of sediment, mostly less than 1 km thick.
- The ocean ridge system is the largest tectonic feature on the earth, is more than 1500 km wide, 64,000 km long and rises to 2 to 3 km high above the abyssal plain.
- It has a central rift valley composed of basalt rocks and is characterized by high heat flow and hydrothermal vents.

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36. Geosphere, cont'd.

- It is faulted but not folded and most shallow earthquakes occur along the central rift.
- *Mid-oceanic ridge* is normally found rising above the ocean floor at the center of the ocean basins. It is a chain of submarine mountains where oceanic crust is created from rising magma plumes and volcanic activity.
- Some volcanic islands are part of the mid-ocean ridge system (Iceland). The mid-oceanic ridge constitutes 23% of the Earth's surface.
- *Transform faults* are large faults on the ocean floor which cut across the oceanic ridges. Transform faults offset the axis of the ocean ridge system and are seismically active.
- *Fracture zones* are the continuations of transform faults which extend far beyond the oceanic ridges.
- Most *seamounts* (sea mountains) are of volcanic origin and only a small proportion reach the ocean surface. The Hawaiian Islands are an example of the few of these still volcanically active.
- A *volcano* is an elevated area of land created from the release of lava and ejection of ash and rock fragments from a volcanic vent. Numerous volcanoes populate the floor of the ocean basins. Scientists estimate that there are approximately 10,000 volcanoes on the ocean floor.
- *Oceanic plateaus* are broad areas of the ocean floor that are at relatively high elevations and are only 1 to 2 km deep.
- Streams flowing into standing water, mainly oceans but also lakes, normally create a *delta* Deltas are bodies of sediment deposited at the mouth of a river. Many are roughly triangular in shape.

5. Earth's Resources

- *Non-renewable resources* are those that are not possible to replace once they are used up or take thousands or millions or years to replace. These include minerals and metals, oil, natural gas, and coal. All of these occur in the ground in limited amounts.
- With some metals and minerals, it is possible to recycle them, but only if they are NOT being used in ways that make them permanently unavailable for re-use.
- Most of the metallic minerals mined in the world, such as copper, gold, silver, lead, and zinc, are associated with magmas found deep within the roots of extinct volcanoes located above subduction zones. Ore deposits commonly form around the magma bodies that feed volcanoes because there is a ready supply of heat, which convectively moves and circulates ore-bearing fluids.
- *Oil and natural gas* are the products of the deep burial and decomposition of accumulated organic material in geologic basins that flank mountain ranges formed by plate-tectonic processes. Heat and pressure at depth transform the decomposed organic material into tiny pockets of gas and liquid petroleum, which then migrate through the pore spaces and larger openings in the surrounding rocks and collect in reservoirs, generally within 5 km of the Earth's surface.
- *Renewable resources* are those that can be replaced (although usually not completely or in the same form) in a relatively short period of time, either by human action, or by natural processes of replenishment or reproduction. These include such resources as forests, crops, livestock, water, fish and other marine life, soils, and wildlife.
- However, if they are over-exploited by humans, their ability to renew can become endangered
- Living *marine resources* are all of the biotic components found within the marine ecosystems. Some of these organisms include benthic invertebrates, bacteria, phytoplankton, zooplankton, crustaceans and fish, just to name a few. Non-living marine resources include mineral deposits and off-shore oil and natural gas.
- *Fertile soils* are another important resource that we get from volcanoes which can clearly

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cause much damage and destruction, but also benefit people. Over thousands to millions of years, the physical breakdown and chemical weathering of volcanic rocks have formed some of the most fertile soils on Earth.

6. Matter and Energy on the Earth

- *Carbon* atoms easily bond with other carbon atoms, and can form long, complex chains. As the "backbone" of literally hundreds of thousands of compounds, the ability of carbon to link together into chains is the basis for organic compounds.
- Through metamorphic processes (such as heating and compressing), organic material can be converted into energy-producing carbon-rich "fossil fuels", such as natural gas and oil. *Coal* is a sedimentary/metamorphic rock produced in swamps where there is a large-scale accumulation of organic matter from plants.
- Nitrogen is vital since it forms simple chemicals called amino acids, the essential building blocks of all proteins, enzymes, and especially DNA. Nitrogen-fixing bacteria that cling to roots within the soil convert this inorganic nitrogen into organic forms (ammonia and nitrate ions) that plants can absorb.
- Energy derived directly from the Sun can be used in these ways:

  Direct solar energy - Used to heat water and homes—can be used to generate electricity with solar cells.*

  Wind Energy - Solar energy causes heating of the atmosphere which results in convection of air and produces winds.

  *Hydroelectric Energy** - Derived from the Sun because the Sun causes evaporation of the oceans. Convection of the atmosphere moves the evaporated water to higher elevations where it can then run down hill and be used to generate electricity.
- Energy derived indirectly from the Sun:

  Biomass Energy - Involves burning of wood, or other organic byproducts. Such organic material is produced by photosynthesis, a chemical process which derives energy from the Sun and stores that energy until the material is burned.

  Fossil Fuels - Biomass energy that is buried within the Earth where it is stored until humans extract and burn it to release the energy. Examples include petroleum and coal.
- *Nuclear Energy:* Radioactive Uranium is concentrated and made into fuel rods that generate large amounts of heat as a result of radioactive decay. This heat is used to turn water into steam. Expansion of the steam can then be used to drive a turbine and generate electricity.
- *Geothermal energy* can be harnessed from the Earth's natural heat associated with active volcanoes or geologically young inactive volcanoes still giving off heat at depth.
- Steam from high-temperature geothermal fluids can be used to drive turbines and generate electrical power, while lower temperature fluids provide hot water for space-heating purposes, heat for greenhouses and industrial uses, and hot or warm springs at resort spas.

7. Matter and Energy Cycles

- The *thermal convection* within the Earth's *mantle* is the driving force behind the geological processes that shape our planet.
- The fundamental energy source within the Earth is heat, primarily provided by radioactive decay in the mantle. Converting this to kinetic energy is through convection. Convection cells occur in the earth, which manifest themselves on the surface by major movements of the earth's lithosphere that result in earthquakes and volcanoes.
- *Convection* is heat transfer by the flow of materials. Convection occurs when a material is heated up and expands. A material thus expanded is less dense than the surrounding materials and rises. At the same time, colder materials sink into the place from which the

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