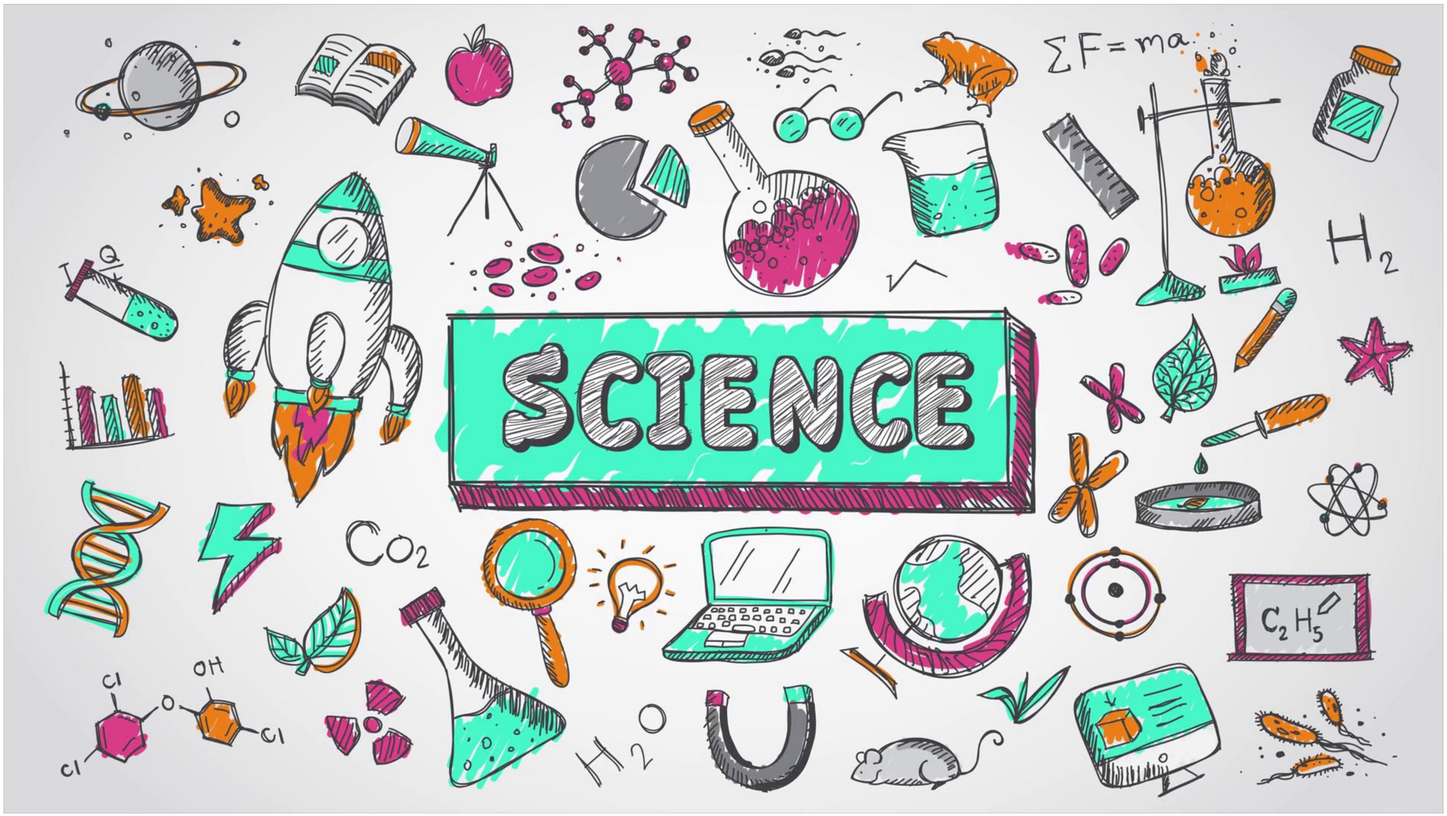

Fifth Grade – Eighth Grade Curriculum

CORE KNOWLEDGE GRADE 5 - SCIENCE

Exploring the Universe (Astronomy)

- Identify tools astronomers use to explore the universe
- Construct a Galilean refracting telescope
- Describe constellations and asterisms
- Locate the asterisms the Big Dipper and the Little Dipper on a sky map
- Identify factors that determine which stars and constellations we see
- Locate constellations on sky maps
- Describe and classify galaxies
- Describe the Milky Way Galaxy
- Identify the stages in the life cycles of stars
- Describe the life cycles of stars
- Identify characteristics of our solar system
- Identify characteristics of our Sun
- Describe the planets in our solar system
- Compare and contrasting the planets
- Identify characteristics of asteroids, meteoroids, dwarf planets, and comets
- Describe the two motions of Earth
- Identify the cause of day and night on Earth
- Identify why the Sun, Moon, and stars appear to move across the sky
- Identify the causes of the Earth's seasons
- Compare the number of hours of daylight at different times of the year
- Construct a graph to show changing hours of daylight
- Identify the phases of the Earth's Moon
- Identify how solar and lunar eclipses occur

Examining the Structure of Matter (Chemistry)

- Identify elements that make up matter
- Identify and interpreting information on the Periodic Table of the Elements
- Classify elements as metals, non-metals, or metalloids
- Describe properties of elements
- Describe the structure of an atom

- Identify valence electrons
- Use diagrams to represent atoms of elements
- Describe compounds
- Identify organic and inorganic compounds
- Identify elements in a chemical formula
- Identify what happens during chemical bonding
- Describe metallic bonding
- *Describe ionic bonding*
- Describe covalent bonding
- Identify the structural formula of a molecule

Investigating Matter and Its Interactions (Chemistry)

- Classify matter as a pure substance or a mixture
- Identify mixtures as homogeneous or heterogeneous
- Classify mixtures as solutions, colloids, or suspensions
- Identify characteristics of solids, liquids, gases, and plasmas
- Identify phase changes when heat is added
- Identify phase changes when heat is removed
- Observe and describing cohesion, surface tension, and adhesion
- Observe and identifying physical changes
- Identify physical properties of matter
- Compare the viscosity of liquids
- Conduct a viscosity experiment
- Measure temperature
- Measure the mass of solids and liquids
- Measure the volume of liquids and solids
- Measure the volume of rectangular solids
- Describe density
- Compare the density of metals
- Compare the density of solids and liquids
- Observe and identifying characteristics of chemical changes
- Identify endothermic and exothermic chemical reactions
- Observe and describe chemical reactions: combustion, synthesis, and decomposition
- Describe chemical reactions: neutralization

- Identify acids and bases

Examining the Interactions of the Earth's Systems (Environmental Science)

- Identify Earth's four major systems
- Describe how human activities cause changes to the environment and affect Earth's systems
- Describe the layers of the geosphere
- Describe how the movement of tectonic plates causes changes to the geosphere
- Describe and observing processes that change the geosphere: weathering, erosion, and deposition
- Describe how erosion and deposition change the geosphere
- Describe and observing fossils
- Classify rocks
- Describe the rock cycle
- Identify rocks and minerals
- Describe the layers of the atmosphere
- Describe the effects of greenhouse gases and ozone
- Describe weather conditions
- Describe characteristics of air masses
- Describe the hydrosphere
- Identify sources of saline and fresh water
- Describe the water cycle
- Identify and describing natural disasters
- Describe climate
- Identify and describing climatic regions
- Describe terrestrial biomes
- Describe freshwater and marine regions of the aquatic biome
- Describe the effects of forests on the Earth's systems
- Identify ways to protect forests

Exploring Forces and Motion (Physics)

- Describe force
- Demonstrate how forces affect matter

- Describe the four fundamental forces in nature
- Identify weight as a force
- Measure weight
- Describe magnetism and magnetic fields
- Describe the effect a magnet has on other substances
- Describe an electromagnet
- Describe the Earth's magnetism
- Use a compass
- Describe contact forces involving solids
- Measure force by using a spring scale
- Conduct a friction experiment
- Describe contact forces involving fluids
- Describe Newton's laws of motion

<u>Investigating Tools and Machines (Engineering)</u>

- Describe and measure work
- Observe how sleds and rollers reduce the effort needed to do work
- Describe machines
- Identify simple machines
- Identify, describe, and compare inclined planes
- Identify and describe a wedge, screw, and wheel and axle
- Identify and describe first-class levers
- Identify and describe second-class levers
- Identify and describe third-class levers
- Describe a pulley
- Use a fixed pulley, a movable pulley, and a pulley system to lift a load
- Measure and compare the amounts of effort needed to raise a load by using a fixed pulley, a movable pulley, and a pulley system
- Calculate the amount of effort needed to raise a load and the distance the rope is pulled when a pulley or pulley system is used
- Observe and describe gears
- Describe the functions of tools
- Research the history and development of a tool
- Identify engineering occupations
- Describe the role of engineers

Examining the Endocrine System (Physiology)

- The human body has two types of glands: duct glands (such as the salivary glands), and ductless glands, also known as endocrine glands.
- Endocrine glands secrete (give off) chemicals called hormones. Different hormones control different body processes.
- Pituitary gland: located at the bottom of the brain; secretes hormones that control other glands, and hormones that regulate growth
- Thyroid gland: located below the voice box; secretes a hormone that controls the rate at which the body burns and uses food
- Pancreas: both a duct and ductless gland; secretes a hormone called insulin that regulates how the body uses and stores sugar; when the pancreas does not produce enough insulin, a person has a sickness called diabetes (which can be controlled)
- Adrenal glands: secrete a hormone called adrenaline, especially when a person is frightened or angry, causing rapid heartbeat and breathing
- Puberty Glands and hormones: growth spurt, hair growth, breasts, voice change

Examining Life Cycles and Reproduction (Physiology)

The Life Cycle and Reproduction

- Life cycle: development of an organism from birth to growth, reproduction, death

  Example: Growth stages of a human: embryo, fetus, newborn, infancy, childhood, adolescence, adulthood, old age
- All living things reproduce themselves. Reproduction may be asexual or sexual.

  Examples of asexual reproduction: fission (splitting) of bacteria, spores from mildews, molds, and mushrooms, budding of yeast cells, regeneration and cloning

  Sexual reproduction requires the joining of special male and female cells, called gametes, to form a fertilized egg.

Reproduction in Plants

- Asexual reproduction

  Example of algae

Vegetative reproduction: runners (for example, strawberries) and bulbs (for example, onions), growing plants from eyes, buds, leaves, roots, and stems

- Sexual reproduction by spore-bearing plants (for example, mosses and ferns)
- Sexual reproduction of non-flowering seed plants: conifers (for example, pines), male and female cones, wind pollination
- Sexual reproduction of flowering plants (for example, peas)
  - Functions of sepals and petals, stamen (male), anther, pistil (female), ovary (or ovule)
  - Process of seed and fruit production: pollen, wind, insect and bird pollination, fertilization, growth of ovary, mature fruit
  - Seed germination and plant growth: seed coat, embryo and endosperm, germination (sprouting of new plant), monocots (for example, corn) and dicots (for example, beans)

Sexual Reproduction in Animals

- Reproductive organs: testes (sperm) and ovaries (eggs)
- External fertilization: spawning
- Internal fertilization: birds, mammals
- Development of the embryo: egg, zygote, embryo, growth in uterus, fetus, newborn

The Human Reproductive System

- Females: ovaries, fallopian tubes, uterus, vagina, menstruation
- Males: testes, scrotum, penis, urethra, semen
- Sexual reproduction: fertilization, zygote, implantation of zygote in the uterus, pregnancy, embryo, fetus, newborn

GRADE 6 SCIENCE:

I. PLATE TECTONICS

• The surface of the earth

The surface of the earth is in constant movement.

The present features of earth come from its ongoing history. After the sun was formed, matter cooled creating the planets. The continents were once joined (Pangaea).

• Layered structure of the earth

Crust: surface layer of mainly basalt or granite, 5 to 25 miles thick

Mantle: 1,800 miles thick, rock of intermediate density, moves very slowly

Outer core: liquid iron and nickel Inner core: solid iron and nickel, 800 miles thick, about 7,000 degrees C

• Crust movements

The surface of earth is made up of rigid plates that are in constant motion.

Plates move because molten rock rises and falls under the crust causing slowly flowing currents under the plates.

Plates move at speeds ranging from 1 to 4 inches (5-10 centimeters) per year.

Earthquakes usually occur where stress has been built up by plates moving in opposite directions against each other. Earthquakes cause waves (vibrations) which have:

focus, the point below the surface where the quake begins

epicenter, the point on the surface above the focus

Severity of ground shaking is measured on the Richter scale; each unit on the scale represents a tenfold severity increase

• Volcanoes usually occur where plates are pulling apart or coming together, but some occur at holes (hot spots) in the crust away from plate boundaries. As plates move over these hot spots, they cause chains of volcanoes and island chains like the Hawaiian Islands.

• Evidence for long-term movement of plates includes fit of continents and matches of rock types, fossils, and structures; ocean floor age and topography; ancient climate zones; locations of earthquakes, volcanoes, and mountain ranges; magnetic directions in ancient rocks.

II. Oceans

• Surface

The world ocean covers most of the earth's surface (71 per cent).

Three major subdivisions of the world ocean: Atlantic, Pacific, and Indian Oceans

Islands consist of high parts of submerged continents, volcanic peaks, coral atolls.

• Subsurface land features

Continental shelf, continental slope, continental rise, abyssal plains

Mid-ocean ridges and trenches, plate tectonics

Mid-Atlantic Ridge, Mariana Trench

• Ocean bottom: average depth of sediment .3 mile, consists of rock particles and organic remains

• Composition of seawater: dilute solution of salts which come from weathering and erosion of continental rocks.

Sodium chloride is the main salt.

• Currents, tides, and waves

Surface currents: large circular streams kept in motion by prevailing winds and rotation of the earth; Gulf Stream (North Atlantic), Kuroshio (North Pacific)
Subsurface currents are caused by upwelling from prevailing offshore winds (Peru, Chile) and density differences (Antarctica); the upwelling pushes up nutrients from the ocean floor.
Tides are caused by gravitational forces of the sun and moon; there are two tides daily.
Waves are caused by wind on the ocean's surface.
Water molecules tend to move up and down in place and not move with the wave.
Crest and trough, wave height and wavelength, shoreline friction
Tsunamis: destructive, fast-moving large waves caused mainly by earthquakes
• Marine life
Life zones are determined by the depth to which light can penetrate making photosynthesis possible, and by the availability of nutrients.
The bottom (benthic zone) extends from sunlit continental shelf to dark sparsely populated depths. Shallow lighted water extending over continental shelf contains 90% of marine species.
Pelagic zone: water in open oceans
Classification of marine life
Bottom-living (benthic) such as kelp and mollusks
Free-swimming (nekton) such as fish and whales
Small drifting plants and animals (plankton), which are the dominant life and food source of the ocean
The basis for most marine life is phytoplankton (plant-plankton), which carry on photosynthesis near surface; contrast zooplankton (animal plankton).
Most deep water life depends on rain of organic matter from above. The densest concentration of marine life is found in surface waters, such as those off Chile, where nutrient-rich water wells up to the bright surface.
III. Astronomy: Gravity, Stars, and Galaxies
• Gravity: an attractive force between objects
Newton's law of universal gravitation: Between any two objects in the universe there is an attractive force, gravity, which grows greater as the objects move closer to each other.
How gravity keeps the planets in orbit
• Stars
The sun is a star.
Kinds of stars (by size): giants, dwarfs, pulsars
Supernova; black holes Apparent movement of stars caused by rotation of the earth
Constellations: visual groupings of stars, for example, Big Dipper, Orion
Astronomical distance measured in light years
• Galaxies
The Milky Way is our galaxy; the Andromeda Galaxy is closest to the Milky Way.
Quasars are the most distant visible objects (because the brightest).
IV. Energy, Heat, and Energy Transfer
A. Energy
• Six forms of energy: mechanical, heat, electrical, wave, chemical, nuclear
• The many forms of energy are interchangeable, for example, gasoline in a car, windmills, hydroelectric plants.

• Sources of energy: for example, heat (coal, natural gas, solar, atomic, geothermal, and thermonuclear), mechanical motion (such as falling water, wind) See below, Energy: Nuclear energy, re Stars. 169
• Fossil fuels: a finite resource
Carbon, coal, oil, natural gas
Environmental impact of fossil fuels: carbon dioxide and global warming theory, greenhouse effect, oil spills, acid rain
• Nuclear energy
Uranium, fission, nuclear reactor, radioactive waste
Nuclear power plants: safety and accidents (for example, Three Mile Island, Chernobyl)
B. Heat
• Heat and temperature: how vigorously atoms are moving and colliding
• Three ways that heat energy can be transferred: conduction, convection, radiation
The direction of heat transfer
C. Physical Change: Energy Transfer
• States of matter (solid, liquid, gas) in terms of molecular motion
In gases, loosely packed atoms and molecules move independently and collide often. Volume and shape change readily.
In liquids, atoms and molecules are more loosely packed than in solids and can move past each other. Liquids change shape readily but resist change in volume. In solids, atoms and molecules are more tightly packed and can only vibrate. Solids resist change in shape and volume.
• Most substances are solid at low temperatures, liquid at medium temperatures, and gaseous at high temperatures.
• A change of phase is a physical change (no new substance is produced).
• Matter can be made to change phases by adding or removing energy.
• Expansion and contraction
Expansion is adding heat energy to a substance, which causes the molecules to move more quickly and the substance to expand.
Contraction is when a substance loses heat energy, the molecules slow down, and the substance contracts.
Water as a special case: water expands when it changes from a liquid to a solid.
• Changing phases: condensation; freezing; melting; boiling
Different amounts of energy are required to change the phase of different substances. Each substance has its own melting and boiling point.
The freezing point and boiling point of water (in degrees Celsius and Fahrenheit)
• Distillation: separation of mixtures of liquids with different boiling points.

V. The Human Body

• The circulatory and lymphatic systems
Briefly review from grade 4: circulatory system
Lymph, lymph nodes, white cells, tonsils Blood pressure, hardening and clogging of arteries
• The immune system fights infections from bacteria, viruses, fungi.
White cells, antibodies, antigens
Vaccines, communicable and non-communicable diseases, epidemics

Bacterial diseases: tetanus, typhoid, tuberculosis; antibiotics like penicillin, discovered by Alexander Fleming
Viral diseases: common cold, chicken pox, mononucleosis, rabies, polio, AIDS
VI. Science Biographies
Marie Curie (advances in science of radioactivity; discovered the elements polonium and radium)
Lewis Howard Latimer (worked with Alexander Graham Bell on drawings of Bell's invention, the telephone; improved Thomas Edison's light bulb)
Isaac Newton (known for advances in physics; outlined laws of gravity and invented the telescope)
Alfred Wegener (known for theory that the continents were once joined together and split apart to form the continents; now known as "the continental drift")

GRADE 7 SCIENCE:

I. Atomic Structure

• Review (from grade 5): Structure of atoms: protons, neutron, electrons
Molecules
Compounds are formed by combining two or more elements and have properties different from the constituent elements.
• Early theories of matter
The early Greek theory of four elements: earth, air, fire, and water
Later theories of Democritus: everything is made of atoms and nothing else ("atom" in Greek means that which can't be cut or divided); atoms of the same kind form a pure "element" Alchemy in middle ages
• Start of modern chemistry
Lavoisier and oxygen: the idea that matter is not gained or lost in chemical reactions
John Dalton revives the theory of the atom.
Mendeleev develops the Periodic Table, showing that the properties of atoms of elements come in repeating (periodic) groups.
Niels Bohr develops a model of the atom in shells that hold a certain number of electrons.
Bohr's model, plus the discovery of neutrons, helped explain the Periodic Table: atomic number, atomic weight, and isotopes.

II. Chemical Bonds and Reactions

• To get a stable outer shell of electrons, atoms either give away, take on, or share electrons.
• Chemical reactions rearrange the atoms and the electrons in elements and compounds to form chemical bonds.
• When single atoms combine with themselves or with other atoms, the result is a molecule.
O2 is a molecule of oxygen. NaCl is a molecule of salt, and because it has more than one element is called a compound.
• Ionic bond
Atoms like sodium that have just one or two extra electrons are very energetic in giving them away. Elements with the same number of extra or few electrons can join with each other to make an ionic bond. Example: NaCl, table salt.
• Metallic bond
In the metallic bond, electrons are not given away between elements, but are arranged so that they are shared between atoms. Pure metals show this sharing, and the atoms can rearrange themselves in different ways, which explains why you can pound metals into different shapes.
• Covalent bond
Some atoms share electrons in a definite way, making them very stable and unreactive. Examples are H2and O2. Carbon, which can take up or give away 4 electrons in covalent bonds, can help make molecules that can adopt almost any shape. It is the basis of life.
• Kinds of reactions
Oxidation: a chemical reaction that commonly involves oxygen. More generally, oxidation is a reaction in which an atom accepts electrons while combining with other elements. The atom that gives away electrons is said to be oxidized.

Examples: rusting of iron, burning of paper. Heat is given off.
Reduction: the opposite of oxidation. Reduction involves the gaining of electrons. An oxidized material gives them away and heat is taken up.
Acids: for example, vinegar, HCl, H_2SO_4; sour; turn litmus red
Bases: for example, baking soda; bitter; turn litmus blue pH: ranges from 0-14; neutral = 7, acid = below 7, base = above 7
Reactions with acids and bases
In water solution, an acid compound has an H ion (a proton lacking an electron), and the base compound has an OH ion (with an extra electron).
When the two come together, they form HOH (water) plus a stable compound called a "salt."
• How chemists describe reactions by equations, for example: $HCl + NaOH = NaCl + H_2O$
• A catalyst helps a reaction, but is not used up.

III. Cell Division and Genetics

• Cell division, the basic process for growth and reproduction
Two types of cell division: mitosis (growth and asexual reproduction), meiosis (sexual reproduction)
Asexual reproduction: mitosis; diploid cells (as in amoeba)
Sexual reproduction: meiosis: haploid cells; combinations of traits
How change occurs from one generation to another: either mutation or mixing of traits through sexual reproduction
Why acquired characteristics are not transmitted
• Gregor Mendel's experiments with purebred and hybrid peas
Dominant and recessive genes
Mendel's statistical analysis led to understanding that inherited traits are controlled by genes (now known to be DNA).
• Modern understanding of chromosomes and genes
Double helix (twisted ladder) of DNA coding; how DNA makes new DNA
How DNA sequence makes proteins
Genetic engineering
Modern researchers in genetics: Francis Crick, James Watson, Severo Ochoa, Barbara McClintock

IV. History of the Earth and Life Forms

A. Paleontology
• Fossils as a record of the Earth's history and past life forms
• How fossils are formed, and types of fossils (mold, cast, trace, true-form)
B. Geologic Time
• The age of the earth is about 4.6 billion years, based on geologic evidence and radioactive dating. Life has existed on earth for more than 3 billion years. How movements of the earth's plates have affected the distribution of organisms
• Organizing geologic time: Scientists have organized the earth's history into four major eras:
Precambrian Era (earliest forms of life, such as bacteria and blue-green algae; later in the period, invertebrates such as jellyfish)

Paleozoic Era (Pangaea; invertebrate life, such as trilobites, early in this era, followed by development of vertebrates later in the era, including fish; development of insects, amphibians, and the beginnings of reptiles; development of simple plants, such as mosses and ferns)
Mesozoic Era (Pangaea separates into continents; "Age of Reptiles"; dinosaurs, flowering plants, small mammals and birds)
Cenozoic (Present) Era (Ice Age; mammoths; gradual development of mammals, birds and other animals recognizable today; humans; flowering plants, forests, grasslands)

V. Evolution

A. Evolution

• Evolution is the change in a population of organisms over time caused by both genetic change and environmental factors.

Adaptation and mutation

• Charles Darwin: voyages of the Beagle; Origin of Species (1859)

B. Natural Selection

• Natural selection as the mechanism of evolution: Darwin's theory that life forms better adapted to their current environment have a better chance of surviving and will pass on their traits to their offspring; Trait variation and change from generation to generation

• Evidence for the theory of evolution includes comparative anatomy, geology, fossils, and DNA research.

C. Extinction and Speciation

• Extinction occurs when an environment changes and a species is no longer adapted to it.

• New species can develop when part of the population becomes separated and evolves in isolation.

• Life forms have evolved from simple organisms in oceans through amphibians to higher forms such as primates.

VI. Science Biographies

●Charles Darwin (scientist known for theory of natural selection)
●Antoine Lavoisier (chemist who discovered the process of oxidation)
●Lise Meitner (physicist who helped discover nuclear fission)
●Dmitri Mendeleev (scientist who devised the periodic table)

GRADE 8 SCIENCE:

I. Physics

A. Motion

•Velocity and speed

The velocity of an object is the rate of change of its position.

Speed is the magnitude of velocity expressed in distance covered per unit of time.

Changes in velocity can involve changes in speed or direction or both.

• Average speed = total distance traveled divided by the total time elapsed

Formula: Speed = Distance/Time (S = D/T)

Familiar units for measuring speed: miles or kilometers per hour

B. Forces

• The concept of force: force as a push or pull on an object

Examples of familiar forces (such as gravity, magnetic force)

A force has both direction and magnitude.

Measuring force: expressed in units of mass, pounds in English system, newtons in metric system

• Unbalanced forces cause changes in velocity.

If an object is subject to two or more forces at once, the effect is the net effect of all forces.

The motion of an object does not change if all the forces on it are in balance, having net effect of zero.

The motion of an object changes in speed or direction if the forces on it are unbalanced, having net effect other than zero.

To achieve a given change in the motion of an object, the greater the mass of the object, the greater the force required.

C. Density and Buoyancy

• When immersed in a fluid (i.e. liquid or gas), all objects experience a buoyant force.

The buoyant force on an object is an upward (counter-gravity) force equal to the weight of the fluid displaced by the object.

Density = mass per unit volume

Relation between mass and weight (equal masses at same location have equal weights)

• How to calculate density of regular and irregular solids from measurements of mass and volume

The experiment of Archimedes

• How to predict whether an object will float or sink

D. Work

• In physics, work is a relation between force and distance: work is done when force is exerted over a distance.

Equation: Work equals Force x Distance (W = F x D)

Common units for measuring work: foot-pounds (in English system), joules (in metric system; 1 joule = 1 newton of force x 1 meter of distance)

E. Power

• In physics, power is a relation between work and time: a measure of work done (or energy expended) and the time it takes to do it.

Equation: Power equals Work divided by Time (P = W/T), or Power = Energy/Time

Common units of measuring power: foot-pounds per second, horsepower (in English system); watts, kilowatts (in metric system)

II. Electricity and Magnetism

A. Electricity

• Basic terms and concepts (review from grade 4):

Electricity is the charge of electrons in a conductor.

Opposite charges attract, like charges repel.

Conductors and insulators

Open and closed circuits

Short circuit: sudden surge of amperage due to the reduction of resistance in a circuit; protection from short circuits is achieved by fuses and circuit breakers

Electrical safety

• Electricity as the charge of electrons

Electrons carry negative charge; protons carry positive charge

Conductors: materials like metals that easily give up electrons

Insulators: materials like glass that do not easily give up electrons

• Static electricity

A static charge (excess or deficiency) creates an electric field.

Electric energy can be stored in capacitors (typically two metal plates, one charged positive and one charged negative, separated by an insulating barrier). Capacitor discharges can release fatal levels of energy.

Grounding drains an excess or makes up a deficiency of electrons, because the earth is a huge reservoir of electrons. Your body is a ground when you get a shock of static electricity.

Lightning is a grounding of static electricity from clouds.

• Flowing electricity

Electric potential is measured in volts.

Electric flow or current is measured in amperes: 1 ampere = flow of 1 coulomb of charge per second (1 coulomb = the charge of 6.25 billion billion electrons).

The total power of an electric flow over time is measured in watts. Watts = amps x volts; amps = watts/volts; volts = watts/amps.

The unit of electrical resistance is the ohm.

B. Magnetism and Electricity

• Earth's magnetism

Earth's magnetism is believed to be caused by movements of charged atoms in the molten interior of the planet.

Navigation by magnetic compass is made possible because the earth is a magnet with north and south magnetic poles.

• Connection between electricity and magnetism

Example: move a magnet back and forth in front of wire connected to a meter, and electricity flows in the wire. The reverse: electric current flowing through a wire exerts magnetic attraction.

Spinning electrons in an atom create a magnetic field around the atom.

Unlike magnetic poles attract, like magnetic poles repel.

Practical applications of the connection between electricity and magnetism, for example:

An electric generator creates alternating current by turning a magnet and a coil of wire in relation to each other; an electric motor works on the reverse principle.
A step-up transformer sends alternating current through a smaller coil of wire with just a few turns next to a larger coil with many turns. This induces a higher voltage in the larger coil. A step-down transformer does the reverse, sending current through the larger coil and creating a lower voltage in the smaller one.

III. Electromagnetic Radiation and Light

• Waves and electromagnetic radiation

Most waves, such as sound and water waves, transfer energy through matter, but light belongs to a special kind of radiation that can transfer energy through empty space.

• The electromagnetic spectrum

From long waves, to radio waves, to light waves, to x-rays, to gamma rays
Called "electromagnetic" because the radiation is created by an oscillating electric field which creates an oscillating magnetic field at right angles to it, which in turn creates an oscillating electric field at right angles, and so on, with both fields perpendicular to each other and the direction the wave is moving.
The light spectrum: from infrared (longest) to red, orange, yellow, green, blue, violet (shortest)
Speed in a vacuum of all electromagnetic waves including light: 300,000 km per second, or 186,000 miles per second; a universal constant, called c

• Refraction and reflection

Refraction: the slowing down of light in glass causes it to bend, which enables lenses to work for television, photography, and astronomy
How Isaac Newton used the refraction of a prism to discover that white light was made up of rays of different energies (or colors)
Reflection: concave and convex reflectors; focal point

IV. Sound Waves

• General properties of waves

Waves transfer energy by oscillation without transferring matter; matter disturbed by a wave returns to its original place.
Wave properties: wavelength, frequency, speed, crest, trough, amplitude
Two kinds of waves: transverse (for example, light) and longitudinal (for example, sound)
Common features of both kinds of waves:
Speed and frequency of wave determine wavelength.
Wave interference occurs in both light and sound.
Doppler effect occurs in both light and sound.

• Sound waves: longitudinal, compression waves, made by vibrating matter, for example, strings, wood, air

While light and radio waves can travel through a vacuum, sound waves cannot. Sound waves need a medium through which to travel.
Speed
Sound goes faster through denser mediums, that is, faster through solids and liquids than through air (gases).
At room temperature, sound travels through air at about 340 meters per second (1,130 feet per second).
Speed of sound = Mach number

Supersonic booms; breaking the sound barrier
Frequency
Frequency of sound waves measured in "cycles per second" or Hertz (Hz)
Audible frequencies roughly between 20 and 20,000 Hz
The higher the frequency, the higher the subjective "pitch"
Amplitude or loudness is measured in decibels (dB).
Very loud sounds can impair hearing or cause deafness.
Resonance, for example, the sound board of a piano, or plates of a violin

V. Chemistry of Food and Respiration

• Energy for most life on earth comes from the sun, typically from sun, to plants, to animals, back to plants.

• Living cells get most of their energy through chemical reactions.

All living cells make and use carbohydrates (carbon and water), the simplest of these being sugars.

All living cells make and use proteins, often very complex compounds containing carbon, hydrogen, oxygen, and many other elements.

Making these compounds involves chemical reactions which need water, and take place in and between cells, across cell walls. The reactions also need catalysts called "enzymes."

Many cells also make fats, which store energy and food.

• Energy in plants: photosynthesis

Plants do not need to eat other living things for energy.

Main nutrients of plants: the chemical elements nitrogen, phosphorus, potassium, calcium, carbon, oxygen, hydrogen (some from soil or the sea, others from the air)

Photosynthesis, using chlorophyll, converts these elements into more plant cells and stored food using energy from sunlight.

Leafy plants mainly get their oxygen dissolved in water from their roots, and their carbon mainly from the gas CO_2.

Plant photosynthesis uses up CO_2 and releases oxygen.

• Energy in animals: respiration

Animal chemical reactions do the opposite of plants—they use up oxygen and release CO_2.

In animals the chief process is not photosynthesis but respiration, that is, the creation of new compounds through oxidation.

Animals cannot make carbohydrates, proteins, and fats from elements. They must eat these organic compounds from plants or other animals, and create them through respiration. Respiration uses oxygen and releases CO_2, creating an interdependence and balance between plant and animal life.

• Human nutrition and respiration

Humans are omnivores and can eat both plant and animal food.

Human respiration, through breathing, gets oxygen to the cells through the lungs and the blood.

The importance of hemoglobin in the blood

• Human health

While many other animals can make their own vitamins, humans must get them from outside.

A balanced diet: the food pyramid or "MyPlate" for humans (review); identification of the food groups in terms of fats, carbohydrates, proteins, vitamins, and trace elements

VI. Science Biographies

Albert Einstein (physicist whose theories of relativity allowed great advancements in the study of space, matter, energy, time, and gravity)

Dorothy Hodgkin (chemist who determined the structure of vitamin B12)

James Maxwell (scientist who created mathematical equations that expressed the basic laws of light, electricity, and magnetism)

Charles Steinmetz (scientist who made key advances in electric power)