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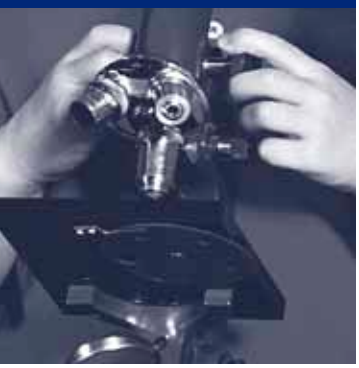

Science: Kindergarten

Teachers: Effective instruction in science requires hands-on experience and observation. In the words of the 1993 report from the American Association for the Advancement of Science, Benchmarks for Science Literacy, "From their very first day in school, students should be actively engaged in learning to view the world scientifically. That means encouraging them to ask questions about nature and to seek answers, collect things, count and measure things, make qualitative observations, organize collections and observations, discuss findings, etc."

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I. Plants and Plant Growth

Teachers: Through reading aloud, observation, and activities such as growing plants from seeds in varying conditions, explore the following with children:

- What plants need to grow: sufficient warmth, light, and water
- Basic parts of plants: seed, root, stem, branch, leaf
- Plants make their own food.
- Flowers and seeds: seeds as food for plants and animals (for example, rice, nuts, wheat, corn)
- Two kinds of plants: deciduous and evergreen
- Farming
  - How some food comes from farms as crops
  - How farmers must take special care to protect their crops from weeds and pests
  - How crops are harvested, kept fresh, packaged, and transported for people to buy and consume

II. Animals and Their Needs

Teachers: Through reading aloud, observation, and activities, explore with children the common characteristics and needs of animals, including:

- Animals, like plants, need food, water, and space to live and grow.
- Plants make their own food, but animals get food from eating plants or other living things.
- Offspring are very much (but not exactly) like their parents.
- Most animal babies need to be fed and cared for by their parents; human babies are especially in need of care when young.
- Pets have special needs and must be cared for by their owners.

III. The Human Body

- The five senses and associated body parts:
  - Sight: eyes
  - Hearing: ears
  - Smell: nose
  - Taste: tongue
  - Touch: skin
- Taking care of your body: exercise, cleanliness, healthy foods, rest

IV. Introduction to Magnetism

Teachers: Through reading aloud, observation, and experiments with magnets, introduce children to the idea that there are forces we cannot see that act upon objects. Children should:

- Identify familiar everyday uses of magnets (for example, in toys, in cabinet locks, in "refrigerator magnets," etc.).
- Classify materials according to whether they are or are not attracted by a magnet.

V. Seasons and Weather

Teachers: The emphasis in kindergarten should be on observation and description; technical explanations of meteorological phenomena should be taken up in later grades; see grades 2 and 4 for more detailed study of Meteorology.

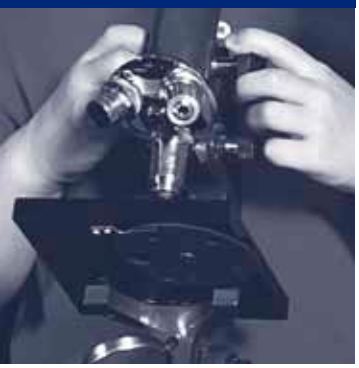
- The four seasons
- Characteristic local weather patterns during the different seasons
- The sun: source of light and warmth
- Daily weather changes
  - Temperature: thermometers are used to measure temperature
  - Clouds
  - Rainfall: how the condition of the ground varies with rainfall; rainbows
  - Thunderstorms: lightning and thunder, hail, safety during thunderstorms
  - Snow and snowflakes, blizzard

VI. Taking Care of the Earth

- Conservation: Some natural resources are limited, so people must be careful not to use too much of them (example: logging and reforestation).
- Practical measures for conserving energy and resources (for example, turning off unnecessary lights, tightly turning off faucets, etc.)
- Some materials can be recycled (for example, aluminum, glass, paper).
- Pollution (for example, littering, smog, water pollution) can be harmful, but if people are careful they can help reduce pollution.

VII. Science Biographies

George Washington Carver (botanist/discovered ways to keep soil rich)
Jane Goodall (studied chimpanzees)
Wilbur and Orville Wright (made first airplane)



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I. Living Things and Their Environments

Teachers: Introduce the idea of interdependence between living things and their environment.

Note: The food chain will be studied again in grade 3.

A. HABITATS

- Living things live in environments to which they are particularly suited.
- Specific habitats and what lives there, for example:
  - Forest [oak trees, squirrels, raccoons, snails, mice]
  - Meadow and prairie [wildflowers, grasses, prairie dogs]
  - Underground [fungi, moles, worms]
  - Desert [cactus, lizard, scorpion]
  - Water [fish, oysters, starfish]
- The food chain or food web: a way of picturing the relationships between living things
  - Animals: big animals eat little ones, big animals die and are eaten by little ones.
  - Plants: nutrients, water, soil, air, sunlight

B. OCEANS AND UNDERSEA LIFE

- Most of the earth is covered with water.
- Locate oceans: Pacific, Atlantic, Indian, Arctic.
- Oceans are salt water (unlike fresh water rivers and lakes).
- Coast, shore, waves, tides (high and low)
- Currents, the Gulf Stream
- Landscape of the ocean floor: mountain peaks and deep valleys (trenches)
- Diversity of ocean life: from organisms too small for the eye to see (plankton), to giant whales
- Dangers to ocean life (for example, overfishing, pollution, oil spills)

C. ENVIRONMENTAL CHANGE AND HABITAT DESTRUCTION

- Environments are constantly changing, and this can sometimes pose dangers to specific habitats, for example:
  - Effects of population and development
  - Rainforest clearing, pollution, litter

D. SPECIAL CLASSIFICATIONS OF ANIMALS

- Herbivores: plant-eaters (for example, elephants, cows, deer)
- Carnivores: flesh-eaters (for example, lions, tigers)
- Omnivores: plant and animal-eaters (for example, bears)
- Extinct animals (for example, dinosaurs)

II. The Human Body

A. BODY SYSTEMS

Teachers: Introduce the idea of body systems, and have children identify basic parts of the following body systems:

Note: Major body systems will be studied in greater detail in grades 2–6.

- Skeletal system: skeleton, bones, skull
- Muscular system: muscles
- Digestive system: mouth, stomach
- Circulatory system: heart and blood
- Nervous system: brain, nerves

B. GERMS, DISEASES, AND PREVENTING ILLNESS

- Taking care of your body: exercise, cleanliness, healthy foods, rest
- Vaccinations

III. Matter

Note: Children are likely to have a notion of atoms that, in absolute scientific terms, is inaccurate. The goal in this grade is to introduce concepts and terms that, over time, will be more precisely defined. Use the Teacher Handbook to define what you and your students should know and learn in Grade 1.

Teachers: Introduce children to the idea that everything is made of matter, and that all matter is made up of parts too small to see.

- Basic concept of atoms
- Names and common examples of three states of matter:
  solid (for example, wood, rocks)
  liquid (for example, water)
  gas (for example, air, steam)
- Water as an example of changing states of matter of a single substance

IV. Properties of Matter: Measurement

Teachers: Have children describe and classify objects according to what they are made of, and according to their physical properties (color, shape, size, weight, texture, etc.).

- Units of measurement:
  Length: centimeter, inch, foot
  Volume: gallon, quart
- Temperature: degrees Fahrenheit

V. Introduction to Electricity

Teachers: Through reading aloud, observation and experiment, explore with children basic principles of electricity and electrical safety rules.

Note: Electricity will be studied in more detail in grade 4.

- Static electricity
- Basic parts of simple electric circuits (for example, batteries, wire, bulb or buzzer, switch)
- Conductive and nonconductive materials
- Safety rules for electricity (for example, never put your finger, or anything metallic, in an electrical outlet; never touch a switch or electrical appliance when your hands are wet or when you're in the bathtub; never put your finger in a lamp socket; etc.)

VI. Astronomy: Introduction to the Solar System

- Sun: source of energy, light, heat
- Moon: phases of the moon (full, half, crescent, new)
- The eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune)
  (Note: In 2006, Pluto was classified as a dwarf planet.)
- Stars
  Constellations, Big Dipper
  The sun is a star.
- Earth and its place in the solar system
  The earth moves around the sun; the sun does not move.
  The earth revolves (spins); one rotation takes one day (24 hours).
  Sunrise and sunset
  When it is day where you are, it is night for people on the opposite side of the earth.

VII. The Earth

See also World History and Geography: Spatial Sense.

A. GEOGRAPHICAL FEATURES OF THE EARTH'S SURFACE

- The shape of the earth, the horizon
- Oceans and continents
- North Pole and South Pole, Equator

Note: Topics in geology will be studied in more detail in grade 4.

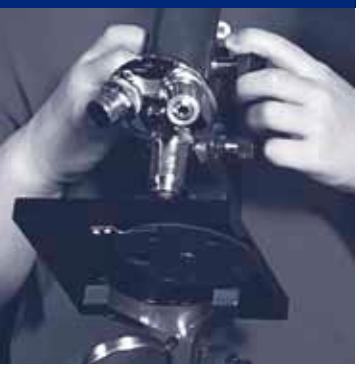
B. WHAT'S INSIDE THE EARTH

- Inside the earth
  Layers: crust, mantle, core
  High temperatures
- Volcanoes and geysers
- Rocks and minerals
  Formation and characteristics of different kinds of rocks: metamorphic, igneous, sedimentary
  Important minerals in the earth (such as quartz, gold, sulfur, coal, diamond, iron ore)

VIII. Science Biographies

See above, Environmental Change and Habitat Destruction, *re* Rachel Carson; Electricity, *re* Thomas Edison; Human Body: Vaccinations, *re* Edward Jenner; Human Body: Germs, Diseases, *re* Louis Pasteur.

Rachel Carson (got people to stop using DDT)
Thomas Edison (invented an electric light bulb)
Edward Jenner (found a way to stop smallpox)
Louis Pasteur (made milk safe to drink)



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I. Cycles in Nature

A. SEASONAL CYCLES

- The four seasons and earth's orbit around the sun (one year)
- Seasons and life processes
  - Spring: sprouting, sap flow in plants, mating and hatching
  - Summer: growth
  - Fall: ripening, migration
  - Winter: plant dormancy, animal hibernation

B. LIFE CYCLES

- The life cycle: birth, growth, reproduction, death
- Reproduction in plants and animals
  - From seed to seed with a plant
  - From egg to egg with a chicken
  - From frog to frog
  - From butterfly to butterfly: metamorphosis (see below: Insects)

C. THE WATER CYCLE

Note: In fourth grade, students will review the water cycle and study other topics in meteorology.

- Most of the earth's surface is covered by water.
- The water cycle
  - Evaporation and condensation
  - Water vapor in the air, humidity
  - Clouds: cirrus, cumulus, stratus
  - Precipitation, groundwater

II. Insects

- Insects can be helpful and harmful to people.
  - Helpful: pollination; products like honey, beeswax, and silk; eat harmful insects
  - Harmful: destroy crops, trees, wooden buildings, clothes; carry disease; bite or sting
- Distinguishing characteristics
  - Exoskeleton, chitin
  - Six legs and three body parts: head, thorax and abdomen
  - Most but not all insects have wings.
- Life cycles: metamorphosis
  - Some insects look like miniature adults when born from eggs, and they molt to grow (examples: grasshopper, cricket).
  - Some insects go through distinct stages of egg, larva, pupa, adult (examples: butterflies, ants).

- Social insects
  Most insects live solitary lives, but some are social (such as ants, honeybees, termites, wasps).
  Ants: colonies
  Honeybees: workers, drones, queen

III. The Human Body

A. CELLS

- All living things are made up of cells, too small to be seen without a microscope.
  Cells make up tissues.
  Tissues make up organs.
  Organs work in systems.

B. THE DIGESTIVE AND EXCRETORY SYSTEMS

Teachers: Explore with children what happens to the food we eat by studying body parts and functions involved in taking in food and getting rid of waste. Children should become familiar with the following:

- Salivary glands, taste buds
- Teeth: incisors, bicuspids, molars
- Esophagus, stomach, liver, small intestine, large intestine
- Kidneys, urine, bladder, urethra, anus, appendix

C. TAKING CARE OF YOUR BODY: A HEALTHY DIET

- The "food pyramid" or "MyPlate"
- Vitamins and minerals

IV. Magnetism

Teachers: Magnetism was introduced in kindergarten. Review and introduce new topics in second grade, with greater emphasis on experimentation.

- Magnetism demonstrates that there are forces we cannot see that act upon objects.
- Most magnets contain iron.
- Lodestones: naturally occurring magnets
- Magnetic poles: north-seeking and south-seeking poles
- Magnetic field (strongest at the poles)
- Law of magnetic attraction: unlike poles attract, like poles repel
- The earth behaves as if it were a huge magnet: north and south magnetic poles (near, but not the same as, geographic North Pole and South Pole)
- Orienteering: use of a magnetized needle in a compass, which will always point to the north

V. Simple Machines

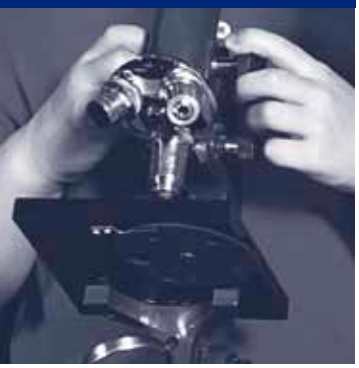
Teachers: Examine with children how specific tools are made to perform specific jobs—for example, hammers, screwdrivers, pliers, etc. Through observation and experimentation, examine with children how simple machines help make work easier, and how they are applied and combined in familiar tools and machines.

- Simple machines
  - lever
  - pulley
  - wheel-and-axle
    - gears: wheels with teeth and notches
    - how gears work, and familiar uses (for example, in bicycles)
  - inclined plane
  - wedge
  - screw
- Friction, and ways to reduce friction (lubricants, rollers, etc.)

VI. Science Biographies

See above, Human Body: Cells *re* Anton van Leeuwenhoek; Simple Machines: Friction, *re* Elijah McCoy.

Anton van Leeuwenhoek (invented the microscope)
Elijah McCoy (invented the automatic lubricator/the real McCoy)
Florence Nightingale (helped the wounded in the Crimean War/made hospitals more sanitary)
Daniel Hale Williams (performed the first open-chest surgery)



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I. Introduction to Classification of Animals

- Scientists classify animals according to the characteristics they share, for example:
  - Cold-blooded or warm-blooded
  - Vertebrates (have backbones and internal skeletons) or invertebrates (do not have backbones or internal skeletons)
- Different classes of vertebrates

Teachers: Children should become familiar with examples of animals in each class and some basic characteristics of each class, such as:

Fish: aquatic animals, breathe through gills, cold-blooded, most have scales, most develop from eggs that the female lays outside her body

Amphibians: live part of their lives in water and part on land, have gills when young, later develop lungs, cold-blooded, usually have moist skin

Reptiles: hatch from eggs, cold-blooded, have dry, thick, scaly skin

Birds: warm-blooded, most can fly, have feathers and wings, most build nests, hatch from eggs, most baby birds must be fed by parents and cared for until they can survive on their own (though some, like baby chickens and quail, can search for food a few hours after hatching)

Mammals: warm-blooded, have hair on their bodies, parents care for the young, females produce milk for their babies, breathe through lungs, most are terrestrial (live on land) though some are aquatic

II. The Human Body

A. THE MUSCULAR SYSTEM

- Muscles
  - Involuntary and voluntary muscles

B. THE SKELETAL SYSTEM

- Skeleton, bones, marrow
- Musculo-skeletal connections
  - Ligaments
  - Tendons, Achilles tendon
  - Cartilage
- Skull, cranium
- Spinal column, vertebrae
- Joints
- Ribs, rib cage, sternum
- Scapula (shoulder blades), pelvis, tibia, fibula
- Broken bones, x-rays

C. THE NERVOUS SYSTEM

- Brain: medulla, cerebellum, cerebrum, cerebral cortex
- Spinal cord
- Nerves
- Reflexes

D. VISION: HOW THE EYE WORKS

- Parts of the eye: cornea, iris and pupil, lens, retina
- Optic nerve
- Farsighted and nearsighted

E. HEARING: HOW THE EAR WORKS

- Sound as vibration
- Outer ear, ear canal
- Eardrum
- Three tiny bones (hammer, anvil, and stirrup) pass vibrations to the cochlea
- Auditory nerve

III. Light and Optics

Teachers: Through experimentation and observation, introduce children to some of the basic physical phenomena of light, with associated vocabulary.

Note: Students will study light in more detail in grade 8.

- The speed of light: light travels at an amazingly high speed.
- Light travels in straight lines (as can be demonstrated by forming shadows).
- Transparent and opaque objects
- Reflection
  - Mirrors: plane, concave, convex
  - Uses of mirrors in telescopes and some microscopes
- The spectrum: use a prism to demonstrate that white light is made up of a spectrum of colors.
- Lenses can be used for magnifying and bending light (as in magnifying glass, microscope, camera, telescope, binoculars).

IV. Sound

Teachers: Through experimentation and observation, introduce children to some of the basic physical phenomena of sound, with associated vocabulary.

Note: Students will study sound in more detail in grade 8.

- Sound is caused by an object vibrating rapidly.
- Sounds travel through solids, liquids, and gases.
- Sound waves are much slower than light waves.
- Qualities of sound
  - Pitch: high or low, faster vibrations = higher pitch, slower vibrations = lower pitch
  - Intensity: loudness and quietness
- Human voice
  - Larynx (voice box)
  - Vibrating vocal cords: longer, thicker vocal cords create lower, deeper voices
- Sound and how the human ear works
- Protecting your hearing

See above, II.E: Hearing.

V. Ecology

Teachers: Some topics here, such as habitats, were introduced in first grade. In this grade, develop in more detail, and explore new topics.

- Habitats, interdependence of organisms and their environment
- The concept of a "balance of nature" (constantly changing, not a static condition)
- The food chain or food web: producers, consumers, decomposers (Although the tendency is to recognize the limits of these models as well. See also Grade 1.)
- Ecosystems: how they can be affected by changes in environment (for example, rainfall, food supply, etc.), and by man-made changes
- Man-made threats to the environment
  - Air pollution: emissions, smog
  - Water pollution: industrial waste, run-off from farming
- Measures we can take to protect the environment (for example, conservation, recycling)

VI. Astronomy

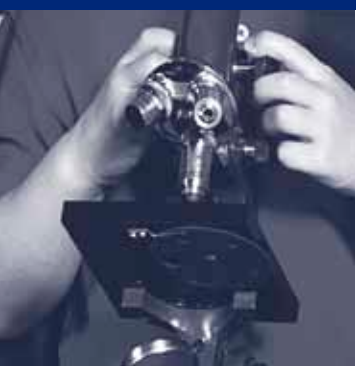
- The "Big Bang" as one theory
- The universe: an extent almost beyond imagining
- Galaxies: Milky Way and Andromeda
- Our solar system
  - Sun: source of energy (heat and light)
  - The eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune
- Planetary motion: orbit and rotation
  - How day and night on earth are caused by the earth's rotation
  - Sunrise in the east and sunset in the west
  - How the seasons are caused by the earth's orbit around the sun, tilt of the earth's axis
- Gravity, gravitational pull
  - Gravitational pull of the moon (and to a lesser degree, the sun) causes ocean tides on earth
  - Gravitational pull of "black holes" prevents even light from escaping
- Asteroids, meteors ("shooting stars"), comets, Halley's Comet
- How an eclipse happens
- Stars and constellations
- Orienteering (finding your way) by using North Star, Big Dipper
- Exploration of space
  - Observation through telescopes
  - Rockets and satellites: from unmanned to manned flights
  - Apollo 11, first landing on the moon: "One small step for a man, one giant leap for mankind."
  - Space shuttle

VII. Science Biographies

See above, Sound, *re* Alexander Graham Bell; Astronomy, *re* Copernicus; Exploration of Space, *re* Mae Jemison; Ecology, *re* John Muir.

Alexander Graham Bell (invented the telephone)
Copernicus (had new sun-centered idea about the solar system)
Mae Jemison (astronaut and medical pioneer)
John Muir (conservationist who helped create many national parks)

Science: Grade 4



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I. The Human Body

Note: The lymphatic system will be studied in grade 6.

See below, Science Biographies, Charles Drew.

A. THE CIRCULATORY SYSTEM

- Pioneering work of William Harvey
- Heart: four chambers (atrium/atria or atriums [plural] and ventricle/ventricles), aorta
- Blood
  - Red blood cells (corpuscles), white blood cells (corpuscles), platelets, hemoglobin, plasma, antibodies
  - Blood vessels: arteries, veins, capillaries
  - Blood pressure, pulse
  - Coagulation (clotting)
- Filtering function of liver and spleen
- Fatty deposits can clog blood vessels and cause a heart attack.
- Blood types (four basic types: A, B, AB, O) and transfusions

B. THE RESPIRATORY SYSTEM

- Process of taking in oxygen and getting rid of carbon dioxide
- Nose, throat, voice box, trachea (windpipe)
- Lungs, bronchi, bronchial tubes, diaphragm, ribs, alveoli (air sacs)
- Smoking: damage to lung tissue, lung cancer

II. Chemistry: Basic Terms and Concepts

Note: Children are likely to have a notion of atoms that, in absolute scientific terms, is inaccurate. There is no need to be concerned with this inaccuracy at this grade level, since the goal here is to introduce concepts and terms that, over time, will be more precisely defined and understood in greater depth.

A. ATOMS

- All matter is made up of particles too small for the eye to see, called atoms.
- Scientists have developed models of atoms; while these models have changed over time as scientists make new discoveries, the models help us imagine what we cannot see.
- Atoms are made up of even tinier particles: protons, neutrons, electrons.
- The concept of electrical charge
  - Positive charge (+): proton
  - Negative charge (-): electron
  - Neutral (neither positive nor negative): neutron
  - "Unlike charges attract, like charges repel" (relate to magnetic attraction and repulsion)

B. PROPERTIES OF MATTER

- Mass: the amount of matter in an object, similar to weight
- Volume: the amount of space a thing fills
- Density: how much matter is packed into the space an object fills
- Vacuum: the absence of matter

C. ELEMENTS

- Elements are the basic kinds of matter, of which there are a little more than one hundred.
  There are many different kinds of atoms, but an element has only one kind of atom.
  Familiar elements, such as gold, copper, aluminum, oxygen, iron
  Most things are made up of a combination of elements.

D. SOLUTIONS

- A solution is formed when a substance (the solute) is dissolved in another substance (the solvent), such as when sugar or salt is dissolved in water; the dissolved substance is present in the solution even though you cannot see it.
- Concentration and saturation (as demonstrated through simple experiments with crystallization)

III. Electricity

Teachers: Through reading, observation, and experiment, examine the following:

See above, Chemistry, *re* electrons.

- Electricity as the charge of electrons
- Static electricity
- Electric current
- Electric circuits, and experiments with simple circuits (battery, wire, light bulb, filament, switch, fuse)
  Closed circuit, open circuit, short circuit
- Conductors and insulators
- Electromagnets: how they work and common uses
- Using electricity safely

Note: Students will study electricity in more detail in grade 8.

IV. Geology: The Earth and Its Changes

A. THE EARTH'S LAYERS

- Crust, mantle, core (outer core and inner core)
- Movement of crustal plates
- Earthquakes
  Faults, San Andreas fault
  Measuring intensity: seismograph and Richter scale
  Tsunamis
- Volcanoes
  Magma
  Lava and lava flow
  Active, dormant, or extinct
  Famous volcanoes: Vesuvius, Krakatoa, Mount St. Helens
- Hot springs and geysers: Old Faithful (in Yellowstone National Park)
- Theories of how the continents and oceans were formed: Pangaea and continental drift

See also Geography 4: Major Mountain Ranges.

B. HOW MOUNTAINS ARE FORMED

- Volcanic mountains, folded mountains, fault-block mountains, dome-shaped mountains
- Undersea mountain peaks and trenches (Mariana Trench)

C. ROCKS

- Formation and characteristics of metamorphic, igneous, and sedimentary rock

D. WEATHERING AND EROSION

- Physical and chemical weathering
- Weathering and erosion by water, wind, and glaciers
- The formation of soil: topsoil, subsoil, bedrock

V. Meteorology

- The water cycle (review from grade 2): evaporation, condensation, precipitation
- Clouds: cirrus, stratus, cumulus (review from grade 2)
- The atmosphere
  Troposphere, stratosphere, mesosphere, thermosphere, exosphere
  How the sun and the earth heat the atmosphere
- Air movement: wind direction and speed, prevailing winds, air pressure, low and high pressure, air masses
- Cold and warm fronts: thunderheads, lightning and electric charge, thunder, tornadoes, hurricanes
- Forecasting the weather: barometers (relation between changes in atmospheric pressure and weather), weather maps, weather satellites
- Weather and climate: "weather" refers to daily changes in temperature, rainfall, sunshine, etc., while "climate" refers to weather trends that are longer than the cycle of the seasons.

VI. Science Biographies

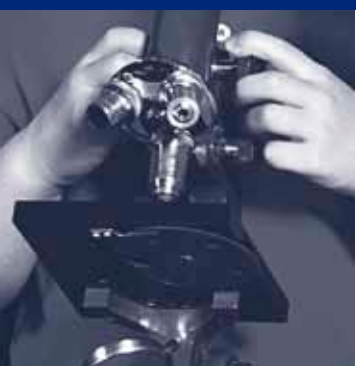
Benjamin Banneker (published almanac; reproduced plans to build Washington, D.C. entirely from memory)

Elizabeth Blackwell (first female to graduate from medical school in the United States)

Charles Drew (pioneered work in blood research, blood transfusions, and the development of blood banks)

Michael Faraday (chemist and physicist whose work led to the development of the electric motor and electric generator)

Science: Grade 5



Teachers: Effective instruction in science requires hands-on experience and observation. In the words of the 1993 report from the American Association for the Advancement of Science, Benchmarks for Science Literacy, "From their very first day in school, students should be actively engaged in learning to view the world scientifically. That means encouraging them to ask questions about nature and to seek answers, collect things, count and measure things, make qualitative observations, organize collections and observations, discuss findings, etc."

While experience counts for much, book learning is also important, for it helps bring coherence and order to a child's scientific knowledge. Only when topics are presented systematically and clearly can children make steady and secure progress in their scientific learning. The child's development of scientific knowledge and understanding is in some ways a very disorderly and complex process, different for each child. But a systematic approach to the exploration of science, one that combines experience with book learning, can help provide essential building blocks for deeper understanding at a later time.

I. Classifying Living Things

Teachers: As the children study animal classification, discuss: Why do we classify? How does classification help us understand the natural world?

Note: A useful mnemonic device is "King Philip Came Over For Good Spaghetti."

- Scientists have divided living things into five large groups called kingdoms, as follows:
  Plant
  Animal
  Fungus (mushrooms, yeast, mold, mildew)
  Protist (algae, protozoans, amoeba, euglena)
  Moneran, also called Prokaryote (bacteria, blue-green algae/cyano bacteria)
- Each kingdom is divided into smaller groupings as follows:
  Kingdom
  Phylum
  Class
  Order
  Family
  Genus
  Species
  (Variety)
- When classifying living things, scientists use special names made up of Latin words (or words made to sound like Latin words), which help scientists around the world understand each other and ensure that they are using the same names for the same living things.
  Homo sapiens: the scientific name for the species to which human beings belong (genus *Homo*, species *sapiens*)
  Taxonomists: biologists who specialize in classification
- Different classes of vertebrates and major characteristics: fish, amphibians, reptiles, birds, mammals (review from grade 3)

Teachers: Introduce an example of how an animal is classified, in order for students to become familiar with the system of classification, not to memorize specific names. For example, a collie dog is classified as follows:

Kingdom: Animalia
Phylum: Chordata (Subphylum: Vertebrata)
Class: Mammalia (mammal)
Order: Carnivora (eats meat)

Family: Canidae (a group with doglike characteristics)
Genus: *Canis* (a coyote, wolf, or dog)
Species: *familiaris* (a domestic dog)
Variety: Collie

II. Cells: Structures and Processes

Note: Students will study cell division in more detail, including the processes of mitosis and meiosis, in grade 7.

See below, III. B, Photosynthesis *re* plant cells.

- All living things are made up of cells.
- Structure of cells (both plant and animal)
  - Cell membrane: selectively allows substances in and out
  - Nucleus: surrounded by nuclear membrane, contains genetic material, divides for reproduction
  - Cytoplasm contains organelles, small structures that carry out the chemical activities of the cell, including mitochondria (which produce the cell's energy) and vacuoles (which store food, water, or wastes).
- Plant cells, unlike animal cells, have cell walls and chloroplasts.
- Cells without nuclei: monerans (bacteria)
- Some organisms consist of only a single cell: for example, amoeba, protozoans, some algae.
- Cells are shaped differently in order to perform different functions.
- Organization of cells into tissues, organs, and systems:
  - In complex organisms, groups of cells form tissues (for example, in animals, skin tissue or muscle tissue; in plants, the skin of an onion or the bark of a tree).
  - Tissues with similar functions form organs (for example, in some animals, the heart, stomach, or brain; in some plants, the root or flower).
  - In complex organisms, organs work together in a system (recall, for example, from earlier studies of the human body, the digestive, circulatory, and respiratory systems).

III. Plant Structures and Processes

A. STRUCTURE: NON-VASCULAR AND VASCULAR PLANTS

- Non-vascular plants (for example, algae)
- Vascular plants
  - Vascular plants have tubelike structures that allow water and dissolved nutrients to move through the plant.
  - Parts and functions of vascular plants: roots, stems and buds, leaves

B. PHOTOSYNTHESIS

- Photosynthesis is an important life process that occurs in plant cells, but not animal cells (photo = light; synthesis = putting together). Unlike animals, plants make their own food, through the process of photosynthesis.
- Role in photosynthesis of: energy from sunlight, chlorophyll, carbon dioxide and water, xylem and phloem, stomata, oxygen, sugar (glucose)

C. REPRODUCTION

See below, IV. Life Cycles and Reproduction: asexual and sexual reproduction.

- 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)

IV. Life Cycles and Reproduction

A. 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.

B. 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

V. The Human Body

A. CHANGES IN HUMAN ADOLESCENCE

- Puberty
  Glands and hormones (see below, Endocrine System), growth spurt, hair growth, breasts, voice change

B. THE ENDOCRINE SYSTEM

- 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

C. THE REPRODUCTIVE SYSTEM

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

Note: There is some flexibility in the grade-level placement of the study of topics relating to human reproduction, as different schools and districts have differing local requirements, typically introducing these topics in either fifth or sixth grade.

VI. Chemistry: Matter and Change

A. ATOMS, MOLECULES, AND COMPOUNDS

- Basics of atomic structure: nucleus, protons (positive charge), neutrons (neutral), electrons (negative charge)
- Atoms are constantly in motion, electrons move around the nucleus in paths called shells (or energy levels).
- Atoms may join together to form molecules and compounds.
- Common compounds and their formulas:
  water H_2O
  salt NaCl
  carbon dioxide CO_2

B. ELEMENTS

Note: Students will examine the relation between the periodic table and atomic structure in more detail in grade 7.

- Elements have atoms of only one kind, having the same number of protons. There are a little more than 100 different elements.
- The Periodic Table: organizes elements with common properties
  Atomic symbol and atomic number
- Some well-known elements and their symbols:

Hydrogen	H
Helium	He
Carbon	C
Nitrogen	N
Oxygen	O
Sodium	Na
Aluminum	Al
Silicon	Si
Chlorine	Cl
Iron	Fe
Copper	Cu
Silver	Ag
Gold	Au

- Two important categories of elements: metals and non-metals
  Metals comprise about $\frac{2}{3}$ of the known elements.
  Properties of metals: most are shiny, ductile, malleable, conductive

C. CHEMICAL AND PHYSICAL CHANGE

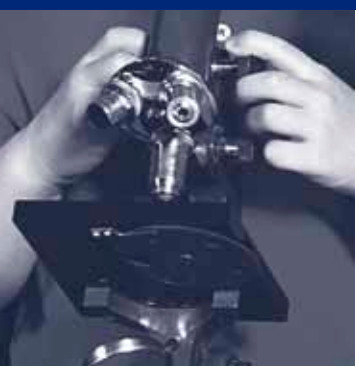
Note: Qualitative description and investigation of chemical change is sufficient at this grade level.

- Chemical change changes what a molecule is made up of and results in a new substance with a new molecular structure. Examples of chemical change: rusting of iron, burning of wood, milk turning sour
- Physical change changes only the properties or appearance of the substance, but does not change what the substance is made up of. Examples of physical change: cutting wood or paper, breaking glass, freezing water

VII. Science Biographies

See also World History 5: The Renaissance, *re* Galileo. See above, Classifying Living Things, *re* Linnaeus; Cells, *re* Ernest Just; Human Body—Endocrine System (Hormones), *re* Percy Lavon Julian.

Galileo ("Father of modern science" who provided scientific support for Copernicus's sun-centered universe)
Percy Lavon Julian (biologist and inventor who developed synthetic cortisone to treat arthritis pain)
Ernest Just (biologist and medical pioneer who specialized in studying cells and reproduction in marine animals)
Carl Linnaeus (botanist and "Father of taxonomy" who standardized the classification system)



Science: Grade 6

Teachers: Effective instruction in science requires not only hands-on experience and observation but also book learning, which helps bring coherence and order to a student's scientific knowledge. Only when topics are presented systematically and clearly can students make steady and secure progress in their scientific learning. The Science sequence for the middle school grades aims for more intensive and selective study of topics, a number of which were introduced in earlier grades. It also continues the practice of studying topics from each of the major realms of science (physical, life, and earth science). Students are expected to do experiments and write reports on their findings.

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 deepwater 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

See below, Energy: Nuclear energy, *re* Stars.

- 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)

- 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

Note: See Science 5 for the human reproductive system. There is some flexibility in the grade-level placement of the study of topics relating to human reproduction, as different schools and districts have differing local requirements, typically introducing these topics in either fifth or sixth grade.

- 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

See above, Plate Tectonics *re* Wegener; Energy *re* Curie; Astronomy, Gravity, *re* Newton. See also World History 6, The Enlightenment, *re* Newton.

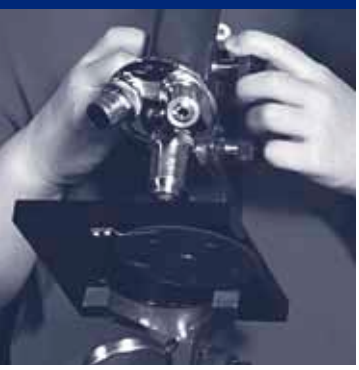
Marie Curie (advances in science of radioactivity; discovered the elements polonium and radium)

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")

Science: Grade 7



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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.

See below, Science Biographies, Lavoisier and Mendeleev.

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.
  O_2 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 H_2 and O_2. 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.

Note: A useful mnemonic device is "OIL RIG" — "oxidation is loss, reduction is gain."

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

Note: Review from grade 5: Cell Structures and Processes.

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)

See below, Science Biographies, Charles Darwin.

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.

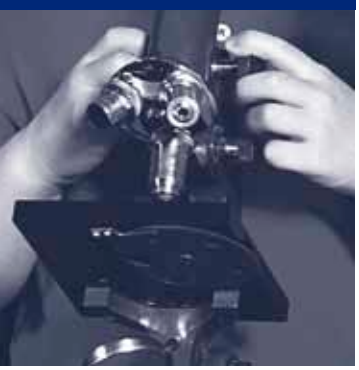
C. EXTINCTION AND SPECIATION

- 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

See above, Evolution *re* Darwin; Atomic Structure: Start of modern chemistry, *re* Lavoisier and Mendeleev.

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)



Science: Grade 8

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I. Physics

A. MOTION

- Velocity and speed
  - The velocity of an object is the rate of change of its position in a particular direction.
  - 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. ENERGY

- In physics, energy is defined as the ability to do work.
- Energy as distinguished from work
  - To have energy, a thing does not have to move.
  - Work is the transfer of energy.
- Two main types of energy: kinetic and potential
  - Some types of potential energy: gravitational, chemical, elastic, electromagnetic
  - Some types of kinetic energy: moving objects, heat, sound and other waves
- Energy is conserved in a system.

F. 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
    - 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)

Core Knowledge at a Glance

	Preschool	Kindergarten	First Grade	Second Grade	Third Grade
Language Arts/English	I. Oral Language II. Nursery Rhymes, Poems, Finger-Plays, and Songs III. Storybook Reading and Storytelling IV. Emerging Literacy Skills	I. Listening and Speaking II. Reading III. Writing IV. Language Conventions V. Poetry VI. Fiction VII. Sayings and Phrases	I. Listening and Speaking II. Reading III. Writing IV. Language Conventions V. Poetry VI. Fiction VII. Sayings and Phrases	I. Listening and Speaking II. Reading III. Writing IV. Language Conventions V. Poetry VI. Fiction VII. Sayings and Phrases	I. Reading and Writing II. Poetry III. Fiction IV. Sayings and Phrases
History and Geography	Time: I. Vocabulary II. Measures of Time III. Passage of Time (Past, Present, Future) Space: I. Vocabulary II. Actual and Representational Space III. Simple Maps IV. Basic Geographic Concepts	World: I. Geography: Spatial Sense II. Overview of the Seven Continents American I. Geography II. Native American Peoples, Past and Present III. Early Exploration and Settlement IV. Presidents, Past and Present V. Symbols and Figures	World: I. Geography II. Early World Civilizations III. Modern Civilization and Culture: Mexico American I. Early People and Civilizations II. Early Exploration and Settlement III. From Colonies to Independence: The American Revolution IV. Early Exploration of American West V. Symbols and Figures	World: I. Geography II. Early Asian Civilizations III. Modern Japanese Civilization IV. The Ancient Greek Civilization American I. American Government: The Constitution II. The War of 1812 III. Westward Expansion IV. The Civil War V. Immigration and Citizenship VI. Fighting for a Cause VII. Geography of the Americas VIII. Symbols and Figures	World: I. World Geography II. The Ancient Roman Civilization III. The Vikings American I. The Earliest Americans II. Early Exploration of North America III. The Thirteen Colonies: Life and Times Before the Revolution
Visual Arts	I. Attention to visual detail II. Creating Art III. Looking and Talking about Art	I. Elements of Art II. Sculpture III. Looking at and Talking About Art	I. Art from Long Ago II. Elements of Art III. Kinds of Pictures: Portrait and Still Life	I. Elements of Art II. Sculpture III. Kinds of Pictures: Landscapes IV. Abstract Art V. Architecture	I. Elements of Art II. American Indian Art III. Art of Ancient Rome and Byzantine Civilization
Music	I. Attention to Differences in Sound II. Imitate and Produce Sounds III. Listen and Sing IV. Listen and Move	I. Elements of Music II. Listening and Understanding III. Songs	I. Elements of Music II. Listening and Understanding (Composers; Orchestra; Opera; Ballet; Jazz) III. Songs	I. Elements of Music II. Listening and Understanding (Orchestra; Keyboards; Composers) III. Songs	I. Elements of Music II. Listening and Understanding (Orchestra; Composers) III. Songs
Mathematics	I. Patterns and Classification II. Geometry III. Measurement IV. Numbers and Number Sense V. Addition and Subtraction with Concrete Objects VI. Money	I. Patterns and Classification II. Numbers and Number Sense III. Money IV. Computation V. Measurement VI. Geometry	I. Patterns and Classification II. Numbers and Number Sense III. Money IV. Computation V. Measurement VI. Geometry	I. Numbers and Number Sense II. Fractions III. Money IV. Computation V. Measurement VI. Geometry	I. Numbers and Number Sense II. Fractions and Decimals III. Money IV. Computation V. Measurement VI. Geometry
Science	I. Human Characteristics, Needs and Development II. Animal Characteristics, Needs and Development III. Plant Characteristics, Needs and Growth IV. Physical Elements (Water, Air, Light) V. Introduction to Magnetism VI. Seasons and Weather VII. Taking Care of the Earth VIII. Tools	I. Plants and Plant Growth II. Animals and Their Needs III. Human Body (Five Senses) IV. Introduction to Magnetism V. Seasons and Weather VI. Taking Care of the Earth VII. Science Biographies	I. Living Things and Their Environments II. Human Body (Body Systems) III. Matter IV. Properties of Matter: Measurement V. Introduction to Electricity VI. Astronomy VII. The Earth VIII. Science Biographies	I. Cycles in Nature (Seasonal Cycles; Life Cycles; Water Cycle) II. Insects III. Human Body (Cells; Digestive and Excretory Systems) IV. Magnetism V. Simple Machines VI. Science Biographies	I. Introduction to Classification of Animals II. Human Body (Muscular, Skeletal, and Nervous Systems; Vision and Hearing) III. Light and Optics IV. Sound V. Ecology VI. Astronomy VII. Science Biographies

	Fourth Grade	Fifth Grade	Sixth Grade	Seventh Grade	Eighth Grade
Language Arts/English	I. Writing, Grammar, and Usage II. Poetry III. Fiction IV. Speeches V. Sayings and Phrases	I. Writing, Grammar, and Usage II. Poetry III. Fiction and Drama IV. Speeches V. Sayings and Phrases	I. Writing, Grammar, and Usage II. Poetry III. Fiction and Drama IV. Sayings and Phrases	I. Writing, Grammar, and Usage II. Poetry III. Fiction, Nonfiction, and Drama IV. Foreign Phrases Commonly Used in English	I. Writing, Grammar, and Usage II. Poetry III. Fiction, Nonfiction, and Drama IV. Foreign Phrases Commonly Used in English
History and Geography	World: I. World Geography (Spatial Sense; Mountains) II. Europe in Middle Ages III. The Spread of Islam and the "Holy Wars" IV. Early and Medieval African Kingdoms V. China: Dynasties and Conquerors American I. The American Revolution II. Making a Constitutional Government III. Early Presidents and Politics IV. Reformers V. Symbols and Figures	World: I. World Geography (Spatial Sense; Lakes) II. Early American Civilizations III. European Exploration, Trade, and the Clash of Cultures IV. The Renaissance and the Reformation V. England from the Golden Age to the Glorious Revolution VI. Russia: Early Growth and Expansion VII. Feudal Japan American I. Westward Expansion II. The Civil War: Causes, Conflicts, Consequences III. Native Americans: Cultures and Conflicts IV. U.S. Geography	World: I. World Geography (Spatial Sense; Deserts) II. Lasting Ideas from Ancient Civilizations III. The Enlightenment IV. The French Revolution V. Romanticism VI. Industrialism, Capitalism, and Socialism VII. Latin American Independence Movements American I. Immigration, Industrialization, and Urbanization II. Reform	I. America Becomes a World Power II. World War I: "The Great War," 1914–1918 III. Russian Revolution IV. America from the Twenties to the New Deal V. World War II VI. Geography of United States	I. The Decline of European Colonialism II. The Cold War III. The Civil Rights Movement IV. The Vietnam War and the Rise of Social Activism V. The Middle East and Oil Politics VI. The End of the Cold War: The Expansion of Democracy and Continuing Challenges VII. Civics: The Constitution—Principles and Structure of American Democracy VIII. Geography of Canada and Mexico
Visual Arts	I. Art of the Middle Ages in Europe II. Islamic Art and Architecture III. Art of Africa IV. Art of China V. Art of a New Nation: The United States	I. Art of the Renaissance II. American Art: Nineteenth-Century United States III. Art of Japan	I. Art History: Periods and Schools (Classical; Gothic; Renaissance; Baroque; Rococo; Neoclassical; Romantic; Realistic)	I. Art History: Period and Schools (Impressionism; Post-Impressionism; Expressionism and Abstraction; Modern American Painting)	I. Art History: Periods and Schools (Painting Since World War II; Photography; 20th-Century Sculpture) II. Architecture Since the Industrial Revolution
Music	I. Elements of Music II. Listening and Understanding (Orchestra; Vocal Ranges; Composers) III. Songs	I. Elements of Music II. Listening and Understanding (Composers; Connections) III. American Musical Traditions (Spirituals) IV. Songs	I. Elements of Music II. Classical Music: From Baroque to Romantic (Bach, Handel, Haydn, Mozart, Beethoven, Schubert, Chopin, Schumann)	I. Elements of Music II. Classical Music: Romantics and Nationalists (Brahms, Berlioz, Liszt, Wagner, Dvorak, Grieg, Tchaikovsky) III. American Musical Traditions (Blues and Jazz)	I. Elements of Music II. Non-Western Music III. Classical Music: Nationalists and Moderns IV. Vocal Music (Opera; American Musical Theater)
Mathematics	I. Numbers and Number Sense II. Fractions and Decimals III. Money IV. Computation V. Measurement VI. Geometry	I. Numbers and Number Sense II. Ratio and Percent III. Fractions and Decimals IV. Computation V. Measurement VI. Geometry VII. Probability and Statistics VIII. Pre-Algebra	I. Numbers and Number Sense II. Ratio, Percent, and Proportion III. Computation IV. Measurement V. Geometry VI. Probability and Statistics VII. Pre-Algebra	I. Pre-Algebra (Properties of the Real Numbers; Polynomial Arithmetic; Equivalent Equations and Inequalities; Integer Exponents) II. Geometry (Three-Dimensional Objects; Angle Pairs; Triangles; Measurement) III. Probability and Statistics	I. Algebra (Properties of the Real Numbers; Relations, Functions, and Graphs; Linear Equations and Functions; Arithmetic of Rational Expression; Quadratic Equations and Functions) II. Geometry (Analytic Geometry; Introduction to Trigonometry; Triangles and proofs)
Science	I. Human Body (Circulatory and Respiratory Systems) II. Chemistry: Basic Terms and Concepts III. Electricity IV. Geology: The Earth and Its Changes V. Meteorology VI. Science Biographies	I. Classifying Living Things II. Cells: Structures and Processes III. Plant Structures and Processes IV. Life Cycles and Reproduction V. Human Body (Endocrine and Reproductive Systems) VI. Chemistry: Matter and Change VII. Science Biographies	I. Plate Tectonics II. Oceans III. Astronomy: Gravity, Stars, and Galaxies IV. Energy, Heat, and Energy Transfer V. The Human Body: Lymphatic and Immune Systems VI. Science Biographies	I. Atomic Structure II. Chemical Bonds and Reactions III. Cell Division and Genetics IV. History of the Earth and Life Forms V. Evolution VI. Science Biographies	I. Physics II. Electricity and Magnetism III. Electromagnetic Radiation and Light IV. Sound Waves V. Chemistry of Food and Respiration VI. Science Biographies

Scope & Sequence

Science

I=Introduced T=Teach & ApplyReview R= Review & Apply

Life Science

Plants	K	1	2	3	4	5	6	7	8
Seeds and plants	I	T	T	R	R	R	R	R	R
Many kinds of plants	I	T	T	R	R	R	R	R	R
How plants grow	I	T	T	R	R	R	R	R	R
Parts of seed plants		I	T	T	R	R	R	R	R
Importance of plants (uses)		I	T	T	R	R	R	R	R
Classification of plants					I	T	T	R	R
Activities of green plants				I	T	T	R	R	R
Plant growth and responses		I	T	T	R	R	R	R	R
Animals	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Kinds; young; growth and change	I	T	T	R	R		R	R	R
Many kinds of animals	I	T	T	R	R	R	R	R	R
Animals of long ago			I						
Development of young, life cycles		I	T	T	R	R	R	R	R
Animals that live together					I	T	T	R	R
Invertebrates & vertibrates						I	T	T	R
Life processes, cellular organization							I	T	T
Animal adaptations							I	T	T
Ecology	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Where plants and animals live	I	T	T	R	R	R	R	R	R
Learning about our world (the senses)		I	T	T	R	R	R	R	R
Uses and misuses of animals								I	I
Ecological relationships			I	T	T	R	R	R	R
Adaptations						I		T	T
Ecosystems, predator/prey, succession					I	T	T	R	R
Climate and life (biomes)							I	I	T

Physical Science

Matter	K	1	2	3	4	5	6	7	8
Classifying objects by their properties		I							
Describing things using comparators	I	T	T						
Living and not living (differences & similarities)		I	T					T	R
Properties and states of matter			I	T	T	R	R		
Properties, states, changes, measurement				I	T	T	R		
Measuring Matter					I	T	T	T	R
Atoms, elements, molecules, compounds						I	T	T	R
Physical changes in matter						I	T		
Mass & weight	I						I		
Particle model, elements						I	T		
Compounds, acids and bases						I	T	T	
Chemical changes in matter						I	T	T	R
Energy	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Energy (movement;heat, cold; sound)	I	T							
Moving things (simple machines)		I		T	T				
Magnets			I	T	T				
Heat and light			I		T	T	R		
Force, work and energy				I	T		R		R
Machines				I	T		R		
Sound				I			T		
Energy and machines				I	T	T	R		

Energy	K	1	2	3	4	5	6	7	8
Electricity and magnetism					I	T	T		
Heat energy									
Understanding electricity						I	T	T	R
Sources of energy						I	T		
Using electricity (basic principles, technological advances							I		

Earth Science

Earth	K	1	2	3	4	5	6	7	8
Rocks, land and water	I	T	T	R	R			R	R
Shape and composition		I	T	T	R			R	R
Air and water		I	T	T		R		R	R
Changes in the earth				I	T	T	R	R	R
Earth's resources				I	T		T	R	R
Rocks, and minerals				I	T	T	R	R	R
Oceans					I	T	T	R	R
Weathering, erosion				I		T	T	R	R
Cleaning up the Earth						I	T		
Crustal movements							I	R	R
Space	K	1	2	3	4	5	6	7	8
The sun and moon	I	T		T					
Day and night, stars	I	T	T	T	R	R		T	R
The sun			I	T	T	R		T	R
Planets (size and distance; motion; phases				I	T	T	R	R	R
Characteristics of the solar system				I	T	T	R	R	R
Beyond the solar system							I	T	R
Exploring space							I	T	R
Weather	K	1	2	3	4	5	6	7	8
Kinds of weather (seasons, clothing)	I	T							
Seasons	I	T		T				R	R
Temperature, clouds, wind, dangers			I	T	T	R	R	R	R
Heating the earth; water cycle				I			T	R	R
Measuring weather			I		T			R	R
Changes in weather						I	T	R	R
Forecasting the weather							I	R	R
The Human Body	K	1	2	3	4	5	6	7	8
Your senses	I				T			R	R
Your body (parts, nutrition, hygiene)	I	T	T		R	R		R	R
Caring for yourself	I	T	T	R		R		R	R
Keeping safe	I	T	T	R				R	R
Good health habits	I	T	T	R				R	R
Digestive system			I		T			T	R
Relationship of sense organs to brain; structures and functions						I			
Skeletal system						I		T	T
Muscular systems						I		T	T
Circulatory system						I		T	T
Respiratory system						I		T	T
Excretory systems						I		T	T
Nervous system							I	T	T
Endocrine systems							I	T	T
Development of new organism; chromosomes							I	T	T
Life cycles							I	T	T