EPS 3800 Earth Science

We will be throwing hundreds of earth science terms at you. You must learn these vocabulary words – so that you can understand what Geologists are talking about. If you have trouble recognizing a vocabulary word/technical term in a homework problem, LOOK IT UP. Your textbook has a "Key Words" list at the end of each chapter, and a "Glossary" – a mini dictionary – at the end of the book.

Scientists are explorers. We use logical reason and empirical evidence to understand how and why the natural world is the way it is.

SCIENTIFIC METHOD: OBSERVATION raises question or problem/gather DATA (sometimes in experiments/sometimes with very careful field observations)/ANALYZE data/propose PREDICTIVE (not just explanative) HYPOTHESIS/TEST prediction (more EXPERIMENTS/more very careful field observations/take MEASUREMENTS)/ discard falsified hypothesis/keeping proposing and testing hypotheses/confirmation gives evidence proof/well proven hypothesis becomes THEORY as conditional truth

a theory is well proven, not a guess

science predicts future events; theories are true because they make accurate predictions

Part 1: the larger Universe

The Earth is not alone; it and we are part of a Universe.

The Universe has a beginning. Space and time came into being at the BIG BANG ≈ 13.8 billion years ago. The exact nature of the Big Bang is still uncertain, but we know it was extremely hot and dense. There is no "before" or "outside" the Universe, because space and time are properties of the Universe. The questions make no scientific sense. However, many philosophers and theologians like to speculate.

Evidence for the Big Bang: Cosmic Microwave Background Radiation, red shift of light of distant galaxies,

GALAXIES and the Milky Way

the STARS; the Sun is a star

the NEBULAR HYPOTHESIS of the origin of the Solar system ≈ 4.5 bya

HELIOCENTRIC model; GEOCENTRIC is wrong!

the SOLAR SYSTEM: the Sun/planets/moons/asteroids/Kuiper Belt Objects

other stars have their own solar systems

Part 2: the Earth

It's best to use a round globe to visualize the round Earth, because a flat map badly distorts the shapes of large-scale Earth features.

GEOLOGIC TIME: the Earth is extremely old – about 4.5 billion years. This is so old that it is difficult to imagine, because this "deep time" is completely outside of human experience. You would be glad to live to 100 years old, but that is nothing compared to the age of the Earth.

Gradualism (or uniformitarianism): the Earth is always changing, but usually very slowly. "The present is the key to the past." Note: there have been rare, but quick and catastrophic change events on Earth.

Scientist often separate the Earth into different parts: LITHOSPHERE/HYDROSPHERE/ATMOSPHERE/BIOSPHERE. we will study the lithosphere only; Oceanography for hydrosphere, Meteorology for atmosphere, Biology for biosphere. "Although we will mostly ignore the hydrosphere to focus on the lithosphere, we want you to remember that about 70% of the Earth is covered by water. Many Geologists joke that "Earth" is the wrong name for our planet; that it should be called "Aqua" for water.

DENSITY and BUOYANCY: different substances have different density; lower density floats higher than higher density and vice versa

density and DIFFERENTIATION: the Earth has layers; CRUST (solid rock)/MANTLE (hot liquid rock)/OUTER CORE (hot liquid iron)/INNER CORE (extremely high pressure, hot solid iron)

the crust is only about 5-50 miles (8-80 km) thick; very thin compared to the whole Earth diameter of nearly 8000 miles (12,900 km)

CONTINENTAL (GRANITIC) vs. OCEANIC (BASALTIC) crust; continental crust floats higher than oceanic crust because of lower vs. higher density

Alfred Wegener and CONTINENTAL DRIFT; strong original skepticism because of no mechanism

evidence for continental drift: similar rocks and FOSSILS on different continents/banded PALEOMAGNETISM on sea floor/apparent pole wandering

ancient PANGAEA supercontinent broke up 180 million years ago; future Amasia supercontinent may form in 100 million years

PLATE TECTONICS: the Earth's solid - RIGID - crust (the lithosphere) is cracked into about two dozen large pieces (plus many small ones) like a cracked eggshell, that float above the hot liquid mantle, and are constantly but slowly moved by CONVECTION CELLS in the hot liquid rock

convection: hot things rise/cold things sink which cycles mantle rock around

RADIOACTIVE elements (mostly uranium) are source of RADIOGENIC heating that keeps mantle hot

EVIDENCE of plate motion: bands of paleomagnetic anomalies, age of plate materials, (recent) direct measurements

HOT SPOT volcanoes (examples: Hawaii, Yellowstone) from mantle plumes are evidence of the existence of the convection cells and plate motion

PLATE BOUNDARIES: CONVERGING (crashing into each other)/DIVERGING (moving apart from each other)/TRANSFORM (sliding past each other); all have earthquakes; motion is only 1-2 inches (2.5 -5 cm) per year

continental/oceanic converging boundary (example: Cascadia Fault between Pacific Northwest = North American plate/Juan de Fuca plate): oceanic plate SUBDUCTS under continental plate, forming very deep OCEANIC TRENCH (Cascadia Trench), and will eventually melt (is recycled) back into the mantle; continental plate is broken and UPLIFTED; VOLCANIC MOUNTAIN RANGE will form (Cascade Mountains)

Mount St. Helens erupted violently May 1980, killing 63 people and millions of trees. Mount Rainier is in sight of downtown Seattle, and is due for a major eruption.

continental/continental converging boundary (example: Himalaya Mountains = Indian plate/Eurasian plate): COMPRESSION builds very tall mountains - Himalayas are tallest in the world - and very deep "roots"

oceanic/oceanic converging boundary (example: Aleutian Islands = Pacific plate/North American plate): one plate SUBDUCTS under the "higher" plate, builds trench and volcanic ARCHIPELAGO/island arc (curved chain of volcanic islands)

oceanic diverging boundary (example: Mid-Atlantic Ridge = South America/Africa and North America/Europe): continental crust splits apart; sea floor spreading - narrow sea forms and ocean grows ever wider, Atlantic Ocean began X million years ago; uplift builds volcanic mountain range - heat outflow - Iceland is a volcanic island, most mid-ocean volcanoes are underwater SEAMOUNTS. weak earthquakes.

most of ocean floor is unexplored and unknown - we have much better maps of the Moon than the ocean floor

East African Rift - Red Sea/Horn of Africa/Kenya/Tanzania is "new" diverging boundary, will form "new" ocean.

transform boundary (example: California/San Andreas fault): Pacific plate is sliding northward past North American plate; rough surfaces grind and sometimes lock; when they release, plates can "jerk" causing earthquakes; NO volcanoes; Los Angeles is on Pacific plate, San Francisco is on North American plate - LA will slide past SanFran in about 35 million years

"The New York City area is not near any active plate boundaries. The Appalachian Mountains are evidence of an ancient boundary, but the eastern United States is PASSIVE or INACTIVE today. Earthquakes are very rare and there are no volcanoes."

Part 3: Minerals and Rocks

MINERALS are unique, naturally occurring, solid, chemical substances

in chemistry, ELEMENTS are the simplest type of chemicals and are made of extremely small ATOMS

there are 90 naturally occurring elements; hydrogen and helium are most common in Universe (75%); iron, oxygen, hydrogen and silicon are most common in the Earth; most others are rare

minerals are almost always unique COMPOUNDS (combinations of elements), with specific CRYSTAL structure - arrangement of their atoms

there are hundreds of different minerals

major types of minerals:
SILICATES (metal, silicon and oxygen) - most common minerals by far;
CARBONATES (metal, carbon and oxygen);
OXIDES (metal and oxygen) - important as metal ores (mining);
SULFATES (metal, sulfur and oxygen) - indicates past presence of water;
SULFIDES (metal and sulfur) - important as metal ores (mining);
HALITES (metal and chlorine/fluorine/iodine) - rock salt is most famous example, most table salt is rock salt dug out the ground, purified and crushed to powder, indicates past presence of water, is why ocean water is salty;
NATIVE ELEMENTS - almost pure nuggets of gold/copper/silver/platinum/carbon (diamond), are very rare

“Notice that most minerals contain oxygen. Most people think of oxygen in the air (atmosphere) we breathe, but there’s much more oxygen in the crust (50% by mass) than in the air (20% by pressure).”

GEMSTONES are minerals that people think are pretty when cut and polished

Mohs hardness scale: 1 = talc, softest; 10 = diamond, hardest

“Earth science/geology is an ‘outdoor’ science. Unlike in physics and chemistry, which are ‘indoor’ sciences, where most work is done inside laboratories, geologists go outside - into the field - because the Earth is the laboratory.”

simple FIELD TESTS to identify minerals:
SCRATCH TEST (check for hardness, use glass plate or steel knife),
LUSTER (metallic/glassy/earthy shininess),
COLOR,
STREAK color (can be different than macroscopic color),
CLEAVAGE (breaks in specific direction, smash with a rock hammer),
FRACTURE (texture of broken surface)

“New York City is a very bad area to do geology/earth science, because the environment is almost completely unnatural. Almost everything is covered in asphalt and concrete. If you pick up a rock in New York City, it may not really be a rock. It will probably be a piece of concrete. For example, if you go to Central Park, you will see all the trees and rocks. You may think; ‘Oh, what a wonderful, natural area.’ No! Central Park is completely artificial. All of the trees were planted by human beings; most of the rocks were moved into position by human beings.”

ROCKS are made of minerals - “Minerals are the building blocks of rocks.”; usually a combination of minerals, but sometimes only one mineral

three types of rocks: IGNEOUS/SEDIMENTARY/METAMORPHIC

igneous rocks form from MAGMA (hot liquid rock) rising up from the mantle that cools off and solidifies

obvious example of magma is the lava coming out of a volcano

igneous rocks that solidify above the Earth’s surface are called EXTRUSIVE

igneous rocks that solidify below the Earth’s surface are called intrusive

a pluton is a large block of intrusive igneous rock

rocks can be slowly weathered - worn down - over time. “Nothing is forever in the Universe.”

Wind, rain, natural chemicals, glaciers

“There is little igneous rock in the New York City area, because the area has not been active in millions of years. Most NYC rocks are sedimentary and metamorphic.”

the rock cycle

Part 4: Earthquakes and Volcanoes