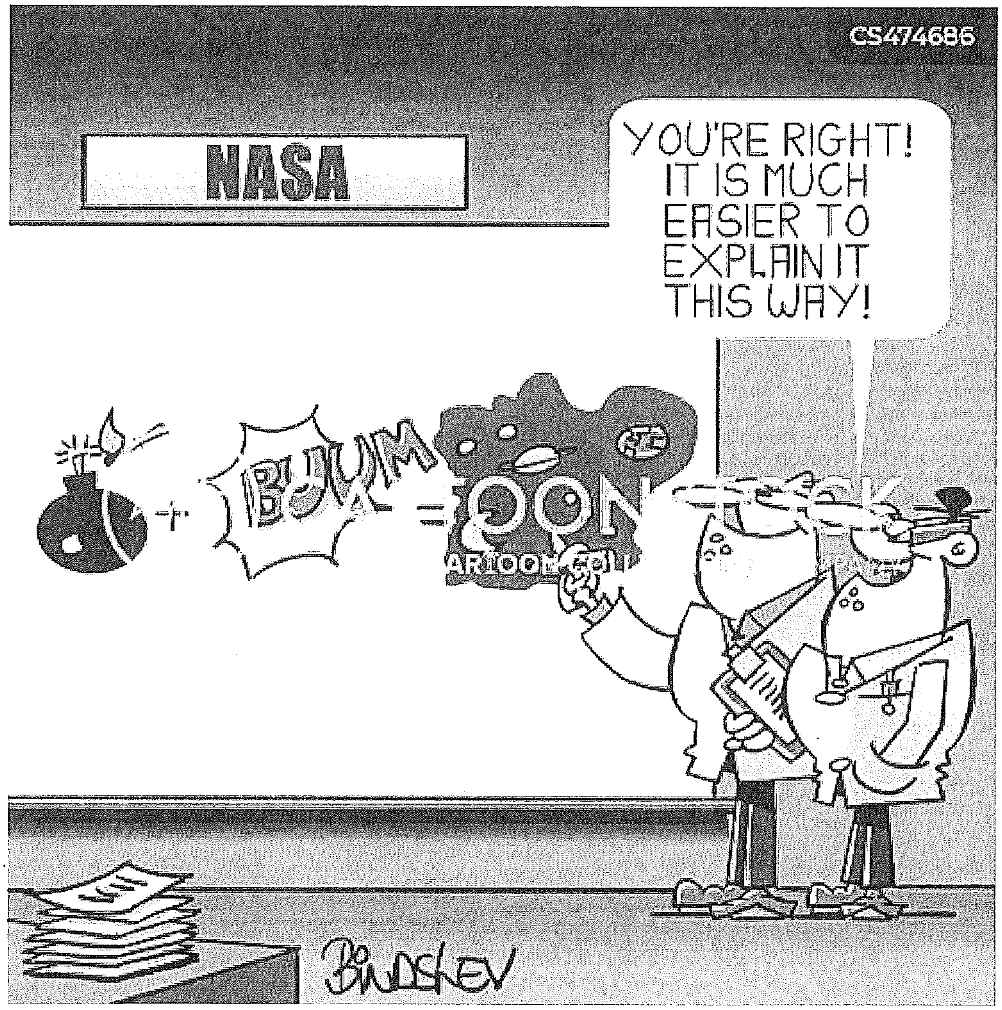
Name Key

Due Date ______________

Unit 6 Astrophysics



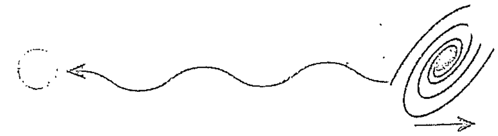
Unit 6 Astrophysics

1. Explain the Big Bang Theory and the 3 pieces of evidence which support it.
2. Know the basic life cycle of stars and the composition of stars.
3. Explain the cycling of material on the earth's surface and interior.
4. Know the layers of earth and results of plate tectonic movement and collisions.

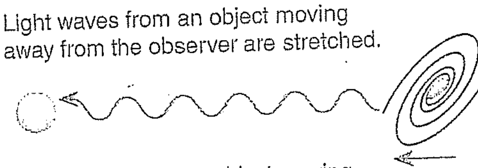
15 Evidence for the Big Bang

Key Idea: Numerous lines of evidence for the Big Bang include the CMB, current movement of the galaxies, and the composition of very old stars and galaxies.

When Albert Einstein published his equations for the General Theory of Relativity they allowed for several solutions to how the universe could behave. In 1924, Alexander Friedmann solved the equations to show that the universe could be expanding (it also could be contracting, or static). Before the end of the decade, observations by Edwin Hubble of the movement of distant galaxies confirmed that the universe was expanding. Since then, the discovery of the cosmic microwave background and the hydrogen and helium composition of early stars has added weight to the theory that the universe was once much smaller, hotter, and denser than it is now.



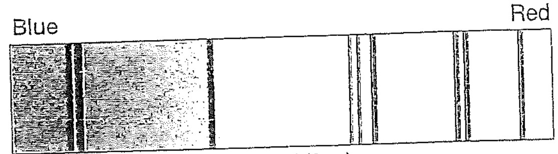
Light waves from an object moving away from the observer are stretched.



Light waves from an object moving towards the observer are compressed.

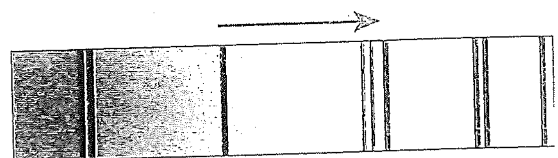
1: Red-shifted galaxies

- Light travels at a constant speed no matter whether an object is moving towards or away from you. What changes is the wavelength of the light. Light waves emitted from an object moving towards you are compressed into the blue part of the spectrum. Light waves emitted from an object moving away from you are expanded into the red part of the spectrum. This is called the **Doppler effect**. It also occurs in sound waves and is the reason why a car moving towards you sounds higher pitched than a car moving away from you. This property of light can be exploited to work out whether a distant galaxy is moving towards or away from us and how fast it is moving.
- Light from a galaxy can be separated into its spectrum. Elements in the galaxy absorb some of the wavelengths of light in this spectrum and produce dark bands. The spectrum of a galaxy moving towards us will have these characteristic bands shifted towards the blue end of its spectrum, while a galaxy moving away from us will have these bands shifted towards the red end of its spectrum and will be **red-shifted**.
- In 1929, Edwin Hubble used the 100 inch Hooker telescope to measure the red-shift of various galaxies. Hubble found that all but the very nearest galaxies were red-shifted, meaning they were moving away from us. Importantly, he also found that the further away they were, the more red-shifted they were and the faster they were moving away.



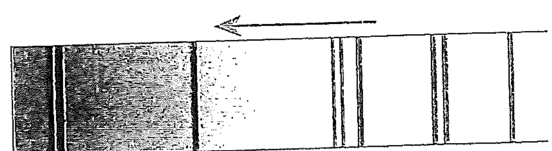
Unshifted

The spectral lines of a stationary galaxy are represented above.



Red-shifted

The spectral lines of a galaxy moving away from will beshifted towards the red end of the spectru

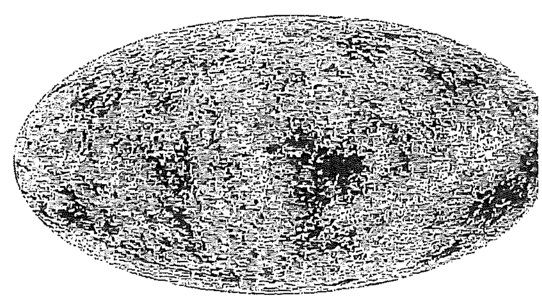


Blue-shifted

If the galaxy is moving towards us the spectral lines will be shifted into the blue end of the spectrum.

2: Cosmic microwave background

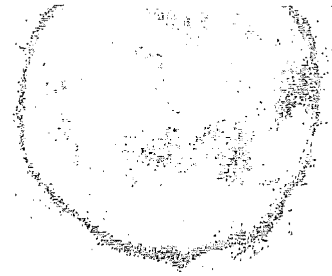
- It was realized as far back as the late 1940s that the heat and energy left over from the Big Bang should still be present and able to be detected. Astrophysicists Ralph Alpher and Robert Herman reasoned that the expansion of the universe since the Big Bang should have stretched the wavelength of the high energy radiation to somewhere in the microwave region of the electromagnetic spectrum, with a temperature of about 5 K (5°C above absolute zero).
- About 15 years later, Arno Penzias and Robert Wilson, working for Bell Telephone Laboratories found that the communications equipment they were working with produced a steady background radio noise no matter how much they cleaned it or what direction they pointed it. Inspection of the background noise showed it to have a "noise temperature" of 4.2 K. The wavelength of this radio noise was measured at 7.35 cm, within the microwave region of the spectrum. Refinements of measurements have now placed the average temperature at 2.728 K. Fluctuations in the temperature indicate precursors to the large scale structures we see in the universe today.



Darker regions in the image of the CMB above show cooler temperatures, brighter regions show higher temperatures. The contrast of the image is 30,000 times (the temperature fluctuations are *very* small. Between the "hot" and "cold" regions there is a temperature difference of 0.0002 K).

- Big Bang theory states that during the few seconds after the Big Bang a small amount of protons and neutrons fused to produce helium and a trace amount of lithium. Heavy elements were not formed because the conditions for the formation of heavier elements require a much greater time (tens of thousands of years) than the Big Bang lasted for. Therefore, when we measure the elements in distant young galaxies we should expect to see large amounts of hydrogen (about 75% of all elements), smaller amount of helium (about 24%), and trace amounts of lithium and other elements.
- Measurements of these elements in young galaxies and stars match these predictions precisely.

early galaxies and stars

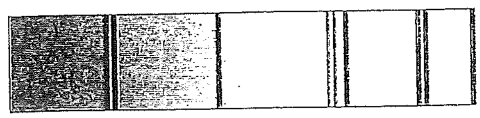


Young stars comprise 75% hydrogen and 25% helium by mass, exactly what would be expected if hydrogen and helium were formed during the Big Bang.

1. Explain what is meant by red-shifted: As distant galaxies or celestial bodies move away from us they appear red as the wavelengths are stretched out over time

2. Study the spectral diagrams below. Compare them to the unshifted spectral diagram opposite. What can you say about galaxy A and galaxy B?

A



B

A is red Shifted
B is blue Shifted

3. Explain how the red-shifting of galaxies provided evidence for the Big Bang: it proves the universe is continually expanding

4. (a) What is the cosmic microwave background? left over radation from the big bang

(b) Explain how the discovery of the CMB provided evidence for the Big Bang: proves the existence of distance galaxies

5. Why could heavy elements not form during the Big Bang? heavy elements require much more time

6. Study the three pieces of evidence for the Big Bang in this activity carefully. What is common to all these pieces of observable evidence and why does this make them much more powerful than if they did not have this common feature?

They all suggest that the universe is expanding

Name ______________________ Date ________________ Class __________

The Expanding Universe

Key Concepts

- What is the big bang theory?
- How did the solar system form?
- What do astronomers predict about the future of the universe?

Astronomers theorize that billions of years ago, the universe was no larger than the period at the end of this sentence. This tiny universe was incredibly hot and dense. The universe then exploded in what astronomers call the **big bang. According to the big bang theory, the universe formed in an instant, billions of years ago, in an enormous explosion.**

Edwin Hubble discovered that most of the galaxies are moving away from us and away from each other. Hubble also discovered that there is a relationship between the distance to a galaxy and its speed. **Hubble's law** states that the farther away a galaxy is, the faster it is moving away from us. Hubble's law provides strong support for the big bang theory.

In 1965, two physicists accidentally detected faint radiation on their radio telescope. This mysterious glow was coming from all directions in space. Scientists later concluded that this glow, now known as **cosmic background radiation,** is radiation left over from the big bang. Astronomers estimate that the universe is about 13.7 billion years old.

After the big bang, there was only cold, dark gas and dust where the solar system is now. **About five billion years ago, a giant cloud of gas and dust collapsed to form our solar system.** A large cloud of gas and dust such as the one that formed our solar system is called a **solar nebula.** Slowly, gravity began to pull the solar nebula together. As the solar nebula shrank, it spun faster and faster and eventually flatted into a rotating disk. Gravity pulled most of the gas into the center of the disk, where the gas eventually became hot and dense enough for nuclear fusion to begin. The sun was born.

Meanwhile, in the outer parts of the disk, gas and dust formed small asteroid-like bodies called **planetesimals.** These formed the building blocks of the planets. Planetesimals collided and grew larger by sticking together and eventually combining to form the planets.

New observations have led many astronomers to conclude that the universe will likely expand forever. Astronomers have discovered that the matter that astronomers can see, such as stars and nebulas, makes up as little as ten percent of the mass of galaxies. The remaining mass in galaxies exists in the form of dark matter. **Dark matter** is matter that does not give off electromagnetic radiation. Astronomers have observed that the expansion of the universe appears to be accelerating. They infer that a mysterious new force, which they call **dark energy,** is causing the expansion of the universe to accelerate. Most of the universe is thought to be made of dark matter and dark energy.

Name ______________________ Date ________________ Class ____________

Stars, Galaxies, and the Universe ▪ *Review and Reinforce*

The Expanding Universe

Understanding Main Ideas

Write an answer for each of the following questions in the spaces provided.

1. In which direction are nearly all galaxies moving?

away

2. What is Hubble's law?

farther away a galaxy is, the faster is it moving away

3. Explain how the sun was formed.

Gravity pulled a solar nebula together It flattened into a rotating disk which had a center hot and dense enough for fusion to begin.

Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

f 4. big bang

c 5. cosmic background radiation

a 6. dark energy

b 7. planetesimal

d 8. dark matter

e 9. solar nebula

a. a force that is causing the expansion of the universe to accelerate

b. the asteroid-like bodies that formed the building blocks of planets

c. leftover thermal energy from the big bang

d. matter that does not give off electromagnetic radiation

e. a large cloud of gas and dust, such as the one that formed our solar system

f. a theory that the universe formed in a huge explosion

Name ______________________ Date ____________ Class ____________

WORKSHEET

16.2 ENRICHMENT WORKSHEET — INTEGRATING PHYSICS

Red Shift, Blue Shift

Read the following paragraphs, and complete the exercises below.

Light can be described as traveling in the form of waves. The distance from the crest (top) of one wave to the crest of the next wave is the wavelength. Each color that the human eye can see has a different wavelength. The longest visible wavelengths are in the red end of the spectrum. The shortest visible wavelengths are in the blue end of the spectrum.

The wavelength of light that an observer sees coming from an object depends on the motion of the object relative to the observer. If either the object or the observer moves, the wavelength will change. The relationship between motion and observed wavelength is called the Doppler effect.

When a blue shift occurs

If a star is moving toward Earth, each light wave that it emits will be released closer to Earth than the previous wave. To an observer on Earth, the distance between wave crests will be smaller than if the star were at rest relative to Earth. The observer would see light that has a shorter wavelength than it had when it was emitted. In this example, the light has shifted toward the blue end of the spectrum, making what is called a blue shift.

When a red shift occurs

If the star is moving away from the observer, the distance between crests appears longer. The observer sees light of a longer wavelength than it had when it was emitted. In this case, the observed light has made what is called a red shift.

Exercises

1. An astronomer discovers two stars. Both stars appear red, but Star A appears redder than Star B. What can the astronomer conclude?

   Star A is farther away

2. If an astronaut in a spacecraft saw a star ahead that seemed to be growing bluer as time passed, what might she assume about the motion of the object relative to the spacecraft? List four possibilities.

   Star moving toward observer

   observer moving toward star

3. How could the Doppler effect be applied to determine if a celestial body is rotating, and, if it is rotating, in which direction it rotates?

   light on one side is slightly red and light on the other slightly blue. it would be rotating

The Life Cycle of a Star

By Cindy Grigg

1 Stars are born in nebulae, vast clouds of dust and gas in space. Some of the gas in a nebula is hydrogen gas. Over millions of years, gravity causes the hydrogen gas to collect in a cloud. As more and more gas is pulled into the cloud, it begins to spin. As the cloud spins, atoms of hydrogen gas bump into one another. The faster the gas spins, the more the atoms bump together. The temperature of the spinning cloud rises.

2 When the temperature reaches ten million degrees Celsius, a chemical change called nuclear fusion begins to take place. In this change, two atoms of hydrogen gas combine to form an atom of helium gas. The gas in the nebula begins to glow. This is the first step in the life cycle of a star. It is called a protostar. This chemical change gives off a large amount of energy in the form of heat. This causes the nebula to break up into a cluster of many baby stars. The new stars give off heat and light from the nuclear fusion of hydrogen atoms.

3 After a star forms, it is in its main life period called the main sequence period. A main sequence star lives and shines fairly steadily for millions of years or more. Stars with greater mass have hotter temperatures and usually shorter lives. When the star's supply of hydrogen is used up, it begins to convert helium into oxygen and carbon. If the star is massive enough, it will continue until it converts carbon and oxygen into neon, sodium, magnesium, sulfur, and silicon. Eventually, these elements are transformed into calcium, iron, nickel, chromium, copper, and others until iron is formed.

4 When the core becomes mostly iron, the star's nuclear reactions can no longer continue. It runs out of fuel and starts cooling down. This is because the temperature required to fuse iron is much too great. The inward pressure of gravity becomes stronger than the outward pressure of the nuclear reaction. The star collapses in on itself. This causes the temperature inside to rise. The intense heat causes the gases to explode. The star swells up into a glowing red giant that may be a hundred times larger than the original star. What happens next depends on the star's mass.

5 From the red giant stage, a dwarf or medium-sized star (like our sun) slowly cools off. The core collapses, and the star shrinks. It becomes a faint, small star called a white dwarf. Eventually it will fade out completely and become a black dwarf.

6 From the red giant stage, a giant or supergiant star will blow up in a huge explosion called a supernova. A supernova may leave behind a tiny, dense, fast-spinning star called a neutron star. Such a star may give out radio waves in pulses as it rotates. These bursts of radiation are called pulsars.

7 A neutron star that was very large can shrink into a body so dense that the star disappears inside itself. This is known as a black hole. The gravitational pull is so strong that everything nearby is pulled inside. Even light cannot escape.

Name ______________________________ Science Pd ____________________

The Life Cycle of a Star

1. In the first step in the life cycle of a star, it is called a:
   - A Protostar
   - B Main sequence period
   - C White dwarf
   - D Red giant

2. A star spends most of its life in this stage:
   - A White dwarf
   - B Red giant
   - C Protostar
   - D Main sequence period

3. When a star runs out of fuel, it collapses on itself and becomes a:
   - A Red giant
   - B Protostar
   - C White dwarf
   - D Main sequence period

4. After the red giant stage, a smaller star will become a:
   - A Red giant
   - B Main sequence period
   - C Protostar
   - D White dwarf

5. At the end of its life cycle, a very large star may become a:
   - A Planet or asteroid
   - B Neutron star, pulsar, or a black hole
   - C White or black dwarf
   - D Giant or supergiant

6. What process causes stars to give off heat and light?
   - A A chemical reaction called fusion
   - B A physical reaction
   - C Gravity
   - D Fire

7. At what temperature does nuclear fusion begin?
   - A 10,000,000 degrees Celsius
   - B 10,000 degrees Celsius
   - C 1,000 degrees Celsius
   - D 10,000,000,000 degrees Celsius

8. Our sun is a medium-sized star. What will its final stage be?
   - A Giant or supergiant
   - B Neutron star
   - C Black hole
   - D White or black dwarf

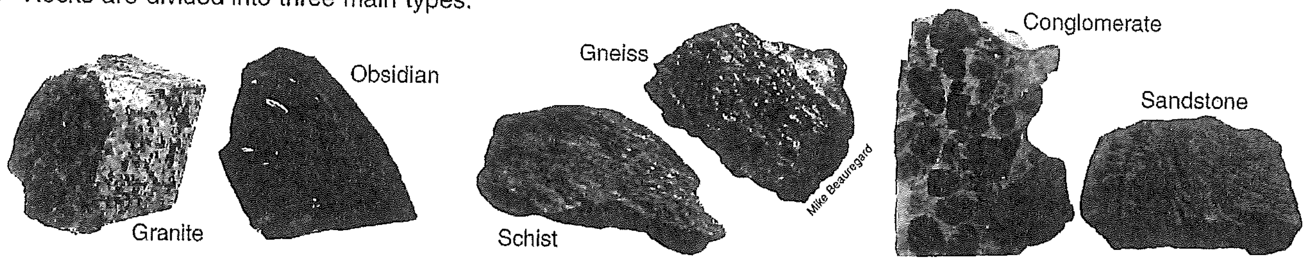
34 The Age of the Earth

ENGAGE: The rocks of the Earth

- The surface (crust) of the Earth is a mixture of different rocks and minerals. Each rock and mineral is formed under characteristic circumstances and so can give information about what the environment was like when they formed.

1. Do some research, and describe the difference between a rock and a mineral: mineral has definite chemical composition, a rock can be composed of different minerals and organic items

- Rocks are divided into three main types:



Igneous
Formed from volcanic activity (e.g. a volcanic eruption).

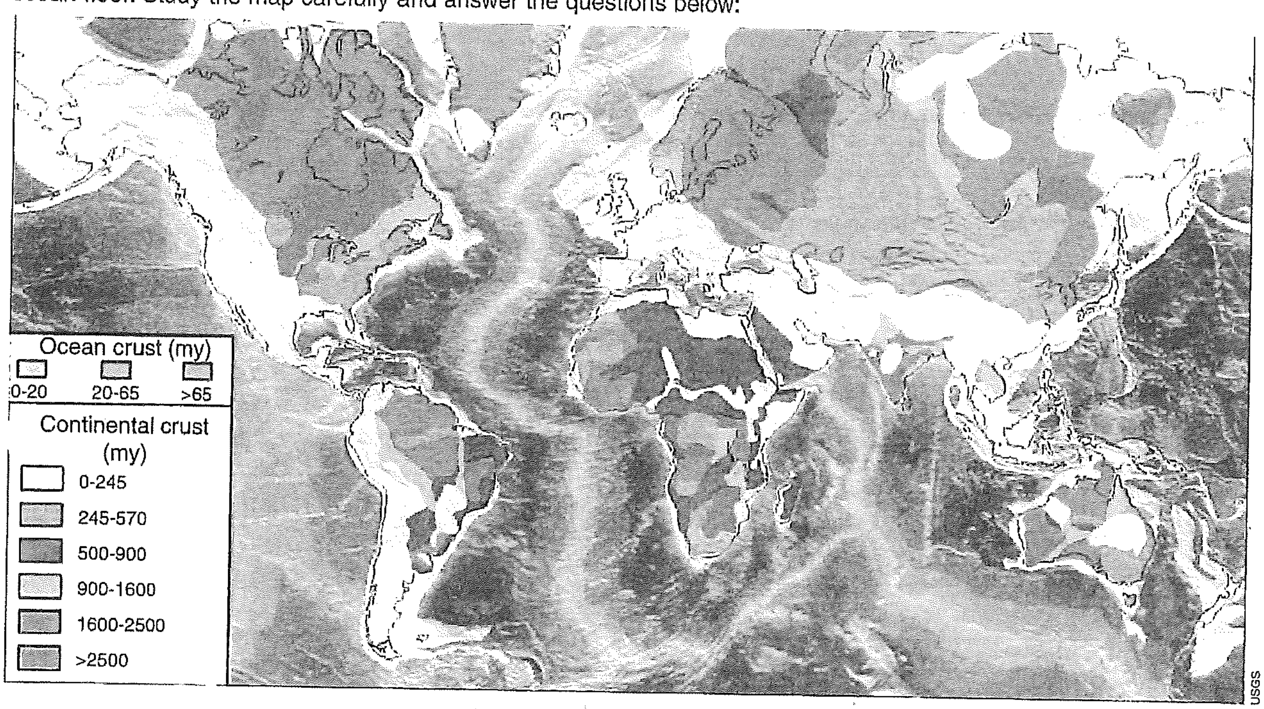
Metamorphic
Formed under extreme heat and pressure (e.g. during mountain building).

Sedimentary
Formed from the deposition and compression of sediments (e.g. coal).

2. Research the rock types found near where you live. What does this say about the history of your area?

EXPLORE: The age of rocks

3. The map below shows the ages (in millions of years, my) of the bedrock (basement rock) around the world including the ocean floor. Study the map carefully and answer the questions below:



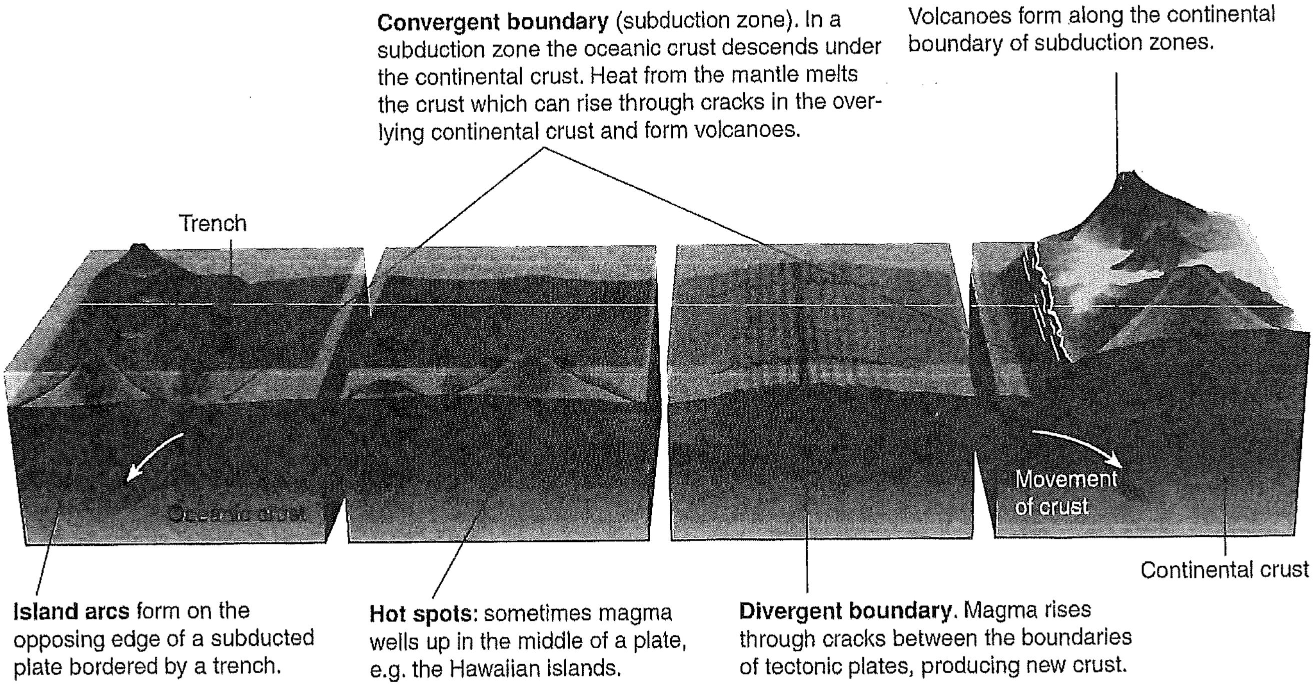
(a) Where are the oldest rocks found? On the continents

(b) Where are the youngest rocks found? middle of the ocean

(c) Suggest why these rocks are found where they are: Youngest are where new rock is being formed, oldest is rock that was first formed

EXPLAIN: Cycling of the crust

- It may not seem like it, but the Earth's surface is very dynamic and constantly moving. The movement is normally very slow but occasionally it can be very rapid. Rapid movement usually occurs during a large earthquake, when parts of the crust can move up to several meters in less than a minute.
- The Earth's crust is divided into several large sections called tectonic plates. In addition to moving, these plates are also growing and shrinking. Regions where the plates are growing are called constructive boundaries. Regions where the plates are shrinking are called destructive boundaries.
- Where plates are moving apart they are called divergent boundaries. Where they are moving together they are called convergent boundaries.



4. (a) Given that oceanic crust subducts under continental crust, which type of crust would you expect to be older?

Continental Crust

(b) How might this explain the map of the rock ages on the previous page? Older rock forms continental crust, while oceanic forms new rock.

5. (a) Why would rock being subducted, melted, and eventually brought back to the surface by volcanic activity have its radiometric clock "reset?"

The rock is recycled with only the contents of the melted core

(b) How would the cycling of the crust affect the age of the rocks likely to be found on the Earth?

new crust is new rock and the farther from the new crust the older the rock is

6. (a) Is a subduction zone a destructive or constructive boundary? destructive

(b) Is a mid ocean ridge a destructive or constructive boundary? constructive

(c) Why do volcanoes form along the boundaries of subduction zones? oceanic crust subducts and releases fluids trapped inside. The fluids migrate upwards until it reaches the surface & erupts.