# GGH1501 - Learning Unit 3

# Learning Unit 3 (Key processes in the physical environment)

**Units left out:**
*Coastal processes and landforms, PB Sect B: 84-85*
*Glacial processes and landforms, PB Sect B: 86-89*

The physical environment of the Earth is both diverse and dynamic. It is diverse in the sense that no two locations are exactly the same and it is dynamic due to the variety of processes that are constantly shaping the physical environment. All the individual physical processes are interconnected, but also interact with a variety of other processes that are occurring within the Earth's four major physical systems (namely the atmosphere, hydrosphere, lithosphere and biosphere) and ultimately contribute towards the creation of one system which sustains life on Earth.

## Key Terms:

**Weather, Climate, and Climate Change:** Section B, pages 32 to 63.

| | |
|---|---|
| **Adiabatic cooling:** | Cooling of air as a result of the expansion of the rising air. Adiabatic means "without heat being involved". |
| **Advection:** | Horizontal movement of air or substances by the wind or ocean currents. |
| **Angle of incidence:** | The angle where solar radiation strikes a specific place at a point in time. |
| **Autumnal equinox:** | In the Northern Hemisphere Sept 22/23. At noon the perpendicular rays of the sun strikes the equator. The Sun is directly above the equator.) |
| **Carbon dioxide:** | A gas found in the atmosphere, $CO_2$; a major contributor to the greenhouse effect. |
| **Climate:** | The weather conditions prevailing in an area in general or over a long period. |
| **Cold front:** | The boundary formed when a cold air mass advances against a warmer one. |
| **Condensation:** | Water changing from a gas state (vapor) to a liquid or solid state. |
| **Convection:** | Circulation in a fluid caused by temperature-induced density differences, such as rising of warm air in the atmosphere. |
| **Coriolis effect:** | The tendency of an object moving across Earth's surface to be deflected from its apparent path as a result of Earth's rotation. |
| **Cyclone:** | Large low-pressure areas in which wind converge in a counterclockwise swirl in the Northern Hemisphere, or clockwise in the Southern Hemisphere. |
| **Desert climate:** | A climate with low precipitation and temperatures warm enough to cause potential evapotranspiration to be substantially higher than precipitation. |

| | |
|---|---|
| **El Niño:** | A circulation change in the eastern tropical Pacific Ocean, from westward flow to eastward flow, that occurs every few years. |
| **Front:** | Boundary between warm air and cold air. |
| **Global warming:** | A general increase in temperatures over a period of at least several decades caused primarily by increased levels of carbon dioxide in Earth's atmosphere. |
| **Greenhouse gasses:** | Trace substances in the atmosphere that contribute to the greenhouse effect, water vapor, carbon dioxide, ozone, methane, and chlorofluorocarbons are important examples. |
| **Gyre:** | A circular ocean current beneath a subtropical high-pressure cell. |
| **Hurricane:** | An intense tropical cyclone that develops over warm ocean areas in the tropics and subtropics, primarily during the warm season. Hurricanes in the Pacific Ocean are called typhoons, in the Indian Ocean they're called cyclones. |
| **Insolation:** | The amount of solar energy intercepted by a particular area of Earth. |
| **Intertropical Convergence Zone (ITCZ):** | A low-pressure zone between the Tropic of Cancer and the Tropic of Capricorn where surface winds converge. |
| **Latent heat:** | Heat stored in water and water vapor, not detectable by people, latent means "hidden". |
| **Little Ice Age:** | The period between 1500-1750, when climates on Earth were especially cool. |
| **Longwave energy:** | Energy reradiated by Earth in wavelengths of about 5.0 – 30.0 microns. Includes infrared radiation, which we sense as heat. |
| **Methane:** | A trace gas found in the atmosphere with chemical formula $CH_4$; a major contributor to the greenhouse effect. |
| **Midlatitude cyclone:** | A storm characterized by a center of low pressure in the midlatitudes usually associated with a warm and cold front. |
| **Midlatitude low-pressure zones:** | Regions of low pressure and air converging from the subtropical and polar high-pressure zones. |
| **Monsoon circulation:** | Seasonal reversal of pressure and wind in Asia, in which winter winds from the Asian interior produce dry winters and summer winds blowing inland from the Indian and Pacific oceans produce wet summers. |
| **Orographic precipitation:** | Precipitation caused by air being forced to rise over mountains. |
| **Ozone:** | A gas composed of molecules with 3 oxygen atoms; it's highly corrosive gas at ground level, but in the upper atmosphere essential to protecting life on Earth by absorbing ultraviolet radiation. |
| **Polar front:** | A boundary between cold polar air and warm subtropical air that circles the globe in the midlatitudes. |
| **Polar high-pressure zones:** | Regions of high pressure and descending air near the North and South poles. |

| | |
|---|---|
| **Quaternary Period:** | The period of geologic time encompassing approximately the last 3 million years. |
| **Radiation:** | Energy in the form of electromagnetic waves that radiate in all directions. |
| **Relative humidity:** | The actual water content of the air compared to how much water the air could potentially hold, expressed as a percentage. |
| **Semiarid climate:** | A climate with precipitation slightly less than potential evapotranspiration for most of the year. |
| **Sensible heat:** | Heat detectable by sense of touch, or with a thermometer. |
| **Shortwave energy:** | Radiant energy emitted by the Sun in wavelengths about 0.2-0.5 microns. |
| **Solar energy:** | The radiant energy from the Sun. |
| **Storm surge:** | An area of elevated sea level in the center of a hurricane that may be several meters high, and which does most of the damage when a hurricane comes ashore. |
| **Subtropical high-pressure (STH) zones:** | Regions of high pressure and descending air at about 25° north and south latitudes. |
| **Summer solstice:** | For places in the Northern Hemisphere, June 20/21 is the date when at noon the Sun is directly overhead along the parallel of 23.5° north latitude; for places in the Southern Hemisphere, December 21/22 is the date when at noon the Sun is directly overhead at places along the parallel of 23.5° south latitude. |
| **Tornado:** | A rapidly rotating column of air usually associated with a thunderstorm, often having winds in excess of 300km/h. |
| **Trade wind:** | The prevailing wind in subtropical and tropical latitudes that blows toward the Intertropical Convergence Zone, typically from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. |
| **Tropic of Cancer:** | The parallel of 23.5° north latitude. |
| **Tropic of Capricorn:** | The parallel of 23.5° south latitude. |
| **Typhoon:** | The name applied to a hurricane in the Pacific Ocean. |
| **Vernal (spring) equinox:** | In the Northern Hemisphere March 20/21, one of two days when at noon the perpendicular rays of the Sun strike the equator(the Sun is directly overhead along the equator). |
| **Warm front:** | A boundary formed when a warm air mass advances against a cooler one. |
| **Water vapor:** | Water in the air in gaseous form. |
| **Wavelength:** | The distance between successive waves of radiant energy, or of successive waves on a water body. |
| **Winter solstice:** | For places in the Southern Hemisphere, June 20/21 is the date when at noon the Sun is directly overhead at places along the parallel of 23.5° north latitude; for places in the Northern Hemisphere, December 21/22 is the date when at noon the Sun is directly overhead at places along the parallel of 23.5° south latitude. |

**Landforms:** Section B, pages 64 to 91.

| | |
|---|---|
| **Chemical weathering:** | The breakdown of rocks and minerals through chemical reactions at Earth's surface. |
| **Composite cone volcano:** | Volcano formed by a mixture of lava eruptions and more explosive ash eruptions. |
| **Convergent plate boundary:** | Boundary between tectonic plates in which the two plates move toward one another, destroying or thickening the crust. |
| **Delta:** | A deposit of sediment formed where a river enters a lake or an ocean. |
| **Discharge:** | The quantity of water flowing past a point on a stream per unit time. |
| **Divergent plate boundary:** | Boundary between tectonic plates in which the two plates move away from each other, and new crust is created between them. |
| **Drainage basin:** | The geographic area that contributes runoff to a particular stream, defined with respect to a specific location along that stream – the runoff from the drainage basin passes that point on the stream. |
| **Earthquake:** | A sudden release of energy within Earth, producing a shaking of the crust. |
| **Epicentre:** | The location on Earth's surface immediately above the focus of an earthquake. |
| **Fault:** | A fracture in Earth's crust along which displacement of rocks has occurred. |
| **Floodplain:** | A low-lying surface adjacent to a stream channel and formed by materials deposited by the stream, |
| **Focus (of an earthquake):** | The location in Earth where motion originates in an earthquake. |
| **Grade:** | A condition in which a stream's ability to transport sediment is balanced by the amount of sediment delivered to it. |
| **Igneous rock:** | Rock formed by crystallization of magma. |
| **Lava:** | Magma that reaches Earth's surface. |
| **Magma:** | Molten rock beneath Earth's surface. |
| **Mantle:** | The portion of Earth above the core and below the crust. |
| **Marine terrace:** | A nearly level surface along a shoreline, elevated above present sea level, formed by coastal erosion at a time when sea level at the location was higher than at present. |
| **Mass movement:** | Downslope movement of rock and soil at Earth's surface, driven mainly by the force of gravity acting on those materials. |
| **Meandering:** | The tendency of flowing water to follow a sinuous course with alternating right- and left-hand bends. |
| **Mechanical weathering:** | The breakdown of rocks into smaller particles caused by application of physical or mechanical forces. |
| **Metamorphic rock:** | Rock formed by modification of other rock types, usually by heat and or pressure. |

| | |
|---|---|
| **Moraine:** | An accumulation of rock and sediment deposited by a glacier, usually in or near the melting area. |
| **Outwash plain:** | Accumulation of sand and gravel carried by meltwater streams from glaciers, usually deposited immediately beyond the terminal moraine from the glacier. |
| **Overland flow:** | Water flowing across the soil surface on a hillslope, usually resulting from precipitation falling faster than the ground can absorb it. |
| **Pleistocene Epoch:** | A period of geologic time consisting of the first part of the Quaternary Period beginning about 3 million years ago and ending 12 000 years ago. |
| **Runoff:** | Flow of water from the land, either on the soil surface, or in streams. |
| **Sediment transport:** | The movement of rock particles by surface erosional processes. |
| **Sedimentary rock:** | Rock formed through accumulation and fusing of many small rock fragments at Earth's surface. |
| **Shield:** | The ancient core of a continent. |
| **Shield volcano:** | A volcano with relatively gentle slopes formed by eruption of relatively fluid lavas. |
| **Soil creep:** | The slow downslope movement of soil caused by many individual, near-random particle movements such as those caused by burrowing animals or freeze and thaw. |
| **Tectonic plates:** | Large pieces of Earth's crust that move relative to one another. |
| **Transform plate boundary:** | Boundary between tectonic plates in which the two plates pass one another in a direction parallel to the plate boundary. |
| **Tsunami:** | Extremely long wave created by an underwater earthquake; the wave may travel hundreds of km per hour. |
| **Volcano:** | A vent in Earth's surface where magma erupts as lava. |

**Biosphere:** Section B, pages 92 to 115.

| | |
|---|---|
| **Actual evapotranspiration (ACTET):** | The amount of water evaporated and or transpired in a given environment. |
| **Biogeochemical cycle:** | The environmental recycling process that supplies essential substances such as carbon, nitrogen, and other nutrients to the biosphere. |
| **Biomagnification:** | The tendency for substances that accumulate in body tissues to increase in concentration as they're passed to higher levels in a food chain. |
| **Biomass:** | The dry mass of living or formerly living matter in a given environment. |
| **Biome:** | A large grouping of ecosystems characterized by particular plant and animal types. |
| **Boreal forest:** | An evergreen needleleaf forest characteristic of cold continental climates. |

| | |
|---|---|
| **Broadleaf deciduous forest:** | A forest with broadleaved trees that lose their leaves in the winter; characteristic of humid midlatitude environments. |
| **Carbon cycle:** | The movement of carbon among the atmosphere, hydrosphere, biosphere and lithosphere as a result of processes such as photosynthesis and respiration, sedimentation, weathering and fossil-fuel combustion. |
| **Carnivore:** | An animal whose primary food supply is other animals. |
| **Desert:** | A vegetation type with sparsely distributed plants, specifically adapted for moisture gathering and moisture retention. |
| **Desertification:** | The process of a region's soil and vegetation cover becoming more desertlike as a result of human land use, usually by overgrazing or cultivation. |
| **Eutrophication:** | A process in which water bodies receive excess nutrients that stimulate excessive plant growth. |
| **Evapotranspiration:** | The sum of evaporation and transpiration. |
| **Food chain:** | The sequential consumption of food in an ecosystem, beginning with green plants, followed by herbivores and carnivores and ending with decomposers. |
| **Groundwater:** | The water beneath Earth's surface at a depth where rocks and/or soils are saturated with water. |
| **Herbivore:** | An animal whose primary food supply is plants. |
| **Horizon:** | A layer in the soil with distinctive characteristics derived from soil-forming processes. |
| **Hydrologic cycle:** | The movement of water from the atmosphere to Earth's surface, across that surface, and back to the atmosphere. |
| **Omnivore:** | An animal that feeds on both plants and other animals. |
| **Photosynthesis:** | A chemical reaction that occurs in green plants in which carbon dioxide and water are converted to carbohydrates and oxygen. |
| **Potential evapotranspiration (POTET):** | The amount of evapotranspiration that would occur if water were available. |
| **Respiration:** | A chemical reaction that occurs in plants and animals in which carbohydrates and oxygen are combined, releasing water, carbon dioxide and heat. |
| **Soil:** | A dynamic, porous layer of mineral and organic matter at Earth's surface. |
| **Transpiration:** | The use of water by plants, normally drawing it from the soil via their roots, evaporating it in their leaves, and releasing it to the atmosphere. |

| | |
|---|---|
| **Trophic level:** | A position in the food chain relative to other organisms, such as producer, herbivore or carnivore. |
| **Tundra:** | A low, slow-growing vegetation type found in high-latitude and high-altitude conditions in which snow covers the ground most of the year. |

## Understanding the climate of the Earth:

Weather results from energy exchanges within the Earth-atmosphere system. The energy that is exchanged is received from the Sun. Due to the rotation of the Earth around its imaginary axis and the changing relative position of the Earth with respect to the Sun, different locations on Earth receive different amounts of energy during different periods of the year. Over long periods of time, and due to the influence of temperature, air pressure, precipitation and atmospheric circulation, weather can be generalised into the climate of a region.

## Energy flow through the Earth-atmosphere system

The energy from the Sun does not reach the Earth's surface in a random manner and it is also not distributed randomly. Various characteristics of the Earth's energy cycles are known and therefore make the Earth's energy budget predictable. For example the length of day and night and the timing of different seasons are known and predictable.

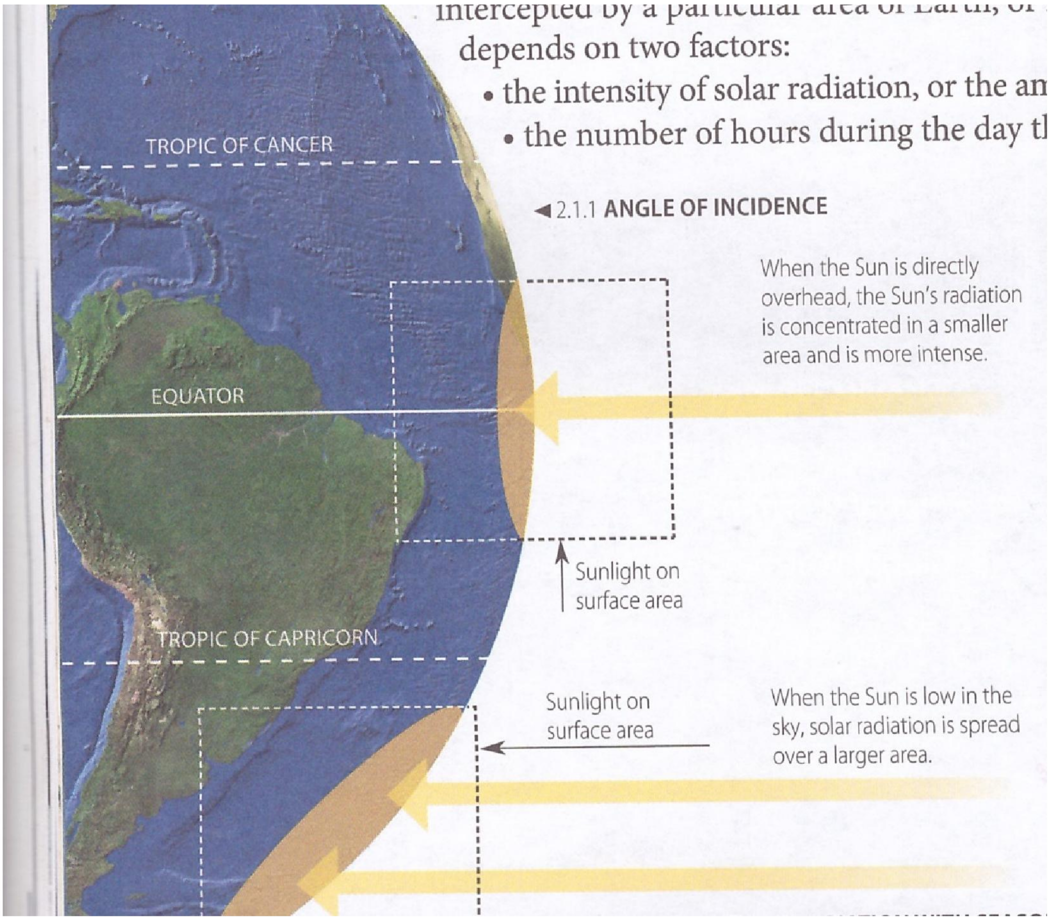
## The influence of the angle of incidence of the rays of the Sun on the intensity of insolation at certain latitudes:

- The intensity of solar radiation depends mainly on the angle at which the Sun's rays hit the surface at a particular place.
- Day length = affected by latitude + season of the year.

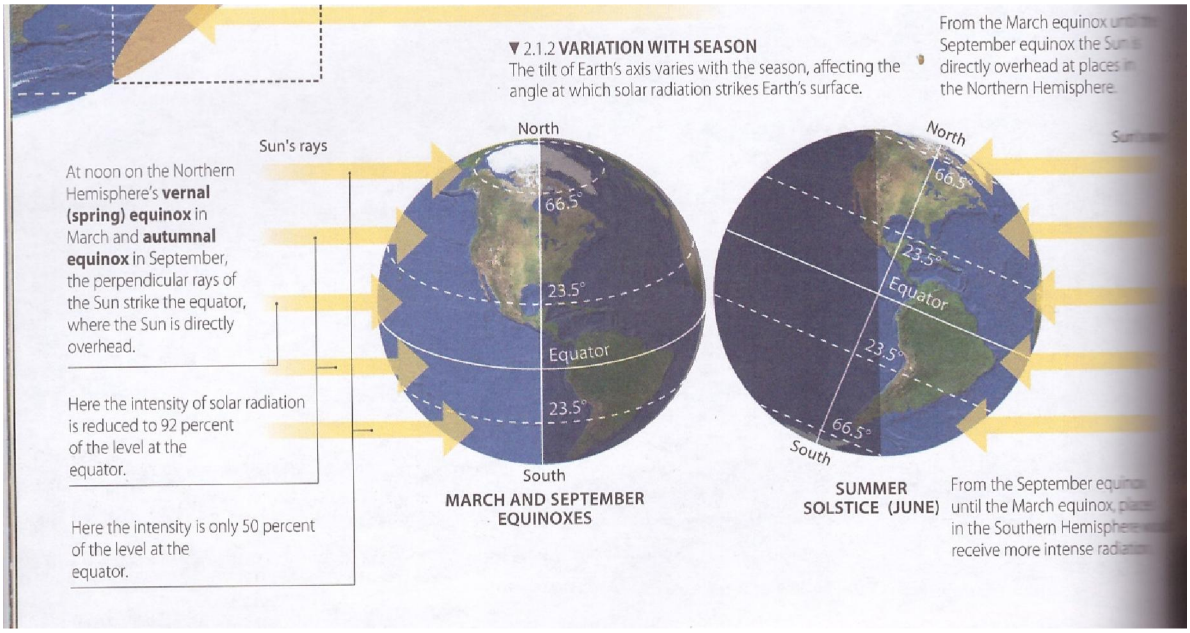
- Energy travels through space as radiation.
- The amount of radiation or solar energy intercepted by a particular area of Earth, or insolation (incoming solar radiation), depends on 2 factors:
  1. The intensity of solar radiation, or the amount arriving per unit of time.
  2. The number of hours during the day that the solar radiation is striking.

Intensity:
- Daily + seasonal differences in intensity = caused by variations in the angle of incidence – angle which solar radiation strikes a particular place at any moment in time.
- Angle = varies from place to place, which time of the day + the seasons.
- Throughout the year the area of Earth's surface where the Sun is overhead at midday shifts due to the Earth's tilt + continual revolution around the Sun.
- The intensity of solar radiation at a given place + time depends on its latitude + season of the year.

Angle of incidence:



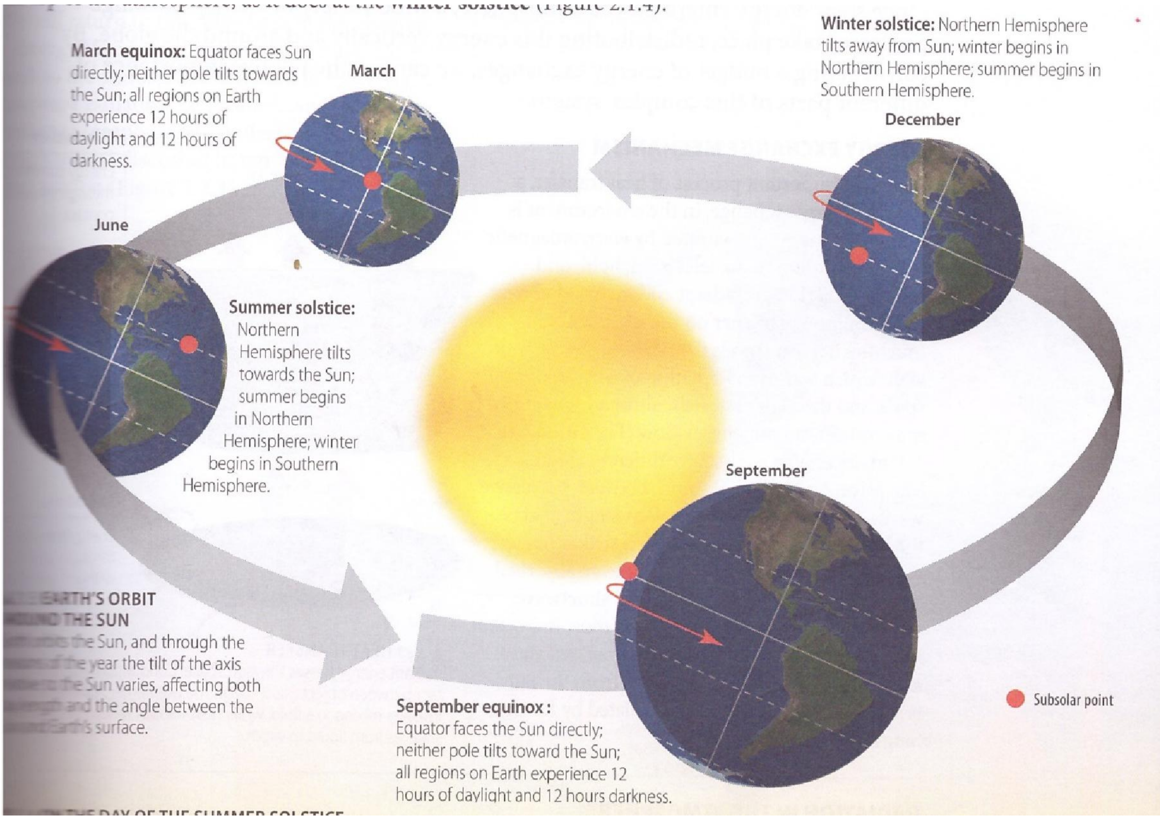

Variation with season:




**[The orbital cycle of the Earth around the Sun and how this affects the way in]()**

## which the Sun's rays strike the Earth:

Orbit around the Sun:




## The reasons for variations in the length of day and night during different seasons and at different locations across the globe:

Day length:

- Variations in the length of day from place to place result from the 23.5° tilt of Earth's axis away from a perpendicular relation to the Sun.
- Places on the equator always receive 12 hours of sunlight + 12 hours of night.
- But in higher latitudes, the amount of daylight varies considerably with the seasons.
- Example – in a 24-hour day at a summer solstice, a Northern Hemisphere city like Winnipeg, Manitoba, Canada receives nearly 6 times as much solar radiation, measured at the top of the atmosphere, as it does in the winter solstice.

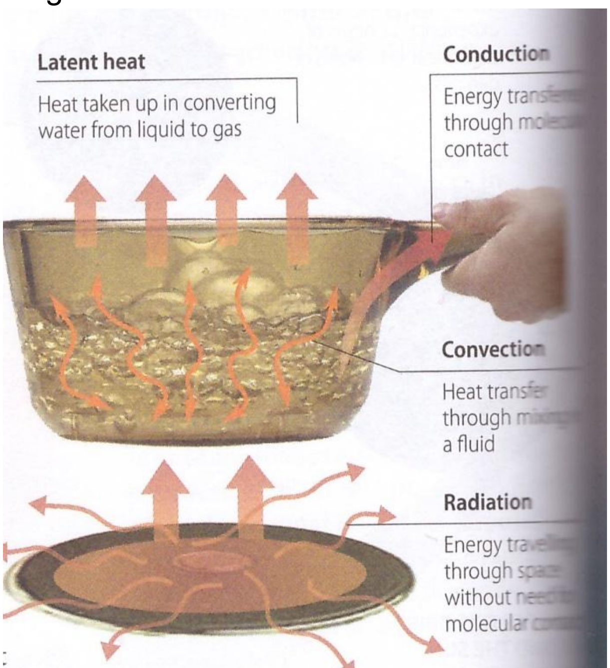
## The ways (or pathways) through which energy from the Sun is exchanged when entering the atmosphere and how this exchange contributes to the Earth's energy budget:

Energy Exchange Mechanism:

- Energy exchange = occur by radiation, conduction, convection + latent heat.
- Radiant energy = sent to Earth as shortwave radiation + returned to space as longwave radiation.

- Once solar energy enters Earth's atmosphere, a wide variety of energy exchange processes take place, redistributing this energy vertically + around the globe.
- By constructing a budget of energy exchange, we can see the relative importance of different parts of this complex system.

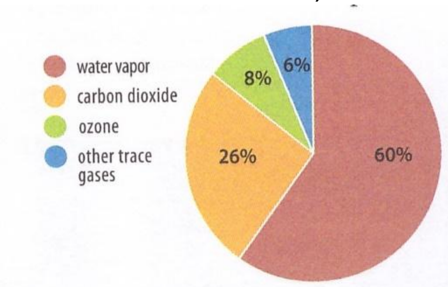
Energy exchange mechanism:
- Most important process of heat transfer in environment = radiation – type of energy exchange.
- Energy transmitted by electromagnetic waves, including radio, TV, light + heat = radiation or radiation energy.
- Feel heat radiation from a burner on a stove without touching it.
- Heat travels from burner → your skin.
- Radiation can travel through space + through materials, although materials may restrict radiant energy flow.
- Radiant energy waves = different lengths.
- Wavelength = distance between successive waves, like waves on a pond.
- Wavelength = affects the behaviour of the energy when it strikes matter; some waves are reflected, and some are absorbed.
- 2 ranges of wavelengths = shortwave + longwave energy = important for understanding how solar energy affects the atmosphere.
- Most energy arriving from the Sun = shortwave, while all energy radiated by Earth = longwave.




▲ 2.2.1 **HEAT TRANSFER**
Radiant energy passes through space. Conduction requires con- tact between objects, as through the pot handle. **Convection** involves mixing in a fluid, while heat transfer requires a change of state, as from liquid to vapor.

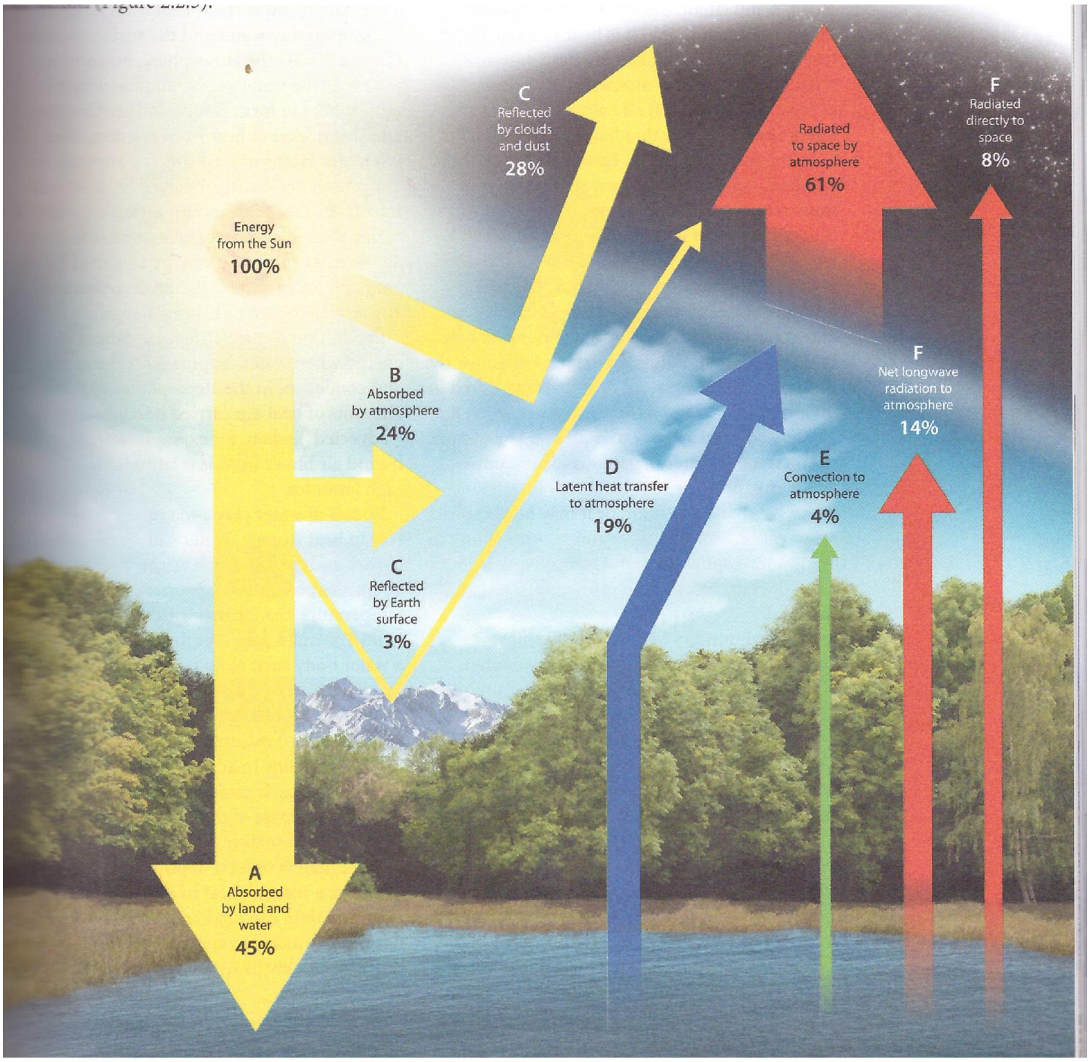
Radiation in the atmosphere:

- As energy form the sun passes through the atmosphere, some wavelengths are absorbed, warming the atmosphere, while others pass through or are reflected, either to be absorbed elsewhere or to travel back into space.
- Clouds = play major role in reflecting energy back to space and in this way atmospheric moisture + weather processes can significantly affect the energy budget, an accounting of the major energy exchanges in the Earth-atmosphere-Sun system.
- When heat = absorbed by an object, its temperature rises, and heat = stored in the object.
- When stored heat = released = object cools.
- Ability of an object to store heat depends on what it is made of.
- Some materials can absorb or release a large amount of heat with only small changes in temperatures, while others heat + cool quickly with only small inputs + releases of energy.
- Of all the gases in the atmosphere, only a few allow much of the incoming shortwave solar energy to pass through but still absorb most outgoing longwave radiation.
- Gases with these properties = greenhouse gases and they are critical to heat exchange in the atmosphere.
- Among the most important ones are:
    - water vapor
    - carbon dioxide ($CO_2$)
    - ozone ($O_3$)
    - methane ($CH_4$)
- Although these gases together constitute a small fraction of the atmosphere, they're the most important in atmospheric heating.
- Water vapor = contributes the most in atmospheric heating.
- Human activities = increasing the amount of some greenhouse gases in the atmosphere + this is believed to be the chief cause of global warming.
- Energy absorbed at ground level = transferred back to the atmosphere + then to space via longwave radiation, convection + latent heat exchange (evaporation or condensation of water).




▲ 2.2.2 **GREENHOUSE GAS EFFECTS ON ATMOSPHERIC HEATING**
Gases in the atmosphere vary in their ability to absorb shortwave and longwave radiation. This diagram shows relative contributiuons of water vapor, carbon dioxide, ozone, and other trace gases to heating of a clear (cloud-free) sky.

<u>Earth's energy budget:</u>




A – about half of the solar radiation that reaches earth is absorbed by the surface; the rest is either
B – absorbed in the atmosphere or
C – reflected back to space. The energy absorbed at the surface is transferred upward, mainly to the atmosphere, by
D – latent heat exchange,
E – convection, and
F – longwave radiation. Energy absorbed by the atmosphere is radiated back to space. The energy exchanges shown here are net exchanges; large amounts of energy are sent back + forth between the earth's surface and the atmosphere by longwave radiation, but the net exchange is upward.

## The definitions of sensible and latent heat:

2 types of heat:
1. Sensible heat:
- Detectable by your sense of touch.
- It's heat you can feel, from warm water or a hot pot and you can measure it with a thermometer.
- Examples:

- Oceans
- rocks
- soil

2. Latent heat:

- In storage of water and water vapor.
- Latent = means hidden = describes the heat that controls the state of water.
- When ice melts = must absorb the heat energy from surroundings = that's way ice melting in your hands feel so cold = it's absorbing the heat from your hands = heat becomes stored in the meltwater as latent heat.
- Latent heat = also stored in water vapor.
- If you ever had a finger scalded by steam, you know the starting amount of latent heat that was stored in the vapor and released from the water when it condensed from a vapor to a liquid on your finger.

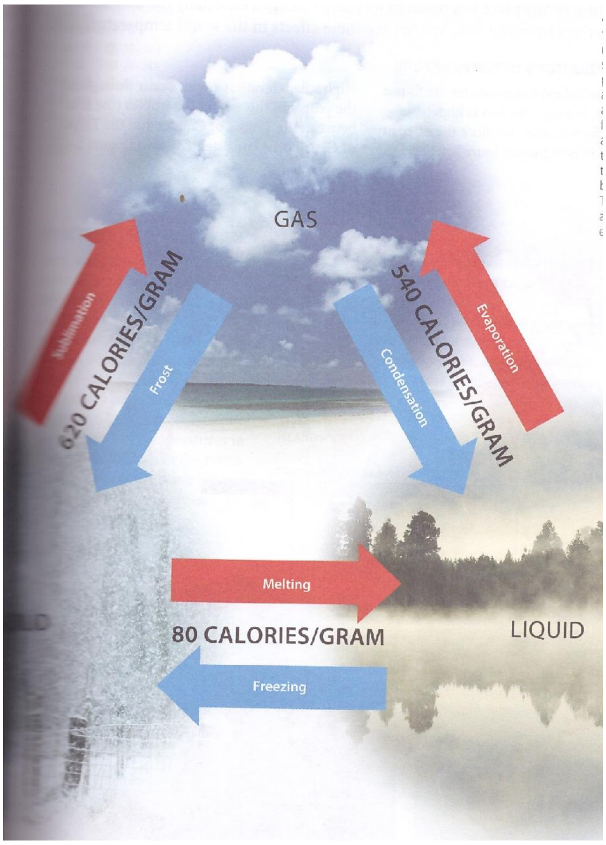
Water vapor – air that contains water in a gaseous form.

Relative humidity – tells us how wet air is, eg. 30°C

**The effects of latent heat being absorbed or released:**

- As water evaporates, as from the ocean or a vegetated land surface, heat is take up in the evaporating water + the surface is cooled.
- The atmosphere = warm
- The water vapor = condenses in the atmosphere to form clouds + precipitation + release of heat from condensation = major factor in warming the atmosphere.
- Amount of energy involved in latent heat transfers in the atmosphere is vast, especially for major weather systems + hurricanes.
- 40 percent of solar energy absorbed by the land + water = transferred to the atmosphere by latent heat exchange.
- In addition to the vertical exchange of energy when water evaporates at the surface + condenses in the atmosphere, large amounts of heat are carried horizontally ("advected") when, for example warm humid air blows from low latitudes to high latitudes.
- Bodies of water play a major role in heat storage.
- Water can absorb + release much larger quantities of heat for a given temperature change than can land.
- Main reason = a water body such as an ocean can be stirred by the wind + carry heat down below its surface to depths of 10 meters or more seasonally.
- In addition water can absorb much more heat than soil per unit mass of these materials.
- In contrast, land surfaces warm + cool to only 2 meters depth seasonally.
- Oceans can store a season's heat in a much larger volume of matter than land areas can, so they don't heat up quickly in summer nor do they cool down as quickly in winter.

Absorbing and releasing latent heat:




- When water goes from solid → liquid → gas, heat is added.
- When it goes from gas → liquid → solid, heat is released.
- Because most evaporation takes place at Earth's surface, and most condensation takes place in the atmosphere, evaporation at the surface + condensation in the atmosphere result in a net transfer of heat from the surface to the atmosphere.
- The amount of heat absorbed in melting (solid → liquid) and released in freezing (liquid → solid) is much less than for conversions between liquid and gas, but still significant.
- Graph = shows the amount of heat absorbed or released, in calories (a unit of energy) per gram of water.

*Energy is not tangible and is therefore a rather abstract concept to understand. You can keep track of the flow of energy by noting the impact thereof on the surrounding environment. The best way to conceptualise energy, in the context of geography, is through temperature. Remember when something is heated up it gains energy and when it cools down it loses energy. This is also applicable to the Earth's surface, to water, to plants and to your body. The Sun is the primary source of energy for all things on Earth. Every form of energy available to us can be traced back to the Sun. The distribution of energy over the Earth is determined by the position of the Earth with respect to the Sun. The resulting dynamics lead to the creation of the seasons and associated weather conditions. This is related to variations in the receipt of energy from the Sun, which contributes to the creation of high and low pressure systems. In this way various processes are set into action, such as evaporation (which leads to the formation of clouds and precipitation), ultimately leading to the creation of weather and climate.

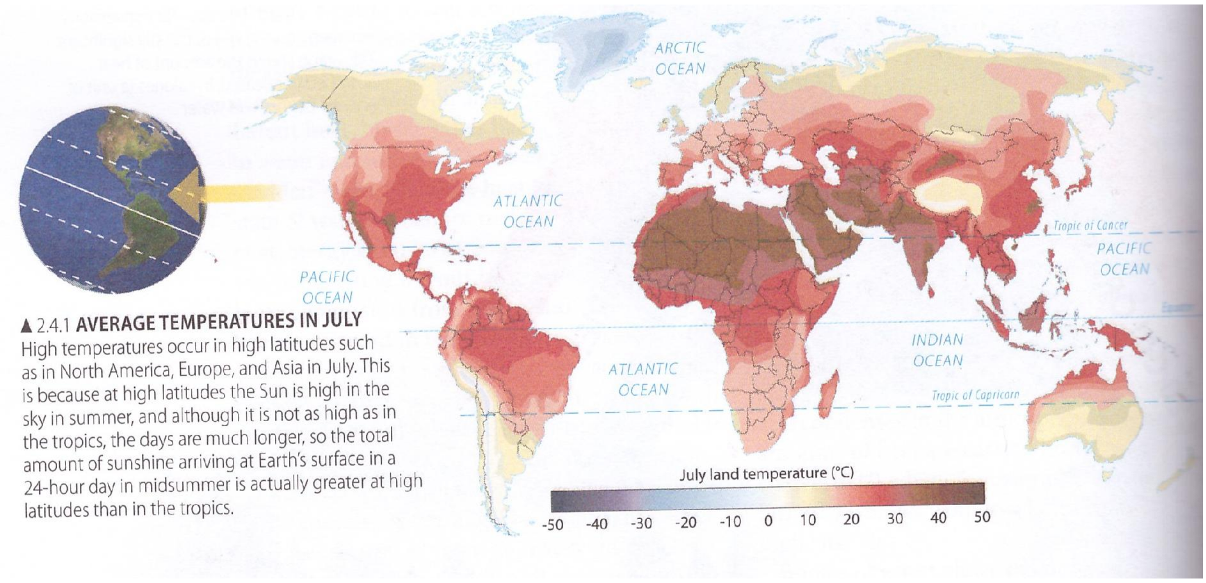
## Temperature and precipitation patterns

Temperature and the amount of precipitation experienced in locations around the world are directly related to the aforementioned flow of energy. Temperature variations are predominantly associated with variations in the angle of incidence of the Sun's rays. Convection influences precipitation, while both temperature and precipitation are affected by atmospheric circulation patterns.

## The spatial variation of temperatures over the globe and how temperatures vary annually:

Seasonal variations in temperature:

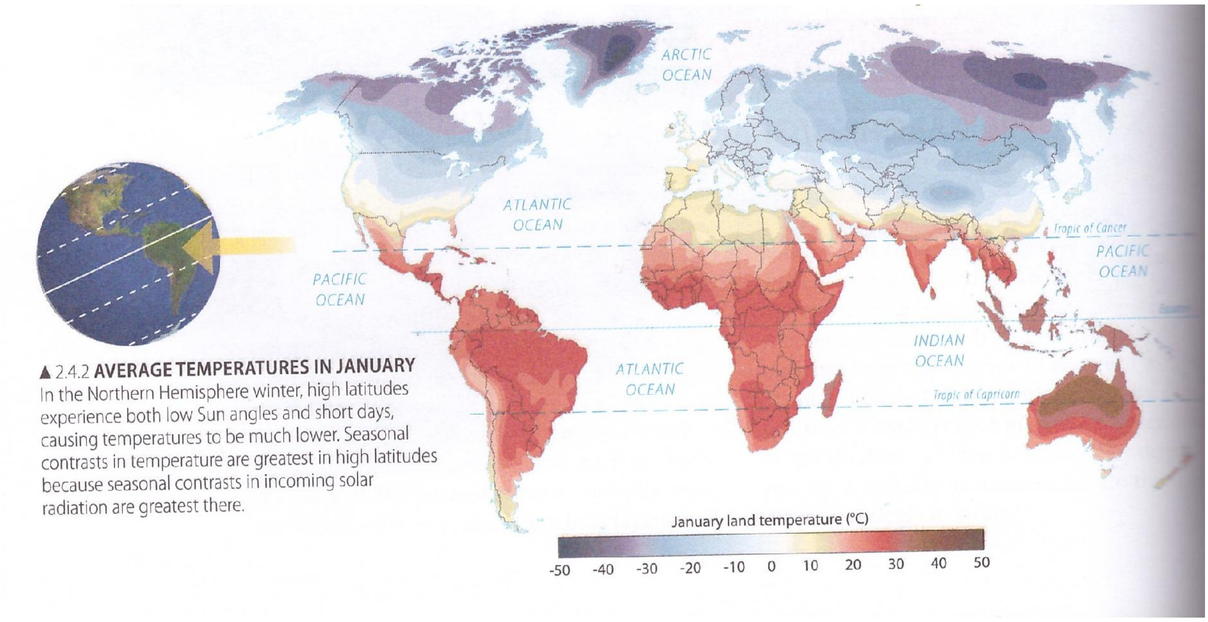
- On average = highest temperatures are found in low latitudes = Sun = highest in the sky in these areas, and therefore the intensity of solar radiation = highest.
- High solar elevation angles occur throughout the year + makes the tropics (the area between the Tropic of Cancer and the Tropic of Capricorn) consistently warm.




▲ 2.4.1 **AVERAGE TEMPERATURES IN JULY**
High temperatures occur in high latitudes such as in North America, Europe, and Asia in July. This is because at high latitudes the Sun is high in the sky in summer, and although it is not as high as in the tropics, the days are much longer, so the total amount of sunshine arriving at Earth's surface in a 24-hour day in midsummer is actually greater at high latitudes than in the tropics.

Average temperature in July:

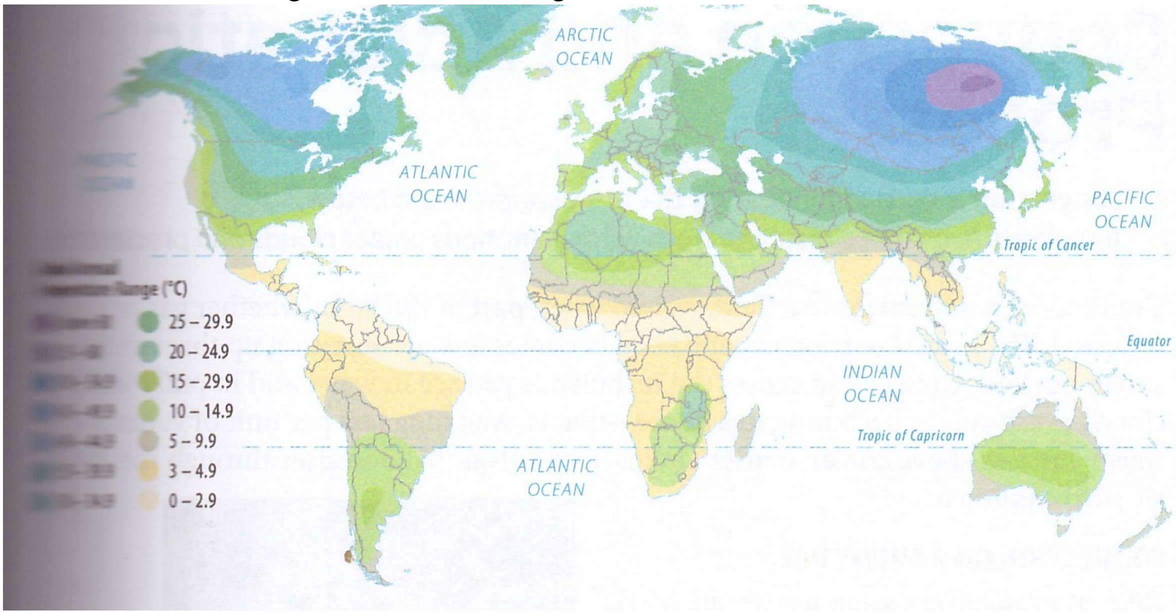
- High temperatures in high latitudes, like Europe, North America + Asia.
- This is because at high latitudes the Sun is high in the sky in the summer + although it's not as high as in the tropics, the days are much longer, so the total amount of sunshine arriving at Earth's surface in a 24-hour day in midsummer is actually greater at high latitudes than in the tropics.




▲ 2.4.2 **AVERAGE TEMPERATURES IN JANUARY**
In the Northern Hemisphere winter, high latitudes experience both low Sun angles and short days, causing temperatures to be much lower. Seasonal contrasts in temperature are greatest in high latitudes because seasonal contrasts in incoming solar radiation are greatest there.

Average temperatures in January:

- In the Northern Hemisphere winter, high latitudes experience both low Sun angles + short days, causing temperatures to be much lower.
- Seasonal contrasts in temperature are greater in high latitudes because seasonal contrasts in incoming solar radiation = greater there.




Temperature ranges:

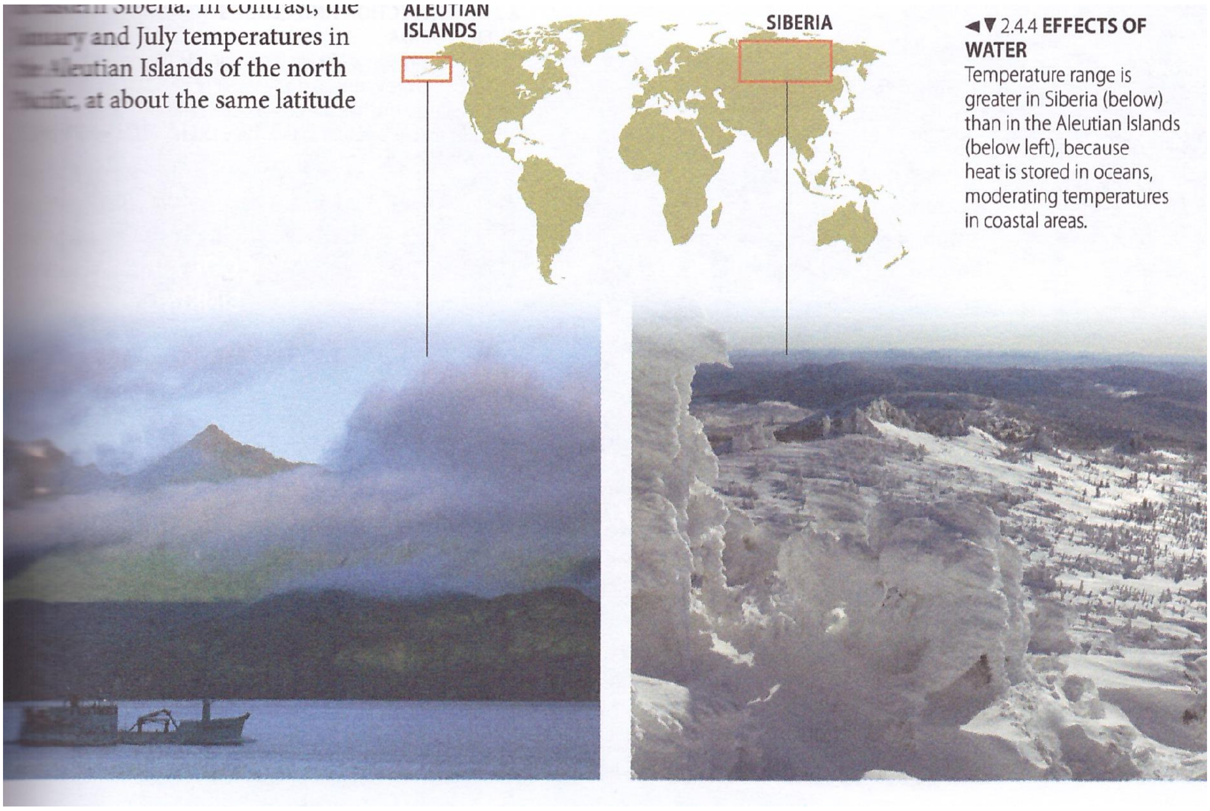
- The difference between summer and winter temperatures = greatest (blue tones)on land areas, especially toward the eastern parts of continents in high latitudes where seasonal contrasts are large.
- In this latitude, winds generally blow from W to E, carrying the influence of the sea to the western part of the continents + the influence of the interior to the eastern parts of the continents.

## The effects of land and water masses on temperature variations:

• Large landmasses in high latitudes, such as North America + Asia have very large

temperature differences between July + January.
• Average July temperatures in Siberia reach above 10°C whereas average January temperatures reach -40°C.
• The differences between July + January temperatures exceed 50°C in eastern Siberia.
• In contrast the January + July temperatures in the Aleutian Islands of the north Pacific. At about the same latitude as Siberia, are about 15°C in July + 5°C in January, a range of about 10°C.
• The moderate climates of areas near the ocean compared with the climatic extremes of midcontinent regions are a results of this heat storage in water, and the advection of heat from ocean areas to adjacent land areas.

Effects of water:



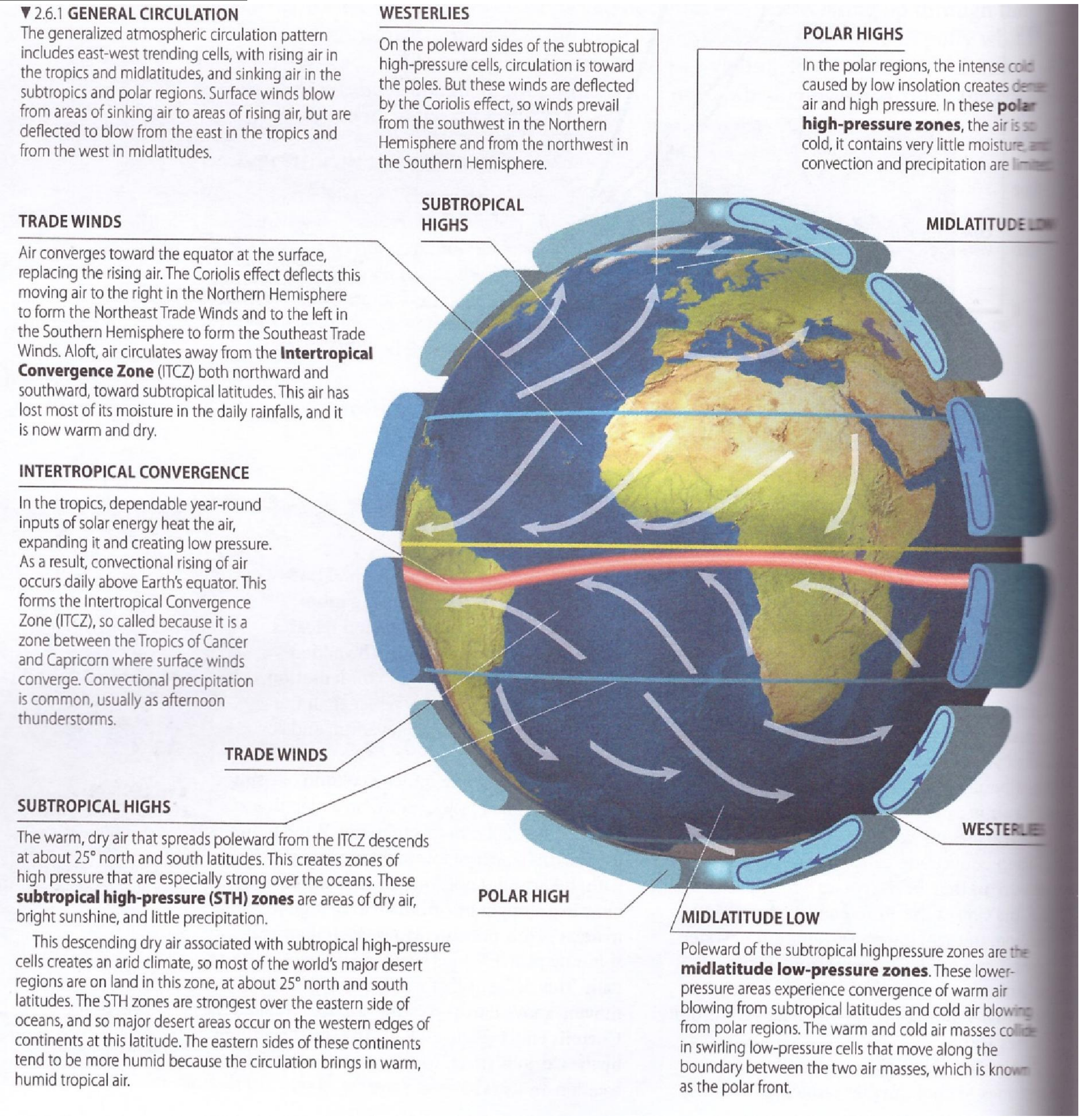
◄▼ 2.4.4 EFFECTS OF WATER
Temperature range is greater in Siberia (below) than in the Aleutian Islands (below left), because heat is stored in oceans, moderating temperatures in coastal areas.

- Temperature range is greater in Siberia than in the Aleutian Islands, because heat is stored in oceans, moderating temperatures in coastal areas.

## The patterns of air circulation on a global scale (convection cells):

- There are areas of rising air in the tropics + midlatitudes, and shrinking air in the subtropics + polar regions.
- Latitudinal circulation zones shift north + south with the seasons.
The global circulation is a set of large-scale convectional cells, in which wind patterns are influenced by both wind + Earth's rotation.

<u>General circulation:</u>



▼2.6.1 **GENERAL CIRCULATION**

The generalized atmospheric circulation pattern includes east-west trending cells, with rising air in the tropics and midlatitudes, and sinking air in the subtropics and polar regions. Surface winds blow from areas of sinking air to areas of rising air, but are deflected to blow from the east in the tropics and from the west in midlatitudes.

**WESTERLIES**

On the poleward sides of the subtropical high-pressure cells, circulation is toward the poles. But these winds are deflected by the Coriolis effect, so winds prevail from the southwest in the Northern Hemisphere and from the northwest in the Southern Hemisphere.

**POLAR HIGHS**

In the polar regions, the intense co[ld] caused by low insolation creates de[nse] air and high pressure. In these **polar high-pressure zones**, the air is so cold, it contains very little moisture, and convection and precipitation are limited.

**TRADE WINDS**

Air converges toward the equator at the surface, replacing the rising air. The Coriolis effect deflects this moving air to the right in the Northern Hemisphere to form the Northeast Trade Winds and to the left in the Southern Hemisphere to form the Southeast Trade Winds. Aloft, air circulates away from the **Intertropical Convergence Zone** (ITCZ) both northward and southward, toward subtropical latitudes. This air has lost most of its moisture in the daily rainfalls, and it is now warm and dry.

**SUBTROPICAL HIGHS**

**MIDLATITUDE LOW**

**INTERTROPICAL CONVERGENCE**

In the tropics, dependable year-round inputs of solar energy heat the air, expanding it and creating low pressure. As a result, convectional rising of air occurs daily above Earth's equator. This forms the Intertropical Convergence Zone (ITCZ), so called because it is a zone between the Tropics of Cancer and Capricorn where surface winds converge. Convectional precipitation is common, usually as afternoon thunderstorms.

**TRADE WINDS**

**SUBTROPICAL HIGHS**

The warm, dry air that spreads poleward from the ITCZ descends at about 25° north and south latitudes. This creates zones of high pressure that are especially strong over the oceans. These **subtropical high-pressure (STH) zones** are areas of dry air, bright sunshine, and little precipitation.

This descending dry air associated with subtropical high-pressure cells creates an arid climate, so most of the world's major desert regions are on land in this zone, at about 25° north and south latitudes. The STH zones are strongest over the eastern side of oceans, and so major desert areas occur on the western edges of continents at this latitude. The eastern sides of these continents tend to be more humid because the circulation brings in warm, humid tropical air.

**WESTERLIES**

**POLAR HIGH**

**MIDLATITUDE LOW**

Poleward of the subtropical highpressure zones are the **midlatitude low-pressure zones**. These lower-pressure areas experience convergence of warm air blowing from subtropical latitudes and cold air blowing from polar regions. The warm and cold air masses collide in swirling low-pressure cells that move along the boundary between the two air masses, which is known as the polar front.

| | |
|---|---|
| **Westerlies:** | • On the poleward sides of the subtropical high-pressure cells, circulation is toward the poles.<br>• But these winds are deflected by the Coriolis effect, so winds prevail from the southwest in the Northern Hemisphere and from the northwest in the Southern Hemisphere. |
| **Polar Highs:** | • In the polar regions, the intense cold caused by low insolation creates dense air + high pressure.<br>• In these polar high-pressure zones, the air is so cold, it contains very little moisture, and convection and precipitation are limited. |
| **Midlatitude low:** | • Poleward of the subtropical highpressure sones are the midlatitude low-pressure zones.<br>• These lowerpressure areas experience |

| | |
|---|---|
| | convergence of warm air blowing from subtropical latitudes and cold air blowing from polar regions.<br>• The warm and cold air masses collide in swirling low-pressure cells that move along the boundary between the 2 air masses, which is known as the polar front. |
| **Subtropical Highs:** | • The warm, dry air that spreads poleward from the ITCZ descends at about 25° N + S latitudes.<br>• This creates zones of HP that are strong over the oceans.<br>• These subtropical high-pressure (STH) zones are areas of dry air, bright sunshine + little precipitation.<br>• This descending dry air associated with subtropical high-pressure cells creates an arid climate, so most of the worlds major desert regions = about 25° N + S latitudes.<br>• The STH zones = strongest over eastern side of oceans + so major desert areas occur on the western edges of continents on this latitude.<br>• Eastern sides of the continents tend to be more humid because the circulation brings in warm + humid tropical air. |
| **Intertropical Convergence:** | • In the tropics, dependable year-round inputs of solar energy heat the air, expanding it + creating LP.<br>• As a result convectional rising of air occurs daily above Earth's equator.<br>• This forms the Intertropical Convergence Zone (ITCZ), so called because it's a zone between the Tropics of Cancer and Capricorn where surface winds converge.<br>• Convectional precipitation is common. Usually as afternoon thunderstorms. |
| **Trade Winds:** | • Air converges toward the equator at the surface, replacing the rising air.<br>• The Coriolis effect deflects this moving air to the right in the Northern Hemisphere to form the Northeast Trade Winds and to the left in the Southern Hemisphere to form the Southeast Trade Winds.<br>• Aloft, air circulates away from the ITCZ both northward + southward, toward subtropical latitudes.<br>• This air has lost most of its moisture in the daily rainfalls, and it's now warm + dry. |

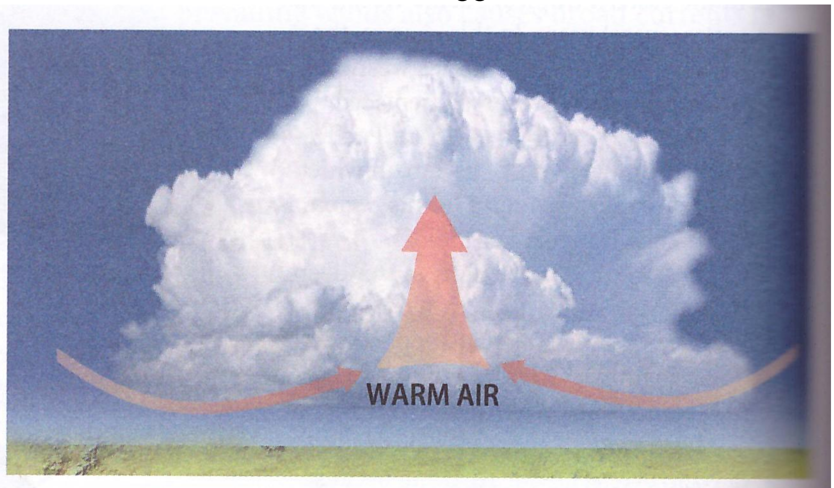
**The four conditions that cause air to rise (which in turn causes precipitation when the air rises to the point where condensation is possible):**

- Precipitation = occurs where humid air rises.
- Precipitation occurs when air rises to cause condensation.

4 types of conditions causing air to rise:

1. Convection:

• Warm, humid day = sky is clear in the morning and Sun is bright.
• Sun = warms ground quickly and the air temperature rises.
• Most of the warming of the air takes place close to the ground, because humid air = good absorber of longwave radiation, which is being reradiated from the ground. (PICTURE)
• Convectional storms = responsible for a large portion of world's precipitation.
• In tropical climates, where strong insolation makes temperatures high, all that's needed for intense daily convectional storms = source of humidity.
• Midlatitude climates = such storms = in summer because higher temperatures allow the air to hold more moisture = means more latent heat can be released = causing strong convection.
• Convection works with other mechanisms that cause air to rise and form precipitation.
• Often the mechanisms = the triggers that lead to more intense convection.

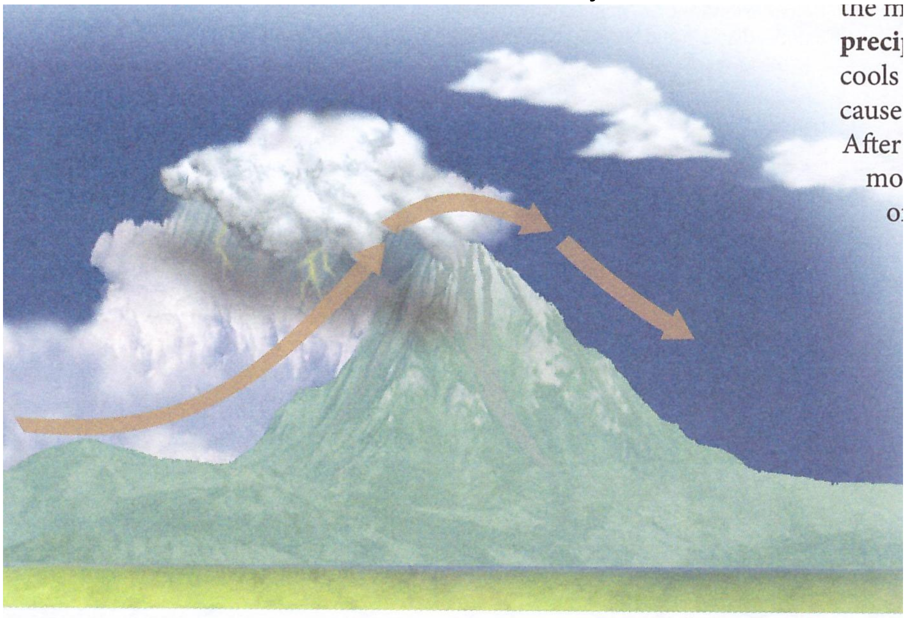



▲ 2.8.1 **CONVECTION**
As the air near the ground warms, it expands, becomes less dense, and rises through the surrounding cooler air above.

2. Orographic uplift:

• Precipitation sometimes occur when horizontal winds move air against mountain ranges, forcing air to rise as it passes over the mountains = called orographic precipitation.
• As air rises, it cools adiabatically (by expansion) = cooling causes condensation = precipitation result.
• After air moved up the windward side of the mountain + over the top = descends on the leeward side.
• As it does so, its relative humidity drops significantly.

• Leeward side = much drier than the rainy windward side.

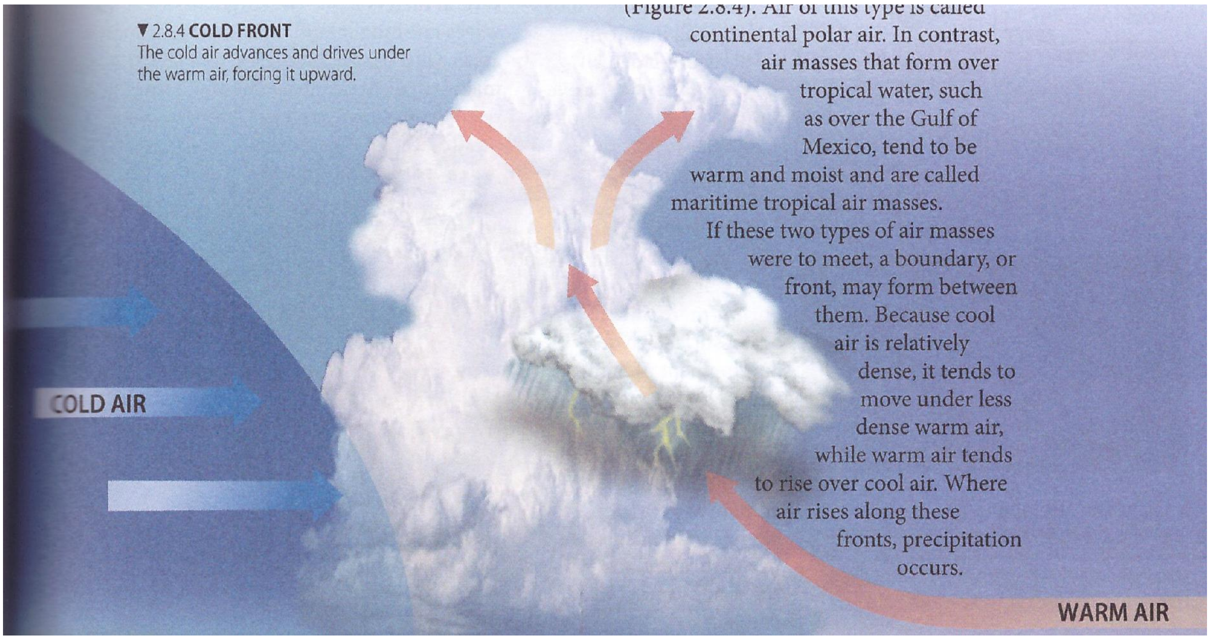


3. Convergence:

• In larger storm systems, large areas of low pressure form, drawing in air that converges from surrounding areas = rising air causes precipitation.
• Regions of low pressure + precipitation = usually move, guided by large-scale circulation patterns.
• See them on satellite images of Earth as large areas of clouds, within which precipitation occurs.

4. Fronts

• Frontal lifting forms along a front – which is the boundary between 2 air masses.
• n air mass – large region of air – hundreds or thousands of square km – with relatively uniform characteristics of temperature and humidity.
• An air mass acquires these characteristics from the land or water over which they form.
• North America = air masses that form over central Canada = cool (because of Canada's high latitude) and dry (because of region's isolation from oceanic moisture sources).
• Air of this type = continental polar air.
• Air masses that form over tropical water (Gulf of Mexico) = warm + moist = maritime tropical air masses.
• If these 2 air masses were to meet, a boundary/front may form between them.
• Cool air = relatively dense = tends to move under less dense warm air, where warm air tends to rise over cool air.
• Where air rises along these fronts, precipitation occurs.



▼ 2.8.4 COLD FRONT
The cold air advances and drives under the warm air, forcing it upward.

*Remember that temperature changes and condensation occurs when latent heat is absorbed from or released to the atmosphere. Heat in the ocean is carried by ocean currents and heat over land is carried by convection.

*Spatial variation refers to how the appearance of certain geographic phenomena varies between different locations. This means that some geographic phenomena may occur in certain locations but not in others, or they do not appear in exactly the same way at all locations. This variation exists because the attributes or the thematic components of geographic phenomena (size, shape, intensity, use, etc.) differ at each location. Temperature, air pressure and precipitation also vary from place to place and therefore present good examples of spatial variation.

## Global climates and climate change

Considering what you know by now about the weather and climate, you would agree that defining climate as “hot or cold” and “wet or dry” is not sufficient because the long term weather conditions experienced at a location and the effects thereof are much more diverse than this. Subsequently this subsection will introduce you to the sophisticated ways in which climates are being classified on the global scale. As you work through this subsection, try to keep the previous subsections in mind because the classification of global climates constitutes a combination of all the individual weather variables and conditions.

### The main parameters used in the classification of climates:

- Climate = the summary of weather conditions over several decades or more – a place’s weather pattern over time.
- The vegetation, natural resources + human activities that characterize a particular region on Earth are heavily influenced by its climate.

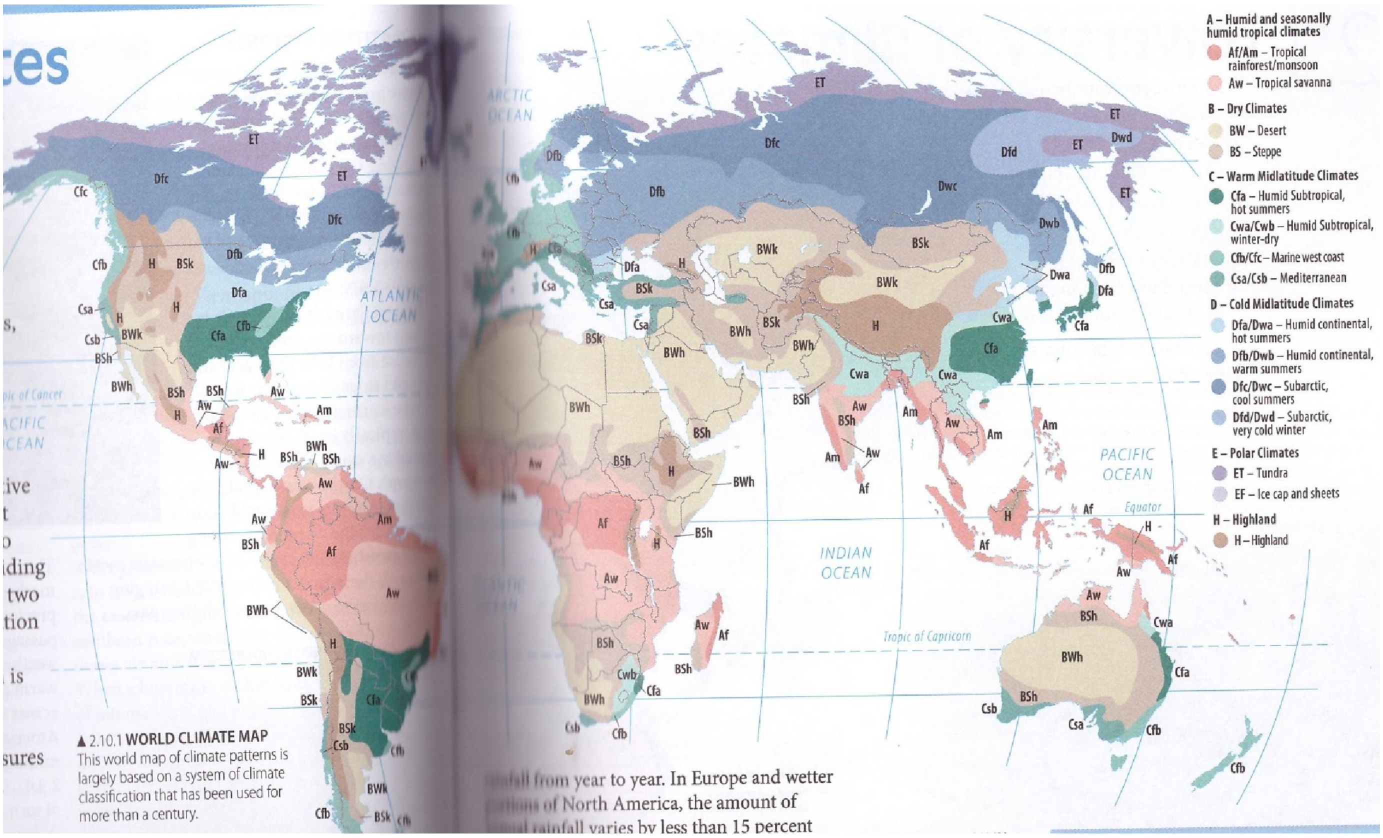
- Geographers have struggled for decades to find an effective classification system for climates.
- Part of the problem is in deciding where to draw boundaries.
- It's a little like deciding how to define the difference between 2 colors, when there's an infinite variation in shades between them.
- To understand a regions distinctive climate, the 2 most important measures are air temperature and precipitation.

Air temperature:
- In everyday conversations, we refer to "hot or cold climates" and "wet or dry climates".
- The most obvious differences in air temperature on Earth are those between the tropics and the poles and those between winter + summer.
- These variations are caused by latitudinal + seasonal variations in solar energy inputs.
- Air temperatures also varies with elevation.
- This variation occurs because of the adiabatic cooling of rising air.
- This is why mountain regions are typically cooler than adjacent lowlands.

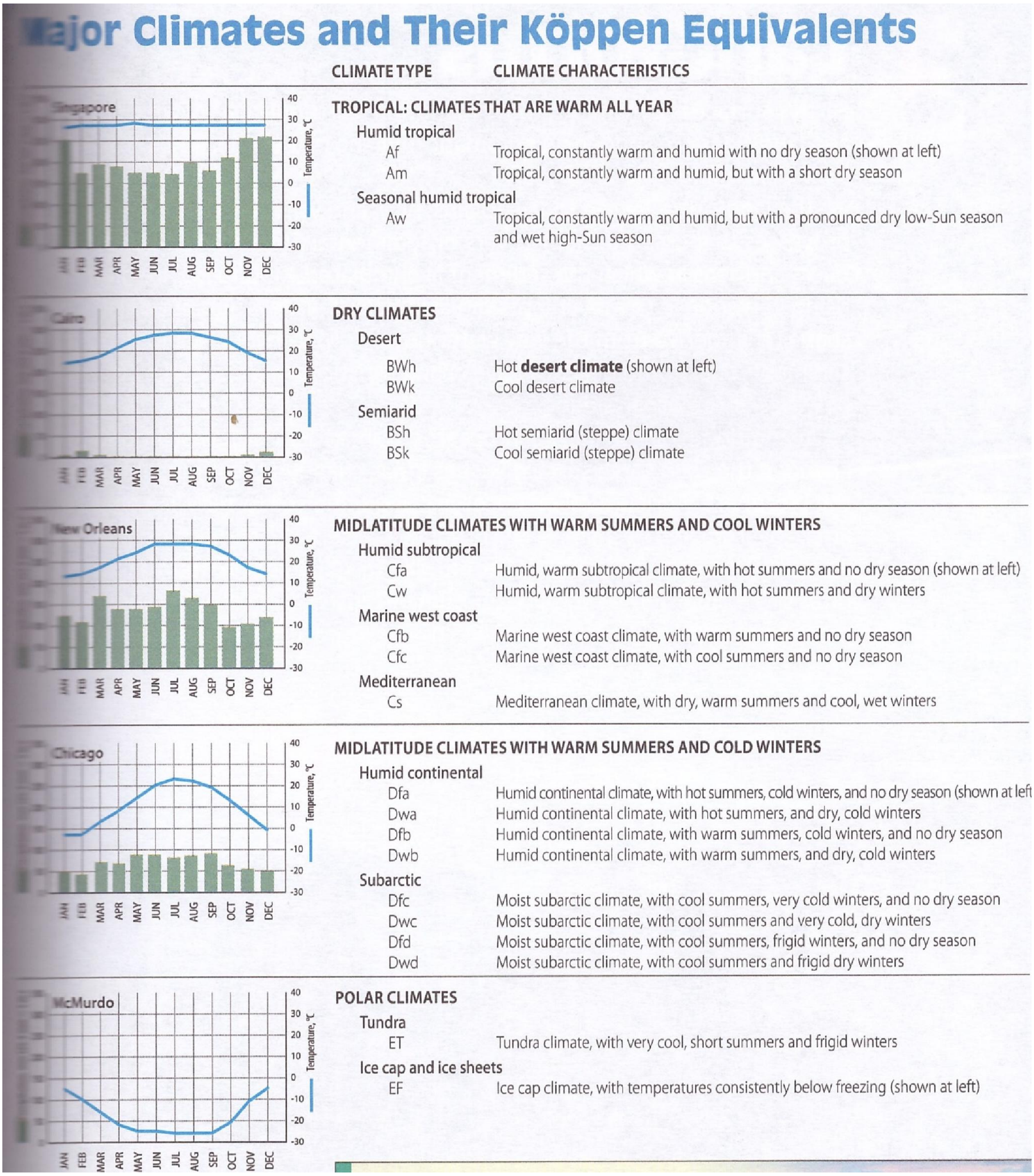
Precipitation:
- Precipitation amount = extremely variable between places + over time.
- A thunderstorm can unleash heavy rain in one place + a light sprinkling just a short distance away.
- Worldwide, annual precipitation generally ranges from virtually none in some desert areas to more than 300cm in wet tropical areas.
- Average rainfall amounts tells us much about the climate of a region, but there is also much they do not tell.
- The timing + reliability of rainfall = equally important.
- In cool areas such as midlatitudes, precipitation frequently takes the form of gentle rainfall, whereas in tropical regions, it may come in torrential downpours.
- We also experience variations in rainfall from year to year.
- In Europe + wetter portions of North America, the amount of annual rainfall varies by less than 15 percent per year on average.
- In many op the tropical + subtropical regions, on the other hand, it fluctuates from 15-20 percent and in the semiarid + arid lands, it fluctuates by 50 percent or more.
- Evaluating water availability involves much more than just measuring rainfall.
- Plants demand water + play a key role in what happens to the precipitation.
- Most climate classification systems consider precipitation in relation to what a region's vegetation needs.
- Plants consume very large amounts of water, totalling about two-thirds of all precipitation that falls on Earth's land areas.
- Because heat energy must be available to evaporate water, warmer climates make a possible greater amount of evaporative water use.
- Thus temperature is considered in distinguishing between arid + humid climates.

**The five main climate types and their respective sub-types (note the**

**[abbreviations used to refer to the main types and their sub-types):]()**



## The climatological characteristics of different climate zones.



**ajor Climates and Their Köppen Equivalents**

| CLIMATE TYPE | | CLIMATE CHARACTERISTICS |
|---|---|---|
| **TROPICAL: CLIMATES THAT ARE WARM ALL YEAR** | | |
| Humid tropical | | |
| | Af | Tropical, constantly warm and humid with no dry season (shown at left) |
| | Am | Tropical, constantly warm and humid, but with a short dry season |
| Seasonal humid tropical | | |
| | Aw | Tropical, constantly warm and humid, but with a pronounced dry low-Sun season and wet high-Sun season |
| **DRY CLIMATES** | | |
| Desert | | |
| | BWh | Hot **desert climate** (shown at left) |
| | BWk | Cool desert climate |
| Semiarid | | |
| | BSh | Hot semiarid (steppe) climate |
| | BSk | Cool semiarid (steppe) climate |
| **MIDLATITUDE CLIMATES WITH WARM SUMMERS AND COOL WINTERS** | | |
| Humid subtropical | | |
| | Cfa | Humid, warm subtropical climate, with hot summers and no dry season (shown at left) |
| | Cw | Humid, warm subtropical climate, with hot summers and dry winters |
| Marine west coast | | |
| | Cfb | Marine west coast climate, with warm summers and no dry season |
| | Cfc | Marine west coast climate, with cool summers and no dry season |
| Mediterranean | | |
| | Cs | Mediterranean climate, with dry, warm summers and cool, wet winters |
| **MIDLATITUDE CLIMATES WITH WARM SUMMERS AND COLD WINTERS** | | |
| Humid continental | | |
| | Dfa | Humid continental climate, with hot summers, cold winters, and no dry season (shown at left |
| | Dwa | Humid continental climate, with hot summers, and dry, cold winters |
| | Dfb | Humid continental climate, with warm summers, cold winters, and no dry season |
| | Dwb | Humid continental climate, with warm summers, and dry, cold winters |
| Subarctic | | |
| | Dfc | Moist subarctic climate, with cool summers, very cold winters, and no dry season |
| | Dwc | Moist subarctic climate, with cool summers and very cold, dry winters |
| | Dfd | Moist subarctic climate, with cool summers, frigid winters, and no dry season |
| | Dwd | Moist subarctic climate, with cool summers and frigid dry winters |
| **POLAR CLIMATES** | | |
| Tundra | | |
| | ET | Tundra climate, with very cool, short summers and frigid winters |
| Ice cap and ice sheets | | |
| | EF | Ice cap climate, with temperatures consistently below freezing (shown at left) |

*Warm midlatitude climates are located close to oceans or large bodies of water while cold climates are located closer to the polar areas.

## Landforms of the Earth and the processes shaping them

The shape of the landscape changes constantly. You might not have lived in one area long enough to observe significant changes to the landscape. Over longer periods of time (and possibly by studying old land surveys of an area) you would be able to observe changes in the landscape. Every landform that you see can be traced to a certain process or conditions at one point in time and the changes that occur (sudden or gradual) can inhibit or promote human-environment interaction. This section of the learning unit will introduce you to the various processes that shape the landscape.

## Processes within the Earth shaping the landscape

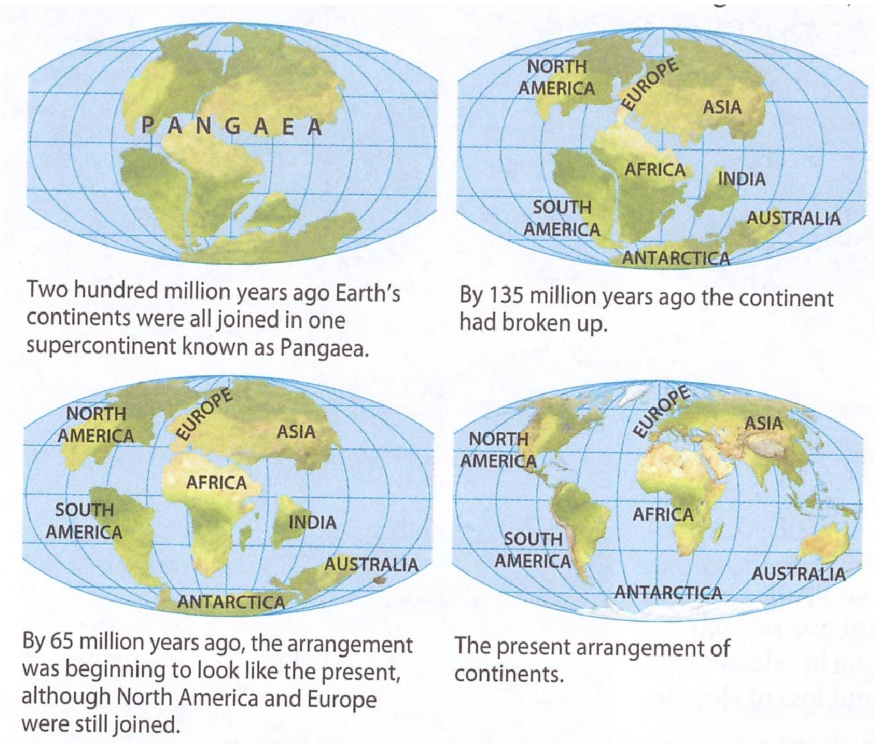
The immense amount of energy that is contained within the Earth's core is bound to have a significant influence on the shape and appearance of the Earth's surface. The forces that shape the landscape and that work from within the Earth, are referred to as endogenic forces and are usually associated with an increase in the surface area of the landscape (for example by creating a ridge or mountain). These forces have a sudden, and often unexpected, impact which can be devastating to both the natural environment and human activities. Two common endogenic forces which are introduced in this section are earthquakes and volcanoes.

### The theory of plate tectonics (with reference to the positions occupied by continents during geological history):

- Earth's crust is composed of tectonic plates that move relative to each other.
- Relative motion between plates creates large-scale landforms at plate boundaries.

• Earth resembles an egg with a cracked shell.
• Earth's crust = thin + rigid, averaging 45km in thickness.
• Rock beneath the crust, known as the mantle = fluid enough to move slowly along in convection currents, driven by heat within Earth's core.
• These currents are analogous to winds in the atmosphere, which carry heat away from Earth's surface.
• This motion of the mantle causes the tectonic plates that make up Earth's rigid crust to move.

Changes caused by plate movements:




Two hundred million years ago Earth's continents were all joined in one supercontinent known as Pangaea.

By 135 million years ago the continent had broken up.

By 65 million years ago, the arrangement was beginning to look like the present, although North America and Europe were still joined.

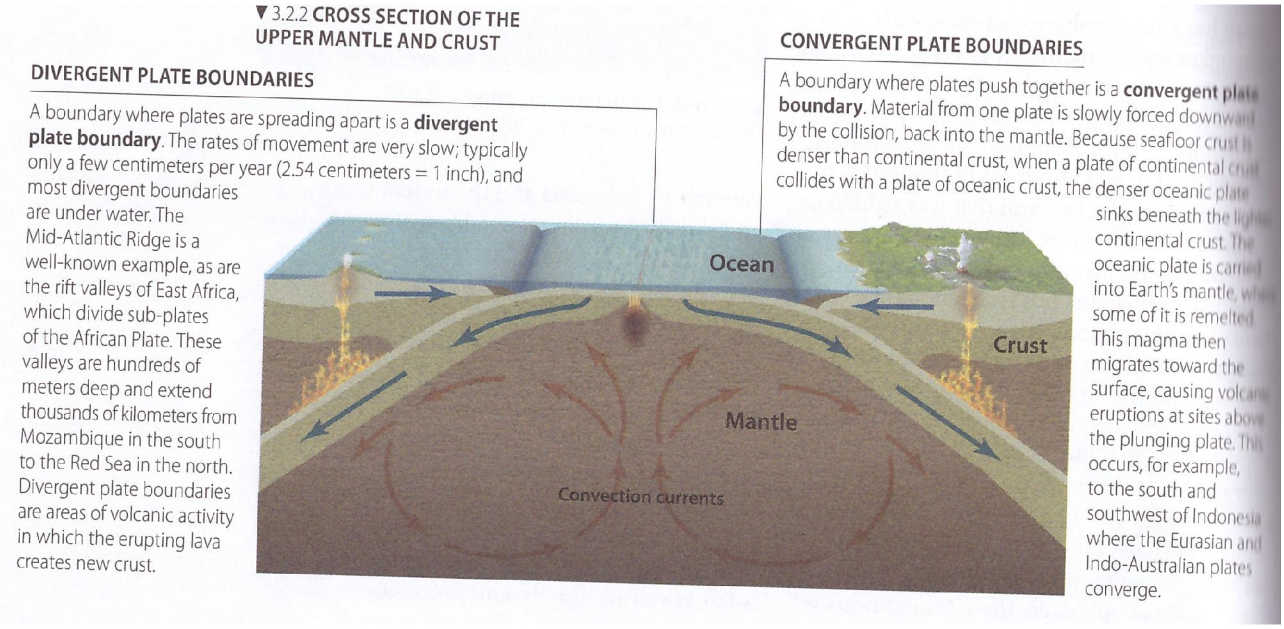
The present arrangement of continents.

- 3 types of boundaries form between moving plates of Earth's crust depending on whether the plates are spreading apart, pushing into each other, or grinding past each other.
- Movement of the plates causes earthquakes to rumble, volcanoes to erupt, and mountains to form.
- Over periods of hundreds of millions of years, the geography of Earth is throughout changed by these movements.

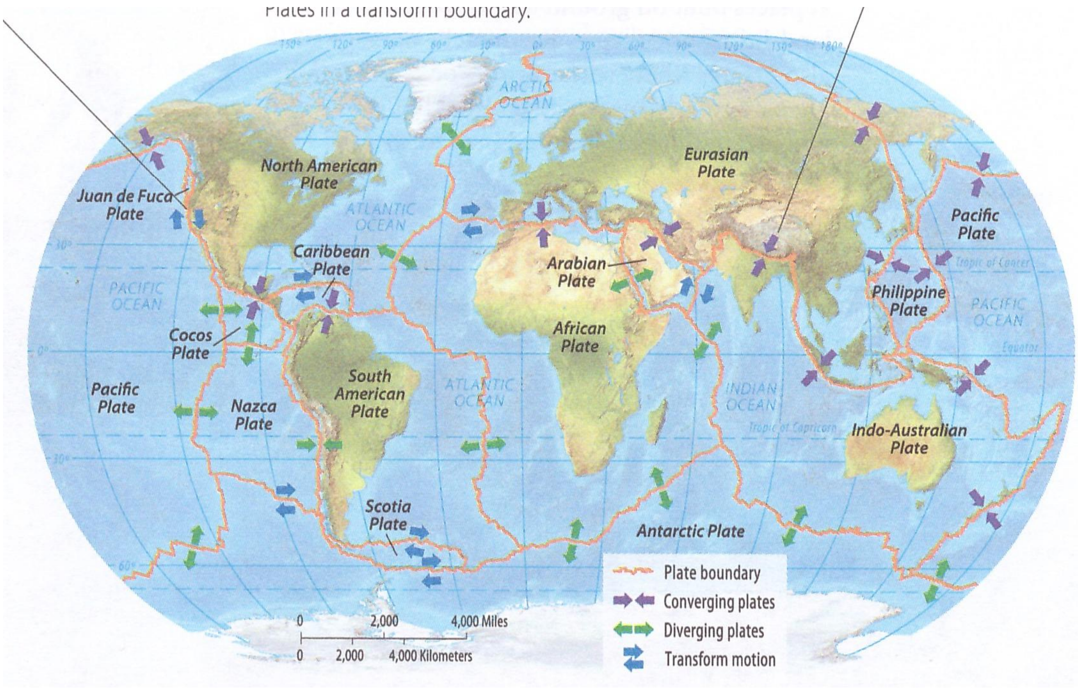
## The difference between divergent, convergent and transform plate boundaries:

| **Divergent plate boundaries:** | **Convergent plate boundaries:** | **Transform plate boundaries:** |
|---|---|---|
| Plates = spreading apart | Plates = push together | Plates = neither converge or diverge, but grind past each other. |
| Rates of movement = very slow = few cm a year | Material from one plate = slowly forced downward by the collision, back into the mantle. | California's San Andreas Fault = moving northwest relative to the North American plate. |
| Most = under water | Because seafloor crust is denser than continental crust, when a plate of continental crust collides with a plate of oceanic crust, the denser the oceanic plate sinks beneath the lighter continental crust. | The boundary between these plates is not a smooth one, + ridges + mountains are built as the 2 plates grind against one another. |

| | | |
|---|---|---|
| Example – Mid-Atlantic Ridge, the rift valleys of East Africa, which divide sub-plates of the African Plate. These valleys = hundreds of meters deep + extend from Mozambique in the south to the Red Sea in the north. | The oceanic plate is carried into Earth's mantle, where some of it's remelted. | The plates bind for long periods and then abruptly slip, causing the earthquakes that frequently strike California. |
| Divergent plate boundaries = areas of volcanic activity in which the erupting lave creates new crust. | The magma = migrates toward the surface, causing volcanic eruptions at sites above the plunging plate. | |
| | Example – occurs to the south + southwest of Indonesia where the Eurasian + Indo-Australian plates converge. | |




## The relative locations of plate boundaries:

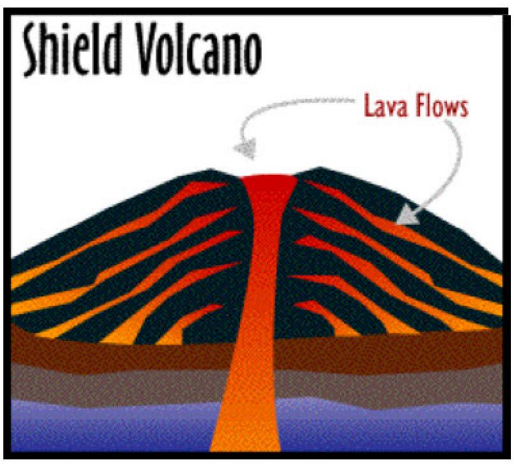



## The characteristics of different volcanoes:

• Volcanoes are clustered along boundaries between tectonic plates.
• Heat within Earth generates magma.
• If this magma reaches the surface and erupts, a volcano is formed.
• Magma may flow over the surface as lava = forming a plain of volcanic rock or a mountain.
• The chemistry of the magma/lava determines its texture + the type of landform.

Types:

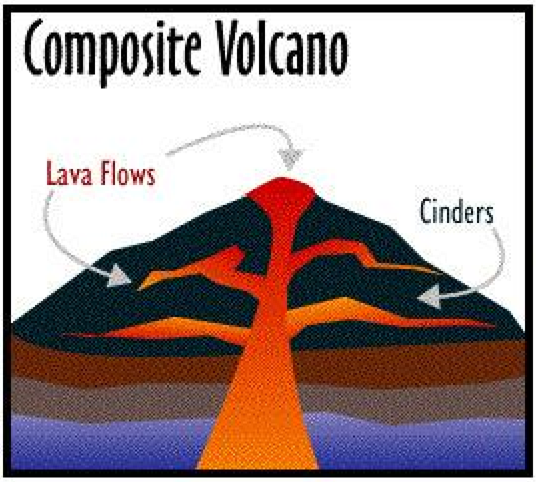
1. Shield volcanoes:
• Erupt runny lava that cools to form a rock called basalt.
• They're called shield volcanoes because of their shape.
• Each on Hawaiian Islands = shield, only one active = Mauna Loa on the island of Hawaii.
• The mid-ocean ridges = formed of similar basaltic lava.



https://www.bing.com/images/search?q=Shield+Volcano+Cross+Section&view=detailv2&id=EDA8595B3A55831AE8C1295648EF64AD2A369EDF&ccid=kAJALKye&simid=608000025273173338&thid=OIP.M9002402cac9eeb239c895d37fa6009d3H0&mode=overlay&first=1

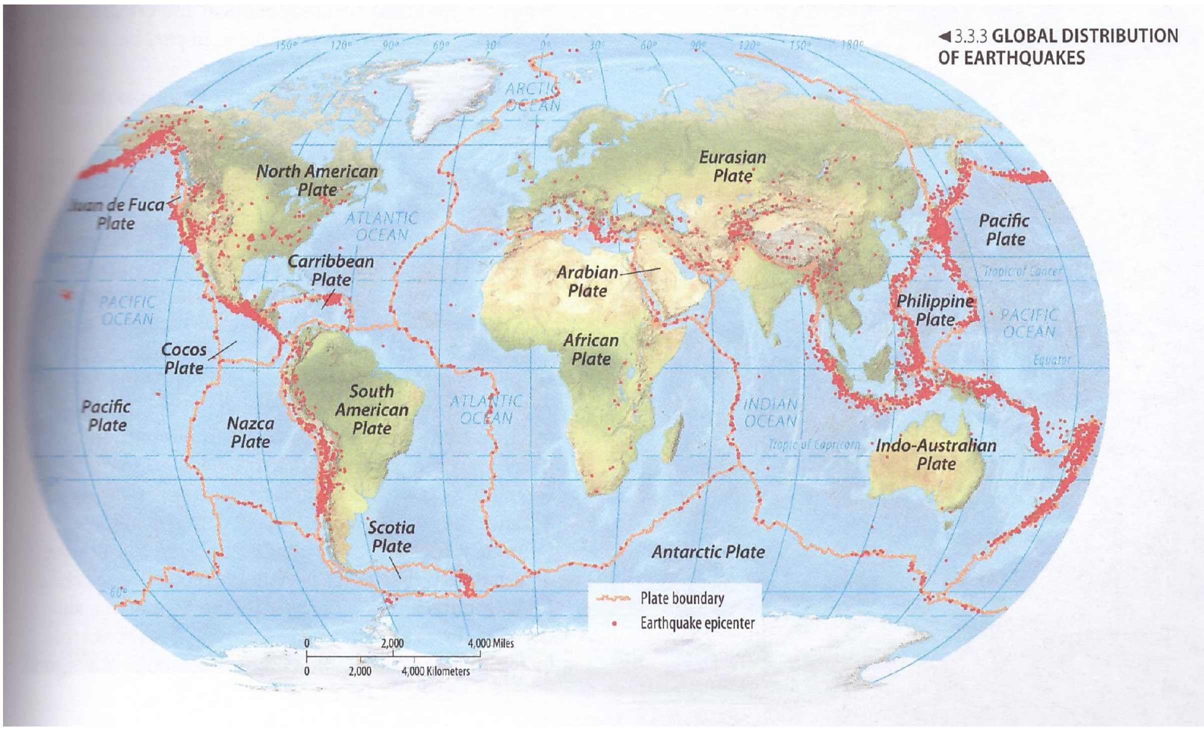
2. Composite cone volcanoes:

• Explosive volcanoes that cause death + destruction = composite cone volcano.
• Made of a mixture of lava + ash.
• Magma = thick + gassy + may erupt explosively through a vent.
• Eruption = sends ash + clouds of sulphurous gas into the atmosphere.
• May also pour lethal gas clouds + dangerous mudflows down the volcano's slopes.
• Repeated eruptions = build a cone-shaped mountain, made up of a mixture of lava and ash layers.
• A lot = dormant (inactive, but with the potential to erupt).
• Some areas = earthquake watch centers provide warnings of volcanic eruptions.
• It's more accurate to predict volcanoes than earthquakes, because volcanoes give many warnings before erupting.




https://www.bing.com/images/search?q=Shield+Volcano+Cross+Section&view=detailv2&id=EDA8595B3A55831AE8C115F297D5E595C18B8B18&selectedindex=22&ccid=rmGKAktg&simid=607987685827479873&thid=OIP.Mae618a024b602ba72dcc30a63651ad93H0&mode=overlay&first=1

**The spatial association between geological hazards and plate boundaries.**



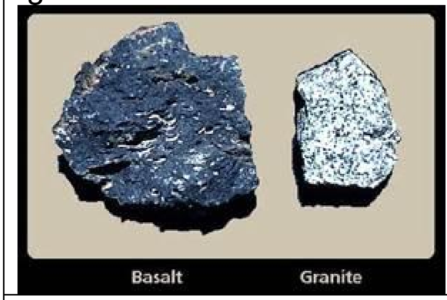
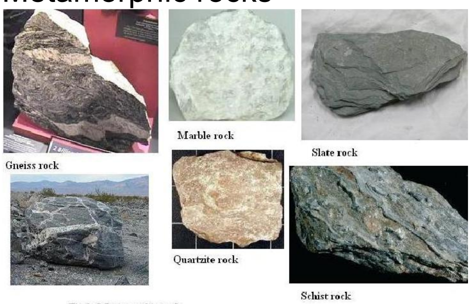

*In order to understand where phenomena such as earthquakes and volcanoes will most likely occur, it is important to introduce another spatial concept, namely spatial association or spatial co-variation. Spatial association refers to the fact that places, facilities or features on Earth are associated with specific environmental conditions or characteristics, or influenced by the spatial variation and distribution of other geographic phenomena. Spatial covariance means exactly the same – i.e. that one geographic phenomenon or process is positively or negatively correlated to another geographic phenomenon or process (in other words they have an influence on each other). In essence spatial association (or co-variation) is used to describe the spatial variation and distribution of one geographic phenomenon in terms of the spatial variation or distribution of one or more other geographic phenomena. In the case of earthquakes and volcanoes, both are associated with the occurrence of tectonic plate boundaries.

## External processes shaping the land

Exogenic forces refer to external processes which break down the surface of the landscape. These forces mostly shape the landscape of the Earth over long periods of time through erosion and weathering, but some events, as mass movements, can occur suddenly and can also be devastating. The following subsection introduces the various external processes by which the landscape is shaped over longer periods of time.

## The major types of rock and how they are formed:

| Rock types: | How they form: | Examples: |
|---|---|---|

| | | |
|---|---|---|
| Igneous rocks<br> | -Molten crustal material (magma) cools + solidifies. | -Basalt (common in volcanic areas, including much of the ocean floor)<br>-Granite ( common in continental areas) |
| Sedimentary rocks<br> | -Formed from particles that have been transported, deposited + cemented together. | -Sandstone<br>-Shale<br>-Limestone form when<br>-sand<br>-clay<br>-calium-rich sediments respectively, accumulate and are cemented to bind their grains together. |
| Metamorphic rocks<br><br>Fig 1: Metamorphic rock | -Existing rocks are exposed to great pressure + heat, altering them into more compact, crystalline rocks. | -Marble (metamorphosed limestone)<br>-Slate (metamorphosed shale) |

## The difference between chemical and mechanical weathering:

| **Chemical weathering:** | **Mechanical weathering:** |
|---|---|
| -A change in the minerals that compose rocks when they're exposed to air + water. | -Rocks get broken down by physical force. |
| -Acids released by decaying vegetation = chemically weathers rocks. | -Rocks expand + contract with frequent changes in temperature = causes them to break apart. |
| -Some of the dissolved products of chemical weathering = carried away by water seeping through the rocks and soil. | -Water can steep into cracks + freezes into ice crystals when the temperature turns colder. |
| -Water = carry these chemical materials to rivers, then the sea. | -The water, which expands = widens cracks in rocks. |
| -This is a source of salinity (dissolved salt) of the oceans. | -Plant roots growing in cracks between rocks also contribute towards mechanical weathering. |
| -Example = oxidation = Iron = element in rocks + combines with oxygen in air to form iron oxide/rust. Iron oxide = | |

| | |
|---|---|
| different properties from the original iron – physically weaker + more easily eroded. Can see on iron/steel = the rusty oxide easily flakes away. | |

## The causes and consequences of erosion:

**Causes:**

- One of the most powerful causes of erosion is water. Water is sometimes called the universal solvent, because it is so effective at dissolving and changing things.
- Rain and runoff contribute to erosion, as do glaciers, snow, and ice.
- Ice can be particularly insidious, because it will literally rip rock and soil apart as it expands and contracts. Many seashores distribute spectacular examples of water erosion, in the form of huge terraces of rocks slowly worn away by the ocean.
-Tectonic movement can also contribute to erosion, as can the wind.
- Wind transports materials from one place to another, and in extremely windy locations it can contribute a powerful scouring force to the process of erosion.
- Materials also naturally tend to slide down a slope, in a process called mass wasting. This downward pull is what causes mountains to slowly melt into hills and plains, and it is constantly happening, although not always in the spectacular form of a landslide.
- Humans can also bring about erosion, usually through poor land management. Overgrazing, for example, is a serious cause of erosion.
- Cows in particular are known for causing serious problems, especially along river banks.
- Areas which have been heavily grazed for centuries show clear signs of erosion and soil exhaustion due to the demands made on the soil.
- Deforestation can also cause erosion, since it strips the protective surface plants and trees from the soil. The soil is no longer held in by roots and plant matter, so it slides away in rainy periods.

**Consequences:**

Agriculture

-Soil erosion removes valuable top soil which is the most productive part of the soil profile for agricultural purposes. The loss of this top soil results in lower yields and higher production costs.
-When top soil is gone, erosion can cause rills and gullies that make the cultivation of paddocks impossible.
-The impacts of erosion on cropping lands include:
  -reduced ability of the soil to store water and nutrients
  -exposure of subsoil which often has poor physical and chemical properties
  -higher rates of runoff, shedding water and nutrients otherwise used for crop growth
  -loss of newly planted crops
  -deposits of silt in low-lying areas.

Waterways

Downstream effects of soil erosion include:

-siltation of watercourses and water storages
-reduction in water quality of creeks, rivers and coastal areas.
- Eroded soil, which can contain nutrients, fertilisers and herbicides or pesticides, can be deposited where there is a reduction in the slope of the land. This can be in sediment traps, along contour banks, or in grassed waterways, dams or wetlands.
- Heavier soil particles are the first to be deposited, while finer colloidal clay particles may remain in suspension. Soil removed by gully erosion (especially finer colloidal clay) may be transported directly to creeks or rivers.

*Weathering is a natural process that affects all landforms and can be monitored to prevent or at least mitigate severe damage. Chemical weathering occurs in numerous forms while mechanical weathering is observed in a few specific processes. The main factors in physical weathering are gravity, water, ice and wind. The prescribed textbook elaborates on the influence of gravity and water but it is important, especially in the South African context, to note the influence of wind. Because South Africa has numerous semi-arid landscapes, wind is an important exogenic force leading to accelerated erosion in the region. Surface erosion occurs more suddenly than weathering and is often aggravated by human activities on land. Surface erosion can be significantly more devastating than weathering, especially for the agriculture industry.

## The role of water in shaping the landscape

*The influence of water is unique because of the scale at which it can shape the landscape. Water can shape an area as small as a farm field or its influence can extend across half of a continent. This subsection is focussed on the influence of water in the process of continually shaping landscapes.

### The process of transporting sediments in rivers and how it creates unique landscapes:

- Sediment = carried by running water.
- Streams create floodplains with meandering channels.

- Streams collect water from 2 sources:
  1. Groundwater
  2. Overland flow
- When rain falls on the land surface, most of it infiltrates, or soaks into soil, where it may drain to streams or to groundwater.

Sediment transport in running water:
- Groundwater migrates slowly through the soil + underlying rocks.
- Most of the water flowing into streams = supplied not by rainfall directly, but by groundwater.
- If rain falls intensely, the soil may not be able to absorb as fast as it falls.
- Runoff/the total flow in streams, comes from soil water, groundwater + overland flow.

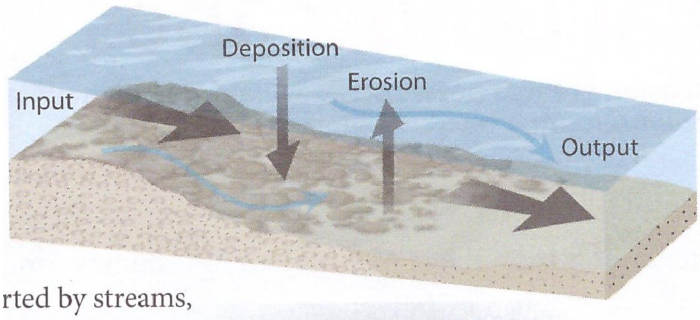
- A stream drains water from an area = the drainage basin.
- Drainage basins may be small as a farm field or as large as a major portion of a continent.
- Smaller basins are within larger basins.
- The greater the area of its drainage basin, the more water a stream must carry.
- Small rills = deliver water + material to larger streams, which join others to form still, larger rivers, which flow to the sea.
- Volume of water a stream carries per unit of time = discharge.
- Discharge of any stream usually increases after storms + decreases during dry spells.
- When water flows across the land, either on a hillslope/channel it carries small particles of rock with it.
- Smaller particles = mixed with water making it look muddy, larger particles = may roll/ bounce along the bottom of the flow.
- The movement of material in a stream = sediment transport.
- The amount of sediment in a stream carries increases as the amount of flowing water increases, so larger streams typically carry more sediment than smaller ones.
- The amount of sediment carried when a river is in flood may be hundreds or thousands of times more than the amount carried at ordinary flow levels.
- Sediment transport also tends to be greater on steep slopes than on gentle ones.


## How floodplains are formed and the different characteristics of floodplains:

Floodplains:

- Sediment = carried downstream by a series of steps.
- Channel beds + banks = made up of materials transported by streams, temporarily deposited + then eroded again as streams take meandering (winding) courses.

- By continually eroding + depositing material in channels + adjacent low-lying surfaces called floodplains, streams tend toward a stable condition = grade.
- Graded stream = transports exactly as much sediment as it collected.
- Streams rarely operate at a condition of grade of long, because daily changes in weather + disturbances from erosion + human activities = upsets the balance.
- As the stream's conditions change + transport of sediment increases or decreases, the shape of the channel may change.
- When increased erosion upstream generates more sediment than a stream can carry = the excess deposits into the channel or floodplain.
- Sediment deposition = slowly raises the elevation of a stream, which can in turn reduce the elevation between places upstream + downstream + reduces the stream's slope.
- Lowering the slope = reduces the amount of sediment arriving from upstream.




◀ 3.8.3 **SEDIMENT IS CONTINUALLY ERODED, TRANSPORTED, AND DEPOSITED**
In any given part of a river, if more sediment is deposited than eroded (input is greater than output), the channel bed rises. If more is eroded than deposited (output is greater than input), the bed is lowered. The shape of a channel is continually adjusting to the amount of water and sediment moving through it.

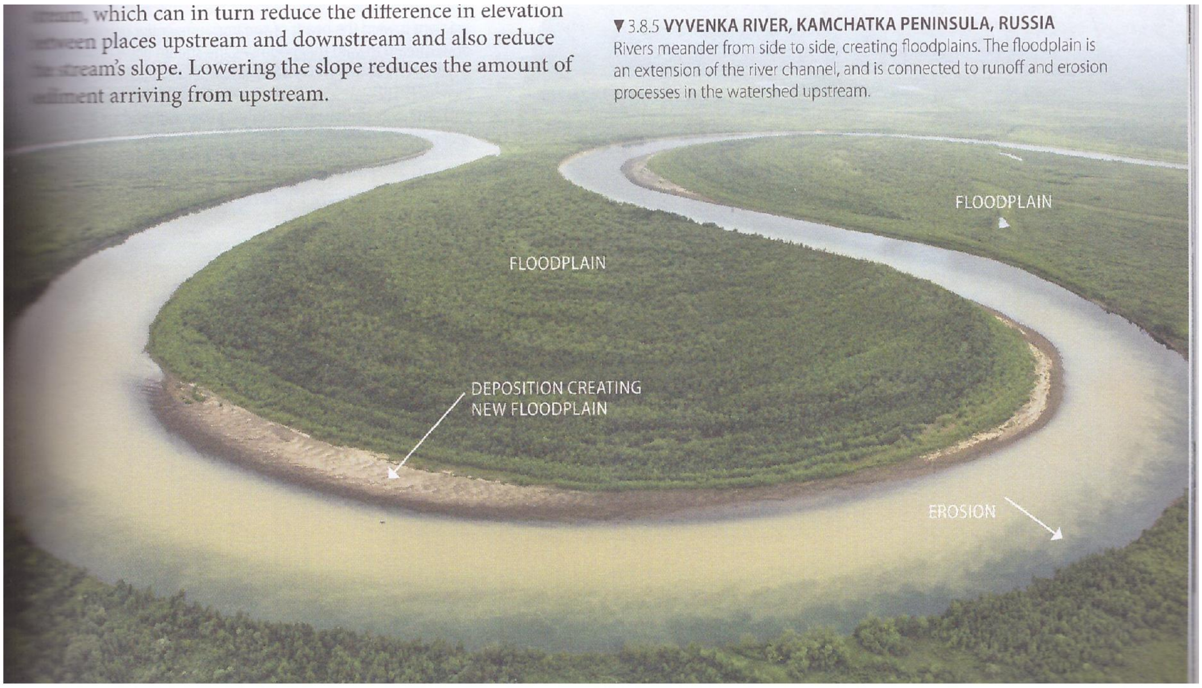
MasteringGEOGRAPHY

rted by streams,


annel or on

of a

▲ 3.8.4 **RIVER COLE, UNITED KINGDOM**
Steep channel banks show areas of erosion, while sloping gravel bars in the channel bed are areas of deposition.

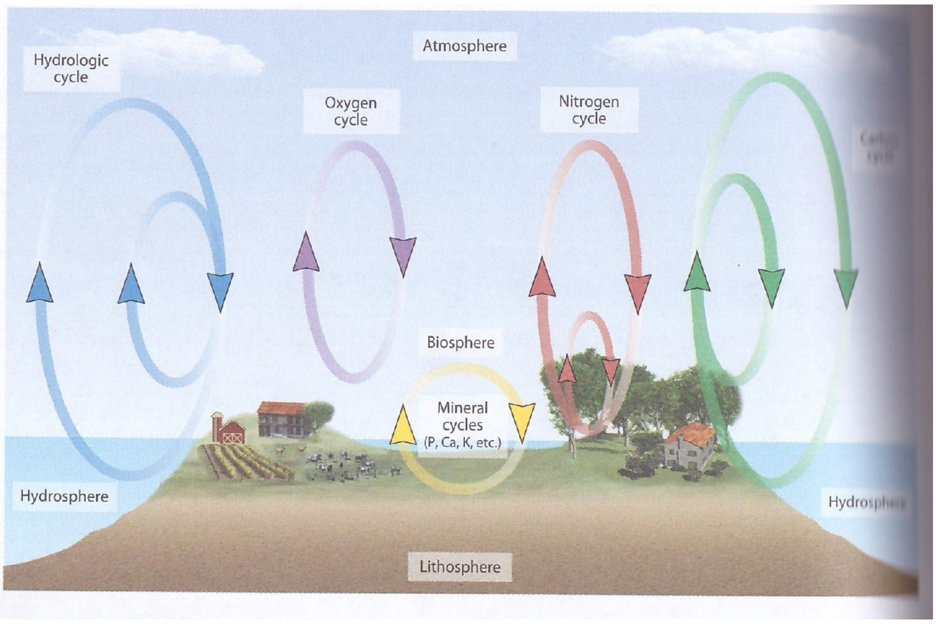



Because sediment transport in rivers is associated with simultaneous erosion and deposition (meaning one area in the river is being eroded while another area is being built up), the implication is that over time the location and pathway that a river takes through the landscape can actually change. These changes can influence human activities and reshape a fluvial landscape. In the context of environmental management it is important to remember that a water basin has many tributary channels that are linked to each other and therefore problems related to water quality in one area can possibly be caused by problems further up the network. Although glacial processes have a significant impact on the shape of the land they have been excluded from the scope of the module because these processes are not very important in the South African context.

## Biogeochemical and water cycles:

### The importance of biogeochemical cycles in supporting life:

►4.1.1
**BIOGEOCHEMICAL CYCLES**
These cycles transfer matter among the atmosphere, biosphere, hydrosphere, and lithosphere. The cycles represented here are shown in greatly simplified form. Important minerals cycling in the environment include phosphorus (P), calcium (Ca), and potassium (K), among others.



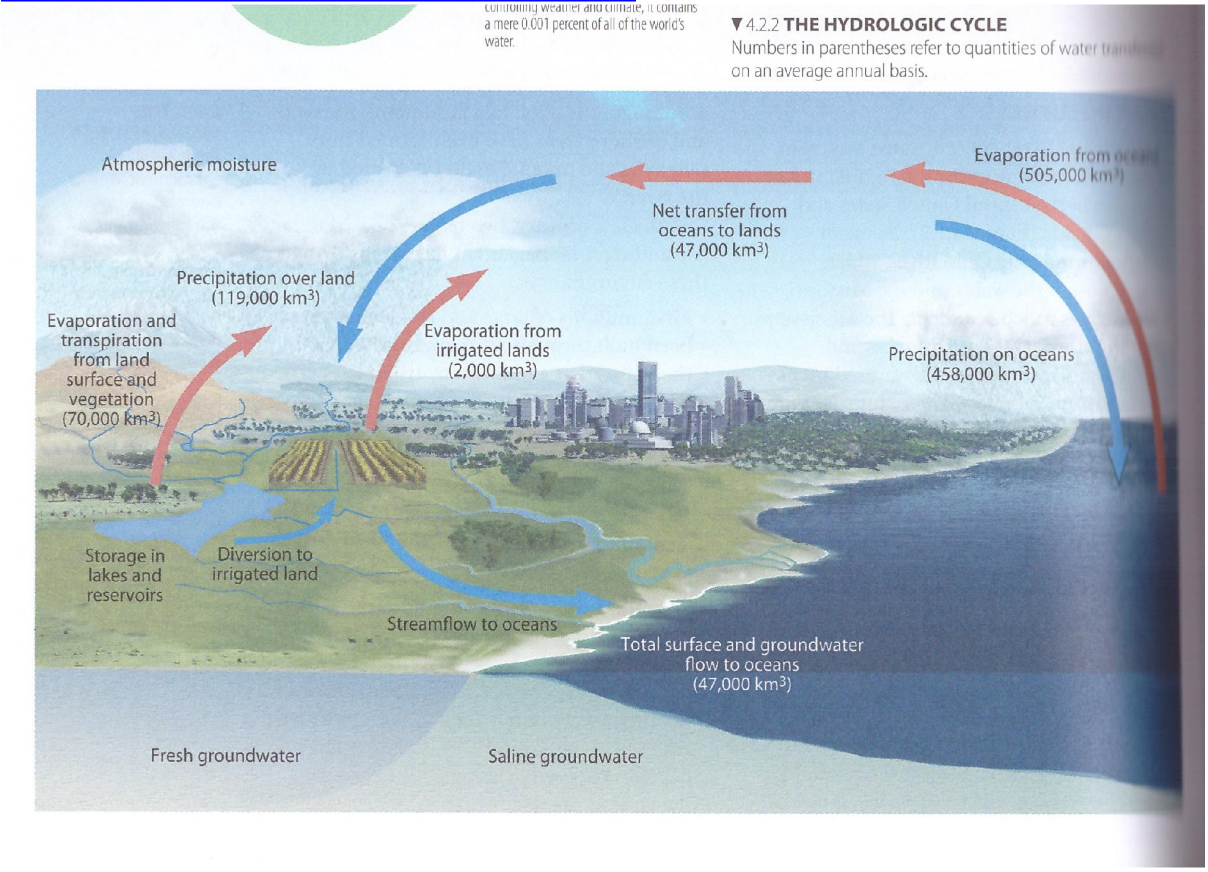

- Biogeochemical cycles = recycling processes that supply essential substances such as carbon, nitrogen + other nutrients to the biosphere.
- Also connect the lithosphere, hydrosphere + biosphere + atmosphere.
- The hydrologic cycle in which water flows among these subsystems = example of the biogeochemical cycle.
- Other important – carbon cycle, which that element moves between atmosphere (as $CO_2$ + other substances), the biosphere (as living + formerly matter), the hydrosphere ( as dissolved compounds) + the lithosphere (as rock + fossil fuels).

<u>Law of conservation of energy:</u>
- Energy is not created or destroyed under ordinary conditions, but it may be changed from one form to another.

<u>Law of conservation of matter:</u>
- Matter may be changed from one form to another under ordinary conditions but cannot be created or destroyed, except in nuclear reactions.

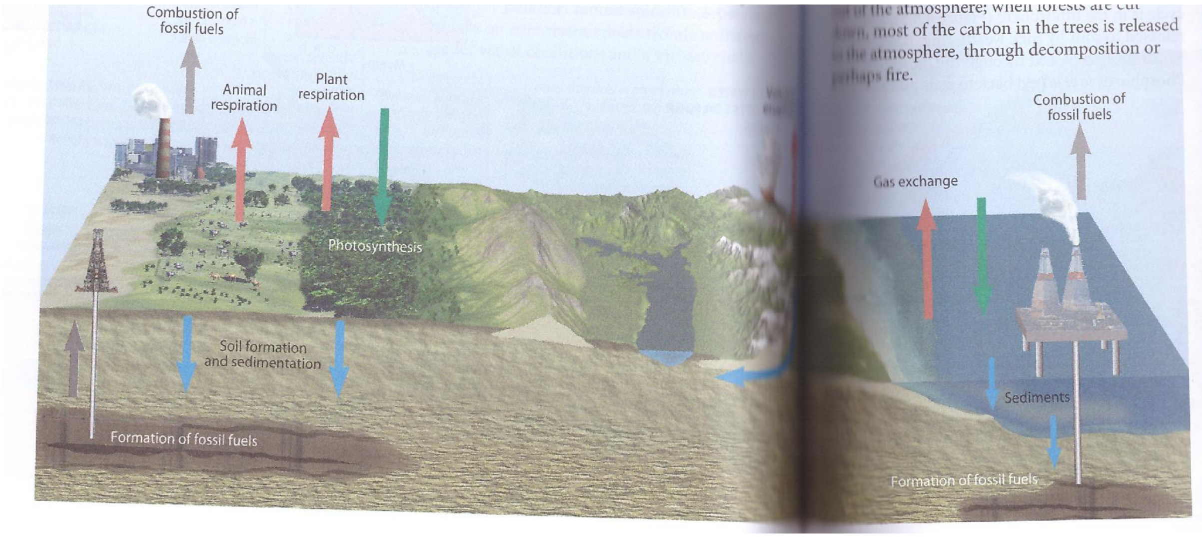
Therefore a change in the quantities of a substance stored or moving in one part of the system can be consequences throughout the system.

## The functioning of the hydrological cycle:




- Water = stored in the atmosphere, biosphere, hydrosphere + lithosphere in solid, gaseous + liquid forms.
- Water cycles through the atmosphere, lithosphere + hydrosphere through means of evaporation, condensation, precipitation + runoff.
- Evaporation converts liquid water in lakes + oceans into vapor, returning it into the atmosphere.
- Water falls from the atmosphere to the ground + ocean through condensation + precipitation.
- Runoff carries water from the land to the sea, most of it temporarily stored as groundwater.
- This flow = hydrologic cycle.

## Carbon cycle:




- Carbon = taken from the atmosphere + stored in biomass through photosynthesis.
- It's returned to the atmosphere through respiration.
- Combustion of fossil fuels + manufacturing of cement release vast quantities of carbon to the atmosphere from long-term storage in rocks.
- Large quantities are also exchanged between the atmosphere + oceans via gas exchange.
- Major storage of carbon are present in the soil, plants, the atmosphere, oceans, rocks + fossil fuels.

## The cycling of carbon through photosynthesis:

Photosynthesis:

Carbon dioxide + water + energy → carbohydrates + oxygen

• For this reaction, land plants obtain carbon dioxide from the air, water from the soil and energy from solar radiation.
• They store carbohydrates in tissue for later use and release oxygen to the atmosphere.
• Plants are the source of atmospheric oxygen, without which animals could not exist.

## The carbon budget:

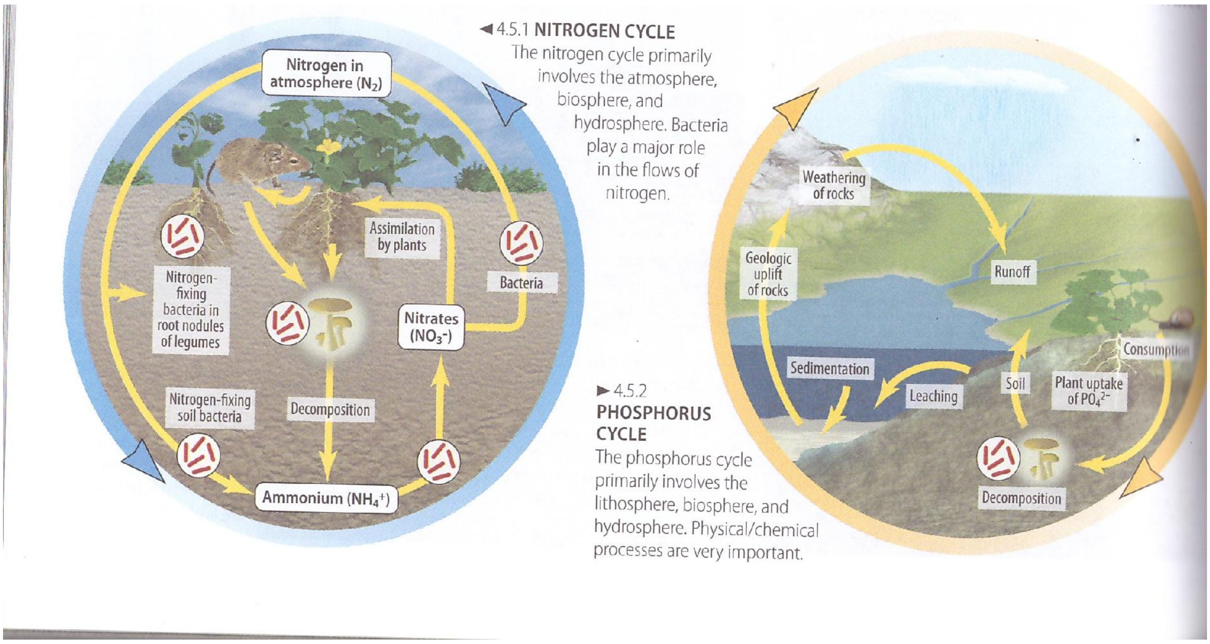
- Total amount of carbon in the atmosphere increased.
- Increase = due to fossil fuel combustion + cement manufacturing.

*Remember that biogeochemical cycles connect all the Earth's physical systems and that the hydrological cycle and the carbon cycle are two specific cycles that connect all four physical systems, because carbon and water move through each of these systems at certain crucial points. Although these cycles are natural cycles that can sustain themselves, human intervention often causes an imbalance, which then results in pollution and environmental degradation.

## Matter, energy and ecosystems:

An ecosystem is a system of biotic (living) organisms and abiotic (non-living) components as they occur in their environment (construed of air, water, soil, etc.) that interacts with each other as a system in order to sustain life. Matter (specifically nitrogen and phosphorus) are crucial components in ecosystems. Without these components, ecosystems will not be sustainable and will not be able to support life. The matter that sustains an ecosystem is stored in the soil and therefore the quality of the soil determines the life supporting qualities of the ecosystem.

### The nitrogen and phosphorus cycles and the effects of imbalances in each:




- Nitrogen + phosphorus cycle among Earth's systems, providing essential nutrients to ecosystems.

Nitrogen cycle:

• Nitrogen = taken from atmosphere + fixed or converted to forms that can be used by plants + animals to build proteins + other molecules.
• Nitrogen fixation = occurs natural + human processes.

Natural nitrogen fixation:
- Carried on in soil, by bacteria + then taken up in plants + incorporated in plant tissue.
- This nitrogen passes from plants to the animals that consume them, before being broken down + released back into the atmosphere.
- Bacteria play a major role in converting nitrogen contained in biomass into mobile forms such as - ammonium ($NH_4$)
  - nitrate ($NO_3$) which are readily dissolved in water.
- Water moving through the soil = carry this soluble nitrogen to streams and to the

ocean.

Human nitrogen fixation:
- Fix nitrogen through fertilizer manufacture.
- This nitrogen = added to agricultural systems from which it's spread through the environment.
- Motor vehicles + fossil-fuel fired power plants also emit large amounts of nitrogen oxides that are returned to the surface in precipitation in bioavailable forms, particularly nitrate.

• Today more nitrogen = fixed by humans than by natural processes.

Phosphorous cycle:

• Major storage in the phosphorus cycle = in the lithosphere.
• It's released to soils by rock weathering, taken up by plants, and passed through the biosphere.
• Phosphorus = released back to soils + water by decomposition of waste + dead biomass.
• Like nitrogen, phosphorus = an essential nutrient for plant growth.
• When we harvest crops, the phosphorus they contain = removed from farm fields and this, along with removal in water that runs off the fields, depletes soil phosphorus stocks.
• We can replace this lost phosphorus + stimulate crop growth, by adding phosphorus fertilizers to the soil.
• These fertilizers are produced by mining phosphate-rich rock, and by mining accumulations of bird droppings in some coastal and island areas.

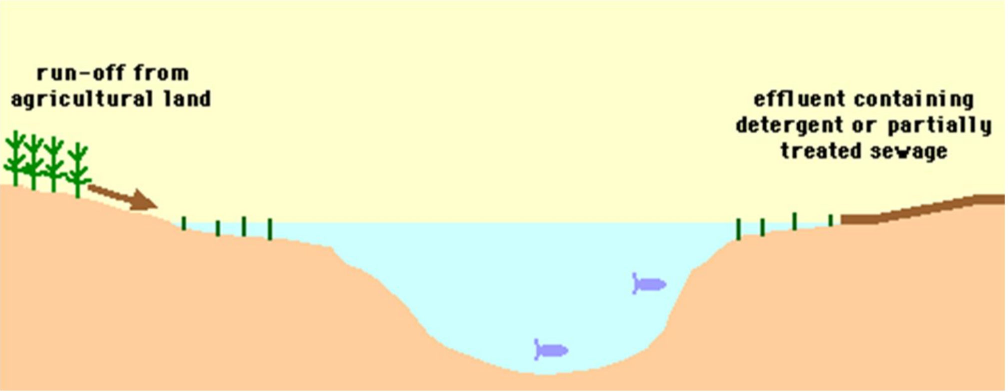
## The causes and consequences of eutrophication:

The main causes of eutrophication are:
•natural run-off of nutrients from the soil and the weathering of rocks
•run-off of inorganic fertiliser (containing nitrates and phosphates)
•run-off of manure from farms (containing nitrates, phosphates and ammonia)
•run-off from erosion (following mining, construction work or poor land use)
•discharge of detergents (containing phosphates)
•discharge of partially treated or untreated sewage (containing nitrates and phosphates)

In most freshwater lakes the limiting nutrient is phosphorus, so an input of phosphorus in the form of phosphate ions (PO43-) results in an increase in biological activity.

Consequences:
- Added algal growth in surface waters stimulates biological activity + increases populations of zooplankton – small animals that feed on algae.
- As the algae and zooplankton die + settle into deeper, darker water, they decompose, consuming oxygen.

- Causes water to have low oxygen content, and some organisms that live in the sea bed or near it cannot survive, hence the term “dead zone”.




http://legacy.chemgym.net/environmental_chemistry/topic_4b/page_2.html

## The role of soil in the Earth’s physical systems and associated processes:

Soil – a dynamic, porous layer of mineral + organic matter that’s vital in supporting Earth’s biosphere.

Soil properties are attributable to 5 major factors:

1. Parent material is the mineral matter from which soil is formed.

- Weathering breaks rock down into smaller particles and new chemical forms.
- The parent material from which soil is formed is important because it influences soil’s chemical + physical characteristics in young soils.

2. Climate regulates both water movements + biological activity:

- Water plays a central role in rock weathering + soil formation.
- In very humid climates, much water passes through the soil + leaches out soluble minerals on its way.
- Because of this leaching, soils in humid climates generally have lower amounts of soluble minerals such as sodium + calcium compared to soils in dry climates.
- However in semiarid areas, water enters the soil + picks up soluble minerals, which are drawn toward the surface as water is evapotranspired; soils of semiarid + arid climates often have a layer rich in relatively soluble minerals near the surface.

3. Biological activity among plants and animals move minerals and adds organic matter to the soil.

- Plants produce organic matter that accumulates on the soil surface, and animals redistribute this organic matter through the soil.
- Plants + animals also play a role in weathering processes.

4. Topography affects water movement and erosion rates:

- Topography also affects the amount of water present in the soil, largely through controlling drainage + erosion.
- Steeply sloping areas generally have better drainage than flat or low-lying areas, and they’re often more eroded.

5. All these factors work over time, typically requiring many thousands of years to create a mature soil:
- Soil = a dynamic, porous layer of mineral + organic matter at Earth's surface.
- Soil formation = a slow process that takes place very gradually over thousands of years.
- Soils that have only been forming for a few thousand years have very different characteristics from those that have been modified by chemical + biological processes for tens of thousands of years.

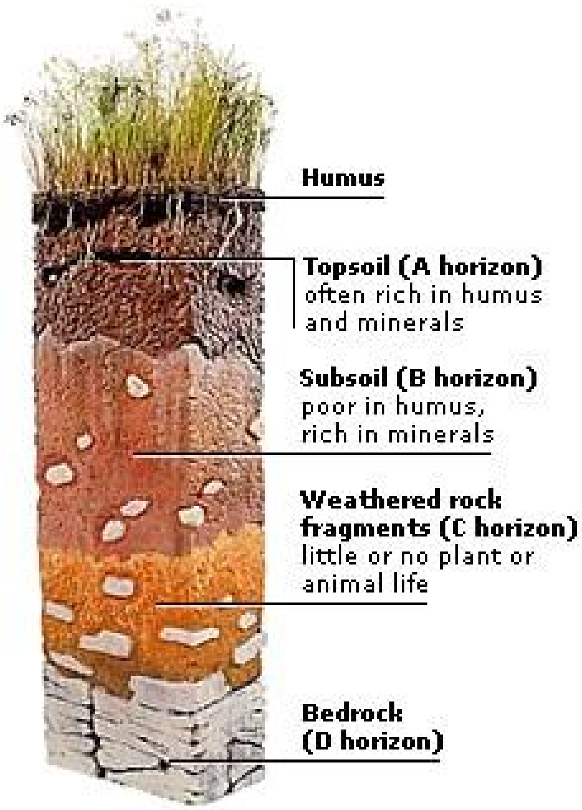



Image obtained from: http://i.infopls.com/images/ency048soilay001.jpg

| | |
|---|---|
| O Horizon: (Humus) | • Litter – leaves, twigs, dead insects, + other organic matter<br>• Accumulates to form a horizon at the surface known as the O (organic) horizon. |
| A Horizon: | • As litter decays, insects, worms + bacteria consume it + carry it underground, where it helps form the A horizon.<br>• Waste from these burrowing animals as well as their dead bodies add more organic matter to the A horizon.<br>• In many soils, the A horizon contains much of the nutrients that support plant life.<br>• Water may erode materials from the soil surface. |
| B Horizon: | • Organisms + water move materials between the A + B horizons.<br>• Clay minerals formed from chemical weathering often accumulate in |

| | |
|---|---|
| | the B horizon + in dry regions soluble minerals such as calcium accumulate in the B horizon. |
| C Horizon: | • The C horizon contains weathered parent materials that have not been altered as completely by soil-forming processes as materials above it. |

- Soil properties vary in layers called soil horizons.
- Soil horizons are formed through the vertical movement of water, minerals + organic matter in the soil + also variations in biological + chemical activity at different depths.
- The characteristics of soil horizons vary greatly from one soil type to another.
- Not all soils contain the A, B, C horizons, but many do.
- The presence of certain horizons + the characteristics of those horizons are key to identifying distinct soil types.

**Soil types:**

| | |
|---|---|
| Alfisol: | • Have a brownish colour reflecting moderate organic matter content.<br>• It formed under a forest cover + has moderately high fertility. |
| Aridisol: | • Soils in arid climates are typically rich in soluble minerals because water isn't available to remove them.<br>• They're also generally low in organic matter because of low rates of plant growth. |
| Mollisol: | • This rich, black soil formed in semiarid climate with grassland vegetation.<br>• It's high in organic matter + nutrients. |
| Oxisol: | • This soil = experienced thousands of years of intense chemical weathering + removal of soluble minerals.<br>• Its reddish colour comes mainly from a high concentration of iron oxides.<br>• Soils of this type = often low in nutrients as a results of leaching of soluble minerals by water. |
| Histosol: | • This soil is composed mainly of dead organic matter, which accumulates because it decays very slowly in the cold Artic climate. |

# ALFISOLS

Alfisols are in semiarid to moist areas.

These soils result from weathering processes that leach clay minerals and other constituents out of the surface layer and into the subsoil, where they can hold and supply moisture and nutrients to plants. They formed primarily under forest or mixed vegetative cover and are productive for most crops.

**ALFISOLS MAKE UP ABOUT 10% OF THE WORLD'S ICE-FREE LAND SURFACE.**

# ARIDISOLS

Aridisols are soils that are too dry for the growth of mesophytic plants. The lack of moisture greatly restricts the intensity of weathering processes and limits most soil development processes to the upper part of the soils. Aridisols often accumulate gypsum, salt, calcium carbonate, and other materials that are easily leached from soils in more humid environments.

Aridisols are common in the deserts of the world.

**ARIDISOLS MAKE UP ABOUT 12% OF THE WORLD'S ICE-FREE LAND SURFACE.**


Mollisols are soils that have a dark colored surface horizon relatively high in content of organic matter. The soils are base rich throughout and therefore are quite fertile.

Mollisols characteristically form under grass in climates that have a moderate to pronounced seasonal moisture deficit. They are extensive soils on the steppes of Europe, Asia, North America, and South America.

**MOLLISOLS MAKE UP ABOUT 7% OF THE WORLD'S ICE-FREE LAND SURFACE.**

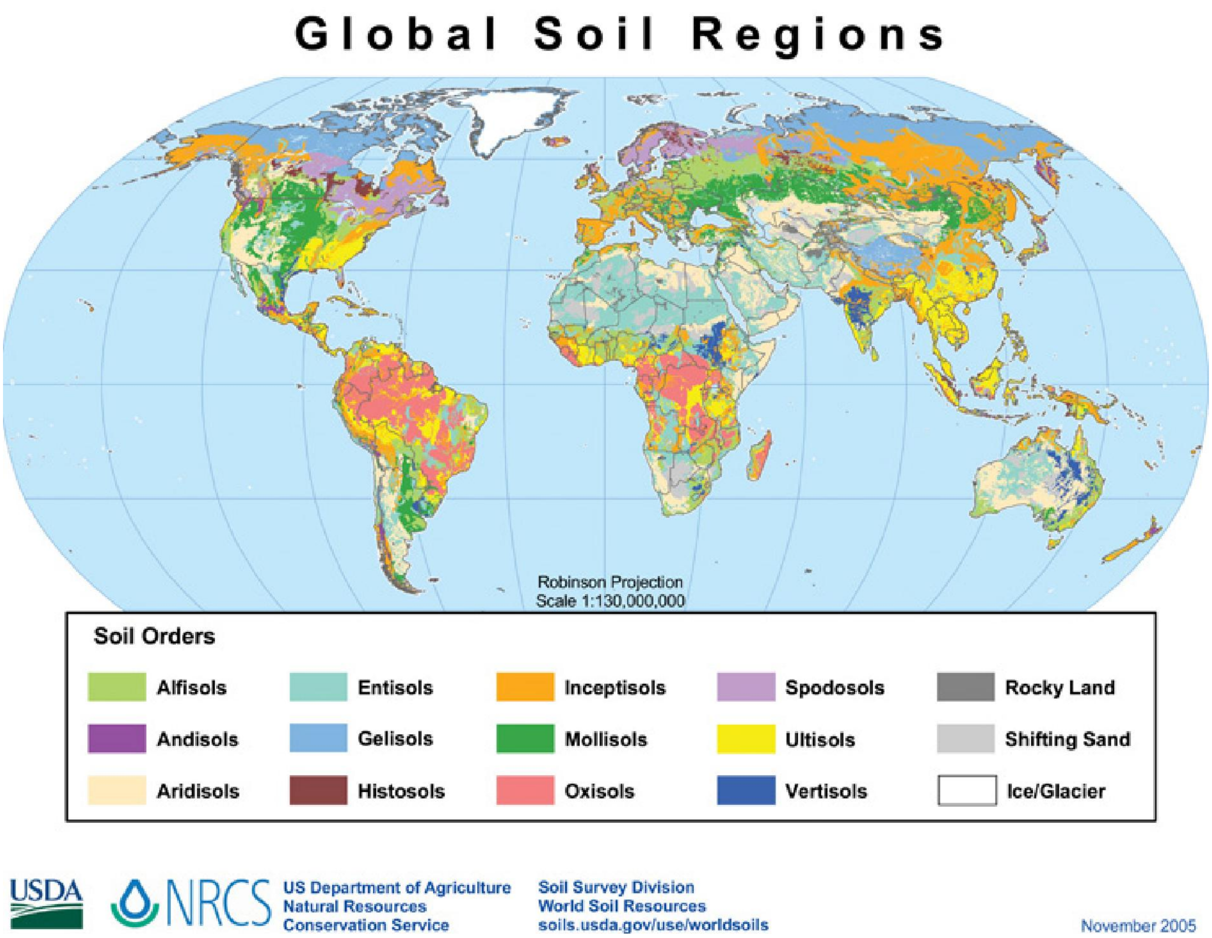

Oxisols are highly weathered soils of tropical and subtropical regions. They are dominated by low activity minerals, such as quartz, kaolinite, and iron oxides. They tend to have indistinct horizons.

Oxisols characteristically occur on land surfaces that have been stable for a long time. They have low natural fertility as well as a low capacity to retain additions of lime and fertilizer.

**OXISOLS MAKE UP ABOUT 8% OF THE WORLD'S ICE-FREE LAND SURFACE.**


Images obtained from: http://passel.unl.edu/Image/mmamo3/TimKettler

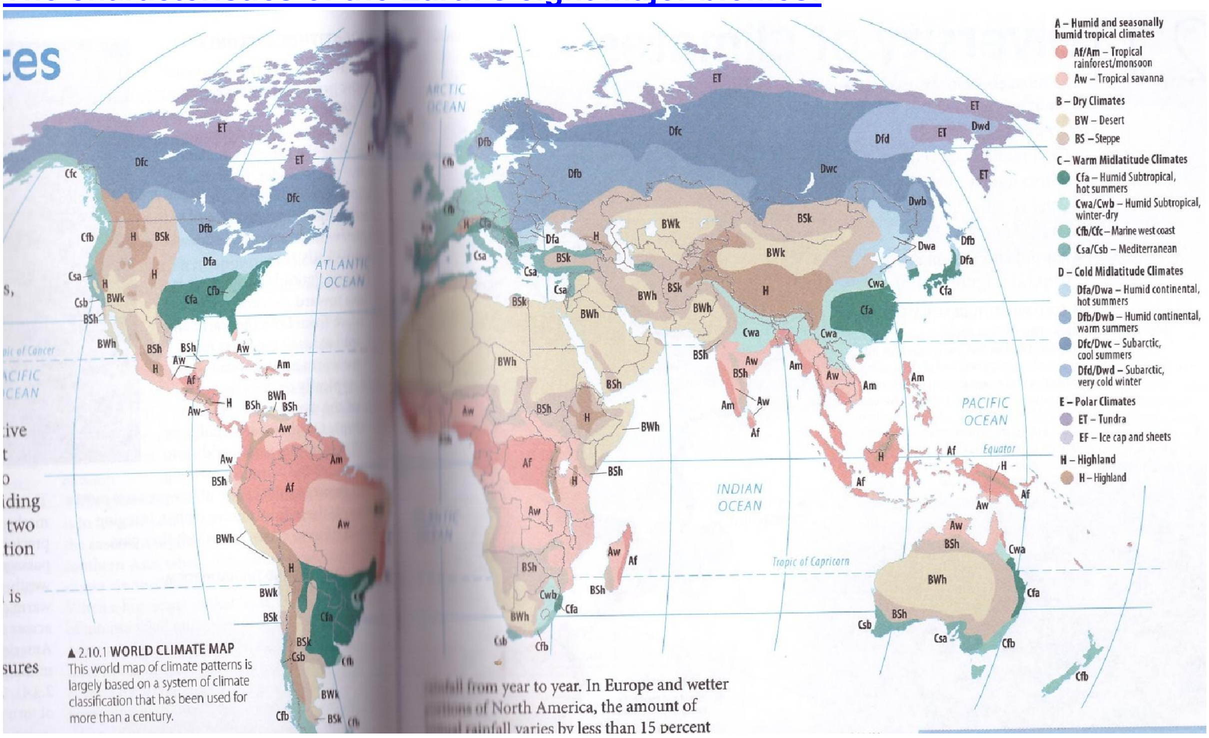
**The spatial distribution of soil types:**




http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_050040.jpg

## Distribution of life forms on Earth:

## The characteristics of the Earth's eight major biomes:



1. <u>Tropical forest:</u>
- Tall, broad-leaved trees retain their leaves all year.
- Has a top layer/canopy, and 2 more layers beneath.
- Each layer = different dominant species + associated animal communities.
- Tropical rain forests = noted for biodiversity.
- Tropical diversity of trees = paralleled by a great variety of animals.
- Complex vertical structure = adds diversity of habitats + species.
- Wide diversity of life places biome at the center of controversy over
    - deforestation
    - species extinction
    - biodiversity.

2. <u>Tropical savanna, mixed grassland and woodland:</u>
- Trees spread widely enough for sunlight to support dense grasses + shrubs beneath them.
- Vegetation = common in climates that have a pronounced dry season, where even the trees may lose their leaves, and some areas dry-season deciduous trees are common.

3. <u>Desert and desert shrub:</u>
- Moisture = scare = large areas of bare ground exist and sparse vegetation is entirely adapted to moisture stress.
- Some desert plants = drought-tolerant varieties of types common in more humid areas, such as grasses.
- Others, such as cacti = almost exclusive to deserts.

4. <u>Mediterranean woodland shrub and grassland:</u>
- Areas = find a mixed woodland and grassland that consists of relatively small trees.
- Fire = common, caused by humans and lightning.
- Many plant species = adapted to frequent fire, and some even require fire to maintain their continued presence in the landscape.

5. <u>Broadleaf or mixed broadleaf and coniferous forest:</u>
- Broadleaf deciduous forest = trees lose their leaves for a portion of the year.
- Exists in environments where seasonally cold conditions limit plant growth.
- During summer growing season = longs days + high solar angle promote rapid growth so that in a year plants may attain 60-75% of the growth of plants in the tropics, even though the growing season = 5-7 months.
- Plants have = evolved wide, flat leaves that capture as much sunlight as possible.
- Broadleaf deciduous forests are less diverse than tropical rain forests.

6. <u>Coniferous forest:</u>
- Coniferous/boreal forest.
- During cold winters, low humidity and frozen ground cause moisture stress, but needleleaved trees survive because the leaves have low surface area in relation to their volume, and they're covered with a waxy coating to reduce water loss.
- Extensive boreal forests = restricted to Northern Hemisphere, since there's little

land in the Southern Hemisphere in latitudes 50°-70°.
- Temperate coniferous forests are found in areas of marine west coast climate, where moderate temperatures and ample rainfall allow year-round plant growth.
- Coniferous forest = much less diverse than the tropical rain forest.

7. Mid-latitude prairie and steppe grassland:
- Grasslands dominate semiarid midlatitude areas with hot summers, cold winters and moderate rainfall.
- Grasses = well suited to this climate because grow rapidly in the short season when temperature + moisture are favourable (generally spring and early summer).
- During dry or cold periods = above-ground parts of these plants die back, but the roots become dormant + survive.
- Allows grasses to survive fire + grow back rapidly, using available moisture at the expense of trees or shrubs that might invade.
- Many grasslands = used for agriculture = produce
    - wheat
    - corn
    - soybeans
    - other small grains.

8. Tundra:
- Vegetation = dominated by low, tender-stemmed plants and low, woody shrubs.
- These survive the cold by lying dormant below the wind, often buried in snow, growing only in short, cool summers.
- Vegetation = grows very slowly but also decays very slowly, leading to accumulation of organic-rich material.

*As you review the information related to biomes you should note the correlation between the distribution of biomes and the various other maps of physical characteristics that have been mentioned so far in this learning unit (temperature, atmospheric circulation, soil, etc.). As a geographer you should be able to identify these correlations and explain the interrelationships that are evident. Let's consider a simple explanation of South Africa's climate, which is generally divided into two main biomes, namely desert shrub as the first major biome and tropical savannah, mixed grassland and woodland as the second major biome. In comparison to the rest of the world, South Africa has mild summer and winter temperatures because it is located in the Southern hemisphere close to the Tropic of Capricorn (do you remember the latitudes and longitude of South Africa from the previous learning unit?) and seasonal temperature ranges are moderate. A distinct low pressure system occurs from time to time over the country during summer, but not during winter. The east and west coast of South Africa is influenced by a warm ocean current and a cold ocean current respectively, providing one of the reasons why the western side of the country is drier than the eastern side. The relief of the country (causing orographic uplift) also help to explain the difference in precipitation and the associated climate regions and biomes in the country.

Guidance for preparing for MCQ's:

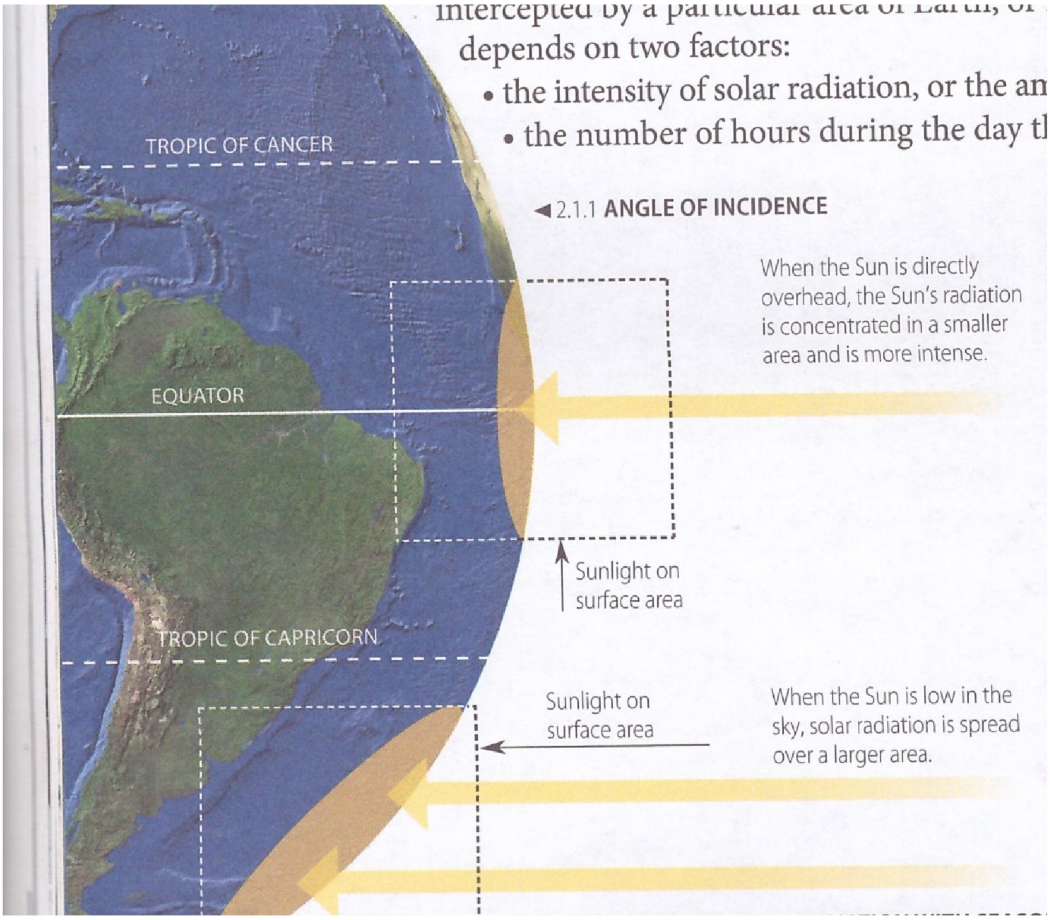
## Earth-sun geometry:

- The intensity of solar radiation depends mainly on the angle at which the Sun's rays hit the surface at a particular place.
- Day length = affected by latitude + season of the year.

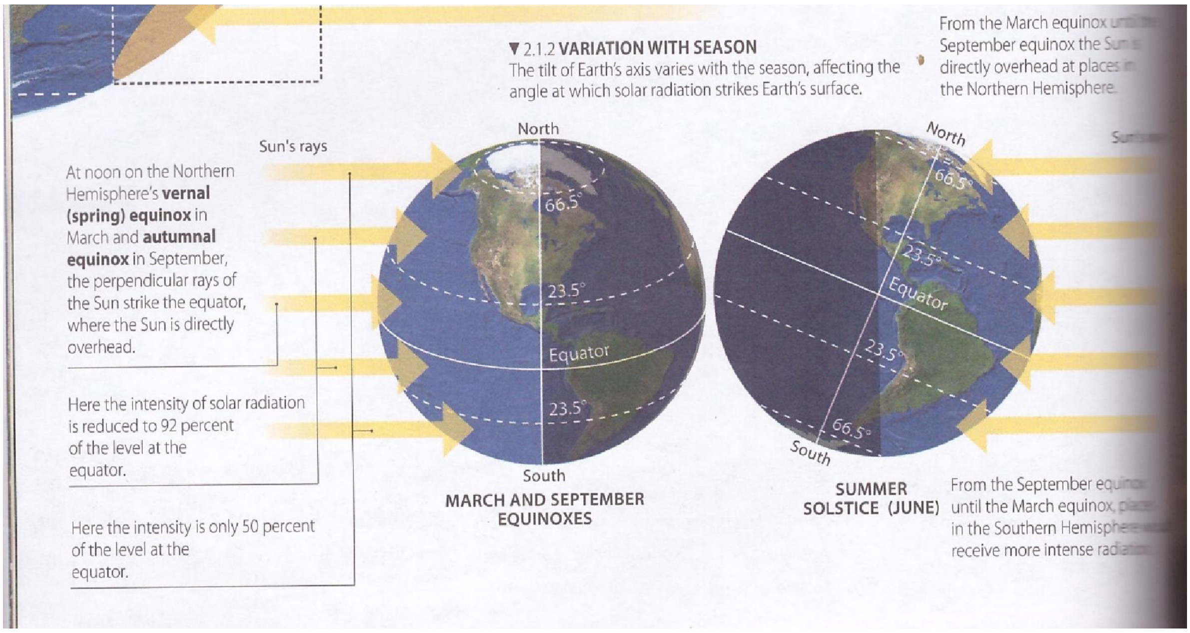
- Energy travels through space as radiation.
- The amount of radiation or solar energy intercepted by a particular area of Earth, or insolation (incoming solar radiation), depends on 2 factors:
  1. The intensity of solar radiation, or the amount arriving per unit of time.
  2. The number of hours during the day that the solar radiation is striking.

Intensity:
- Daily + seasonal differences in intensity = caused by variations in the angle of incidence – angle which solar radiation strikes a particular place at any moment in time.
- Angle = varies from place to place, which time of the day + the seasons.
- Throughout the year the area of Earth's surface where the Sun is overhead at midday shifts due to the Earth's tilt + continual revolution around the Sun.
- The intensity of solar radiation at a given place + time depends on its latitude + season of the year.

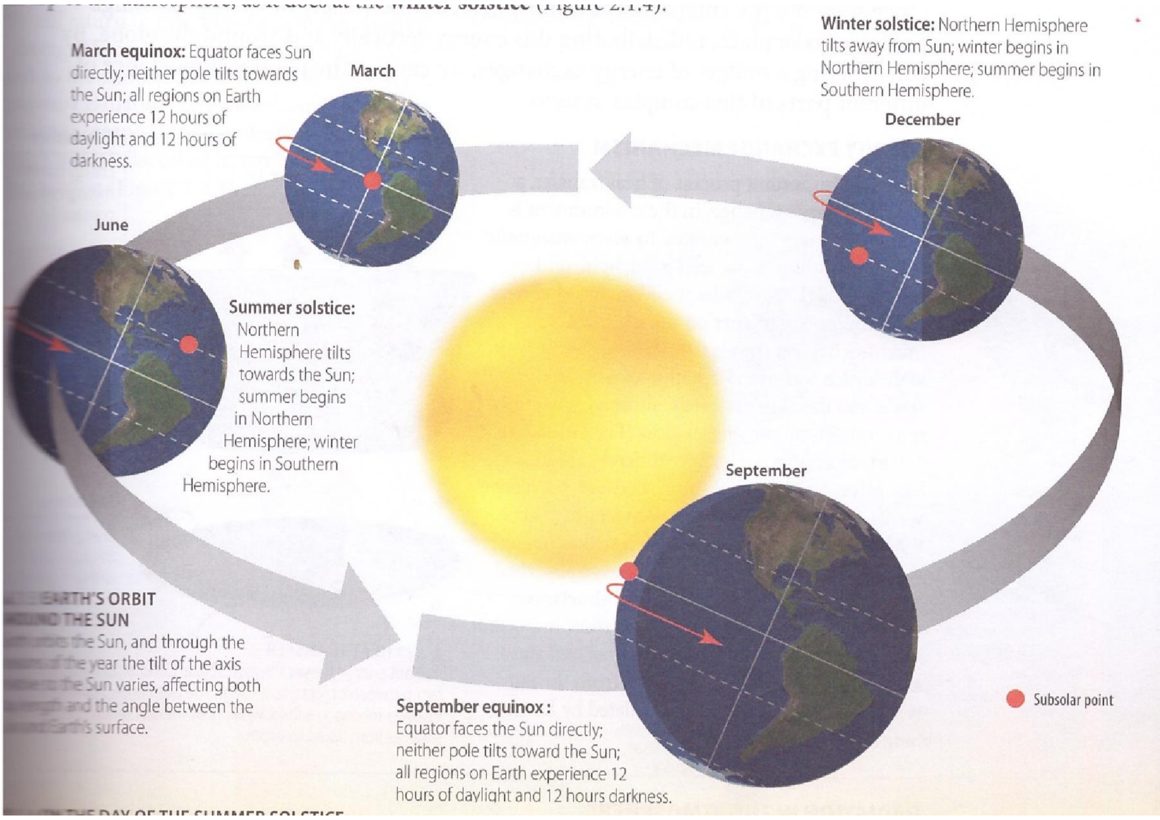
Angle of incidence:




<u>Variation with season:</u>




<u>Orbit around the Sun:</u>



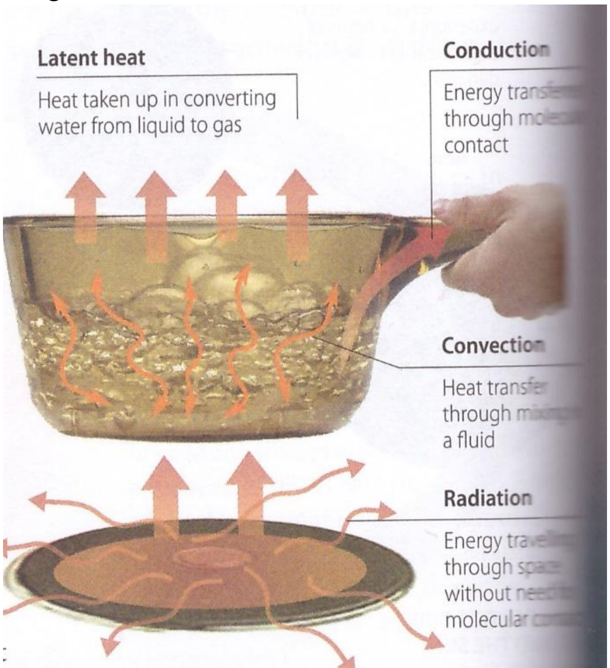

<u>Day length:</u>
- Variations in the length of day from place to place result from the 23.5° tilt of Earth's axis away from a perpendicular relation to the Sun.
- Places on the equator always receive 12 hours of sunlight + 12 hours of night.
- But in higher latitudes, the amount of daylight varies considerably with the seasons.
- Example – in a 24-hour day at a summer solstice, a Northern Hemisphere city like Winnipeg, Manitoba, Canada receives nearly 6 times as much solar radiation, measured at the top of the atmosphere, as it does in the winter solstice.

## **Energy exchange mechanisms:**

- Energy exchange = occur by radiation, conduction, convection + latent heat.
- Radiant energy = sent to Earth as shortwave radiation + returned to space as longwave radiation.

- Once solar energy enters Earth's atmosphere, a wide variety of energy exchange processes take place, redistributing this energy vertically + around the globe.
- By constructing a budget of energy exchange, we can see the relative importance of different parts of this complex system.

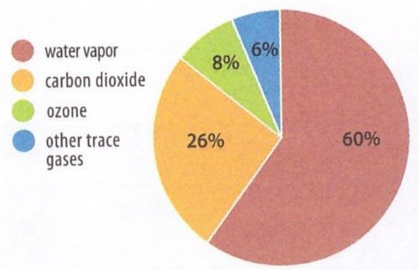
- Most important process of heat transfer in environment = radiation – type of energy exchange.
- Energy transmitted by electromagnetic waves, including radio, TV, light + heat = radiation or radiation energy.
- Feel heat radiation from a burner on a stove without touching it.
- Heat travels from burner → your skin.
- Radiation can travel through space + through materials, although materials may restrict radiant energy flow.
- Radiant energy waves = different lengths.
- Wavelength = distance between successive waves, like waves on a pond.
- Wavelength = affects the behaviour of the energy when it strikes matter; some waves are reflected, and some are absorbed.
- 2 ranges of wavelengths = shortwave + longwave energy = important for understanding how solar energy affects the atmosphere.
- Most energy arriving from the Sun = shortwave, while all energy radiated by Earth = longwave.




▲ 2.2.1 **HEAT TRANSFER**
Radiant energy passes through space. Conduction requires con-tact between objects, as through the pot handle. **Convection** involves mixing in a fluid, while heat transfer requires a change of state, as from liquid to vapor.

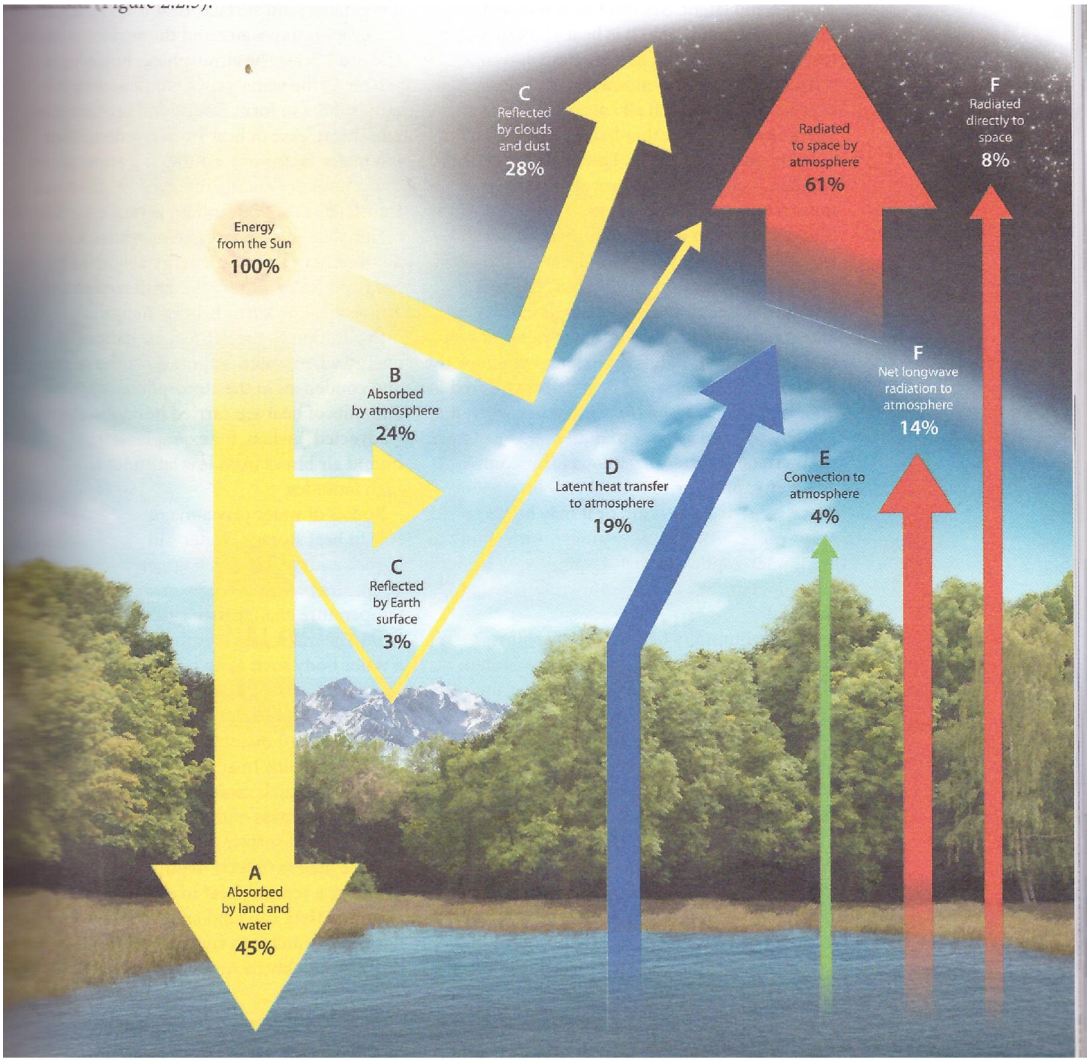
<u>Radiation in the atmosphere:</u>
- As energy form the sun passes through the atmosphere, some wavelengths are absorbed, warming the atmosphere, while others pass through or are reflected, either to be absorbed elsewhere or to travel back into space.
- Clouds = play major role in reflecting energy back to space and in this way atmospheric moisture + weather processes can significantly affect the energy budget, an accounting of the major energy exchanges in the Earth-atmosphere-Sun

system.
- When heat = absorbed by an object, its temperature rises, and heat = stored in the object.
- When stored heat = released = object cools.
- Ability of an object to store heat depends on what it is made of.
- Some materials can absorb or release a large amount of heat with only small changes in temperatures, while others heat + cool quickly with only small inputs + releases of energy.
- Of all the gases in the atmosphere, only a few allow much of the incoming shortwave solar energy to pass through but still absorb most outgoing longwave radiation.
- Gases with these properties = greenhouse gases and they are critical to heat exchange in the atmosphere.
- Among the most important ones are:
    - water vapor
    - carbon dioxide ($CO_2$)
    - ozone ($O_3$)
    - methane ($CH_4$)
- Although these gases together constitute a small fraction of the atmosphere, they're the most important in atmospheric heating.
- Water vapor = contributes the most in atmospheric heating.
- Human activities = increasing the amount of some greenhouse gases in the atmosphere + this is believed to be the chief cause of global warming.
- Energy absorbed at ground level = transferred back to the atmosphere + then to space via longwave radiation, convection + latent heat exchange (evaporation or condensation of water).




▲ 2.2.2 **GREENHOUSE GAS EFFECTS ON ATMOSPHERIC HEATING**
Gases in the atmosphere vary in their ability to absorb shortwave and longwave radiation. This diagram shows relative contributiuons of water vapor, carbon dioxide, ozone, and other trace gases to heating of a clear (cloud-free) sky.

<u>Earth's energy budget:</u>



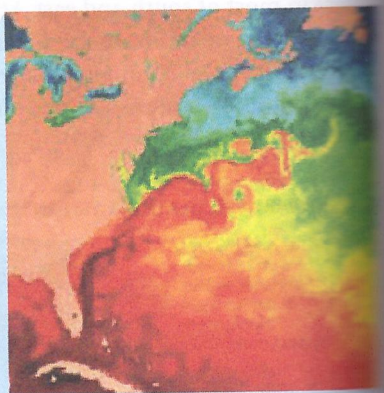

A – about half of the solar radiation that reaches earth is absorbed by the surface; the rest is either
B – absorbed in the atmosphere or
C – reflected back to space. The energy absorbed at the surface is transferred upward, mainly to the atmosphere, by
D – latent heat exchange,
E – convection, and
F – longwave radiation. Energy absorbed by the atmosphere is radiated back to space. The energy exchanges shown here are net exchanges; large amounts of energy are sent back + forth between the earth's surface and the atmosphere by longwave radiation, but the net exchange is upward.

**Oceanic circulation:**

## 2.7

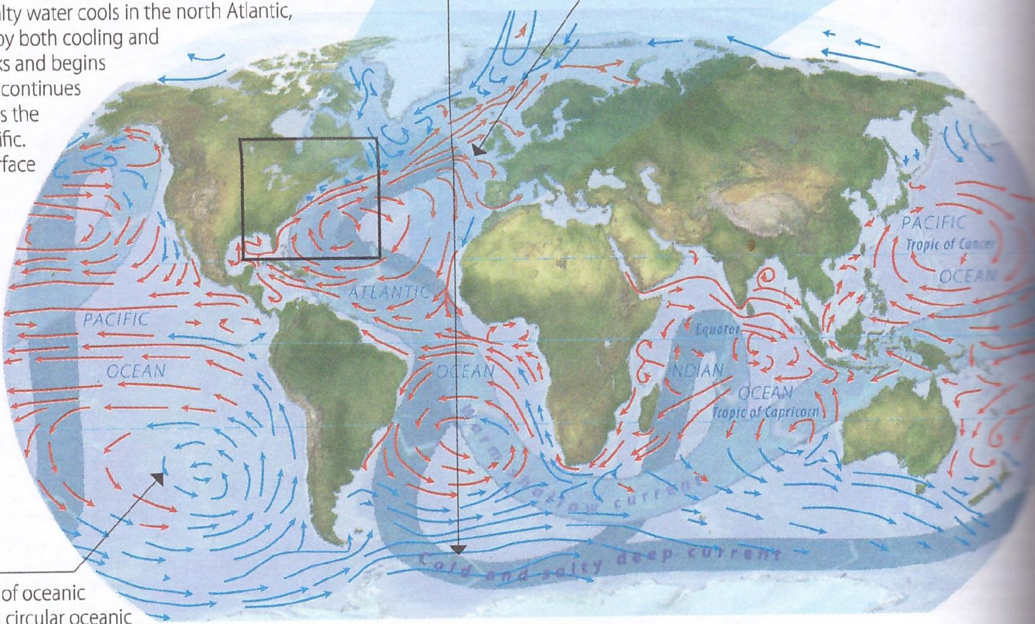
- Wind direction affects ocean surface currents, while water salinity and temperature affect subsurface circulation.
- Ocean circulation patterns vary over periods of years, producing variations in weathe

When wind blows over the ocean, it drags the sea surface, creating waves and currents (Figure 2.7.1). The continuing drag of prevailing winds also causes broad currents in the ocean's surface layers. In addition to wind, differences in seawater temperature and salinity give water different densities, promoting movement of currents from areas of greater density to those of less density. This is similar to the way a high-pressure area in the atmosphere causes wind currents to blow toward a low-pressure area. Both of these factors—wind and temperature/salinity—are important in creating ocean currents that redistribute heat around Earth (Figure 2.7.2).



▲ 2.7.2 **THE GULF STREAM**
This image shows warm water in red and cold water in blue. The Gulf Stream is a strong warm current that flows northeastward across the Atlantic. Giant swirling eddies are prominent.

▼ 2.7.1 **GENERAL OCEANIC CIRCULATION**
In this diagram, surface currents are shown in red, while currents at depth are shown in blue.




**THERMOHALINE CIRCULATION**

In addition to wind-driven surface circulation patterns, water also circulates vertically in the oceans. One of the most important of these circulations is called the thermohaline circulation, because it is driven by variations in both temperature and salinity. Warm water in the Gulf Stream evaporates to the atmosphere, increasing the salinity at the ocean surface. When this salty water cools in the north Atlantic, its density has been increased by both cooling and increased salt content, so it sinks and begins to flow southward. The current continues southward around Africa, across the Indian Ocean, and into the Pacific. There the water rises to the surface and is driven southwest back across the Indian Ocean to the Atlantic, where it eventually becomes the Gulf Stream. Other branches of this current circulate within the Indian Ocean and also merge with the strong westerly current that circles the globe in the high latitudes of the Southern Hemisphere.

**GYRES**

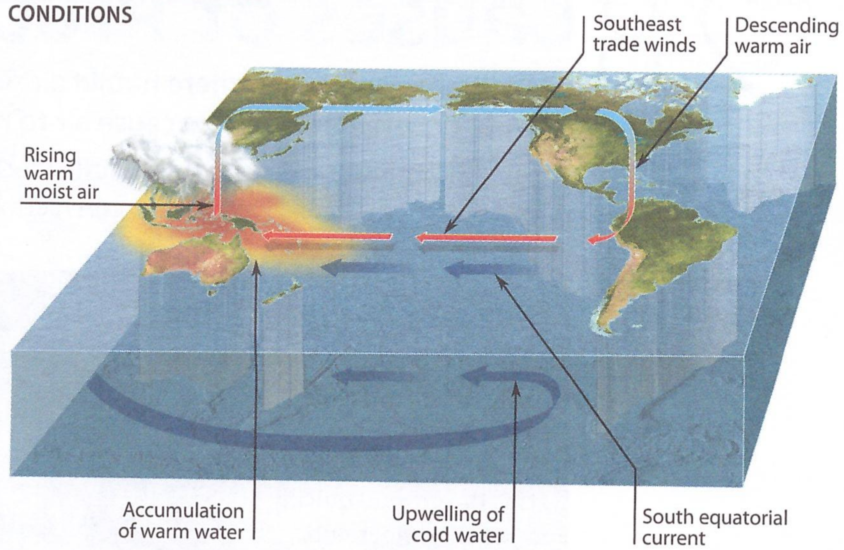
**Gyres** are prominent features of oceanic circulation. These wind-driven circular oceanic flows mirror the movement of prevailing winds. Gyres form beneath tropical high-pressure cells. The Gulf Stream forms the western limb of the gyre in the North Atlantic. Where ocean currents circulate warm water from low equatorial latitudes to higher latitudes, they are carrying heat poleward by advection. Such flows are balanced by cool currents traveling equatorward, most notably along the west coasts of midlatitude and subtropical land areas. These cold currents cool the lower portions of the atmosphere above them, causing air to sink. Without rising air, adjacent landmasses may be very dry. Some of the driest areas on Earth, most notably the Atacama Desert of Peru and Chile, owe their aridity partly to this effect. The same occurs along the coast of southern California and northwest Mexico, as well as along the Namib desert of southern Africa and much of Australia.

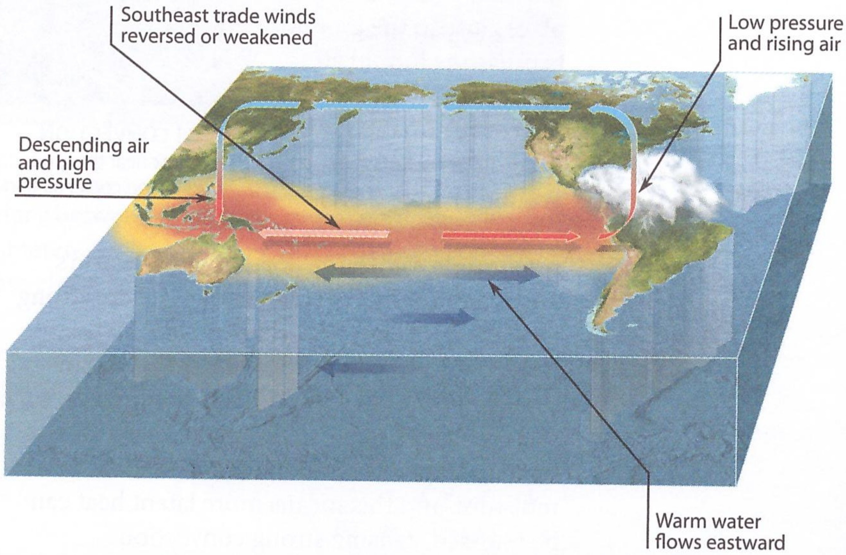
## El Niño-Southern Oscillation (ENSO):

- The close linkage between oceanic + atmospheric circulation is demonstrated by a

phenomenon called El Niño.
- Term = Spanish for “the male child”, a reference to the Christ child, because the phenomenon occurs around Christmastime.
- El Niño is a circulation change in the eastern tropical Pacific Ocean that occurs every several years.
- In this change, the usual cool flow from South America westward is slowed + sometimes reversed, replaced by a warm-water flow from the central Pacific eastward.
- The counterpart of El Niño, in which especially cool waters are found in the region, is known as La Niña (“the female child”).
- The typical (La Niña) circulation causes deep ocean water to rise to the surface off the coast of Peru, delivering nutrients that support fish populations.
- The reversed flow of water contributed to the collapse of the Peruvian anchovy industry in the 1970’s.
- El Niño events are far reaching because a modification of circulation in one part of the globe may cause circulation in one part of the globe may cause circulation patterns to change elsewhere in North + South America + the Pacific region.
- Example – El Niño events are linked to flooding in the US Southwest, reduced rainfall in India + droughts in Australia.
- La Niña often brings wet weather in south + Southeast Asia + dry conditions in the southern US.
- These large-scale ocean currents have profound effects on weather + climate patterns.
- In many cases, the strength of the currents changes over time, ranging from a few years to millennia.
- Variations in the strength of the thermohaline circulation are believed to be correlated with abrupt climate shifts tens of thousands of years ago.

▼ 2.7.3a **NORMAL CLIMATIC CONDITIONS**




▲ 2.7.3b **THE EL NIÑO CYCLE**
Normal (and also La Niña) conditions in the upper diagram and reversed (El Niño) conditions in the lower diagram.

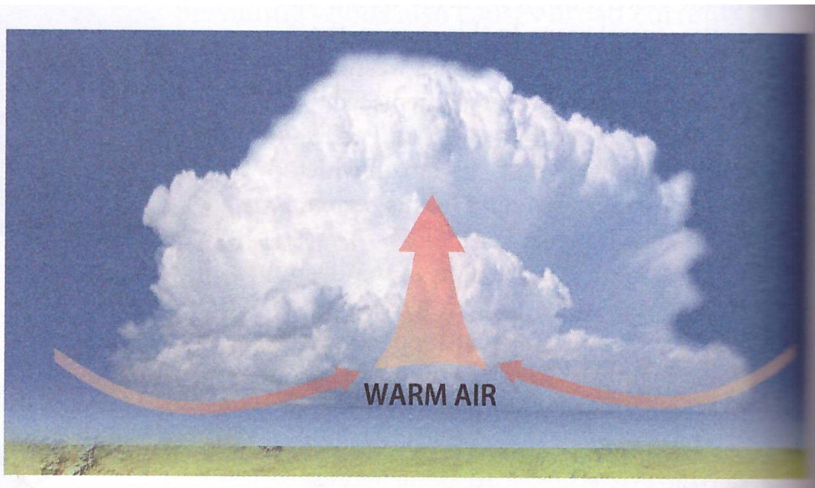
## Causes of precipitation:

- Precipitation = occurs where humid air rises.
- Precipitation occurs when air rises to cause condensation.

4 types of conditions causing air to rise:

1. Convection:

• Warm, humid day = sky is clear in the morning and Sun is bright.
• Sun = warms ground quickly and the air temperature rises.
• Most of the warming of the air takes place close to the ground, because humid air = good absorber of longwave radiation, which is being reradiated from the ground.

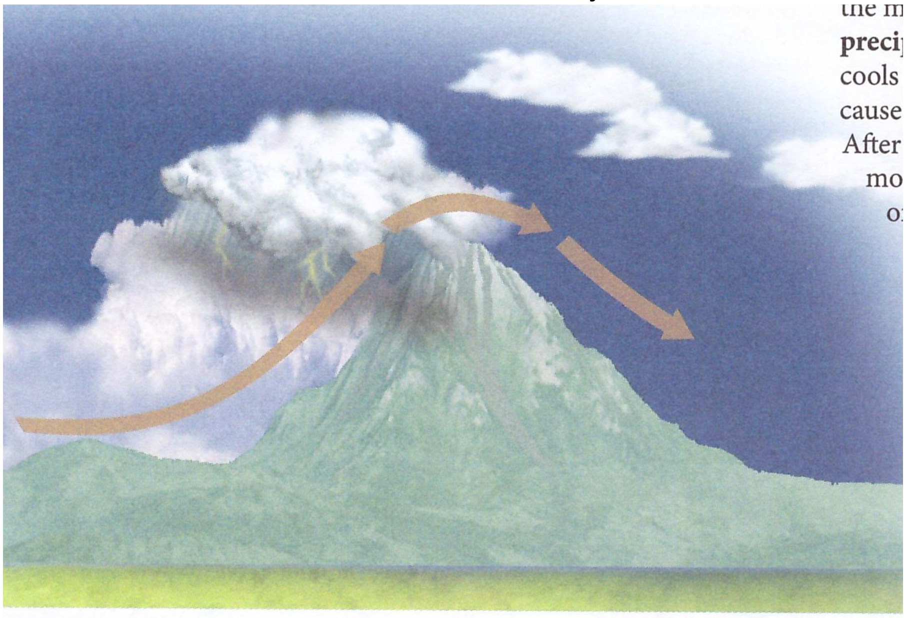



▲2.8.1 **CONVECTION**
As the air near the ground warms, it expands, becomes less dense, and rises through the surrounding cooler air above.

• Convectional storms = responsible for a large portion of world's precipitation.
• In tropical climates, where strong insolation makes temperatures high, all that's needed for intense daily convectional storms = source of humidity.
• Midlatitude climates = such storms = in summer because higher temperatures allow the air to hold more moisture = means more latent heat can be released = causing strong convection.
• Convection works with other mechanisms that cause air to rise and form precipitation.
• Often the mechanisms = the triggers that lead to more intense convection.

<u>2. Orographic uplift:</u>
• Precipitation sometimes occur when horizontal winds move air against mountain ranges, forcing air to rise as it passes over the mountains = called orographic precipitation.
• As air rises, it cools adiabatically (by expansion) = cooling causes condensation = precipitation result.
• After air moved up the windward side of the mountain + over the top = descends on the leeward side.
• As it does so, its relative humidity drops significantly.

• Leeward side = much drier than the rainy windward side.

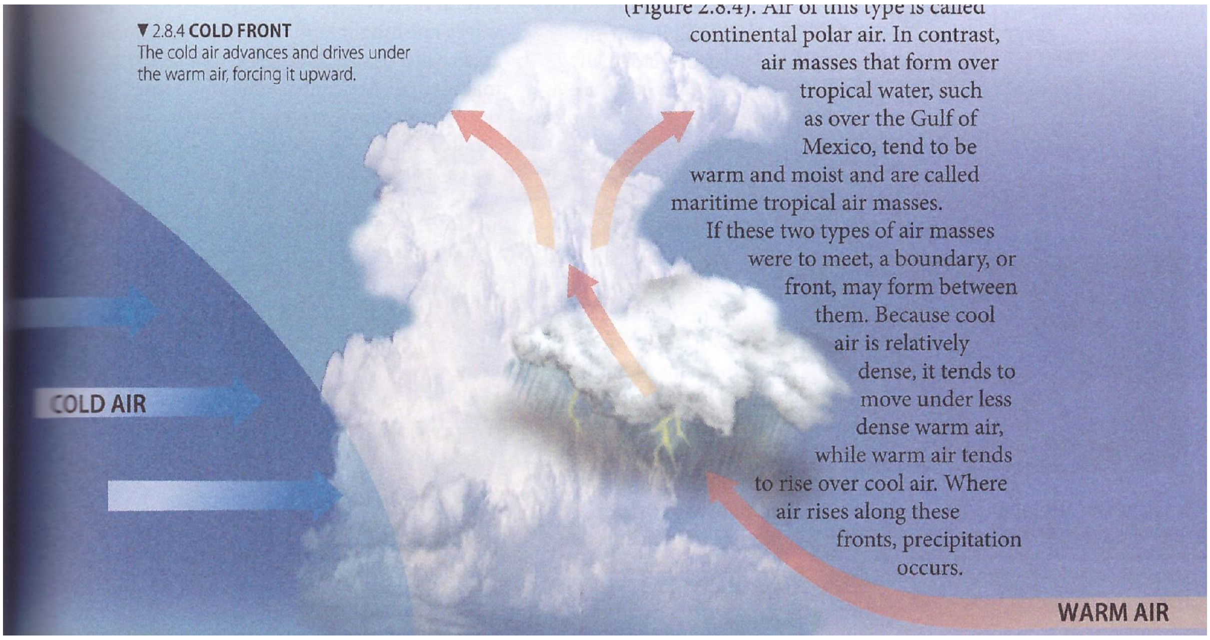


3. Convergence:

• In larger storm systems, large areas of low pressure form, drawing in air that converges from surrounding areas = rising air causes precipitation.
• Regions of low pressure + precipitation = usually move, guided by large-scale circulation patterns.
• See them on satellite images of Earth as large areas of clouds, within which precipitation occurs.

4. Fronts

• Frontal lifting forms along a front – which is the boundary between 2 air masses.
• n air mass – large region of air – hundreds or thousands of square km – with relatively uniform characteristics of temperature and humidity.
• An air mass acquires these characteristics from the land or water over which they form.
• North America = air masses that form over central Canada = cool (because of Canada's high latitude) and dry (because of region's isolation from oceanic moisture sources).
• Air of this type = continental polar air.
• Air masses that form over tropical water (Gulf of Mexico) = warm + moist = maritime tropical air masses.
• If these 2 air masses were to meet, a boundary/front may form between them.
• Cool air = relatively dense = tends to move under less dense warm air, where warm air tends to rise over cool air.
• Where air rises along these fronts, precipitation occurs.

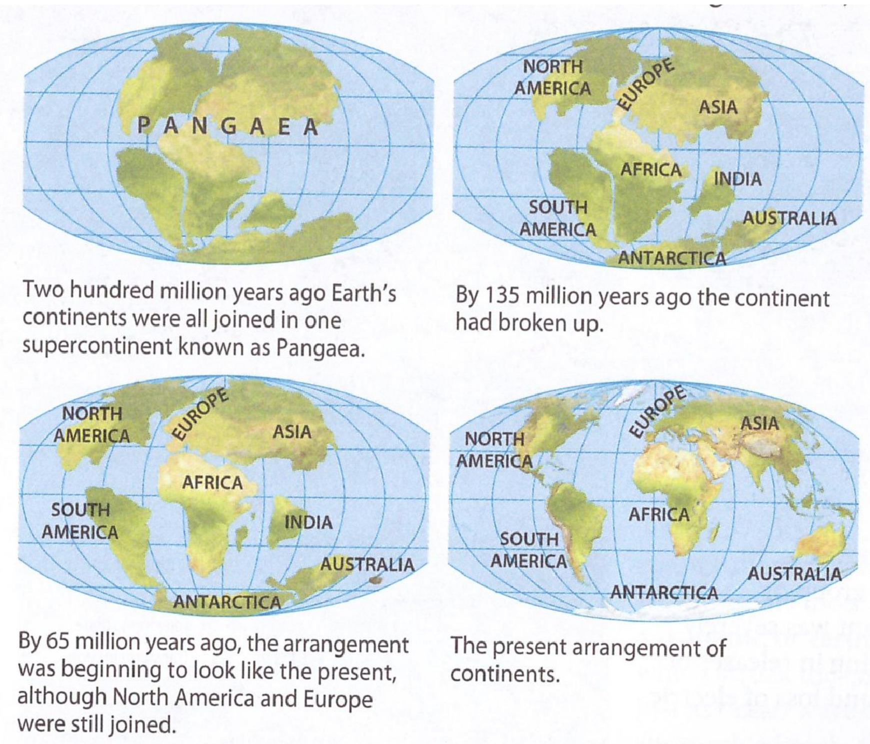



## Tectonic plate framework:

- Earth’s crust is composed of tectonic plates that move relative to each other.
- Relative motion between plates creates large-scale landforms at plate boundaries.

• Earth resembles an egg with a cracked shell.
• Earth’s crust = thin + rigid, averaging 45km in thickness.
• Rock beneath the crust, known as the mantle = fluid enough to move slowly along in convection currents, driven by heat within Earth’s core.
• These currents are analogous to winds in the atmosphere, which carry heat away from Earth’s surface.
• This motion of the mantle causes the tectonic plates that make up Earth’s rigid crust to move.

Changes caused by plate movements:




Two hundred million years ago Earth's continents were all joined in one supercontinent known as Pangaea.

By 135 million years ago the continent had broken up.

By 65 million years ago, the arrangement was beginning to look like the present, although North America and Europe were still joined.

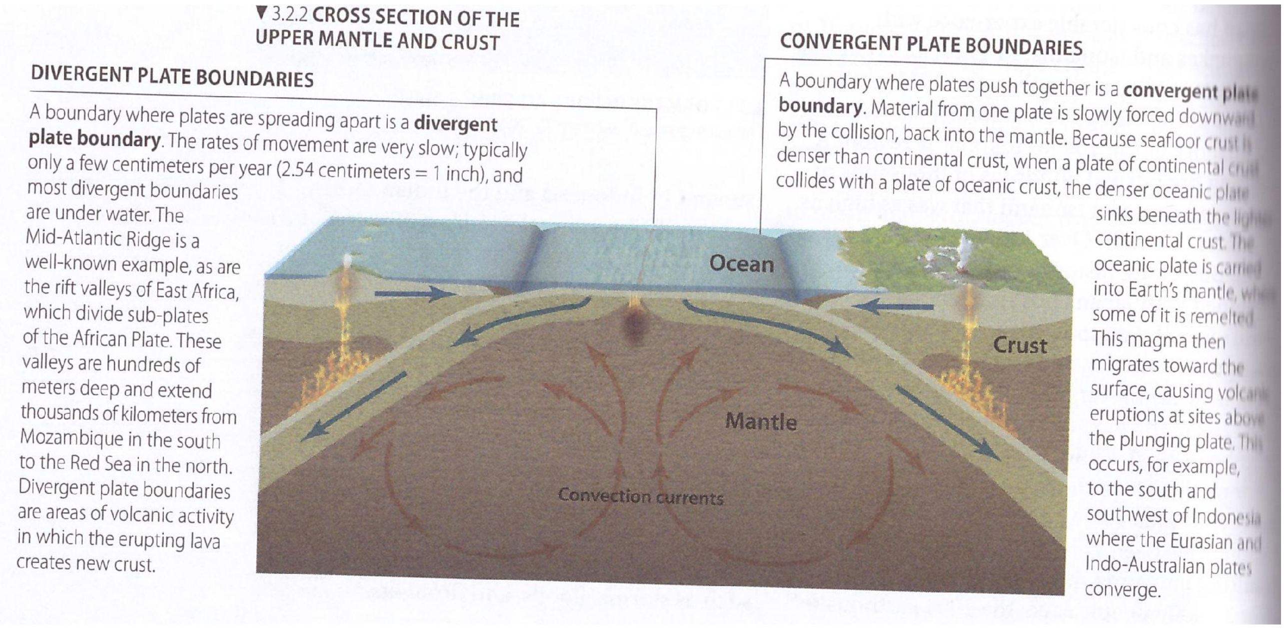
The present arrangement of continents.

- 3 types of boundaries form between moving plates of Earth's crust depending on whether the plates are spreading apart, pushing into each other, or grinding past each other.
- Movement of the plates causes earthquakes to rumble, volcanoes to erupt, and mountains to form.
- Over periods of hundreds of millions of years, the geography of Earth is throughout changed by these movements.

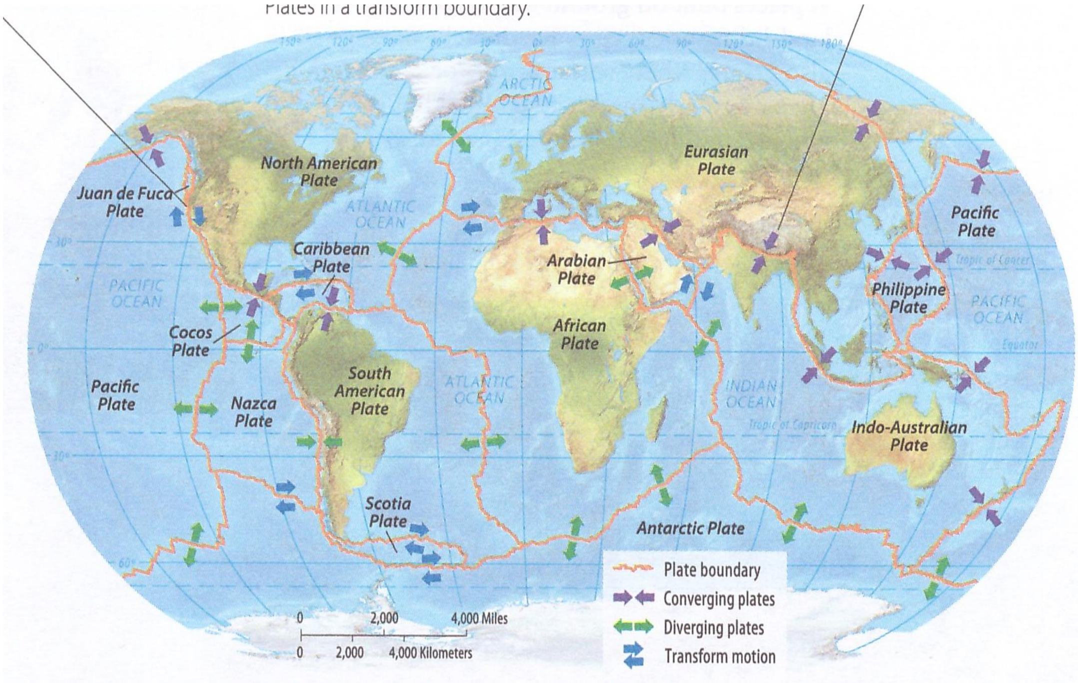
**<u>The difference between divergent, convergent and transform plate boundaries:</u>**

| **<u>Divergent plate boundaries:</u>** | **<u>Convergent plate boundaries:</u>** | **<u>Transform plate boundaries:</u>** |
|---|---|---|
| Plates = spreading apart | Plates = push together | Plates = neither converge or diverge, but grind past each other. |
| Rates of movement = very slow = few cm a year | Material from one plate = slowly forced downward by the collision, back into the mantle. | California's San Andreas Fault = moving northwest relative to the North American plate. |
| Most = under water | Because seafloor crust is denser than continental crust, when a plate of continental crust collides with a plate of oceanic crust, the denser the oceanic plate sinks beneath the lighter continental crust. | The boundary between these plates is not a smooth one, + ridges + mountains are built as the 2 plates grind against one another. |

| | | |
|---|---|---|
| Example – Mid-Atlantic Ridge, the rift valleys of East Africa, which divide sub-plates of the African Plate. These valleys = hundreds of meters deep + extend from Mozambique in the south to the Red Sea in the north. | The oceanic plate is carried into Earth's mantle, where some of it's remelted. | The plates bind for long periods and then abruptly slip, causing the earthquakes that frequently strike California. |
| Divergent plate boundaries = areas of volcanic activity in which the erupting lave creates new crust. | The magma = migrates toward the surface, causing volcanic eruptions at sites above the plunging plate. | |
| | Example – occurs to the south + southwest of Indonesia where the Eurasian + Indo-Australian plates converge. | |




## The relative locations of plate boundaries:




**Vertical movements of Earth's crust:**

- Parts of the crust move vertically as well as horizontally.
- As 2 plates collide, material may be forced downward into Earth's interior or upward to form mountains.
- Over millions of years, vertical movements along plate boundaries produce mountain ranges thousands of meters high.
- Vertical movement of crust also occurs because the crust "floats" on the underlying mantle, much like a boat floats in water.
- If material is added to the crust, it sinks, and if the material is removed, it rises.
- Deposition of sediment or accumulation of ice in glaciers can cause the crust to sink.
- These vertical movements caused by loading + unloading the crust = called isostatic adjustments.

**Geological hazards (Volcanoes and Earthquakes):**

- Volcanic eruptions + earthquakes occur mainly along plate boundaries.
- Volcanic eruptions + earthquakes are relatively infrequent but can be catastrophic.

**Deadly hazards:**

- Earthquakes + volcanoes present major geologic hazards to populations in geologically active areas, particularly near plate boundaries.
- These hazards result from the great power of phenomena, but also because people have chosen to live in places where they occur.
- If earthquakes + volcanic eruptions were frequent then people would have adapted to them, most likely by living elsewhere.

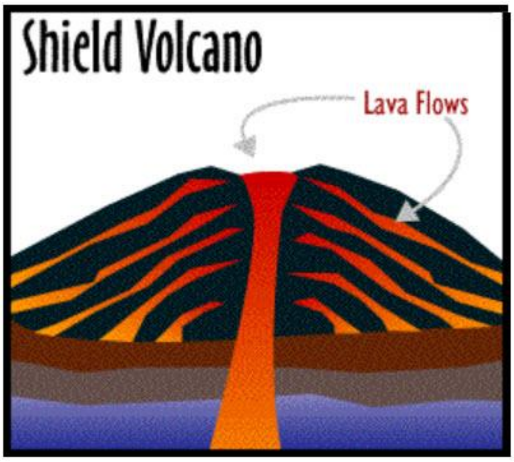
- However major events are infrequent + societies are thus less mindful of the hazards.
- Although the magnitude of an earthquake relates to the energy released, it tells us little about the damage it causes.
- Generally, damage is greater at places closer to the epicentre + at places built on ground that is subject to landsliding or collapse.
- Earthquake damage is also greater where surface rocks or sediments are particularly susceptible to shaking, or where buildings are not designed to absorb the energy.

**<u>Volcanoes:</u>**

• Volcanoes are clustered along boundaries between tectonic plates.
• Heat within Earth generates magma.
• If this magma reaches the surface and erupts, a volcano is formed.
• Magma may flow over the surface as lava = forming a plain of volcanic rock or a mountain.
• The chemistry of the magma/lava determines its texture + the type of landform.

<u>Types:</u>

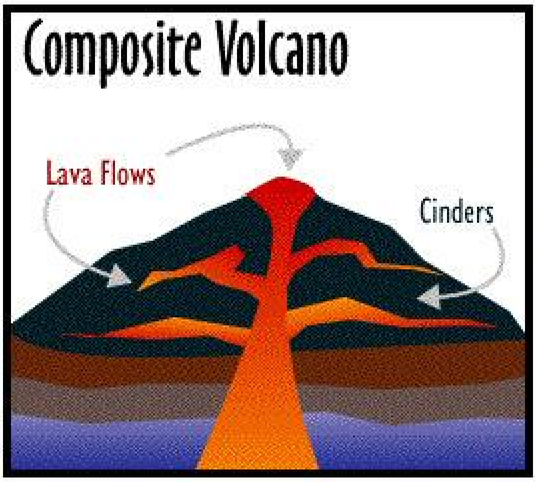
<u>1. Shield volcanoes:</u>
• Erupt runny lava that cools to form a rock called basalt.
• They're called shield volcanoes because of their shape.
• Each on Hawaiian Islands = shield, only one active = Mauna Loa on the island of Hawaii.
• The mid-ocean ridges = formed of similar basaltic lava.




https://www.bing.com/images/search?q=Shield+Volcano+Cross+Section&view=detailv2&id=EDA8595B3A55831AE8C1295648EF64AD2A369EDF&ccid=kAJALKye&simid=608000025273173338&thid=OIP.M9002402cac9eeb239c895d37fa6009d3H0&mode=overlay&first=1

<u>2. Composite cone volcanoes:</u>
• Explosive volcanoes that cause death + destruction = composite cone volcano.
• Made of a mixture of lava + ash.
• Magma = thick + gassy + may erupt explosively through a vent.

• Eruption = sends ash + clouds of sulphurous gas into the atmosphere.
• May also pour lethal gas clouds + dangerous mudflows down the volcano's slopes.
• Repeated eruptions = build a cone-shaped mountain, made up of a mixture of lava and ash layers.
• A lot = dormant (inactive, but with the potential to erupt).
• Some areas = earthquake watch centers provide warnings of volcanic eruptions.
• It's more accurate to predict volcanoes than earthquakes, because volcanoes give many warnings before erupting.

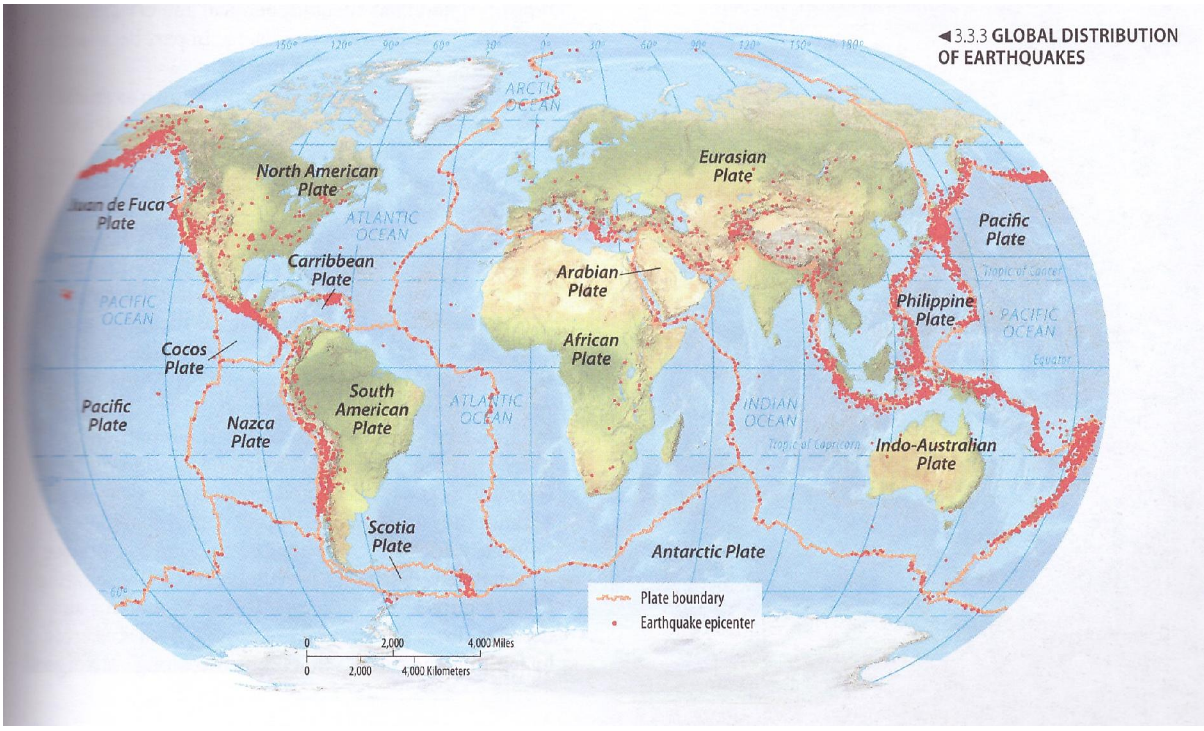



https://www.bing.com/images/search?q=Shield+Volcano+Cross+Section&view=detailv2&id=EDA8595B3A55831AE8C115F297D5E595C18B8B18&selectedindex=22&ccid=rmGKAktg&simid=607987685827479873&thid=OIP.Mae618a024b602ba72dcc30a63651ad93H0&mode=overlay&first=1

**Earthquakes:**

- Thousands of earthquakes – sudden movements of Earth's crust – occur every day.
- They're clustered along plate boundaries.
- The place where Earth's crust actually moves is the focus of the earthquake.
- The focus is generally near the surface but can be as deep as 600km below Earth's surface.
- The point of the surface directly above the focus = the epicentre.
- The energy released at the focus travels worldwide in all directions and at various speeds through different layers of rock.
- Earthquake intensity is measured on a 0-to-9 logarithmic scale (in which an increment of 1 corresponds to a 10-fold increase in energy) called the moment magnitude scale.
- Earthquakes magnitudes:
    - 3-4 = minor
    - 5-6 = break windows + topple weak buildings
    - 7-8 = devastating in populated areas.
- Earthquake in 2011 Japan = magnitude of 9.0

**Global distribution of earthquakes:**




**Slopes and weathering:**

- Rocks decay upon exposure to air + water, breaking them into moveable pieces.
- Rock particles move downslope + through river systems in a series of steps.

- Weathering = process of breaking down rocks into sizes from boulders to pebbles, sand grains, and slit, down to microscopic clay particles + dissolve solids>
- First step in formation of soil.
- Without weathering, the force of gravity + the agents of water, wind + ice would be able to move rocks + shape the land.
- Rocks begin to break down the moment they're exposed to weather at Earth's surface.
- They're attacked by water, oxygen, carbon dioxide, + temperature fluctuations.
- Weathering takes place in 2 ways:

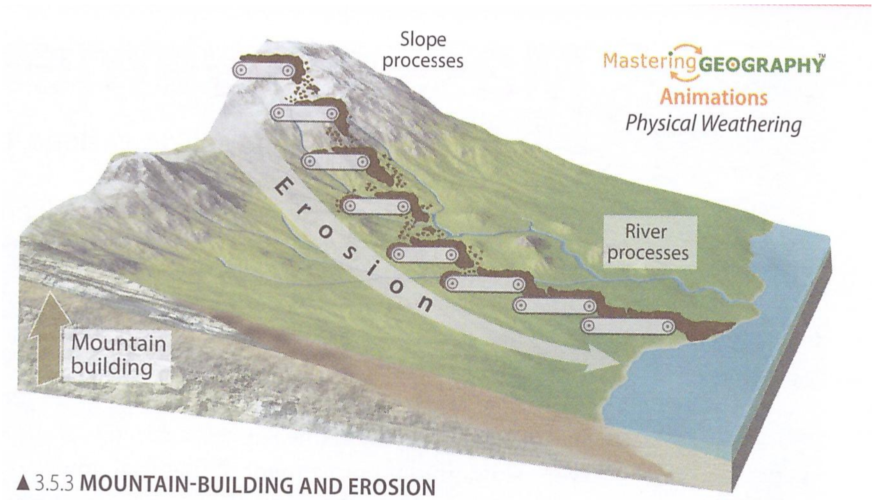
1. Chemical weathering
2. Medical weathering.

| **Chemical weathering:** | **Mechanical weathering:** |
|---|---|
| -A change in the minerals that compose rocks when they're exposed to air + water. | -Rocks get broken down by physical force. |
| -Acids released by decaying vegetation = chemically weathers rocks. | -Rocks expand + contract with frequent changes in temperature = causes them to break apart. |

| | |
|---|---|
| -Some of the dissolved products of chemical weathering = carried away by water seeping through the rocks and soil. | -Water can steep into cracks + freezes into ice crystals when the temperature turns colder. |
| -Water = carry these chemical materials to rivers, then the sea. | -The water, which expands = widens cracks in rocks. |
| -This is a source of salinity (dissolved salt) of the oceans. | -Plant roots growing in cracks between rocks also contribute towards mechanical weathering. |
| -Example = oxidation = Iron = element in rocks + combines with oxygen in air to form iron oxide/rust. Iron oxide = different properties from the original iron – physically weaker + more easily eroded. Can see on iron/steel = the rusty oxide easily flakes away. | |

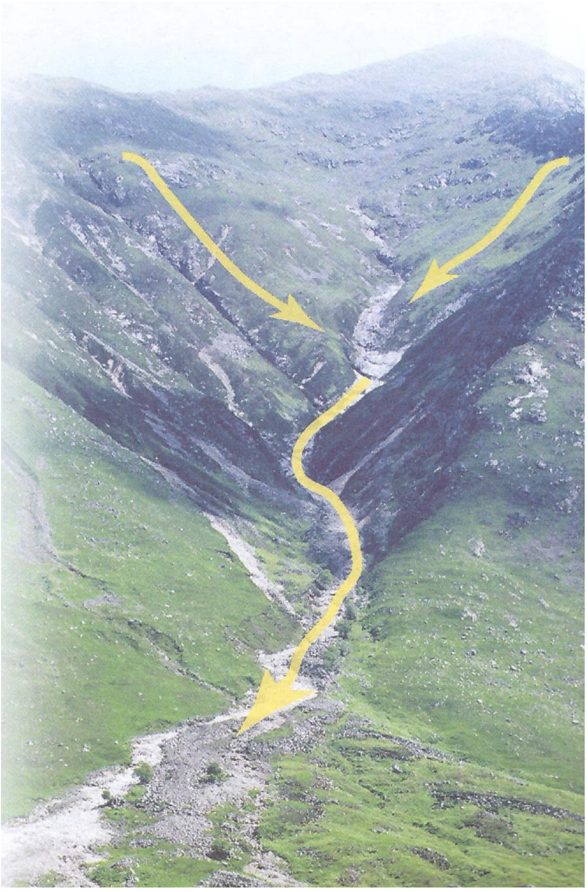
**<u>Moving Weathered material:</u>**

- Once rocks are weathered, they may be carried from one place to another. (Fig 3.5.3)
- Material most commonly moves downhill by gravity.
- Happens in 2 ways:
  1. Mass movement
  2. Surface erosion
- Mass movement = rocks roll, slide or freefall downhill under the steady pull of gravity.
- Surface erosion = water, which flows downhill because of gravity, carries solid rock particles with it (Fig 3.5.4)
- Surface erosion = may also result when wind or ice carries material from one place to another.
- Material moves faster down steeper hills than down gentler ones.
- The steepness of a hill = measured through its slope, which is the difference in the elevation between 2 points (known as a rise) divided by the horizontal distance between 2 points (known as the run).
- The greater the rise + shorter the run between 2 points, the faster the materials move down the hill.
- Wherever slopes occur, gravity is available to move material.
- Even the gentlest slope provides the potential energy necessary to move at least some material downward, either through mass movement or surface erosion.
- Erosion = usually more rapid, however on steep slopes of land than on gentle slopes.




▲ 3.5.3 **MOUNTAIN-BUILDING AND EROSION**
Mountain-building processes lift rocks up, exposing them to weathering. Weathered material is carried in multiple steps, represented by the conveyor belts, downslope to streams, and then along valleys to the sea. Along the way, this weathered material is temporarily stored as soils and river deposits. Storage can be for short time periods, but more likely for hundreds or thousands of years, so the journey of a single grain of sand from source to sea can take a very long time.

**3.5.4 A stream in Glen Etive, Highlands, Scotland:**
Slope processes move sediment downhill, and the stream carries it down the valley.



## Surface erosion:

- Soil surface erosion occurs when heavy rains cause excess water to flow across

the surface, or when high winds blow on bare ground.
- Water + wind erosion are accelerated when soil surface is exposed.

- Most common form of soil erosion = caused by rainfall.
- Intense rain sometimes falls faster than soil can absorb.
- Water that cannot soak into the ground must run off the surface as overland flow.
- As it runs off the surface, water picks up soil particles + carries them down the slope.
- With enough of this overland flow, water can carve channels.

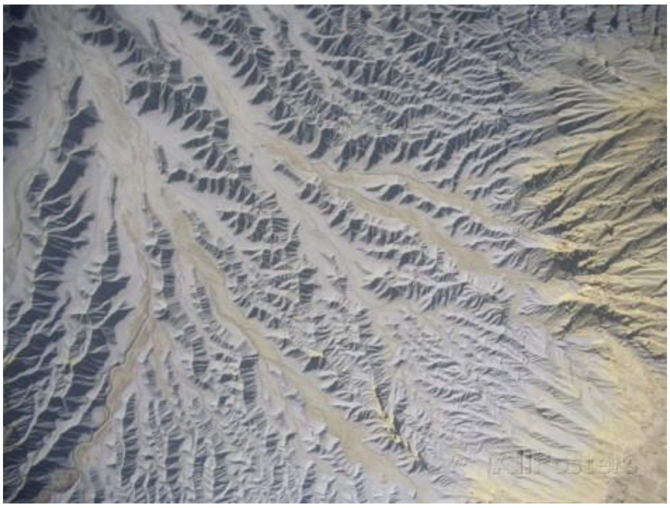
**<u>Rills:</u>**

• Smallest channels eroded by the flow of water = rills.
• Only a few cm deep
• Are small enough that soil creep or a farmers plow can obliterate them.

**<u>Gullies:</u>**

• If channels gather enough water, they become larger + permanent carriers of water.
• As these stream channels deepen, they gather water + eroded soil from adjacent slopes.
• When the streams gather enough water they form gullies or ultimately permanent valleys.

**Surface erosion:**



• Soil surface erosion = result from raindrop impacts on bare soil combined with water flowing across the soil.
• Both are favoured by intense rain falling on bare soil.

**Accelerated erosion:**

• Surface erosion by water is relatively slow in most natural environments because the ground is covered by grass + trees.
• But on large parts of Earth's surface, humans have removed vegetation by clearing forests + plowing fields.
• Once the vegetation ground cover is removed, slow surface erosion can increase, to become accelerated erosion.
• Ground where vegetation has been removed can suffer more surface erosion in a few months than it experienced during the previous several thousand years.
• The eroded soil contributes to water pollution downstream, and the remaining soil may be less productive for agriculture.
• People clear natural vegetation because they want to use trees for fuel, lumber and paper, or they want to use the land for another purpose, especially agriculture + urban development.
• Erosion has increased as a result of the elimination of the vegetation cover for all these reasons, but it's particularly severe where agriculture has replaced forest.
• To meet the needs of a growing population, food production expands in 2 principal ways:
    - by opening up new land for agriculture
    - by using existing farmland more intensively.

• Both strategies can result in erosion of the rich soil necessary for productive agriculture.
• Opening up new land for agriculture was a major contributor to increased erosion in the US during the 18th and 19th centuries.
• Forests were cleared + replaced with plowed fields + pastures in the US.
• Deforestation increased the rate of soil erosion by 10 – 100 times.
• Erosion of agricultural lands is further increasing as farmers use existing fields more intensively.
• In many agricultural areas, soil is being lost faster than it can be replaced by natural soil formation, and so soil fertility is being lost over time.
• Since 1930's abandonment of less-productive lands + adoption of soil conservation technologies have significantly reduced soil erosion on US farms.
• In addition many farmers are finding ways to use fertilizer more efficiently so that less is washed off of fields into streams.
• Stream pollution from agricultural sources remains a major problem, but it has been much reduced.

(800,000 square miles) of forest were replaced with plowed fields and ... the eastern and midwestern United ... deforestation probably increased the ... erosion by 10 to 100 times. Erosion of ... land is further increasing as farmers ... fields more intensively. In many

▼ 3.7.3 **SOIL EROSION IN TWO INDIANA SOYBEAN FIELDS**
(left) A field that had been planted using conventional techniques including plowing the soil. The field experienced heavy erosion when intense early-season rains occurred.
(right) A field adjacent had been planted using soil conservation techniques that leave much of the soil covered in residue from the previous season's corn crop. Soil erosion was dramatically reduced in this field.

## Food chains and webs:

- Food chains = link plant photosynthesis to herbivores + carnivores and ultimately decomposers.
- Complex interactions tie all members of an ecological community to each other.
- An ecosystem = includes all living organisms in an area and the physical environment with which they interact.
- An ecosystem can cover an area as small as a field or a pond.
- On any scale of analysis, large or small, certain fundamental ecosystem elements exist:
  - Nonliving matter + energy = necessary for production + consumption to occur – water, mineral nutrients, gases such as oxygen + carbon dioxide + energy(light +

heat)
- Producers – green plants + other organisms that produce food for themselves + other consumers that eat them."
- Consumers – organisms that eat producers, other consumers, or both.
- Decomposers – small organisms, such as bacteria, fungi, insects and worms that digest and recycle dead organisms."

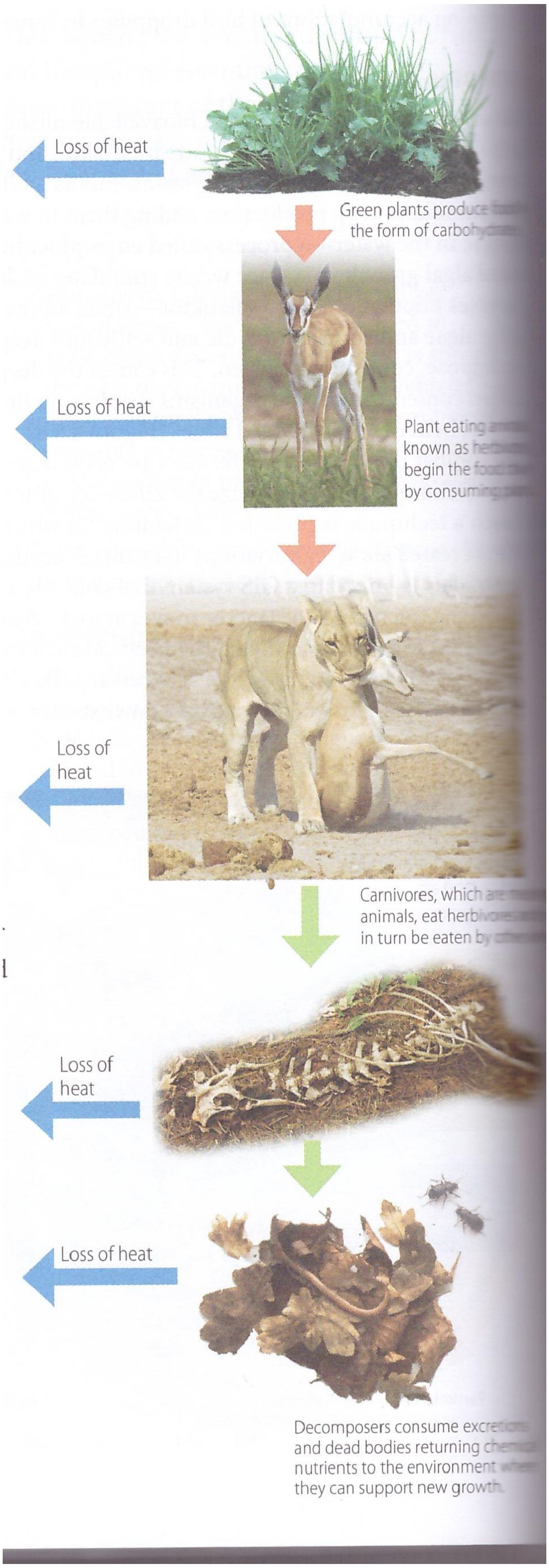
Food chain:

• Green plants produce food in the form of carbohydrates.
• The food is distributed through an ecosystem by way of a food chain.
• Most of the food animals consume = used to keep their bodies functioning and some is stored in their bodies.
• Each step in the food chain = a trophic level.
• Food = passed from one level to a next, but most of the energy is lost.
• About $\frac{1}{10}$ of the energy consumed as food at a given trophic level is converted to new biomass, and the remaining $\frac{9}{10}$ is respired + dissipated as heat, although this proportion varies substantially.
• Because of this loss of energy, the amount of biomass decreases as we go from the first trophic level to higher levels.
• This is why we find large numbers of herbivores, such as mice + rabbits, but relatively few large carnivores like wolves + lions.
• One consequence of food chains is that some chemicals in the environment, especially persistent pesticides such as DDT, can accumulate in animal tissues as they pass up the chain.
• If a substance accumulates in an animal rather than broken down, then at each trophic level the concentration of that pesticide increases through a process called biomagnification.
• This process was a major factor in the decline of some bird populations, including the bald-eagle, in the mid-twentieth century.
• Because of these effects, DDT + similar pesticides have been banned or severely restricted in much of the world, and the pesticides used today break down relatively rapidly to reduce this problem.

Complex relationships:

• Although trophic levels are a one-directional, ladder-like view of energy flow through ecosystems, the reality is more complex.
• We use the term food chain to describe the complex system.
• Individual organisms may feed at multiple trophic levels, and may rely on different food sources at different times.
• For example, black bears are omnivores, but their diet varies through the year and may include shoots of young plants in the spring, roots, insects, some mammals such as young deer and fish.
• The multiplicity of producer-consumer and predator-prey relations in a food web means that there's a high degree of linkage through all parts of an ecosystem.

• A change in the amount of primary production or in the population of a particular specie, may have positive or negative impacts on numerous other species.



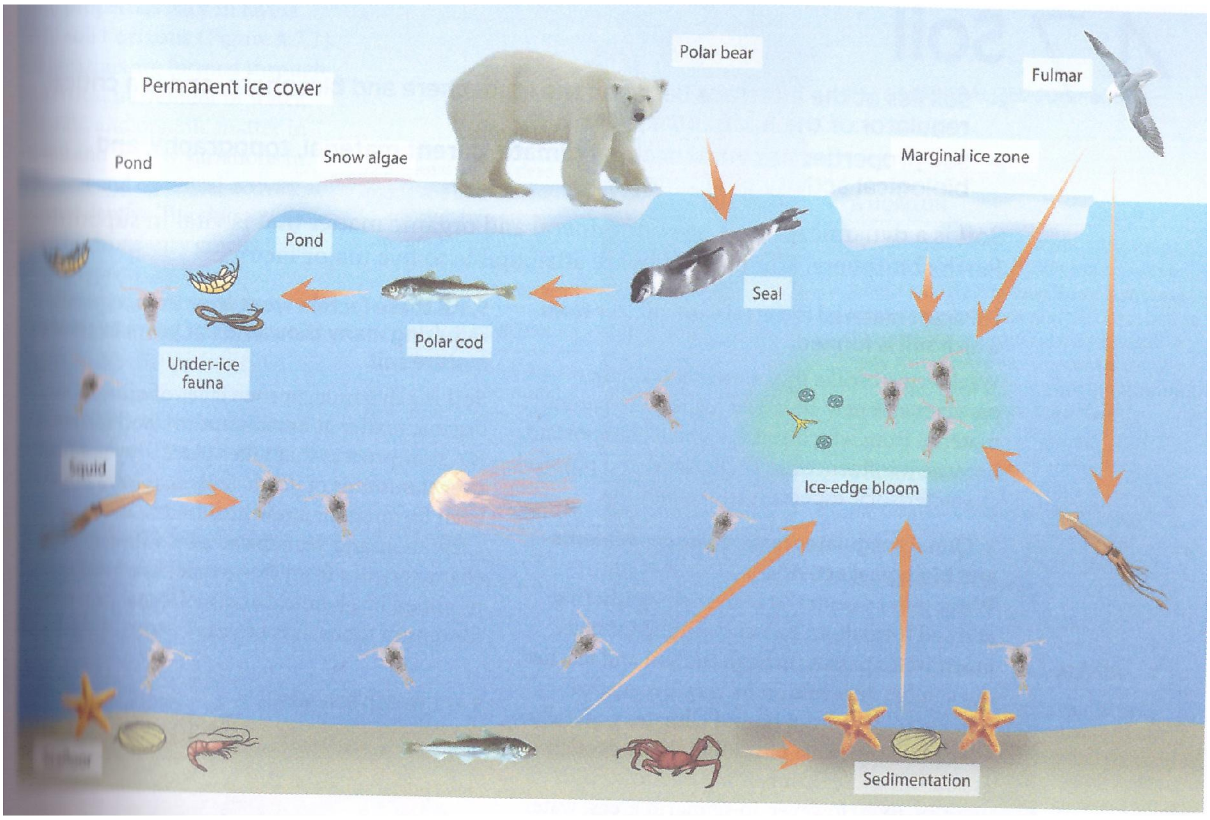

→Green plants produce food in the form of carbohydrates.

→Plant eating animals, known as herbivores, begin the food chain by consuming plants.

→Carnivores, which are meat-eating animals, eat herbivores + may be eaten by other animals.

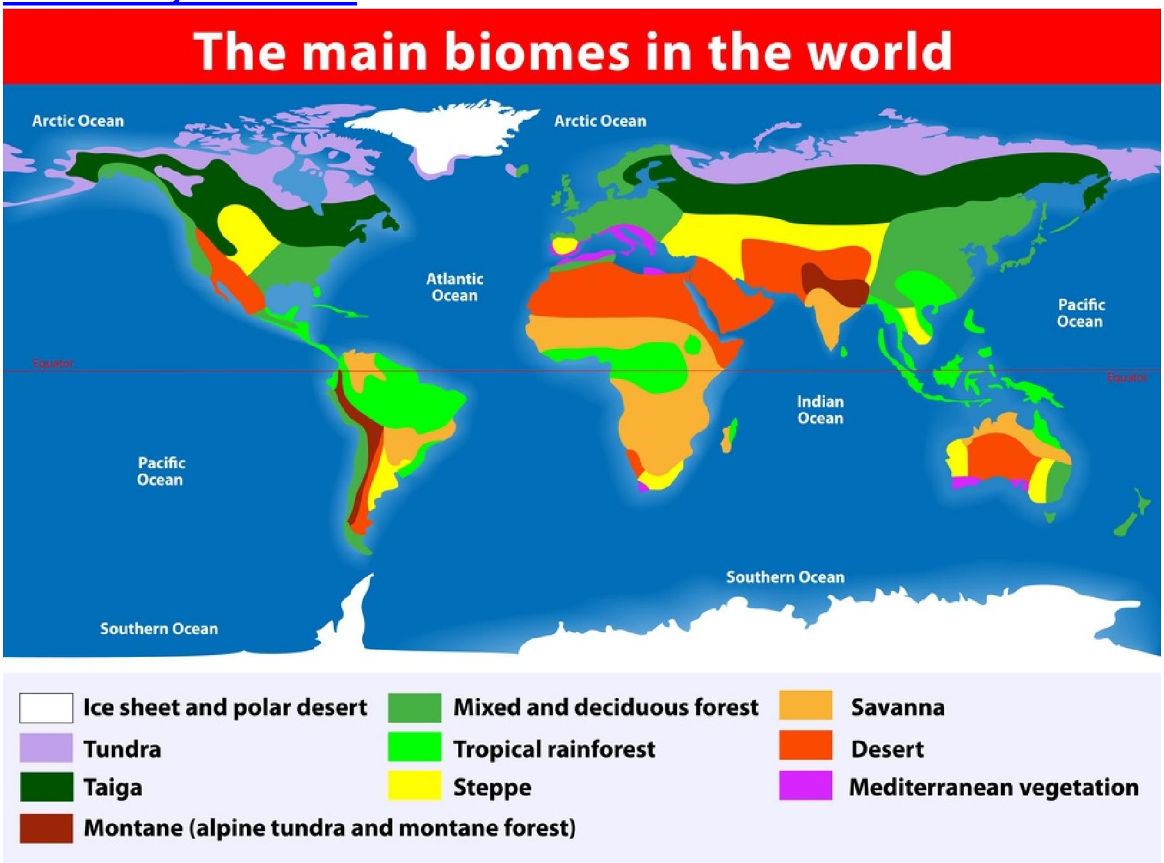
→ Decomposers consume excretions + dead bodies returning chemical nutrients to the environment where they can support new growth.

## **Artic Sea Ice Food Web:**




- Food webs are complex relationships among many species in a community.

## Biodiversity of biomes:



**Identification of landforms on contour maps (Appendix 3.1):**
**SEE APPENDIX 3.1 IN MO002 pg 79-82**

Guidance for questions requiring written answers Note that in the case of Learning Unit 3, we do not distinguish between topics for 6- mark and 4-mark questions, but provide a list of important topics for both these types of questions:

**Consequences of global warming:**

1. More frequent + severe weather:
- Higher temperatures = worsening disasters, including storms, heat waves, floods + droughts.
- A warmer climate creates an atmosphere that can collect, retain + drop more water, changing weather patterns in such a way that wet areas become wetter + dry areas = drier.
- Increasing number of droughts, storms + floods.
- Dry spells = jeopardize access to clean drinking water, fuel out-of-control wildfires, and result in dust storms, extreme heat events + flash flooding.
- Lack of water = leading cause of death.
- Heavier rains = causes streams, rivers, and lakes to overflow, which damages life + property, contaminates drinking water, creates hazardous-material spills, and promotes mold infestation + unhealthy air.
- A warmer, wetter world = a boon for food-borne and waterborne illnesses + disease-carrying insects such as mosquitoes, fleas + ticks.

2. Higher death rates:
- As temperature spike, so does the incidence of illness, emergency room visits + death.
- In places there's more hot days than people are used to, they can't afford air-conditioning + leads to severe health consequences.
- Heat kills a lot of people because of heat-exacerbated, life-threatening illnesses, such as heatstroke, heat exhaustion, cardiovascular and kidney diseases.

3. Dirtier air:
- Rising temperatures worsen air pollution by increasing ground level ozone, which is created by pollution from cars, factories + other sources that react to sunlight + heat.
- Ground-level ozone = main component of smog + hotter things get, the more of it we have.
- Dirtier air = higher hospital admission rates + higher death rates for asthmatics.
- Warmer temperatures = increase airborne pollen, which is bad for those who suffer from hay fever + allergies.

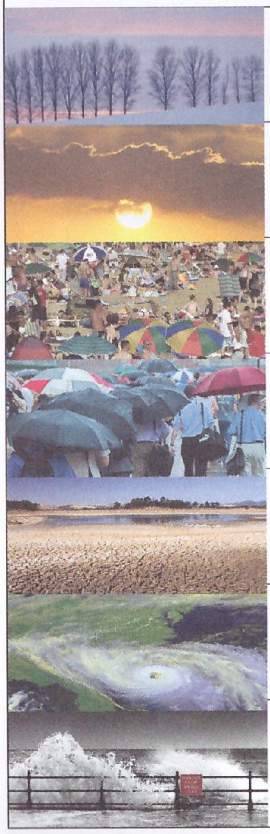
4. Higher wildlife extinction rates:
- As land + sea undergo changes, the animals may die if they don't adapt quickly enough.
- Animals are disappearing a lot faster than they should be, a phenomenon that's linked to climate change, pollution + deforestation.

5. More acidic oceans:

- Marine ecosystems = under pressure as a result of climate change.
- Oceans = becoming more acidic because of their absorption of some of our excess emissions.
- It poses a threat to underwater life, particularly creatures with calcium carbonate shells + skeletons, including mollusks, crabs and corals.
- Large impact on shellfisheries = they harvest these creatures, but if they die due to the acidic water people can't fish them in the amount they did before.

6. Higher sea levels:

- Polar regions = vulnerable to a warming atmosphere.
- Temperatures in the Artic = rising fast + ice sheets = melting.
- Can cause the rising of sea levels = threatening coastal systems + low-lying areas, including entire island nations + world's largest cities.



| PHENOMENON AND DIRECTION OF TREND | LIKELIHOOD THAT TREND OCCURRED IN LATE TWENTIETH CENTURY | LIKELIHOOD OF A HUMAN CONTRIBUTION TO OBSERVED TREND | LIKELIHOOD OF FUTURE TRENDS BASED ON PROJECTIONS FOR TWENTY-FIRST CENTURY |
|---|---|---|---|
| Warmer and fewer cold days and nights over most land areas | ✓✓✓ | ✓✓ | ✓✓✓✓ |
| Warmer and more frequent hot days and nights over most land areas | ✓✓✓ | ✓✓ (nights) | ✓✓✓✓ |
| Increased frequency of warm spells/heat waves over most land areas | ✓✓ | ✓ | ✓✓✓ |
| Increased frequency of heavy precipitation events over most areas | ✓✓ | ✓ | ✓✓✓ |
| Increases in the areas affected by droughts | ✓✓ (in many regions since 1970s) | ✓ | ✓✓ |
| Increased intense tropical cyclone activity | ✓✓ | ✓ | ✓✓ |
| Increased incidence of extremely high sea level (excludes tsunamis) | ✓✓ | ✓ | ✓✓ |

✓✓✓✓ Virtually certain (>99% probability); ✓✓✓ Very likely (>90% probability); ✓✓ Likely (>66% probability); ✓ More likely than not (>50% probability).

## Streams:

- Sediment = carried by running water.
- Streams create floodplains with meandering channels.
- Streams collect water from 2 sources:

1. Groundwater

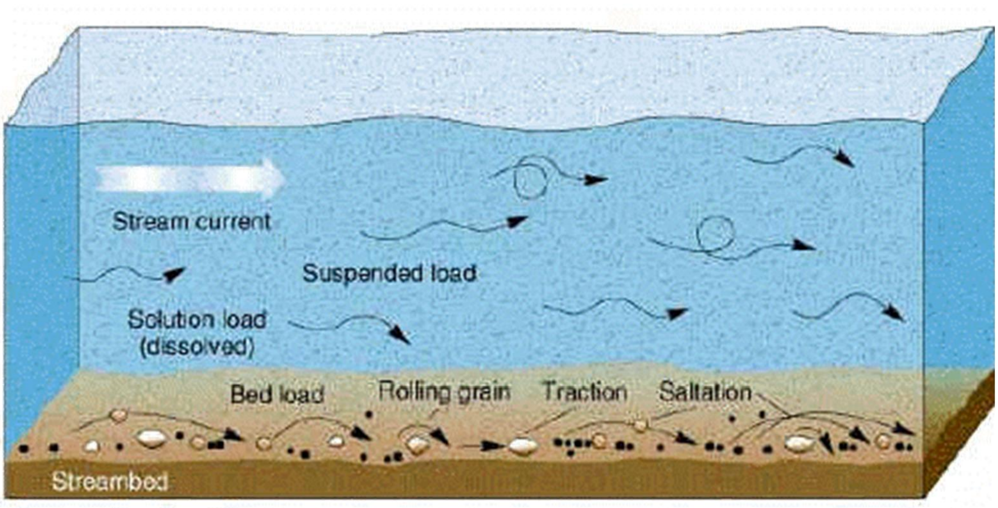
2. Overland flow.

- When rain falls on the land surface, most of it infiltrates/ soaks into the soil = then drains to streams/groundwater.

Sediment transport in running water:

- Groundwater = migrates slowly through the soil + underlying rocks.
- Most water = supplied by groundwater.
- Rains intensely = soil may not be able to absorb it as fast as it falls.
- Runoff/total flow in streams = comes from soil water, groundwater + overland flow.
- Drainage basin = the area a stream drains water from
- The greater the area of the drainage basin, the more water of a stream it must carry.
- Small rills deliver water + material to larger streams, which join others to form still large rivers, which flow to the sea.
- The volume of water that a stream carries per unit of time = discharge.
- Discharge of any stream increases after storms + decreases during dry spells.
- When water flows across the land, either on a hillslope or in a channel, it carries small particles of rock with it.
- Smaller particles are fixed with water making it look muddy, larger particles = may roll or bounce along the bottom of the flow.
- This movement = sediment transport.
- The amount of sediment a stream carries increases as the amount of flowing water increases, so larger streams typically carry more sediment than smaller ones.
- The amount of sediment carried when a river is in flood may be hundreds or thousands of times more than the amount carried at ordinary flow levels.
- Sediment transport also tend to be greater on steep slopes than on gentle ones.

Sediment transport:

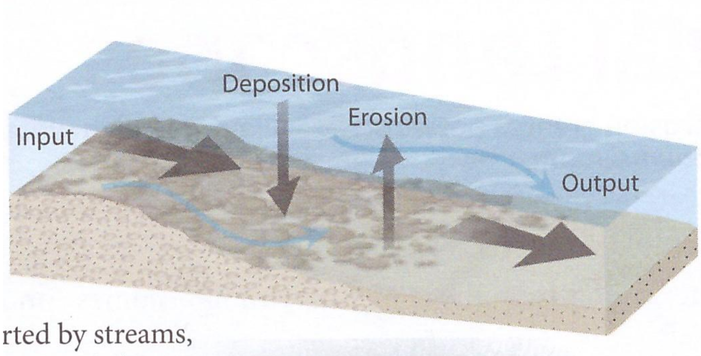



https://www.bing.com/images/search?q=Sediment+transport&view=detailv2&&id=FF63E74A861958F8832C200F5A7C2A5BB8D03EF6&selectedIndex=17&ccid=ulOlETtr&simid=607992307225004019&thid=OIP.Mba53a5113b6bc1174ffa945d6cb469c3H

0&ajaxhist=0

Floodplains:

- Sediment = carried downstream by a series of steps.
- Channel beds + banks = made up of materials transported by streams, temporarily deposited + then eroded again as streams take meandering (winding) courses.
- By continually eroding + depositing material in channels + adjacent low-lying surfaces called floodplains, streams tend toward a stable condition = grade.
- Graded stream = transports exactly as much sediment as it collected.
- Streams rarely operate at a condition of grade of long, because daily changes in weather + disturbances from erosion + human activities = upsets the balance.
- As the stream's conditions change + transport of sediment increases or decreases, the shape of the channel may change.
- When increased erosion upstream generates more sediment than a stream can carry = the excess deposits into the channel or floodplain.
- Sediment deposition = slowly raises the elevation of a stream, which can in turn reduce the elevation between places upstream + downstream + reduces the stream's slope.
- Lowering the slope = reduces the amount of sediment arriving from upstream.




◄ 3.8.3 **SEDIMENT IS CONTINUALLY ERODED, TRANSPORTED, AND DEPOSITED**
In any given part of a river, if more sediment is deposited than eroded (input is greater than output), the channel bed rises. If more is eroded than deposited (output is greater than input), the bed is lowered. The shape of a channel is continually adjusting to the amount of water and sediment moving through it.

MasteringGEOGRAPHY

rted by streams,

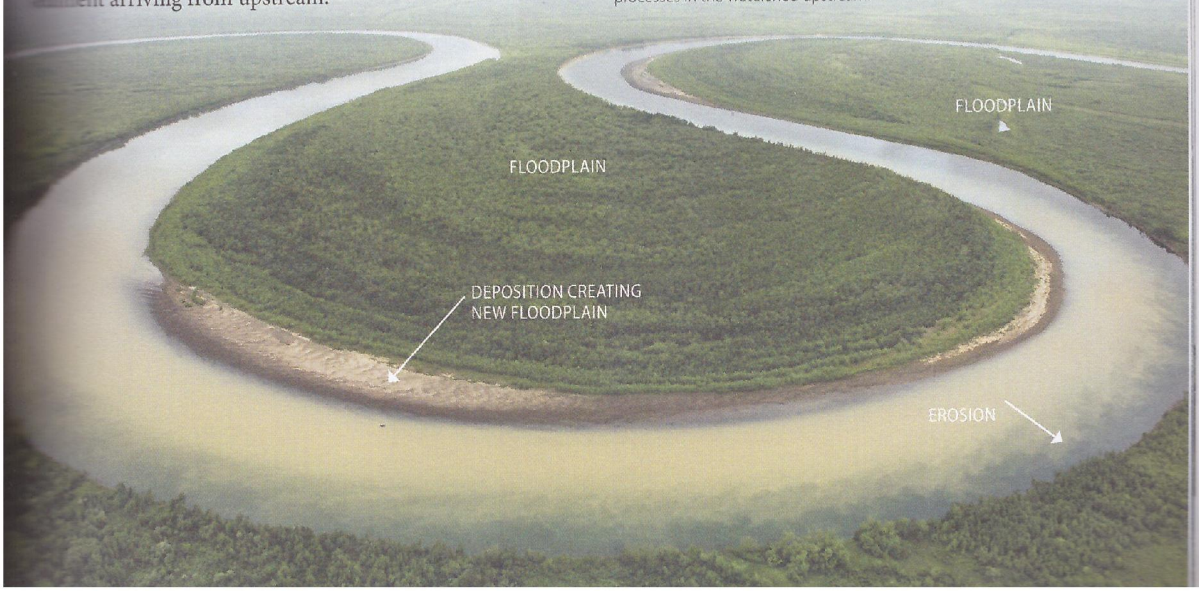

annel or on

of a

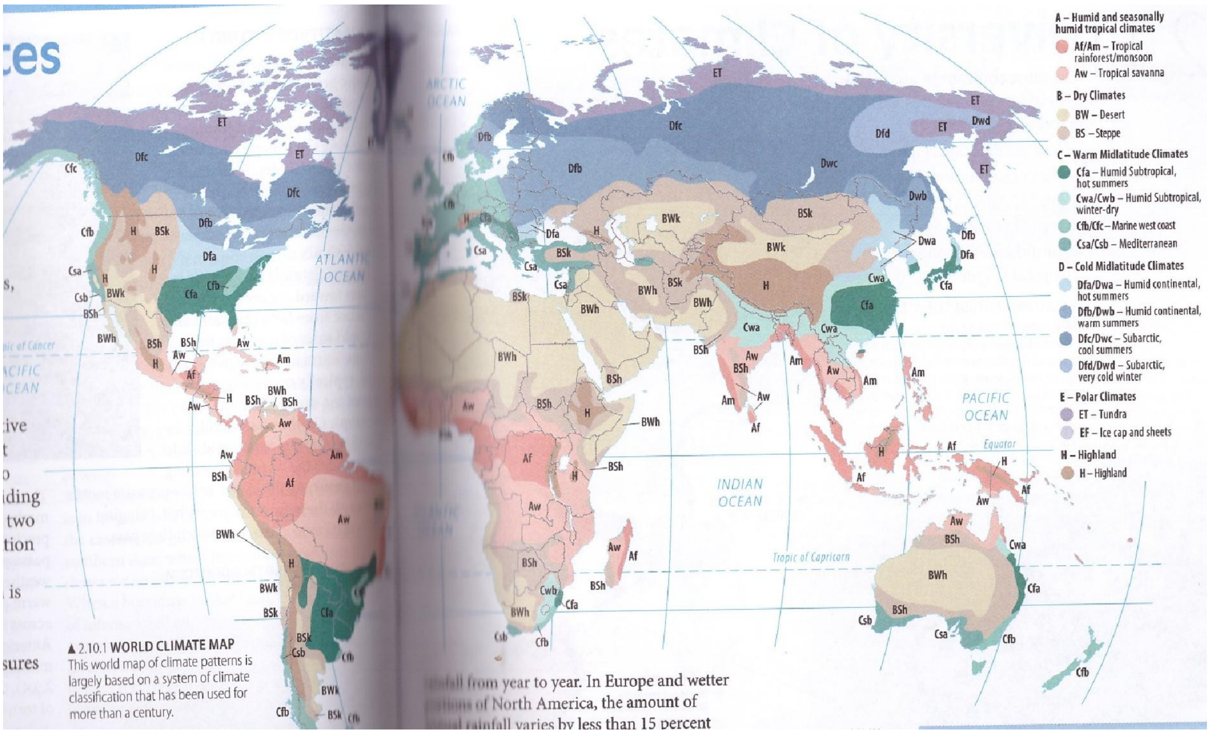
▲ 3.8.4 **RIVER COLE, UNITED KINGDOM**
Steep channel banks show areas of erosion, while sloping gravel bars in the channel bed are areas of deposition.

...tream, which can in turn reduce the difference in elevation between places upstream and downstream and also reduce the stream's slope. Lowering the slope reduces the amount of sediment arriving from upstream.

▼ 3.8.5 **VYVENKA RIVER, KAMCHATKA PENINSULA, RUSSIA**
Rivers meander from side to side, creating floodplains. The floodplain is an extension of the river channel, and is connected to runoff and erosion processes in the watershed upstream.




## Major biomes:




## Soil:

Soil – a dynamic, porous layer of mineral + organic matter that's vital in supporting Earth's biosphere.

Soil properties are attributable to 5 major factors:

1. Parent material is the mineral matter from which soil is formed.

- Weathering breaks rock down into smaller particles and new chemical forms.
- The parent material from which soil is formed is important because it influences soil's chemical + physical characteristics in young soils.

2. Climate regulates both water movements + biological activity:

- Water plays a central role in rock weathering + soil formation.
- In very humid climates, much water passes through the soil + leaches out soluble minerals on its way.
- Because of this leaching, soils in humid climates generally have lower amounts of soluble minerals such as sodium + calcium compared to soils in dry climates.
- However in semiarid areas, water enters the soil + picks up soluble minerals, which are drawn toward the surface as water is evapotranspired; soils of semiarid + arid climates often have a layer rich in relatively soluble minerals near the surface.

3. Biological activity among plants and animals move minerals and adds organic matter to the soil.

- Plants produce organic matter that accumulates on the soil surface, and animals redistribute this organic matter through the soil.
- Plants + animals also play a role in weathering processes.

4. Topography affects water movement and erosion rates:
- Topography also affects the amount of water present in the soil, largely through controlling drainage + erosion.
- Steeply sloping areas generally have better drainage than flat or low-lying areas, and they're often more eroded.

5. All these factors work over time, typically requiring many thousands of years to create a mature soil:
- Soil = a dynamic, porous layer of mineral + organic matter at Earth's surface.
- Soil formation = a slow process that takes place very gradually over thousands of years.
- Soils that have only been forming for a few thousand years have very different characteristics from those that have been modified by chemical + biological processes for tens of thousands of years.

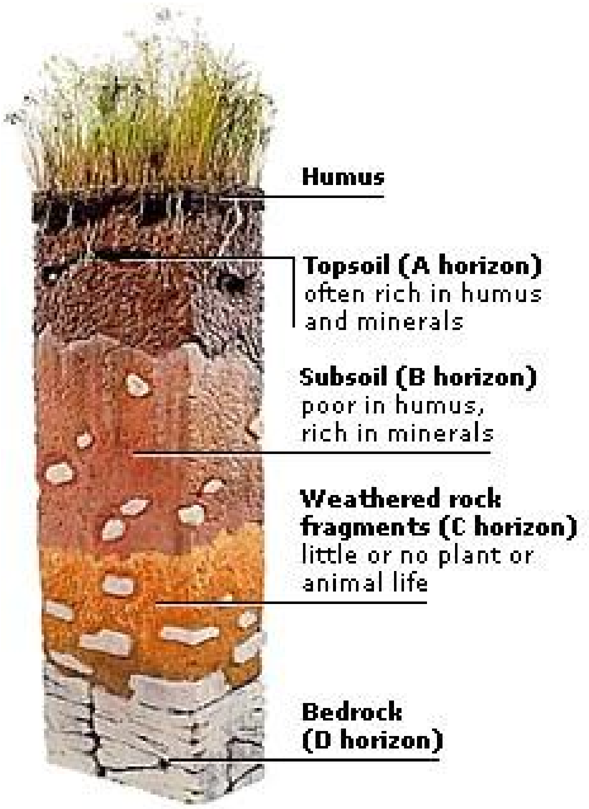



Image obtained from: http://i.infopls.com/images/ency048soilay001.jpg

| | |
|---|---|
| O Horizon: (Humus) | • Litter – leaves, twigs, dead insects, + other organic matter<br>• Accumulates to form a horizon at the surface known as the O (organic) horizon. |
| A Horizon: | • As litter decays, insects, worms + bacteria consume it + carry it underground, where it helps form the A horizon.<br>• Waste from these burrowing animals as well as their dead bodies add more organic matter to the A horizon.<br>• In many soils, the A horizon contains much of the nutrients that |

| | |
|---|---|
| | support plant life.<br>• Water may erode materials from the soil surface. |
| B Horizon: | • Organisms + water move materials between the A + B horizons.<br>• Clay minerals formed from chemical weathering often accumulate in the B horizon + in dry regions soluble minerals such as calcium accumulate in the B horizon. |
| C Horizon: | • The C horizon contains weathered parent materials that have not been altered as completely by soil-forming processes as materials above it. |

- Soil properties vary in layers called soil horizons.
- Soil horizons are formed through the vertical movement of water, minerals + organic matter in the soil + also variations in biological + chemical activity at different depths.
- The characteristics of soil horizons vary greatly from one soil type to another.
- Not all soils contain the A, B, C horizons, but many do.
- The presence of certain horizons + the characteristics of those horizons are key to identifying distinct soil types.

**Soil types:**

| | |
|---|---|
| Alfisol: | • Have a brownish colour reflecting moderate organic matter content.<br>• It formed under a forest cover + has moderately high fertility. |
| Aridisol: | • Soils in arid climates are typically rich in soluble minerals because water isn’t available to remove them.<br>• They’re also generally low in organic matter because of low rates of plant growth. |
| Mollisol: | • This rich, black soil formed in semiarid climate with grassland vegetation.<br>• It’s high in organic matter + nutrients. |
| Oxisol: | • This soil = experienced thousands of years of intense chemical weathering + removal of soluble minerals.<br>• Its reddish colour comes mainly from a high concentration of iron oxides.<br>• Soils of this type = often low in nutrients as a results of leaching of soluble minerals by water. |
| Histosol: | • This soil is composed mainly of dead organic matter, which accumulates because it decays very slowly in the cold Artic climate. |


Alfisols are in semiarid to moist areas.

These soils result from weathering processes that leach clay minerals and other constituents out of the surface layer and into the subsoil, where they can hold and supply moisture and nutrients to plants. They formed primarily under forest or mixed vegetative cover and are productive for most crops.

**ALFISOLS MAKE UP ABOUT 10% OF THE WORLD'S ICE-FREE LAND SURFACE.**


Aridisols are soils that are too dry for the growth of mesophytic plants. The lack of moisture greatly restricts the intensity of weathering processes and limits most soil development processes to the upper part of the soils. Aridisols often accumulate gypsum, salt, calcium carbonate, and other materials that are easily leached from soils in more humid environments.

Aridisols are common in the deserts of the world.

**ARIDISOLS MAKE UP ABOUT 12% OF THE WORLD'S ICE-FREE LAND SURFACE.**


Mollisols are soils that have a dark colored surface horizon relatively high in content of organic matter. The soils are base rich throughout and therefore are quite fertile.

Mollisols characteristically form under grass in climates that have a moderate to pronounced seasonal moisture deficit. They are extensive soils on the steppes of Europe, Asia, North America, and South America.

**MOLLISOLS MAKE UP ABOUT 7% OF THE WORLD'S ICE-FREE LAND SURFACE.**

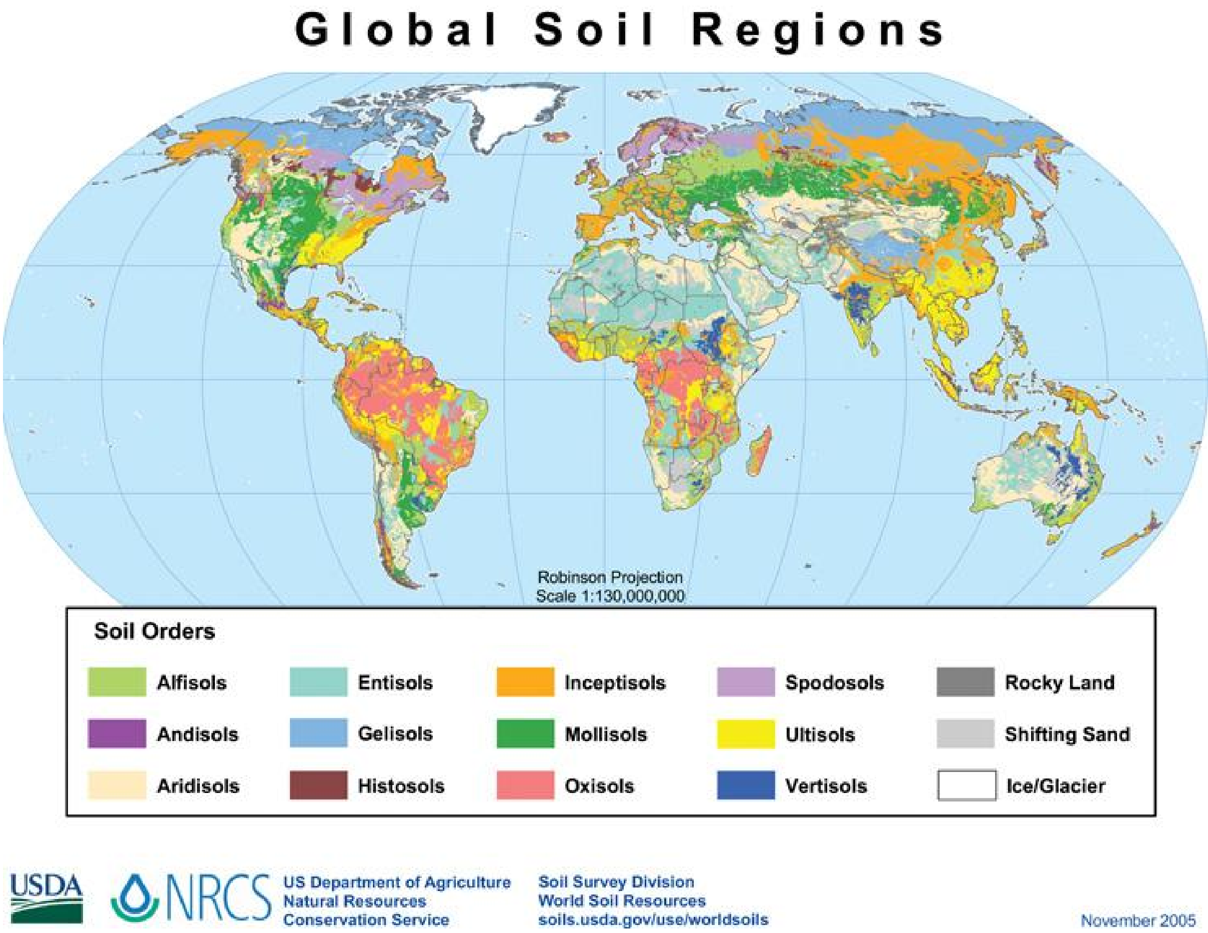

Oxisols are highly weathered soils of tropical and subtropical regions. They are dominated by low activity minerals, such as quartz, kaolinite, and iron oxides. They tend to have indistinct horizons.

Oxisols characteristically occur on land surfaces that have been stable for a long time. They have low natural fertility as well as a low capacity to retain additions of lime and fertilizer.

**OXISOLS MAKE UP ABOUT 8% OF THE WORLD'S ICE-FREE LAND SURFACE.**


Images obtained from: http://passel.unl.edu/Image/mmamo3/TimKettler

**Soil Regions:**




http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_050040.jpg

In addition, note the following:

The prescribed book is written from a Northern Hemisphere perspective. All incidences that refer to solstices or summer or winter as well as equinoxes or spring or autumn should be carefully considered. Summer in the Northern Hemisphere is equal to winter in the Southern Hemisphere and vice versa. Spring in the Northern Hemisphere is equal to autumn in the Southern Hemisphere and vice versa.
You will never be asked to draw the sun-earth geometry, global atmospheric circulation or a biochemical cycle but you should be able to answer questions on each element, process and consequence related to them.

## Test-yourself:

1. Which **one** of the following statements describing the position of the Sun in June each year is **true**? **(Section B; pg 34-35)**

(1) The Sun will be directly above the Equator.
**(2) The Sun will be directly above the Tropic of Cancer.**
(3) The Sun will be directly above the Tropic of Capricorn.
(4) The Sun will be directly above the 40° North latitude.

2. Latent heat transfers are essential in the flow of energy through the Earth's atmosphere system. Which **one** of the following statements is **incorrect**?
**(Section B; pg 38-39)**

(1) Warmer air can hold more moisture than cooler air.
(2) The condensation of water vapour in a cloud releases latent heat.
(3) The transfer of latent heat influences the amount of precipitation.
**<u>(4) It requires much more energy to freeze water than to evaporate water.</u>**

3. For which one of the following combinations of continents is it **true** to state that the highest average atmospheric pressure occurs in January and the lowest average atmospheric pressure in July? **(Section B; pg 45)**

(1) Europe and Africa
(2) South America and Asia
**<u>(3) Asia and Africa</u>**
(4) North America, Europe and Asia
(5) Africa and North America

4. At which one of the following types of tectonic plate boundaries is new crust created? **(Section B; pg 68)**

**<u>(1) A divergent boundary</u>**
(2) A convergent boundary
(3) A transform boundary
(4) A subduction boundary

5. The epicentre of an earthquake is defined as … **(Section B; pg 71)**

(1) the term used for earthquakes that occur along tectonic plates
(2) the point of minimum damage
**<u>(3) the point on the surface directly above the focus of an earthquake</u>**
(4) the location of a possible future earthquake

6. Which one of the following types of soil can be observed in Eastern Europe and the Midwestern United States? **(Section B; pg 106-107)**

(1) utisols
(2) oxisols
(3) spodosols
**<u>(4) mollisols</u>**

7. Which **one** of the following biomes is **not** found in South Africa?
**(Section B; pg 108-109)**

(1) Mediterranean woodland shrub and grassland.

(2) Desert shrub.
(3) Tropical savannah, mixed grassland and woodland.
**<u>(4) Broadleaf or mixed broadleaf and coniferous forest.</u>**

8. Phosphorus is **not** found in the … **(Section B; pg 102-103)**

**<u>(1) atmosphere</u>**
(2) hydrosphere
(3) biosphere
(4) lithosphere

9. Which **one** of the following statements relating to biogeochemical cycles is **true**? **(Section B; pg 94-103)**

(1) The phosphorus cycle involves the atmosphere, hydrosphere, lithosphere and the biosphere.
(2) Photosynthesis produces carbon dioxide which is then stored in biomass.
**<u>(3) Evaporation, condensation, precipitation and runoff are the physical processes that complete the hydrological cycle.</u>**
(4) The nitrogen cycle involves the atmosphere, hydrosphere, lithosphere and the biosphere.

10. Which **one** of the following processes is **not** an example of mechanical weathering? **(Section B; pg 75)**

(1) Frozen water causing rocks to crack and break.
(2) Plants roots cracking and breaking rocks.
**<u>(3) Mechanical drills cracking and breaking rock.</u>**
(4) Intense and sustained heat from the sun cracking and breaking rocks.