Unit 4: Earth Systems

Objectives, EKs & Skill

LEARNING OBJECTIVE

ERT-4.A

Describe the geological changes and events that occur at convergent, divergent, and transform plate boundaries.

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

ESSENTIAL KNOWLEDGE

ERT-4.A.1

Convergent boundaries can result in the creation of mountains, island arcs, earthquakes, and volcanoes.

ERT-4.A.2

Divergent boundaries can result in seafloor spreading, rift valleys, volcanoes, and earthquakes.

ERT-4.A.3

Transform boundaries can result in earthquakes.

ERT-4.A.4

Maps that show the global distribution of plate boundaries can be used to determine the location of volcanoes, island arcs, earthquakes, hot spots, and faults.

ERT-4.A.5

An earthquake occurs when stress overcomes a locked fault, releasing stored energy.

4.1
Plate Tectonics

Earth's Structure

- **Core**: Dense mass of solid nickel, iron, and radioactive elements that release massive amount of heat
- **Mantle:** liquid layer of magma surrounding core, kept liquified by intense heat from core
- **Asthenosphere:** solid, flexible outer layer of mantle, beneath the lithosphere
- **Lithosphere:** thin, brittle layer of rock floating on top of mantle (broken up into tectonic plates)
- **Crust:** very outer layer of the lithosphere, earth's surface

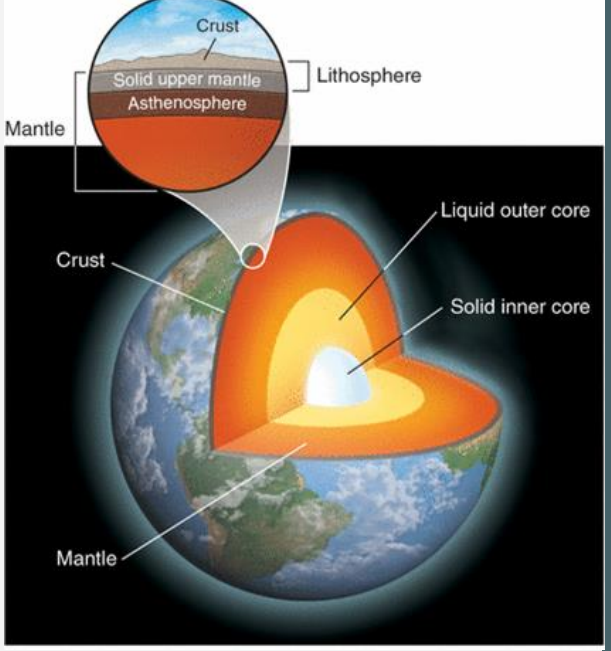


Plate Boundaries

Divergent Plate Boundary

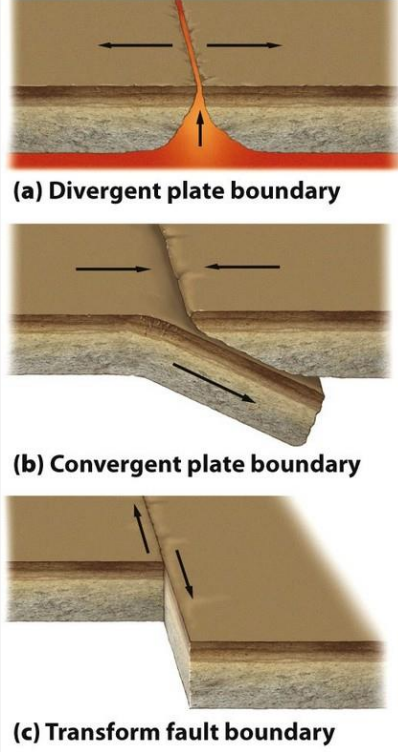
- Plates move away from each other
- Rising **magma plume** from mantle forces plates apart
    - Forms: mid-oceanic ridges, volcanoes, seafloor spreading, and rift valleys (on land)

Convergent Plate Boundary

- Plates move towards each other
- Leads to **subduction** (one plate being forced beneath another)
    - Forms: **mountains**, island arcs, earthquakes, and volcanoes

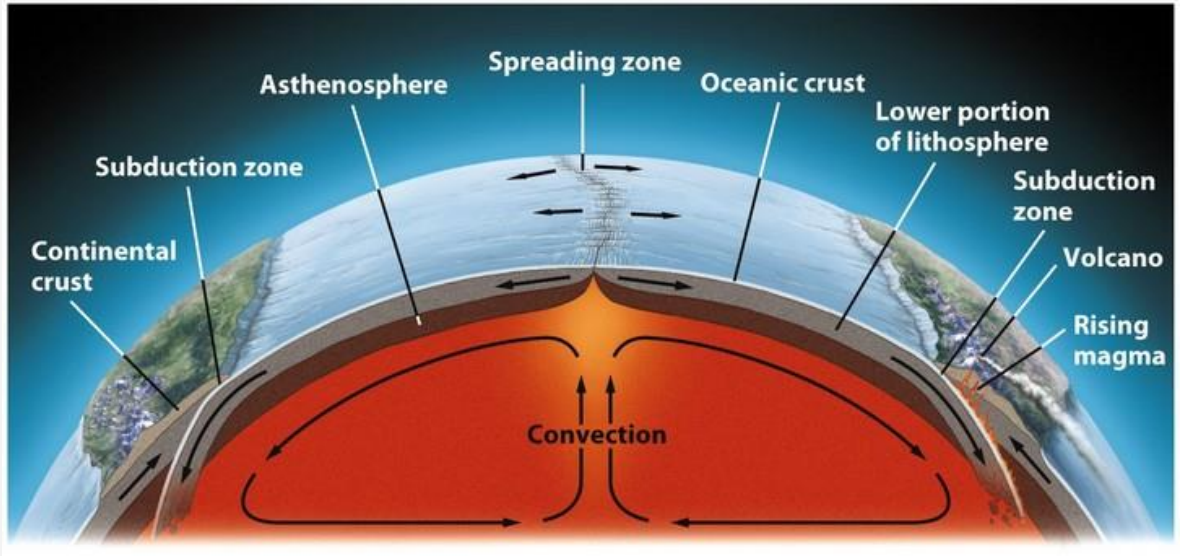
Transform Fault Plate Boundary

- Plates slide past each other in opposite directions
    - Forms: **earthquakes**



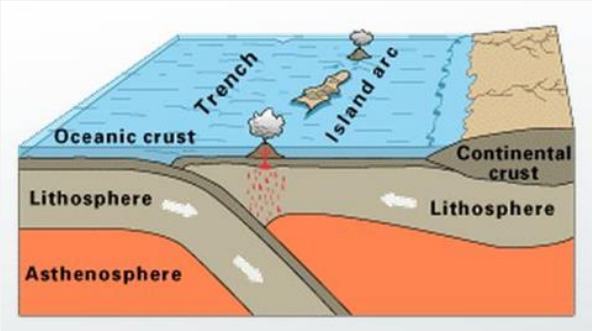
Convection Cycles (Divergent)

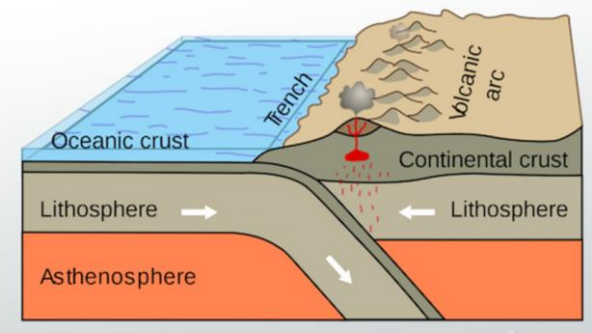
- **Magma** heated by earth's core rises towards **lithosphere**
- Rising magma cools & expands, forcing oceanic plates apart
  - Creates, mid ocean ridges, volcanoes, spreading zones or "seafloor spreading"
- Magma cools, and solidifies into new lithosphere

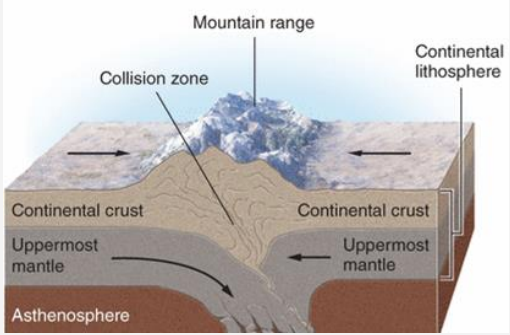


- Spreading magma forces oceanic plate into cont. (**subduction zone**)
  - Sinking oceanic plate melts back into magma
  - Also forces magma up, creating narrow, coastal Mtns. (Andes) & volcanoes on land

Convergent Boundary = Subduction Zone







Oceanic-Oceanic : one plate subducts underneath other

- Forces magma up to lithosphere surface, forming mid ocean volcanoes
  - Island arcs
- Off-shore trench

Oceanic-Continental : dense oceanic plate subducts beneath cont. Plate & melts back into magma

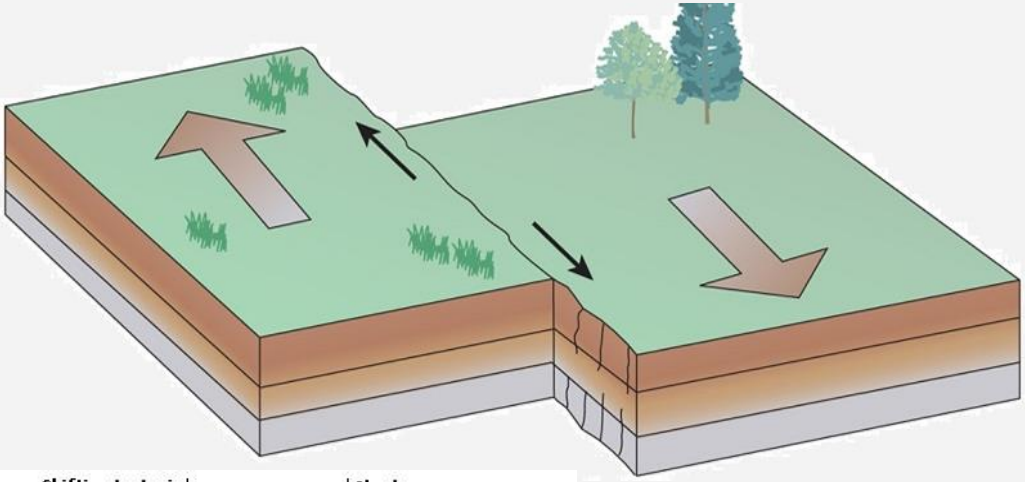
- Forces magma up to lithosphere surface
- Coastal Mountains (Andes), Volcanoes on land, trenches, tsunamis

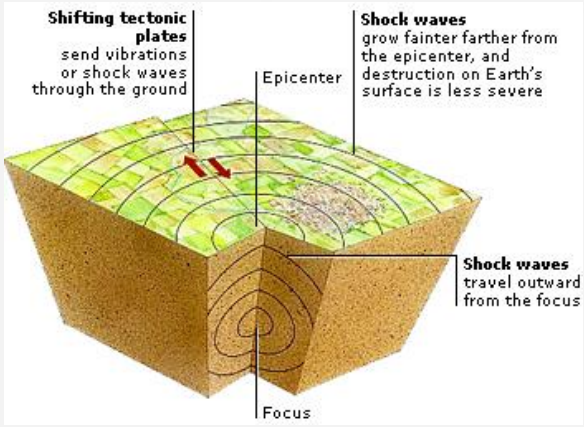
Continental-Continental one plate subducts underneath other, forcing surface crust upward (mountains)

- Ex: Himalayas

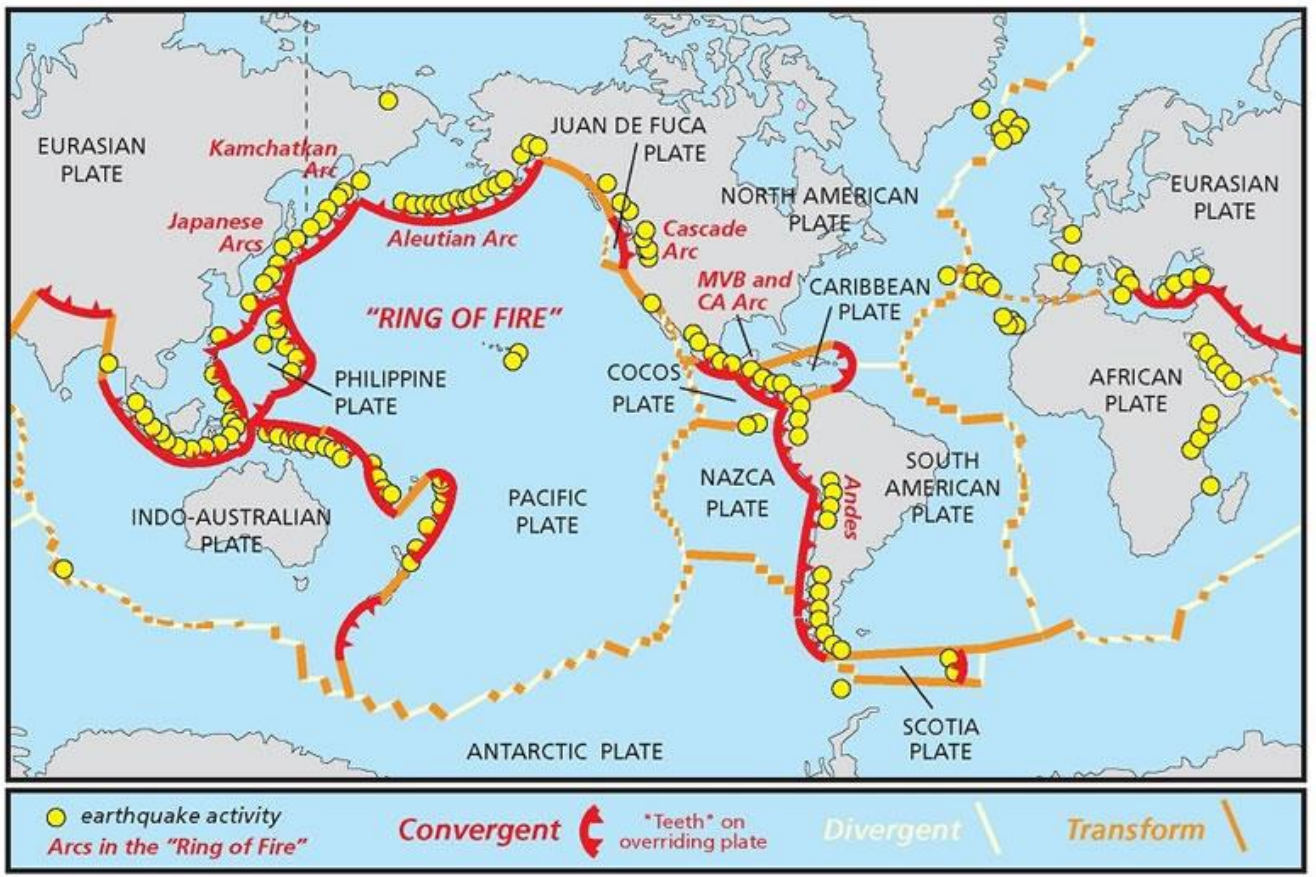
Transform Fault Boundary

- Plates sliding past each other in opp. directions creates a fault (fracture in rock surface)
  - **Earthquakes** = most common activity
  - Occurs when rough edges of plates get stuck on each other
  - **Pressure** builds as plates keep sliding, but edges stay stuck
  - When stress overcomes the locked fault, plates suddenly release, slide past each other and **release energy** that **shakes the lithosphere**





Tectonic Map Can Predict…



Ring of Fire: pattern of volcanoes all around pacific plate

- Offshore island arcs (Japan)

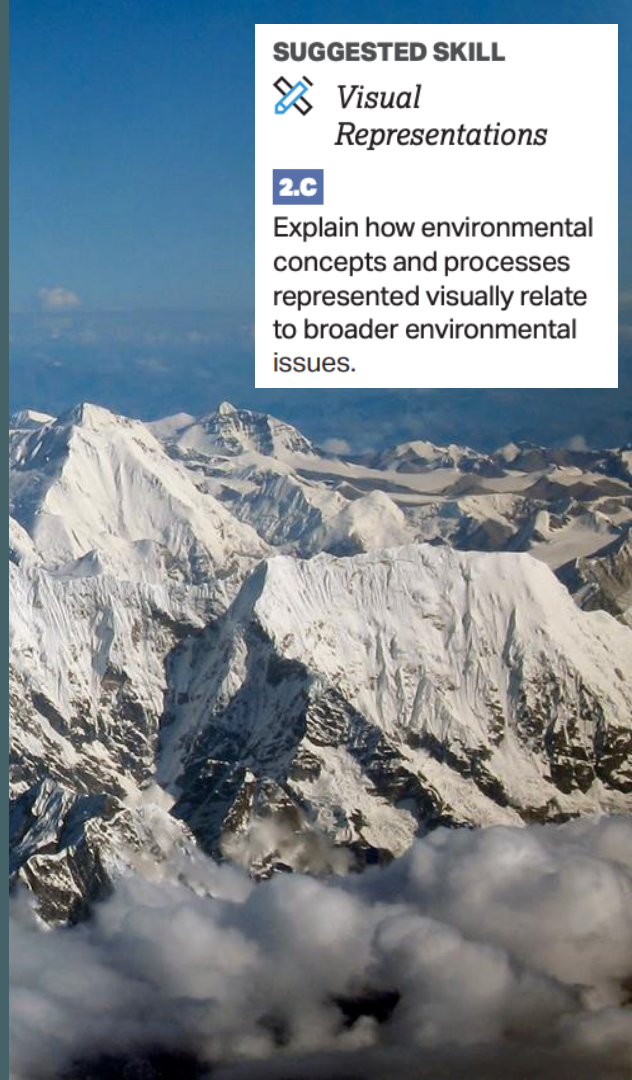
Transform faults: likely location of earthquakes

Hotspots: areas of esp. hot magma rising up to lithosphere

- Mid-ocean Islands (iceland, Hawaii)

Practice FRQ 4.1

Explain how subduction leads to volcanic activity.



SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

4.2 Soil Formation & Erosion

Objectives, EKs, and Skills

LEARNING OBJECTIVE

ERT-4.B

Describe the characteristics and formation of soil.

SUGGESTED SKILL

Scientific Experiments

4.B

Identify a research method, design, and/or measure used.

ESSENTIAL KNOWLEDGE

ERT-4.B.1

Soils are formed when parent material is weathered, transported, and deposited.

ERT-4.B.2

Soils are generally categorized by horizons based on their composition and organic material.

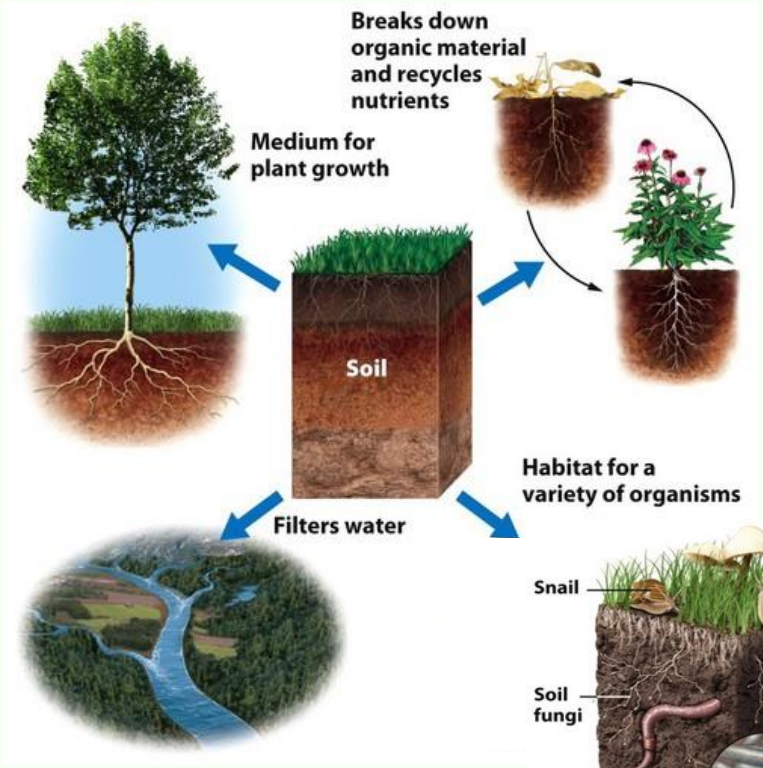
ERT-4.B.3

Soils can be eroded by winds or water. Protecting soils can protect water quality as soils effectively filter and clean water that moves through them.

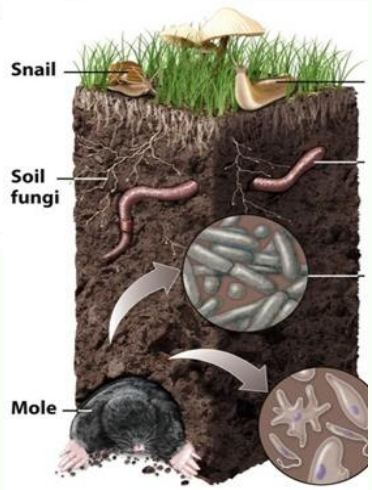
Plants: anchors roots of plants and provides water, shelter, nutrients (N, P, K, Mg) for growth

Water: filters rainwater + runoff by trapping pollutants in pore spaces + plant roots. Clean water enters groundwater + aquifers

Nutrient Recycling: home to decomposers that break down dead organic matter + return nutrients to the soil



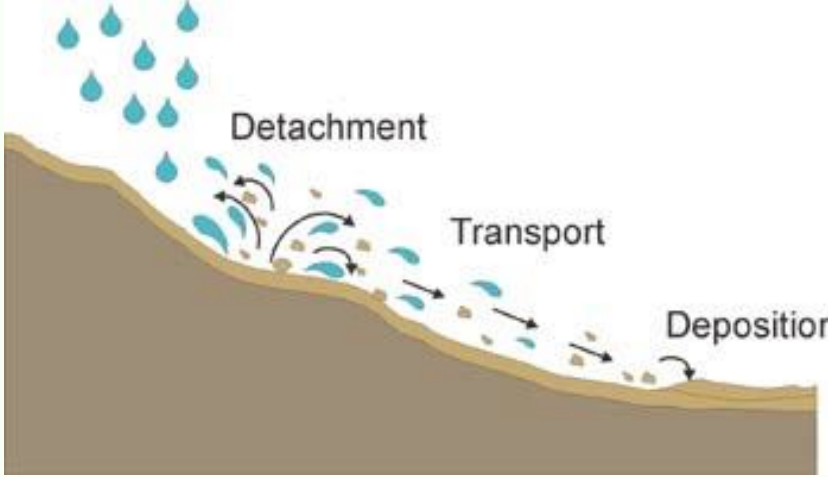
Habitat: provides habitat for org. like earthworms, fungi, bacteria, moles, slugs



What is Soil?

Mix of geologic (rock) and organic (living) components

- **Sand, silt, clay**
- **Humus**: main organic part of soil (broken down biomass like leaves, dead animals, waste, etc.)
- **Nutrients**: ammonium, phosphates, nitrates
- **Water and Air**
- **Living Organisms**

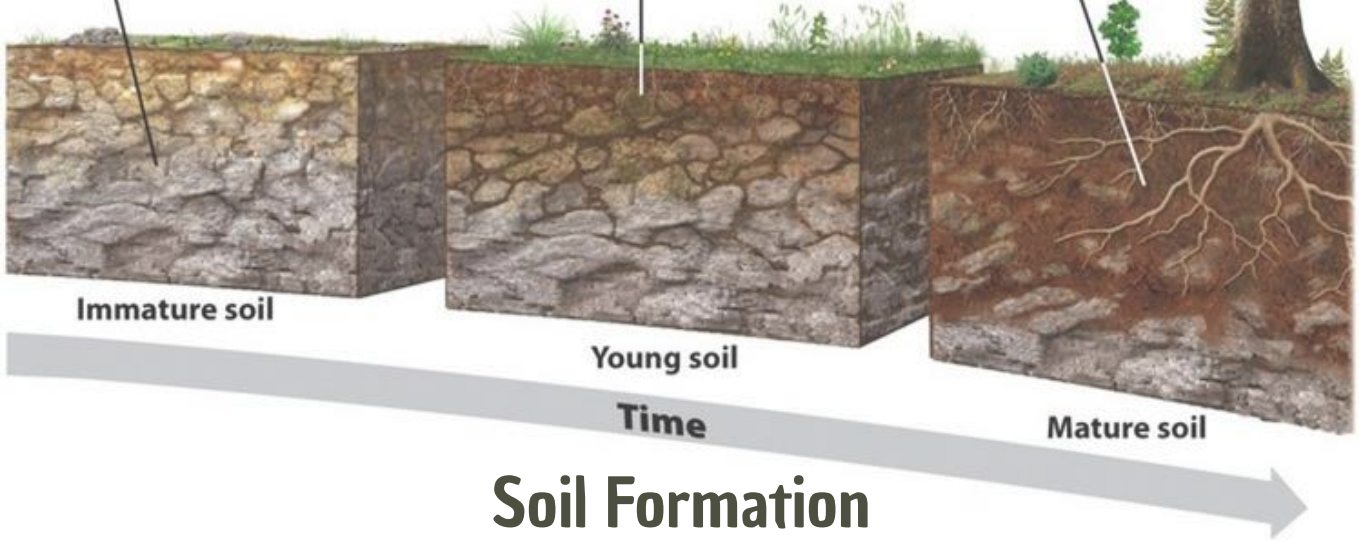


Weathering

- Breakdown of rocks into smaller pieces
  - Physical (wind, rain, freezing/thawing of ice)
  - Biological (roots of trees crack rocks)
  - Chemical (acid rain, acids from moss/lichen)
- Weathering of rocks = soil formation
  - Broken into smaller and smaller pieces
  - Carried away and deposited by erosion

Erosion

- Transport of weathered rock fragments by wind and rain
- Carried to new location and deposited (deposition)



Soil Formation

- From below
  - Weathering of parent material produces smaller, and smaller fragments that make up geological/inorganic part of soil
    - Sand, silt, clay
    - Minerals
- From above
  - Breakdown of organic matter adds humus to soil
  - Erosion deposits soil particles from other areas, adding to soil

Effects on Soil Form.

Parent material: soil pH, nutrient content

Topography: steep slope = too much erosion;
more level ground = deposition

Climate: warmer = faster breakdown of org. matter;
more precip. = more weathering, erosion + deposition

Organisms: Soil organisms like bacteria, fungi, worms breakdown organic matter

Soil Horizons

O-Horizon: layer of organic matter (plant roots, dead leaves, animal waste, etc) on top of soil

- Provides nutrients and limits H_2O loss to evap.

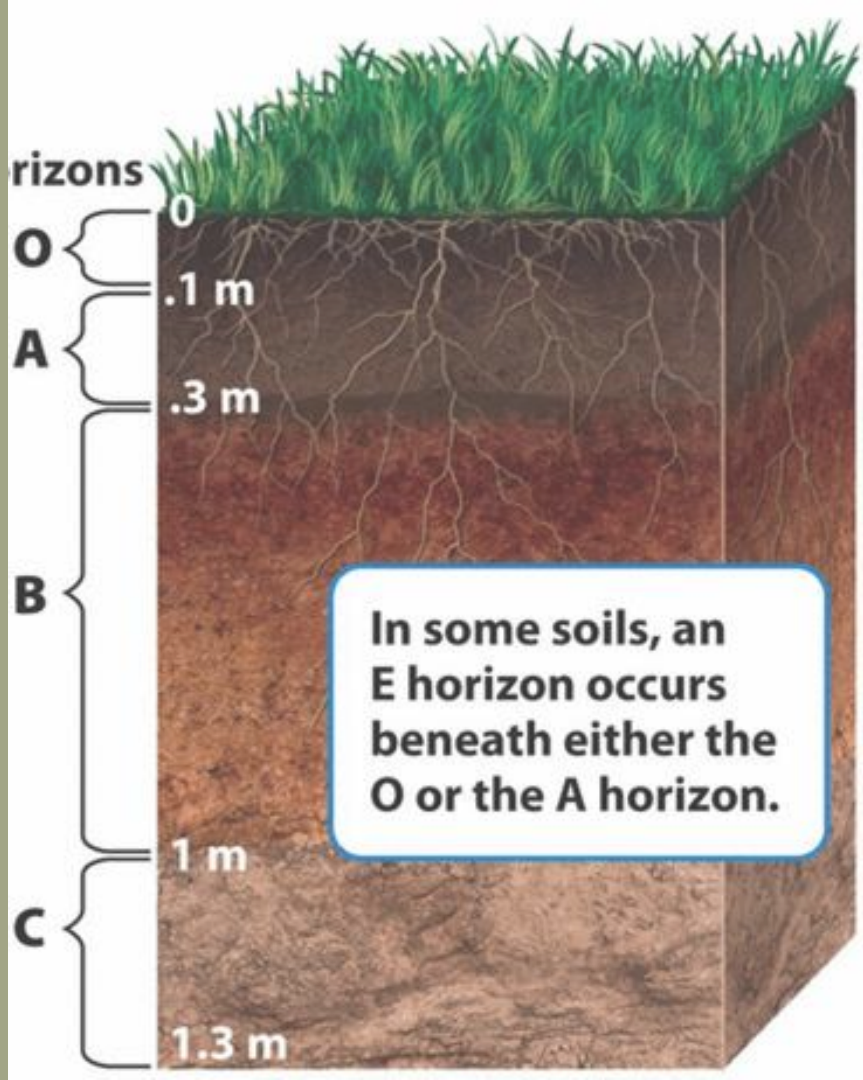
A-Horizon: aka ***topsoil;*** layer of **humus** (decomposed organic matter) and minerals from parent material

- A-Horizon has most biological activity (earthworms, soil microbes) breaking down organic matter to release nutrients

B-Horizon: aka ***subsoil***; lighter layer below topsoil, mostly made of minerals w/little to no org. matter

- Contains some nutrients

C-Horizon: least weathered soil that is closest to the parent material, sometimes called bedrock



Soil Degradation:

The loss of the ability of soil to support plant growth

Loss of Topsoil: tiling (turning soil for ag.) + loss of vegetation disturb soil and make it more easily eroded by wind and rain

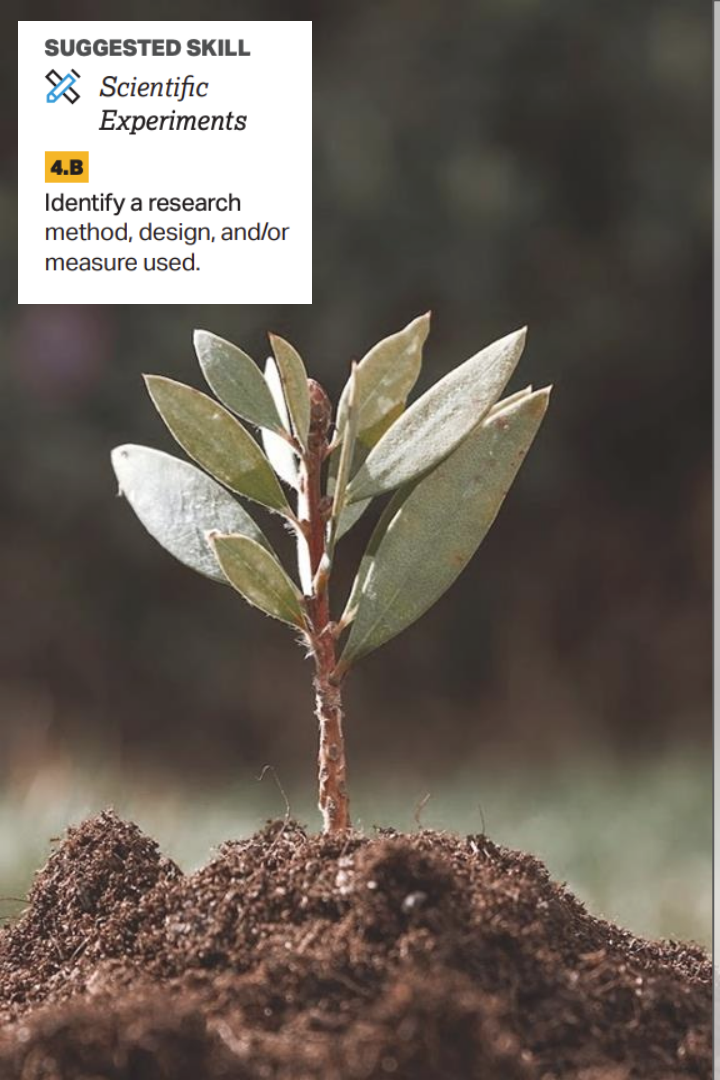
- Loss of top soil dries out soil, removes nutrients + soil organisms that recycle nutrients

Compaction: compression of soil by machines (tractors, bulldozers, etc.), grazing livestock, and humans reduces ability to hold moisture

- Dry soil erodes more easily
- Dry soil supports less plant growth, less root structure, leading to more erosion

Nutrient Depletion: repeatedly growing crops on the same soil removes key nutrients (N, P, K, Na, Mg) over time

- Reduces ability to grow future crops



SUGGESTED SKILL

Scientific Experiments

4.B

Identify a research method, design, and/or measure used.

4.2 Practice FRQ

Design an investigation to measure the effect that climate has on soil formation.

Identify the independent variable and dependent variable in your experiment.

4.3
Soil Composition & Properties

Objectives, EKs, and Skills

LEARNING OBJECTIVE

ERT-4.C

Describe similarities and differences between properties of different soil types.

SUGGESTED SKILL

Scientific Experiments

4.C

Describe an aspect of a research method, design, and/or measure used.

ESSENTIAL KNOWLEDGE

ERT-4.C.1

Water holding capacity—the total amount of water soil can hold—varies with different soil types. Water retention contributes to land productivity and fertility of soils.

ERT-4.C.2

The particle size and composition of each soil horizon can affect the porosity, permeability, and fertility of the soil.

ERT-4.C.3

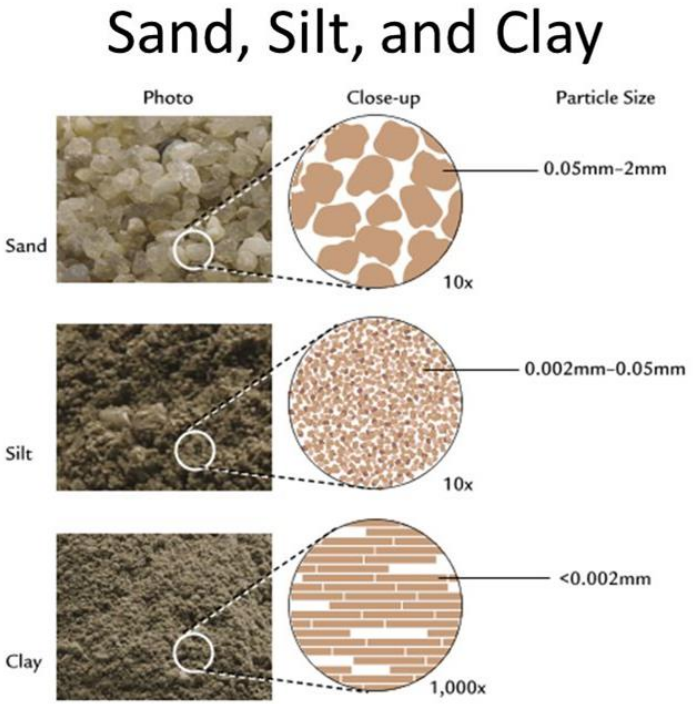
There are a variety of methods to test the chemical, physical, and biological properties of soil that can aid in a variety of decisions, such as irrigation and fertilizer requirements.

ERT-4.C.4

A soil texture triangle is a diagram that allows for the identification and comparison of soil types based on their percentage of clay, silt, and sand.

Soil Particle Size, Texture, and Porosity

- Geologic (rock) portion of soil is made up of 3 particles
  - (biggest to smallest) Sand > silt > clay
- **Soil Texture**: is the % of sand, silt, and clay in a soil
  - Always adds up to 100% *ex: 40-40-20*
- B/c sand is bigger, it has bigger **pores** (empty spaces between particles)
  - This allows air + water to enter sandy soil easily
  - Clay has smallest pores, so it's harder for air + water to enter clay-heavy soils
- **Porosity** is the amount of pore space a soil has
  - more sand in a soil = more porous/higher porosity (easier for water + air to enter)
  - more clay in a soil = less porous/less porosity (harder for water + air to enter)



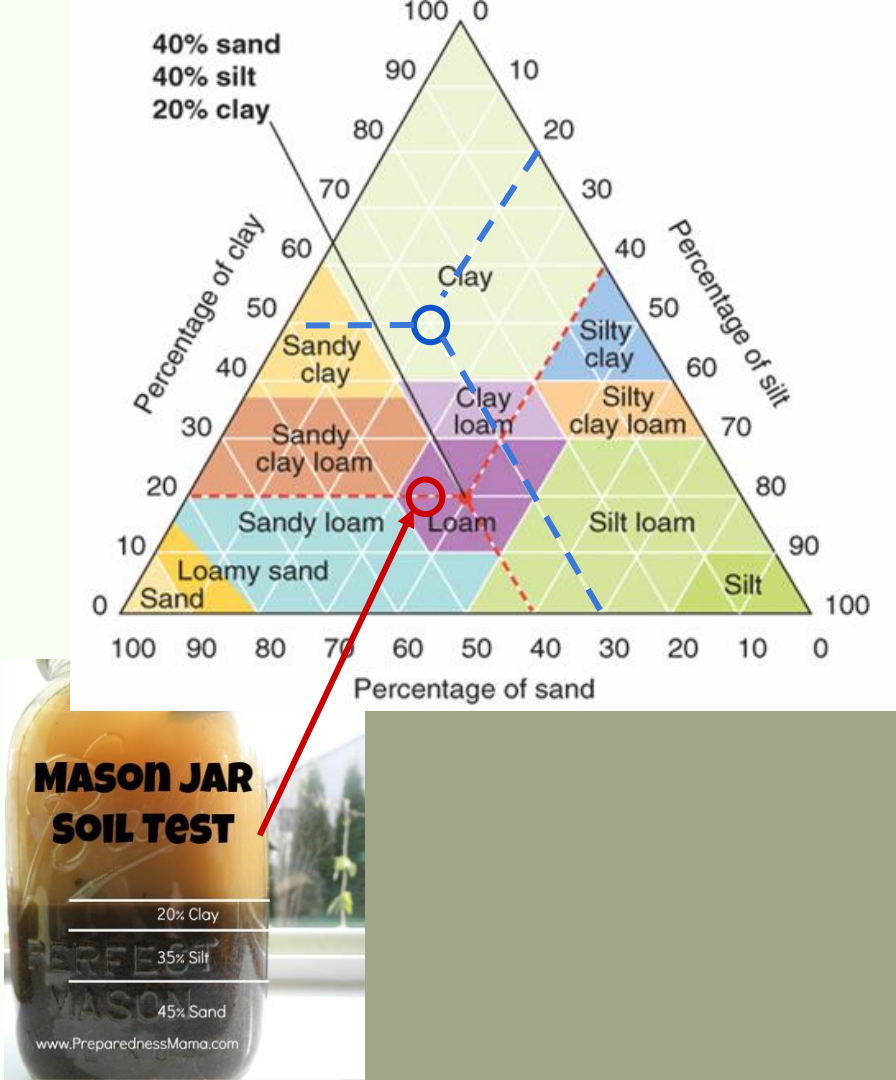
Soil Texture Chart

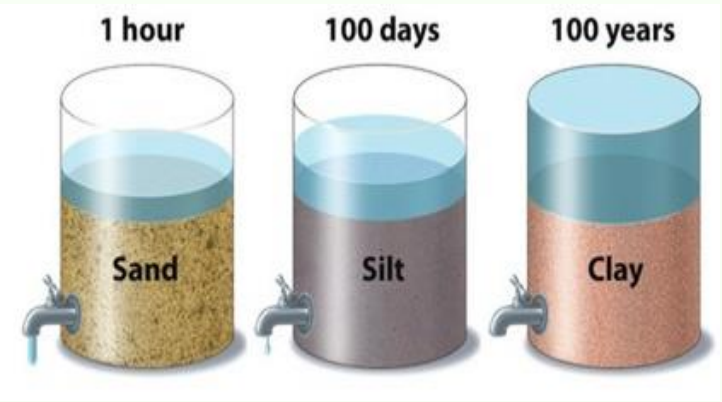
- Soil texture is determined by clay, sand, silt %
  - *Ex: Loam = 40-40-20, sand, silt, clay*
    - *45% sand 35% silt, 20% clay*

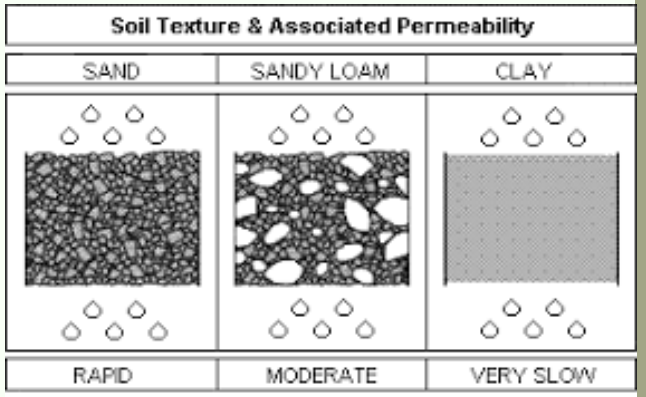
- Tips for using Soil Texture Chart
  - Always start on bottom with sand %
  - Move out to point where sand + silt meet
  - Then go **straight** over to clay
  - Make sure it adds up to 100%

- Practice: Find % sand, silt, clay of the blue circle

  Answer: 30% sand, 20% silt, 50% clay







Porosity, permeability, and H_2O Holding Capacity

- **Porosity**: the pore space within a soil (more sand, more porous)
- **Permeability**: how easily water drains through a soil
- More porous/higher porosity = more permeable/higher permeability
    - Positive relationship between porosity + permeability
- **H_2O holding Capacity**: how well water is retained, or held by a soil
    - More porous/permeable = lower H_2O holding capacity
    - Inverse relationship between porosity/permeability and H_2O holding capacity

Effect on Soil Fertility

Soil that is too sandy (too permeable) drains water too quickly for roots + dries out

Clay-heavy soil doesn't let H_2O drain to roots, or waterlogs (suffocating them)

Ideal soil for most plant growth is loam, which balances porosity or drainage, with H_2O holding cap.

Soil Fertility: ability of soil to support plant growth

Nutrients

- N, P, K^+, Mg^{2+}, Ca^+, Na^+
- Factors that increase soil nutrients
  - Organic matter (releases nutrients)
  - Humus (holds and releases nutrients)
  - Decomposer activity (recycles nut.)
  - Clay (neg. charge binds pos. nutrients)
  - Bases (Calcium carbonate - limestone)
- Factors that decrease soil nutrients
  - Acids leach pos. charge nutrients
  - Excessive rain/irr. leeches nutrients
  - Excessive farming depletes nut.
  - Topsoil erosion

Water

- Needs to hold water, but not too much
- Factors that increase H_2O holding cap.
  - Aerated soil (biological activity)
  - Compost/humus/organic matter
  - Clay content
  - Root structure, especially natives
- Factors that decrease H_2O holding cap.
  - Compacted soil (machines, cows)
  - Topsoil erosion
  - Sand
  - Root loss

Characteristics and Tests of Soil Quality

Characteristic	How to Test	What it tells you
Texture	Let soil settle in jar of water. Measure 3 layers that form (sand, silt, clay)	% of sand, silt, and clay - how porous or permeable soil it
Permeability	Time for H_2O to drain through column of soil	How easily water drains through soil. Too high, soil dries out. Too low, roots don't get water or drown. Medium = optimal
pH	pH strip - H+ ion concentration	How acidic (low pH) or basic/alkaline (high pH) soil is. More acidic soil = less nutrient availability
Color	Compare w/soil book color chart	The darker, the more humus. the more nutrients and moisture
Nutrient Level	Measure ammonium, nitrate, or phosphate lvl	Higher nutrient levels = more plant growth. Low level could indicate acidic soil, deple

SUGGESTED SKILL

Scientific Experiments

4.C

Describe an aspect of a research method, design, and/or measure used.

4.3 Practice FRQ

Identify and **describe** one test that can be conducted on a soil sample.

Explain how the results of the test could allow you to give advice to a farmer trying to grow crops in the soil.

4.4

Atmosphere

Objectives, EKs, and Skill

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

LEARNING OBJECTIVE

ERT-4.D

Describe the structure and composition of the Earth's atmosphere.

ESSENTIAL KNOWLEDGE

ERT-4.D.1

The atmosphere is made up of major gases, each with its own relative abundance.

ERT-4.D.2

The layers of the atmosphere are based on temperature gradients and include the troposphere, stratosphere, mesosphere, thermosphere, and exosphere.

Gasses of Earth's Atmosphere

Nitrogen ~ 78%

Mostly in the form of N_2 (unuseable to plants without being fixed)

Oxygen ~ 21%

Produced by photosynthesis in plants & needed for human/animal respiration

Argon ~ 0.93%

Inert, noble gas

Water Vapor ~ 0-4%

Varies by region & conditions; acts as a temporary GHG, but less concerning than CO_2

Quickly cycles through atm

CO_2 ~ 0.04%

Most important GHG; leads to global warming

Removed from atm. by photosynthesis

Characteristics of Layers

Exosphere: Outermost layer where atm. merges with space

Thermosphere: Therm = hottest temp;

- absorbs harmful X-rays & UV radiation
- charged gas molecules glow under intense solar radiation producing northern lights (*aurora borealis*)

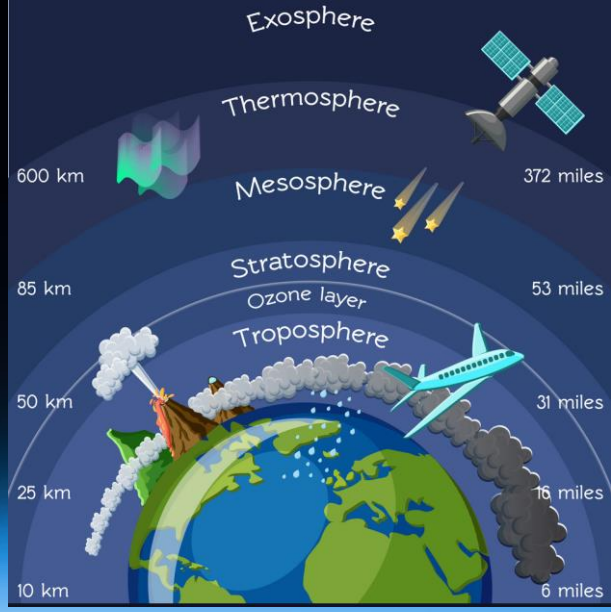
Mesosphere: Meso = for middle; 60-80 km, even less dense

Stratosphere: "S" for second - 16-60 km; less dense due to less pressure from layers above

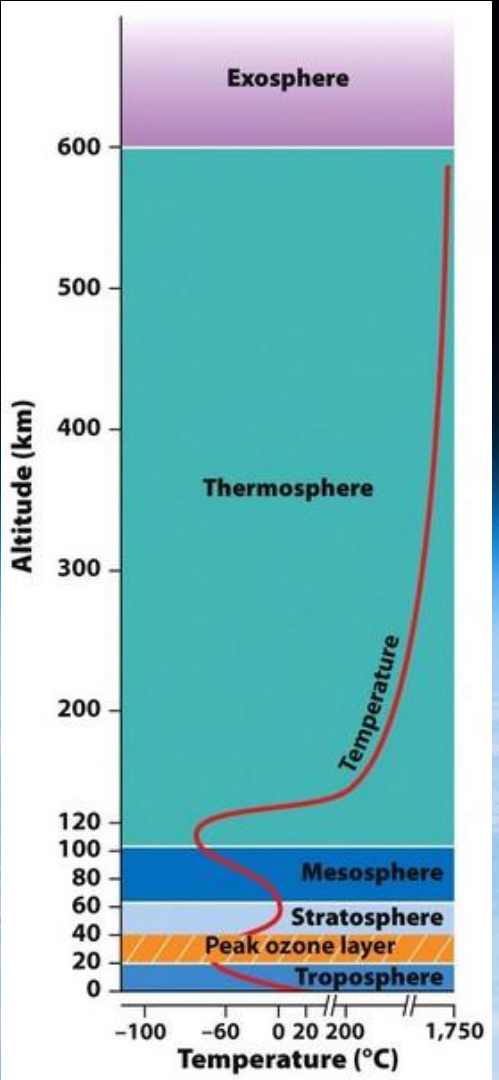
- Thickest O_3 layer is found here; absorbs UV-B & UV-C rays which can mutate DNA of animals (cancer)

Troposphere: Tropo = change (weather occurs here) - 0-16 km, most dense due to pressure of other layers above it

- Most of atmosphere's gas molecules are found here
- Ozone (O_3) in the troposphere is harmful to humans (respiratory irritant) & damages plant stomata, and forms smog



Temperature Gradient



Layers of earth's atm. are based on where temp. gradients change with distance from earth's surface

Thermosphere: temp. Increases due to absorption of highly energetic solar radiation

- Hottest place on earth (3,100°F)

Mesosphere: temp. decreases because density decreases, leaving fewer molecules to absorb sun

- Coldest place on earth (-150°F)

Stratosphere: temp. increases because top layer of stratosphere is warmed by UV rays (like pool surface)

Troposphere: temp. decreases as air gets further from warmth of earth's surface

SUGGESTED SKILL

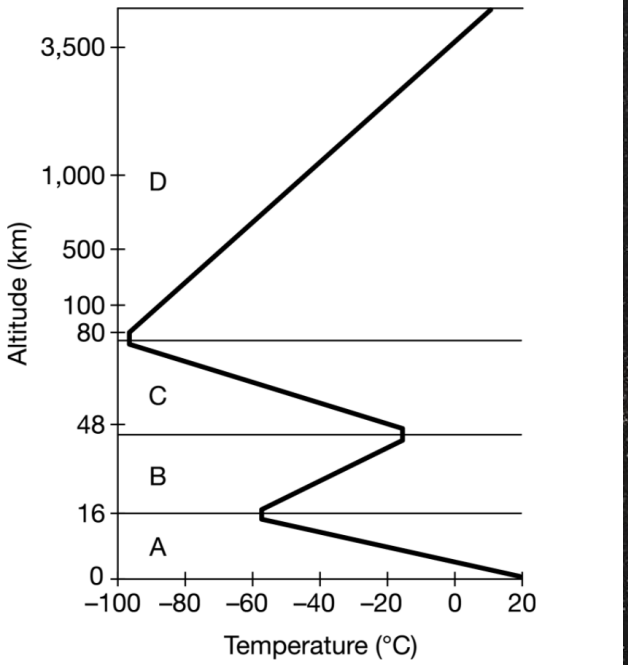
Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

FRQ 4.4 Practice

Identify a layer of earth from the diagram that has an inverse relationship between temperature and altitude. **Describe** why this occurs.



4.5 Global Wind Patterns

Objectives, EKs & Skill

LEARNING OBJECTIVE

ERT-4.E

Explain how environmental factors can result in atmospheric circulation.

ESSENTIAL KNOWLEDGE

ERT-4.E.1

Global wind patterns primarily result from the most intense solar radiation arriving at the equator, resulting in density differences and the Coriolis effect.

SUGGESTED SKILL

Visual Representations

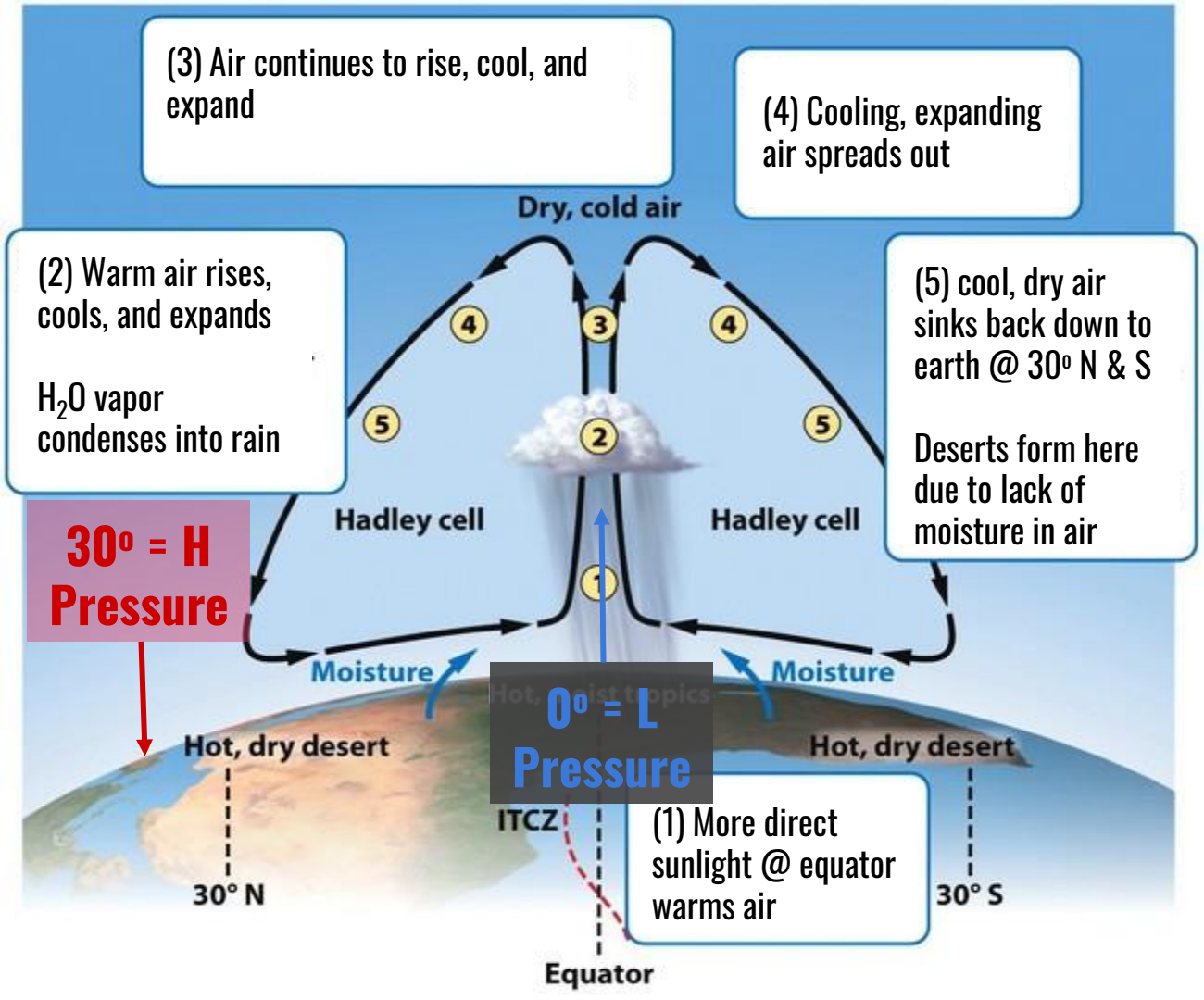
2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

Atmospheric Circulation =

1. Energy from Sunlight
2. Density properties of air
3. Rotation of earth (coriolis effect)

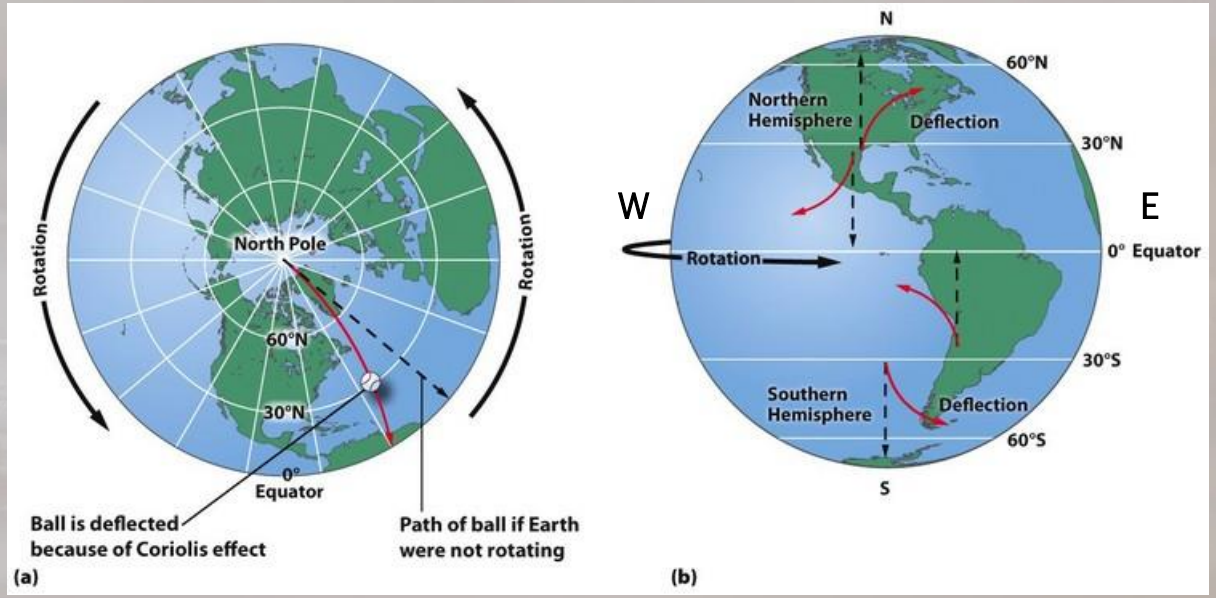


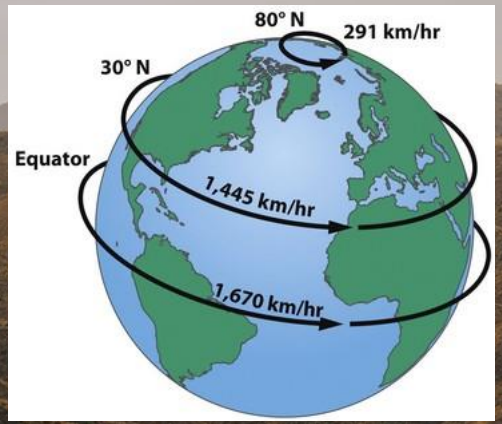
Air Properties

- Warm air rises
- Warm air holds more moisture than cold
- Rising air expands & cools
- Cool air can't hold as much H_2O vapor (condenses → rain)
- After cooling & expanding, air sinks

Coriolis Effect

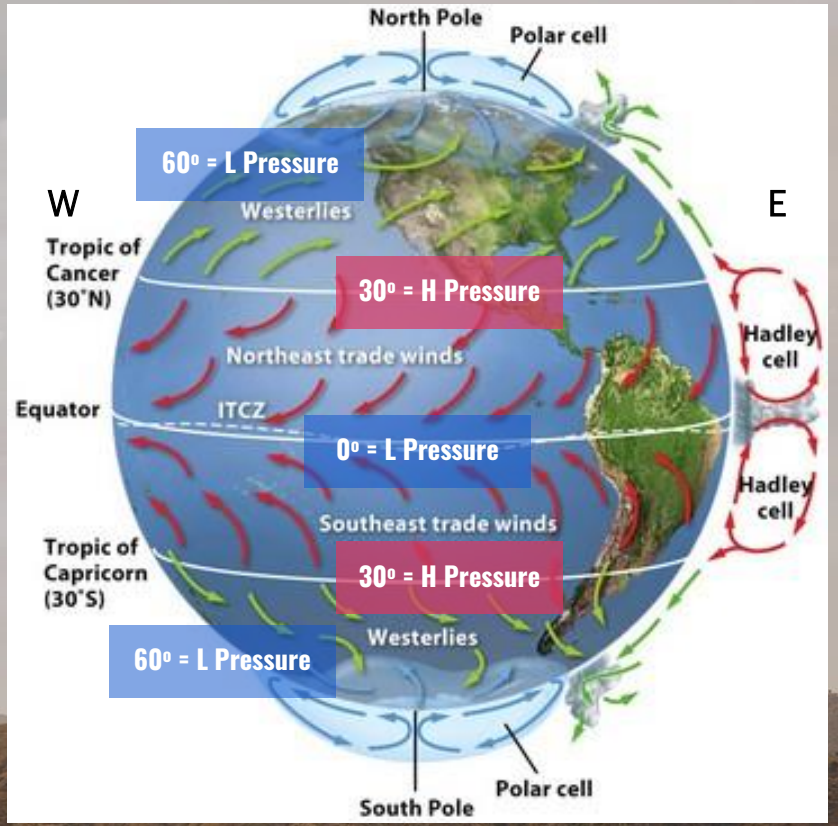
- Deflection of objects traveling through atm. due to spin of earth
- Air @ 30^{0} moves back to L pressure of equator
- Wind between 0-30^{0} moves from E→ W
  - b/c earth is spinning W→ E
- Wind between 30^{0}-60^{0} moves W→ E
  - b/c earth spins faster @ 30^{0} than 60^{0}





Global Wind Patterns

1. Air moves out from 30º to 0º and 60º due to H pressure @ 30º & L pressure @ 0 & 60
    a. Air rising @ equator = low pressure, air sinking down @ 30º = high pressure
2. 0º - 30 winds blow E → W (Eastern trade)
    a. Drives ocean current clockwise in N hemisphere, counterclockwise in S hem.
3. 30º - 60º: winds blow W→ E (Westerlies)
    a. Drives weather patterns of N America



SUGGESTED SKILL

Visual Representations

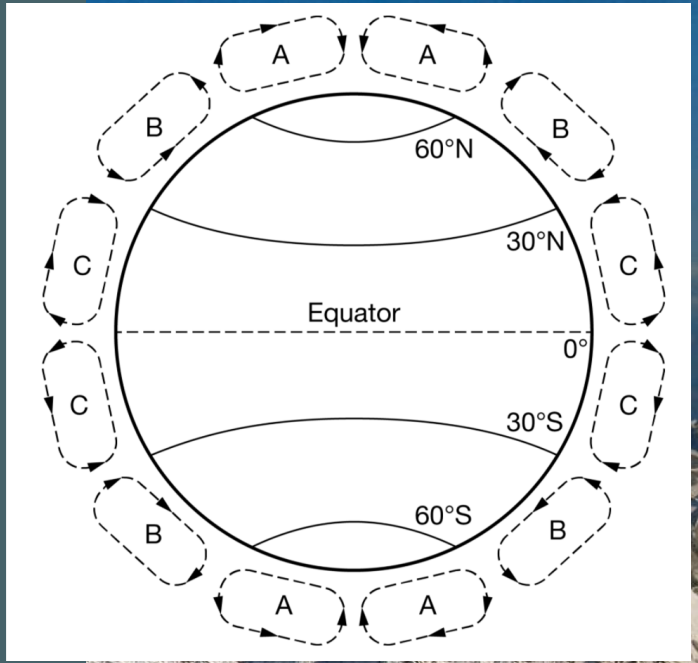
2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

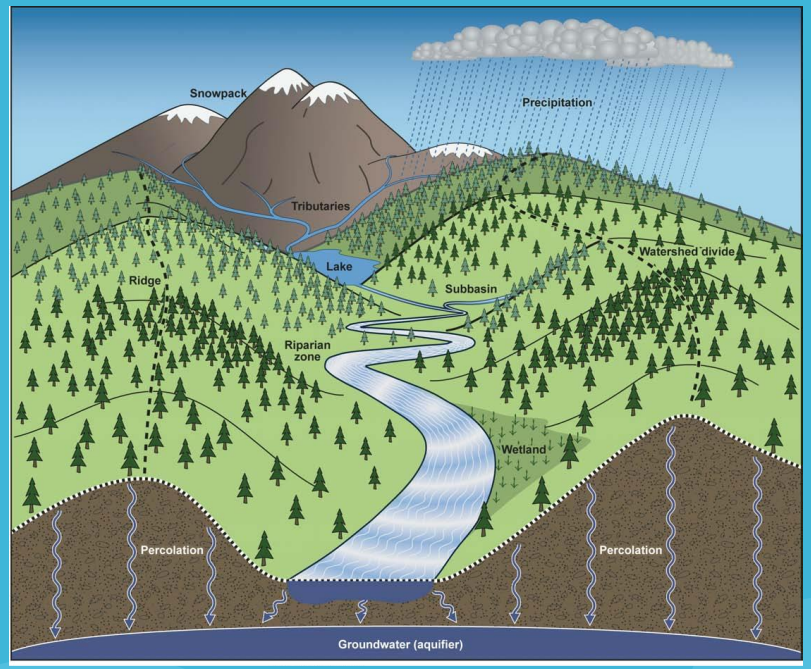
Practice FRQ 4.5

Explain how the sun is responsible for the pattern of air circulation seen in cycle C.



4.6

Watersheds



Objective/EKs/Skill

LEARNING OBJECTIVE

ERT-4.F

Describe the characteristics of a watershed.

ESSENTIAL KNOWLEDGE

ERT-4.F.1

Characteristics of a given watershed include its area, length, slope, soil, vegetation types, and divides with adjoining watersheds.

SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

Watersheds

⚠ All of the land that drains into a specific body of water (river, lake, bay, etc.)

- Determined by slope; ridges of land divide watersheds (diff. runoff directions)
- Vegetation, soil composition, slope play a large role in how watersheds drain
  - More vegetation = more infiltration & groundwater recharge
  - Greater slope = faster velocity of runoff & more soil erosion
  - Soil permeability determines runoff vs. infiltration rates

⚠ Human activities of a watershed impact H_2O quality
Ex: ag, clearcutting, urbanization, dams, mining

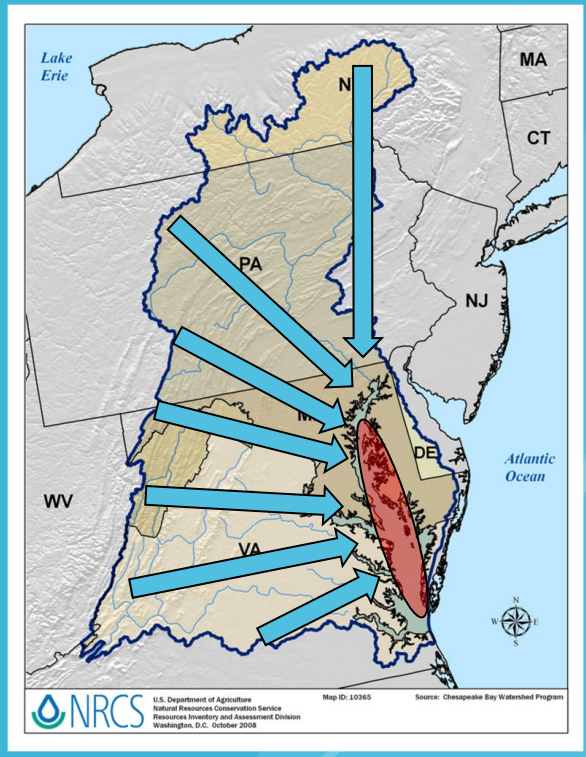
Chesapeake Bay Watershed

6 state region that drains into a series of streams/rivers & eventually into Chesapeake Bay

- Mix of fresh & salt water + nutrients in sediment make estuary habitats like the salt marshes in the bay highly productive

💰 **Estuaries & wetlands provide ecosystem services:**

- Tourism revenue – hotels, restaurants, permits
- Water filtration (grass roots trap pollutants)
- Habitats for food sources (fish & crabs)
- Storm protection (absorbing & buffering floods)



Human Impacts on Chesapeake Bay

⚠ Nutrient pollution (N & P) leads to eutrophication in the Bay

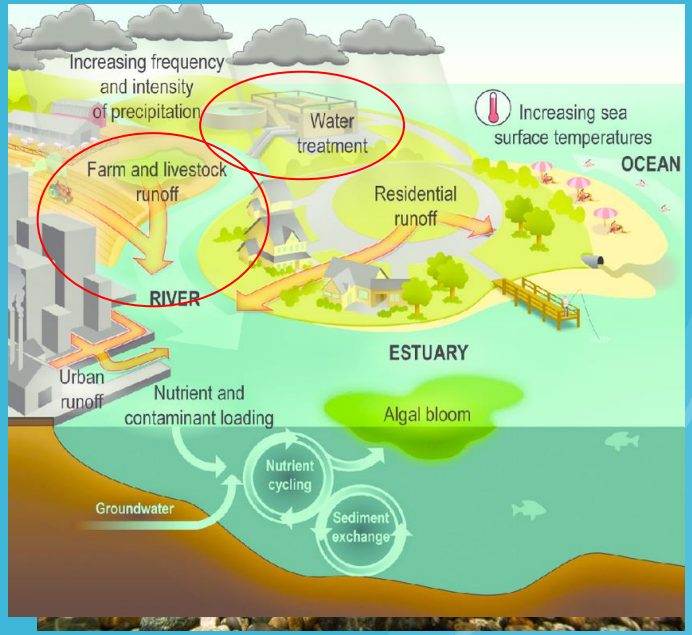
- Algae bloom due to increase of N/P → decreased sunlight → plants below surface die → bacteria use up O_2 for decomp. → hypoxia (low O_2) & dead zones

⚠ Major N/P sources:

1) Discharge from sewage treatment plants (N/P levels from human waste)
2) Animal waste from CAFOS
3) Synthetic fertilizer from ag. fields & lawns

Other major pollutants:

- Endocrine disruptors (from sewage treatment)
- Sediment pollution (deforestation, urbanization, tilling ag. fields)
  - Increases turbidity (reduced photosynth) & covers over rocky streambed habitats



Effects of Clearcutting on Watersheds

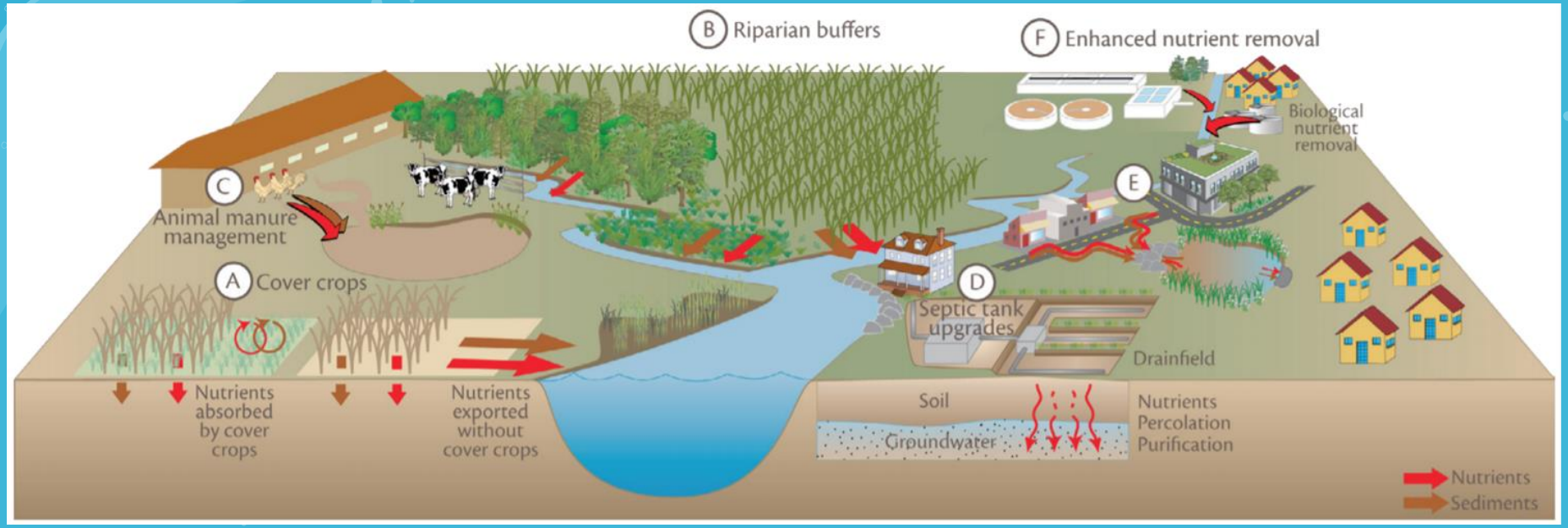
Soil Erosion

- Caused by loss of stabilizing root structure
- Removes soil organic matter & nutrients from forest
- Deposits sediments in local streams
  - Warms water & makes it more turbid (cloudy)

Increased soil & stream temp.

- Loss of tree shade increases soil temperature
  - Soil has lower albedo than leaves of trees
- Loss of tree shade along rivers & streams warms them
  - Erosion of sediments into rivers also warms them

Solutions to Watershed Pollutants



Practice FRQ 4.6

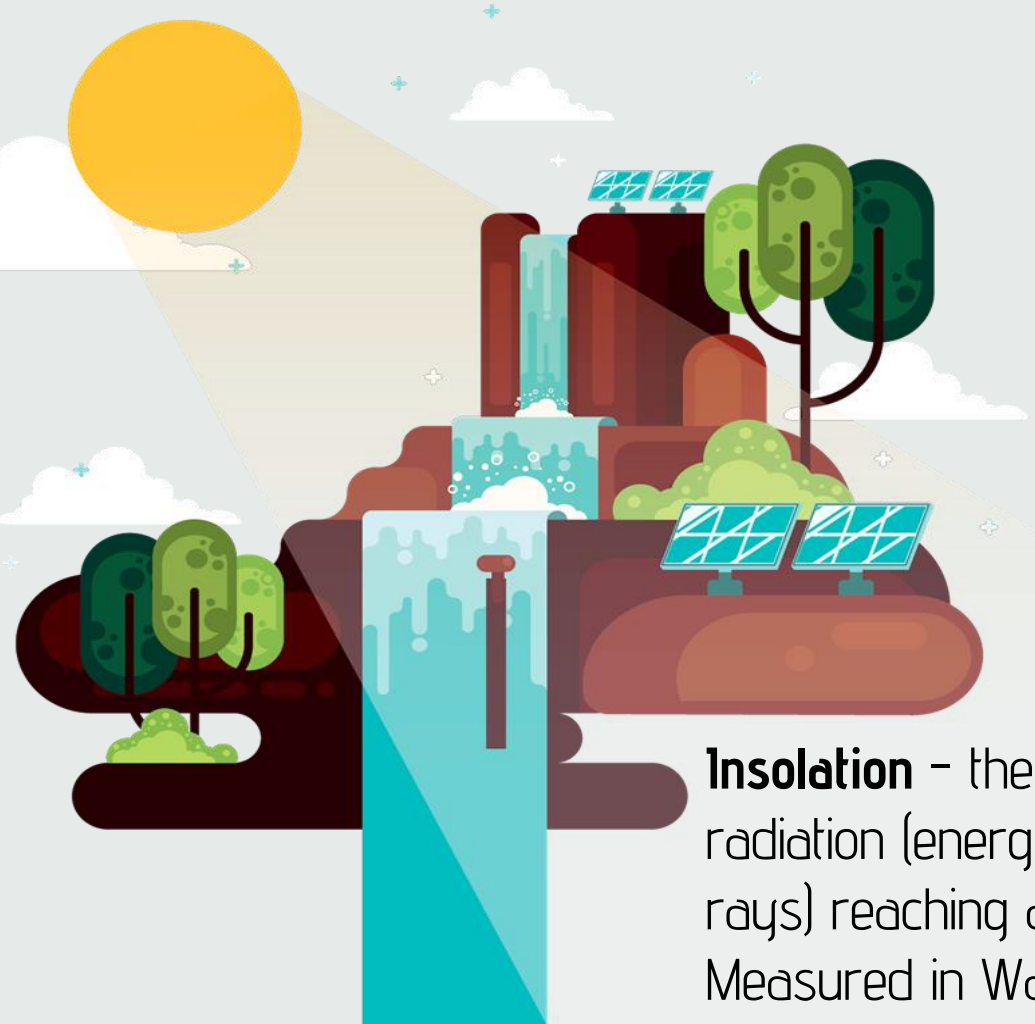
SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

Deforestation can affect water quality. **Identify** one change that can occur in the water quality of streams within a watershed that has been deforested. **Explain** how deforestation can lead to this change.



4.7

Solar Radiation & Earth's Seasons

Insolation – the amount of solar radiation (energy from sun's rays) reaching an area
Measured in Watts/m^2

Objectives, EKs & Skill

LEARNING OBJECTIVE

ENG-2.A

Explain how the sun's energy affects the Earth's surface.

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

ESSENTIAL KNOWLEDGE

ENG-2.A.1

Incoming solar radiation (insolation) is the Earth's main source of energy and is dependent on season and latitude.

ENG-2.A.2

The angle of the sun's rays determines the intensity of the solar radiation. Due to the shape of the Earth, the latitude that is directly horizontal to the solar radiation receives the most intensity.

ENG-2.A.3

The highest solar radiation per unit area is received at the equator and decreases toward the poles.

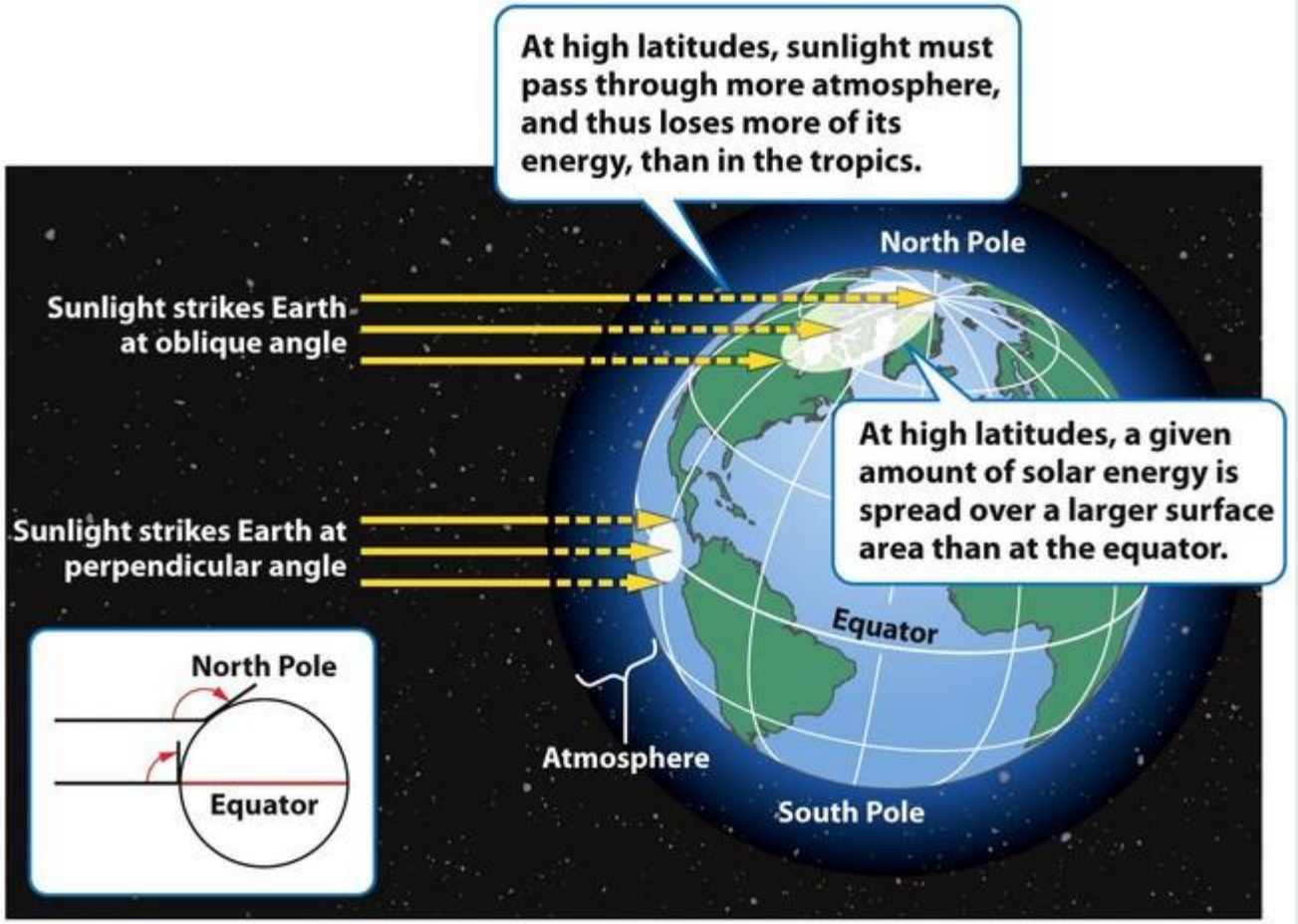
ENG-2.A.4

The solar radiation received at a location on the Earth's surface varies seasonally, with the most radiation received during the location's longest summer day and the least on the shortest winter day.

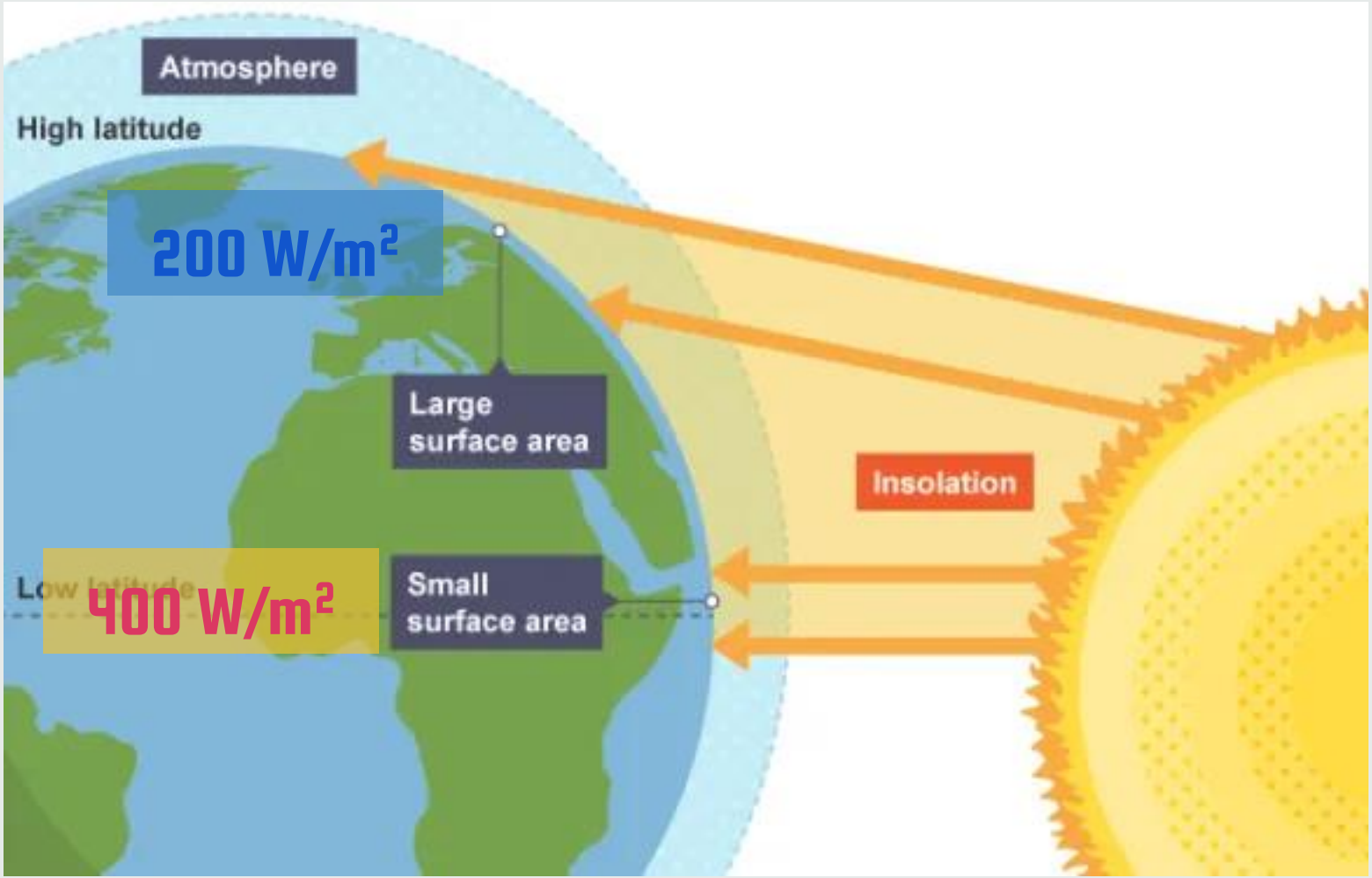
ENG-2.A.5

The tilt of Earth's axis of rotation causes the Earth's seasons and the number of hours of daylight in a particular location on the Earth's surface.

Solar Intensity & Latitude

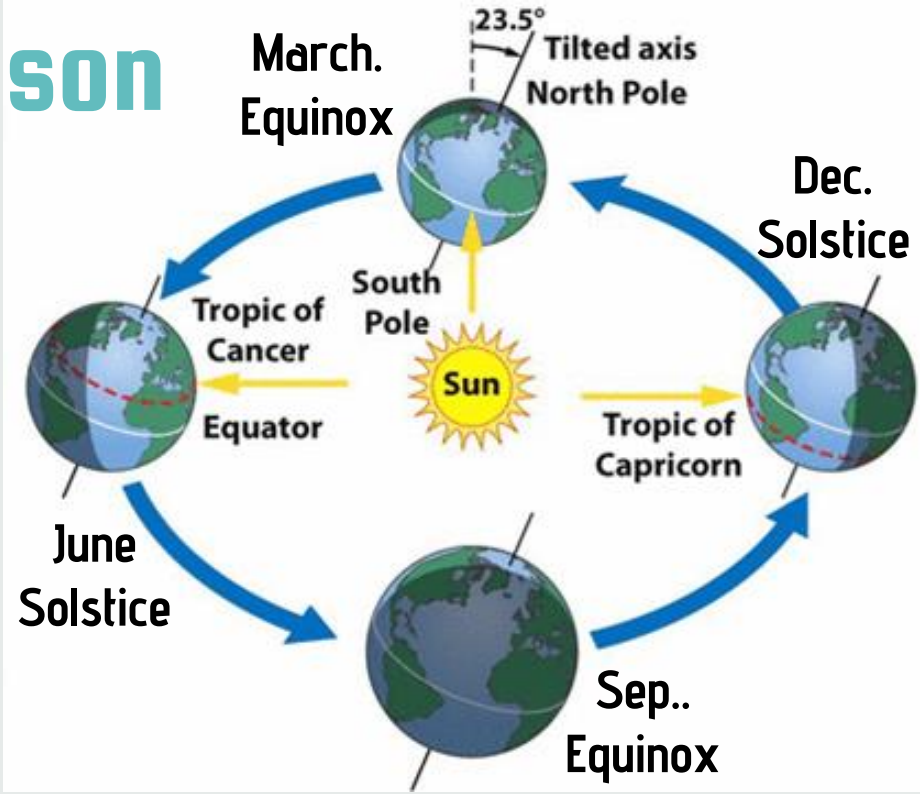


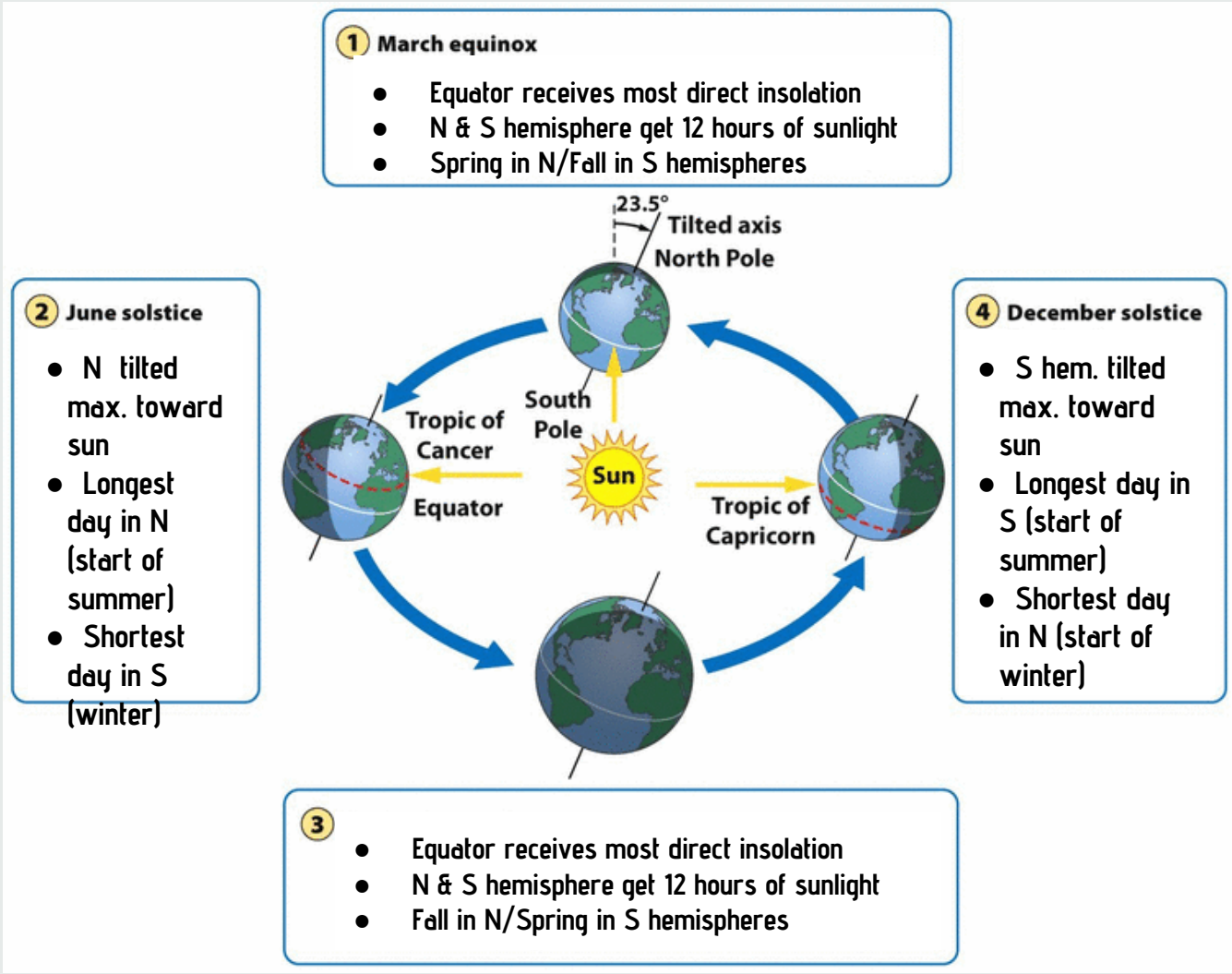
- Solar intensity of insolation (W/m^2) depends on:
  a. **Angle**: how directly rays strike earth's surface
  b. The amount of **atmosphere** sun's rays pass through
- Equator = higher insolation than higher latitudes


Atmosphere
High latitude
200 W/m²
Large surface area
Insolation
Low latitude
400 W/m²
Small surface area

Solar Intensity & Season

- Orbit of earth around sun & tilt on axis changes angle of sun's rays
- This causes varying insolation, varying length of day, and seasons
- Tilt of earth's axis stays fixed during orbit
    - June & December Solstices: N or S hemisphere is maximally tilted toward sun (summer/winter)
    - March & Sept. Equinox: N & S hemispheres equally facing sun



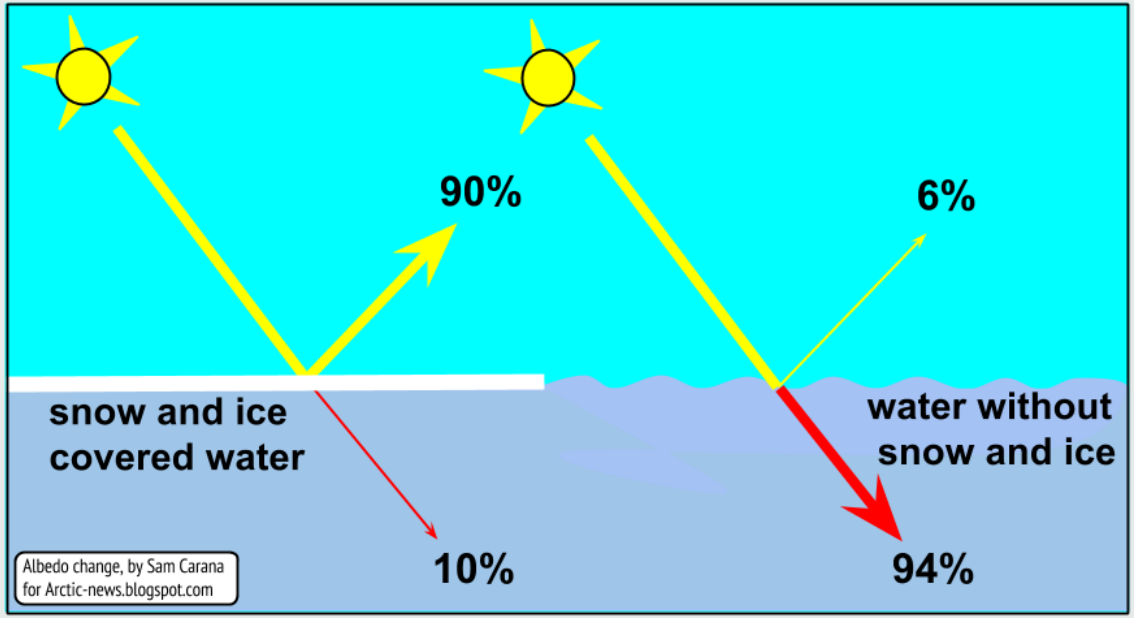


Tilt of Earth's Axis Causes Variation in:

- Angle of Insolation (which changes intensity)
- Length of day
- Season

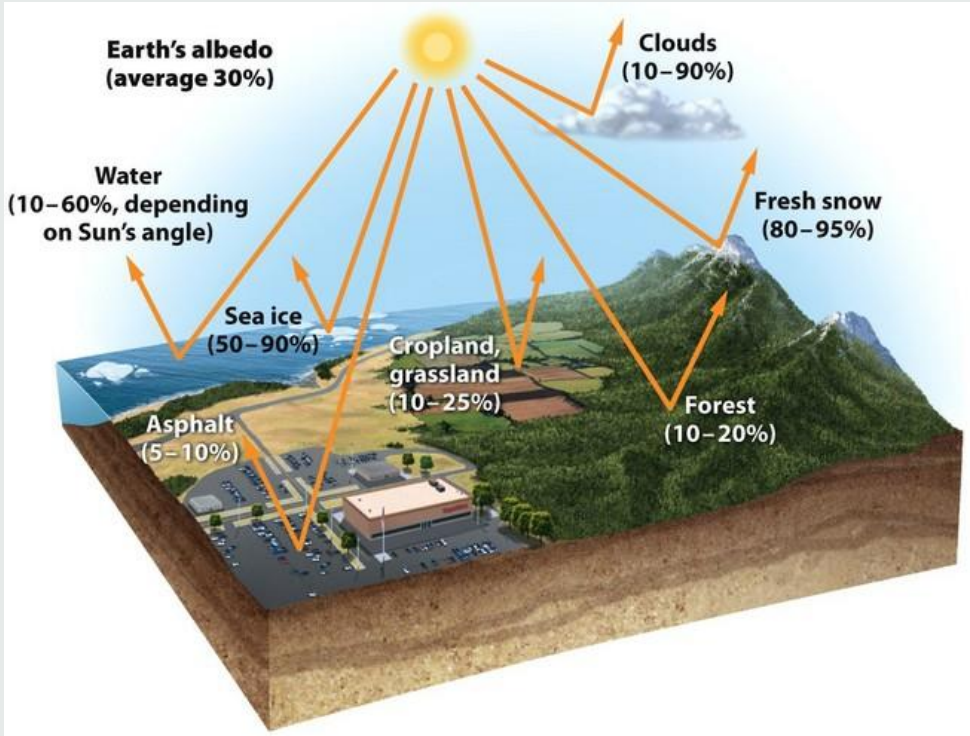
Albedo

- **Albedo**: the proportion of light that is reflected by a surface
- Surfaces with higher albedo reflect more light, and absorb less (ice/snow)
    - Absorb less heat
- Surfaces with low albedo reflect less light, and absorb more (water)
    - Absorb more heat



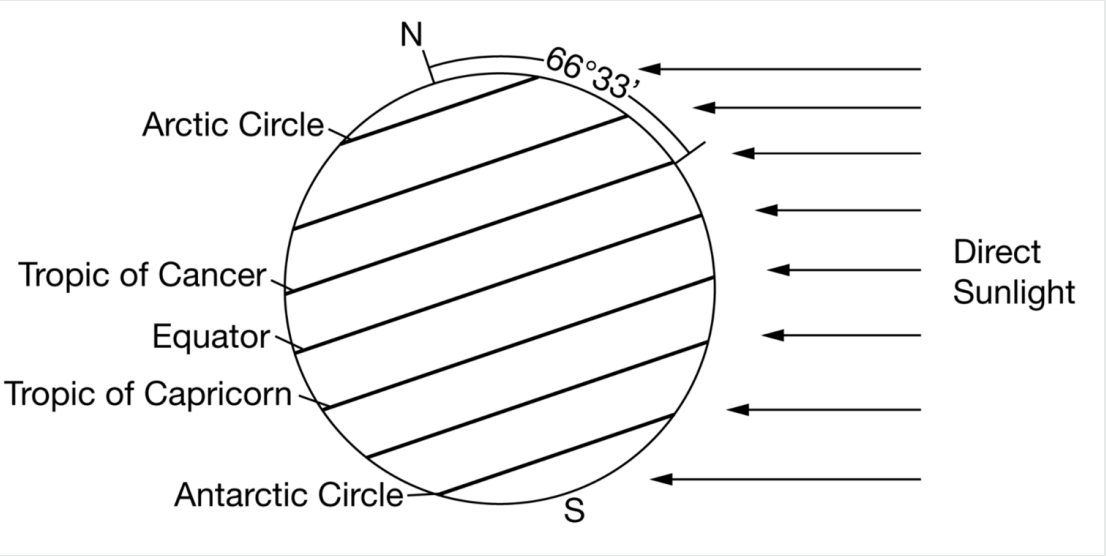
Albedo & Surface Temperature

- Surface temperature is affected by albedo
  - When sunlight is absorbed by a surface, it gives off infrared radiation (heat)
    - Areas w/lower albedo, absorb more sunlight light (heat)
  - <u>Urban Heat Island:</u> urban areas are hotter than surrounding rural area due to low albedo of blacktop
- Polar regions are colder due to higher albedo



Practice FRQ 4.7

Identify which season is taking place in the Northern hemisphere in this diagram. **Describe** how the tilt of the earth's axis is responsible for earth's seasons.



SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of an environmental concept, process, or model represented visually.

4.8
Earth's Geography & Climate

Objectives, EKs & Skill

LEARNING OBJECTIVE

ENG-2.B

Describe how the Earth's geography affects weather and climate.

ESSENTIAL KNOWLEDGE

ENG-2.B.1

Weather and climate are affected not only by the sun's energy but by geologic and geographic factors, such as mountains and ocean temperature.

ENG-2.B.2

A rain shadow is a region of land that has become drier because a higher elevation area blocks precipitation from reaching the land.

SUGGESTED SKILL

Visual Representations

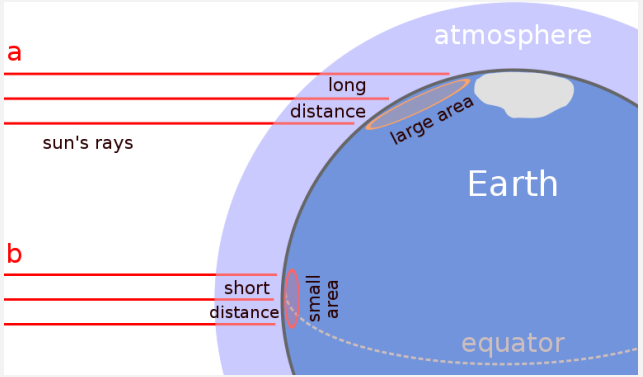
2.B

Explain relationships between different characteristics of environmental concepts, processes, or models represented visually:

- In theoretical contexts
- In applied contexts

Climate & Geography

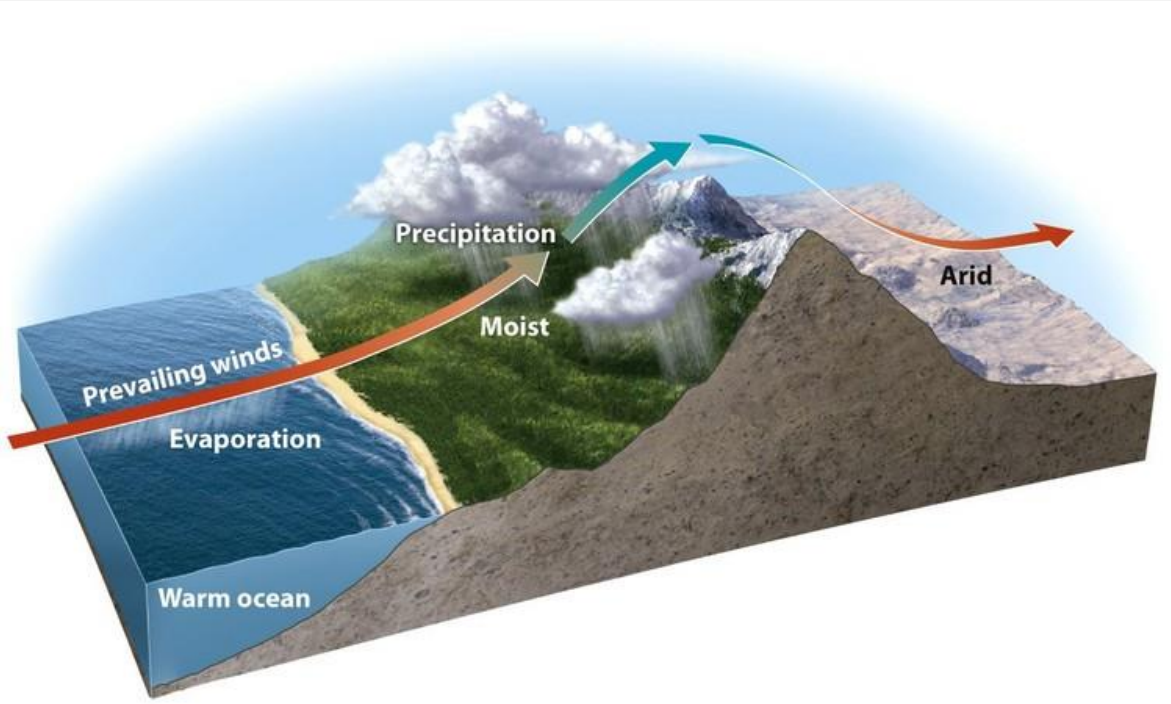
- Climate is largely determined by insolation (latitude → angle of insolation & atmosphere)
  - *Higher latitudes receive less insolation: cooler, less precipitation (especially 30º)*
  - *Equator receives most intense insolation: higher temp, air rises, high precipitation*



- Geography also plays a role
  - Mountains: disrupt wind & produce rain shadow effect
  - Oceans: moderate temperature & add moisture to the air

Rain Shadows

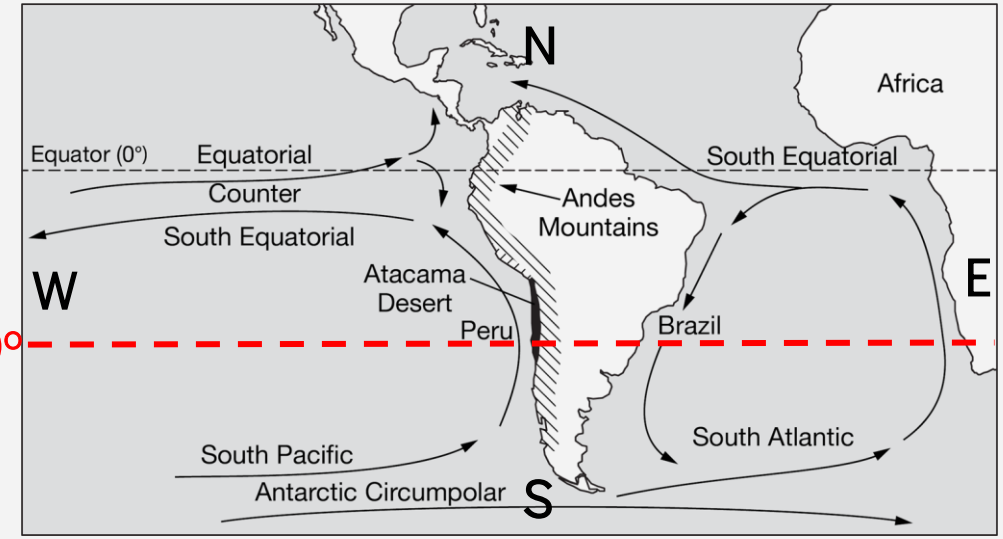
- Warm, moist air from ocean hits the “windward” side of the mtn, rises, cools (condensing H_2O vapor & causing rain) → lush, green vegetation



- Dry air descends down “leeward” side of mtn, warming as it sinks
  - Leads to arid (dry) desert conditions

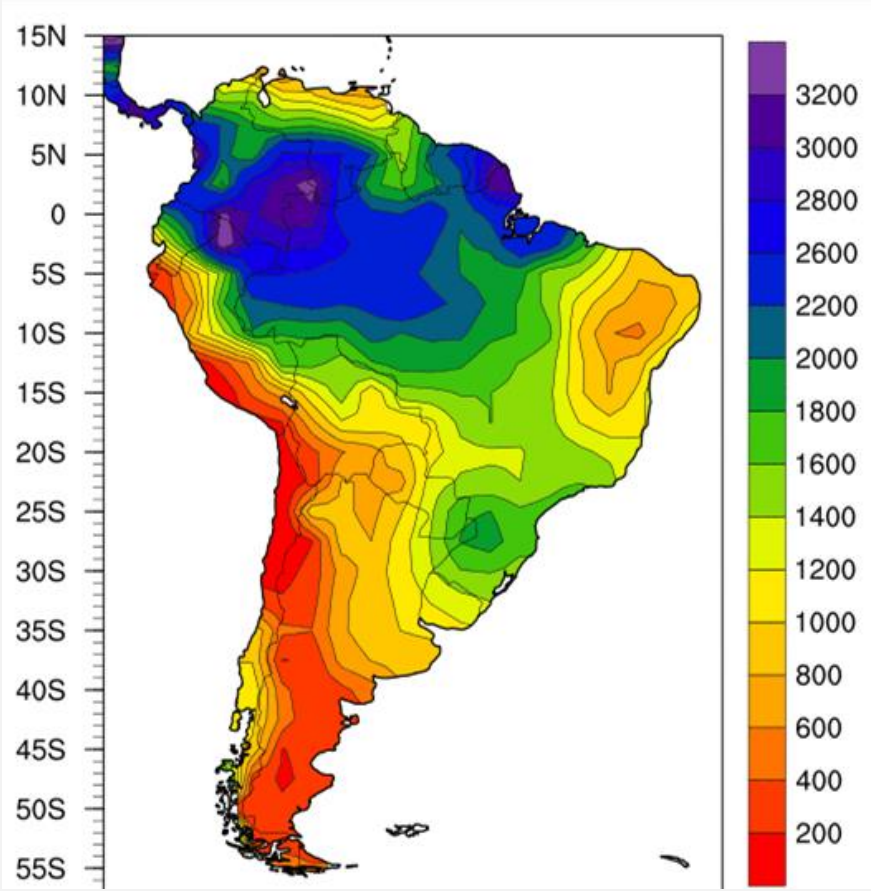
Rain Shadow Ex.

- Eastern trade winds blow moist air from Atlantic across SA
  - Windward (E) side of Andes receives heavy rainfall
  - Leeward (W) side of Andes receives arid (dry) air

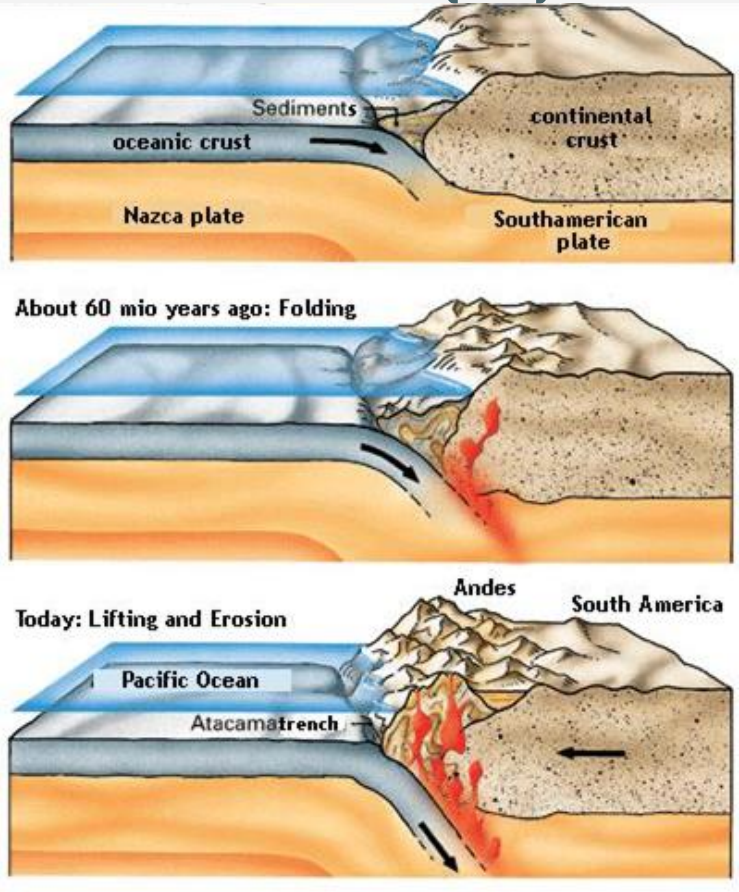


- ~30° latitude also contributes to lack of rain
  - high pressure, dry, descending air from Hadley cell

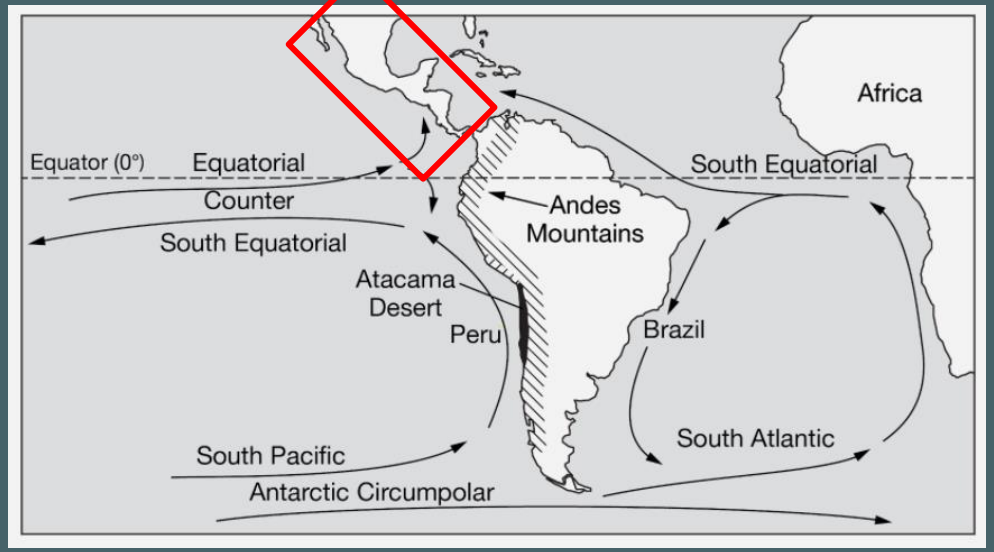
Global Wind Patterns (4.5) & Solar Radiation (4.7)



Tectonic Plate Boundaries (4.1)



Practice FRQ 4.8



Describe the regional precipitation pattern you would expect for the portion of Mexico & central America indicated on the map. **Justify** your answer

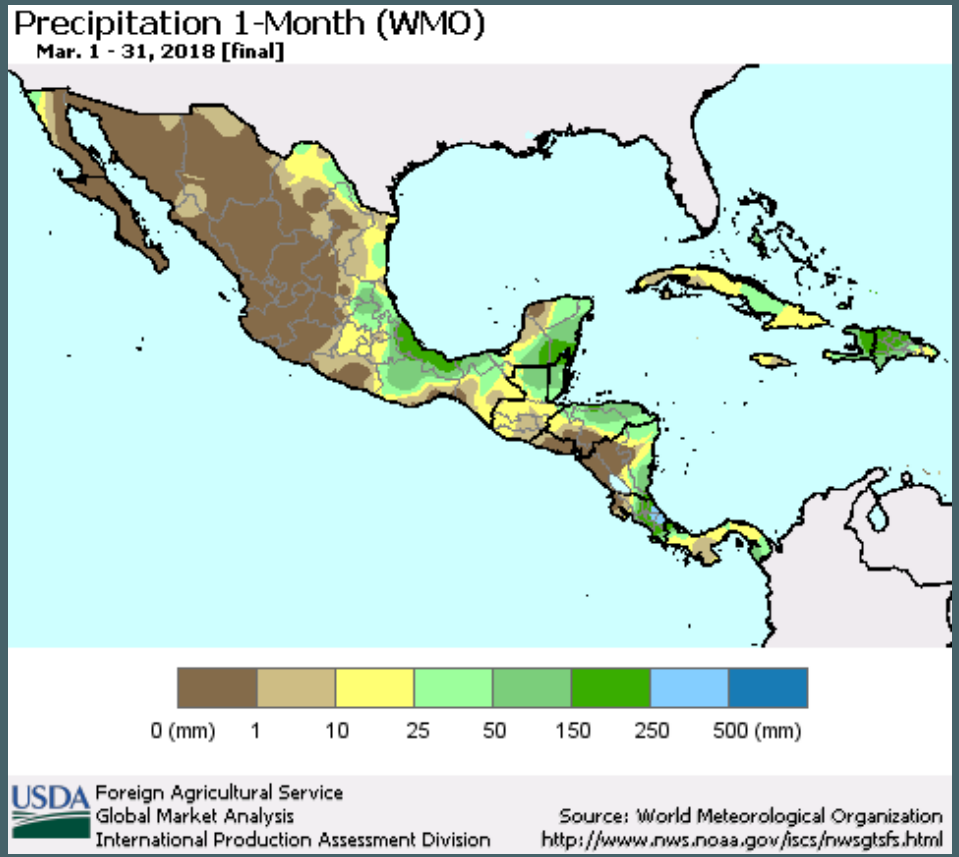
SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

Practice FRQ 4.8



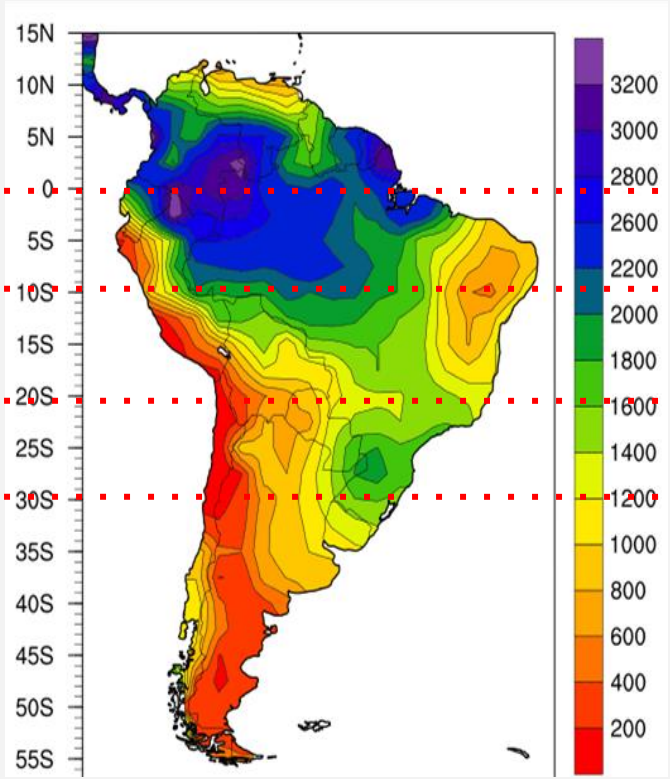
SUGGESTED SKILL

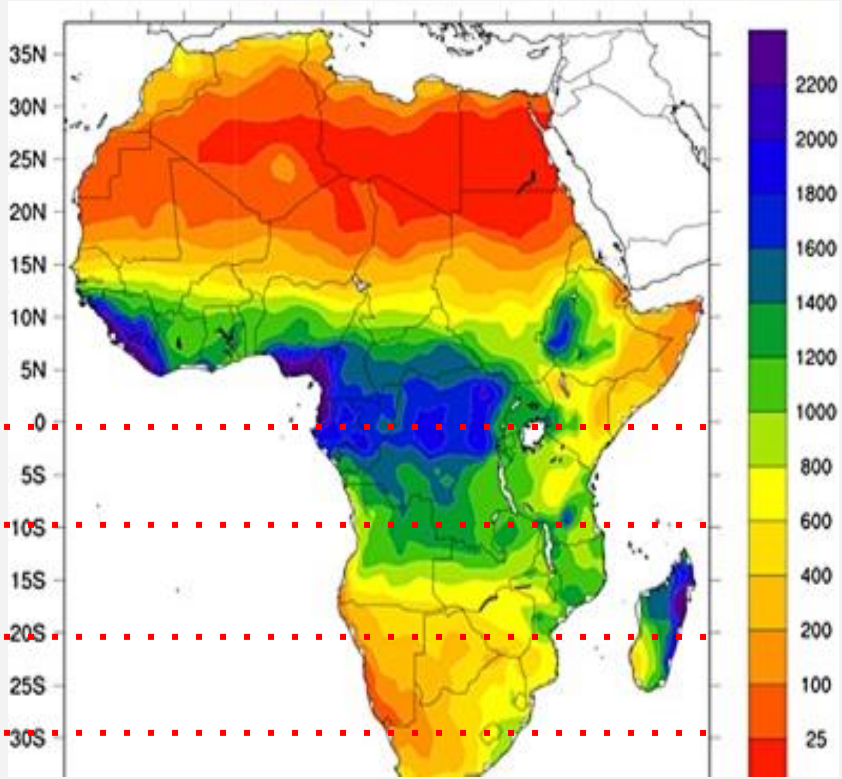
Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

Impact of Geography on Microclimate





4.9
El Nino & La Nina

Objectives, EKs, and Skills

LEARNING OBJECTIVE

ENG-2.C

Describe the environmental changes and effects that result from El Niño or La Niña events (El Niño–Southern Oscillation).

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

ESSENTIAL KNOWLEDGE

ENG-2.C.1

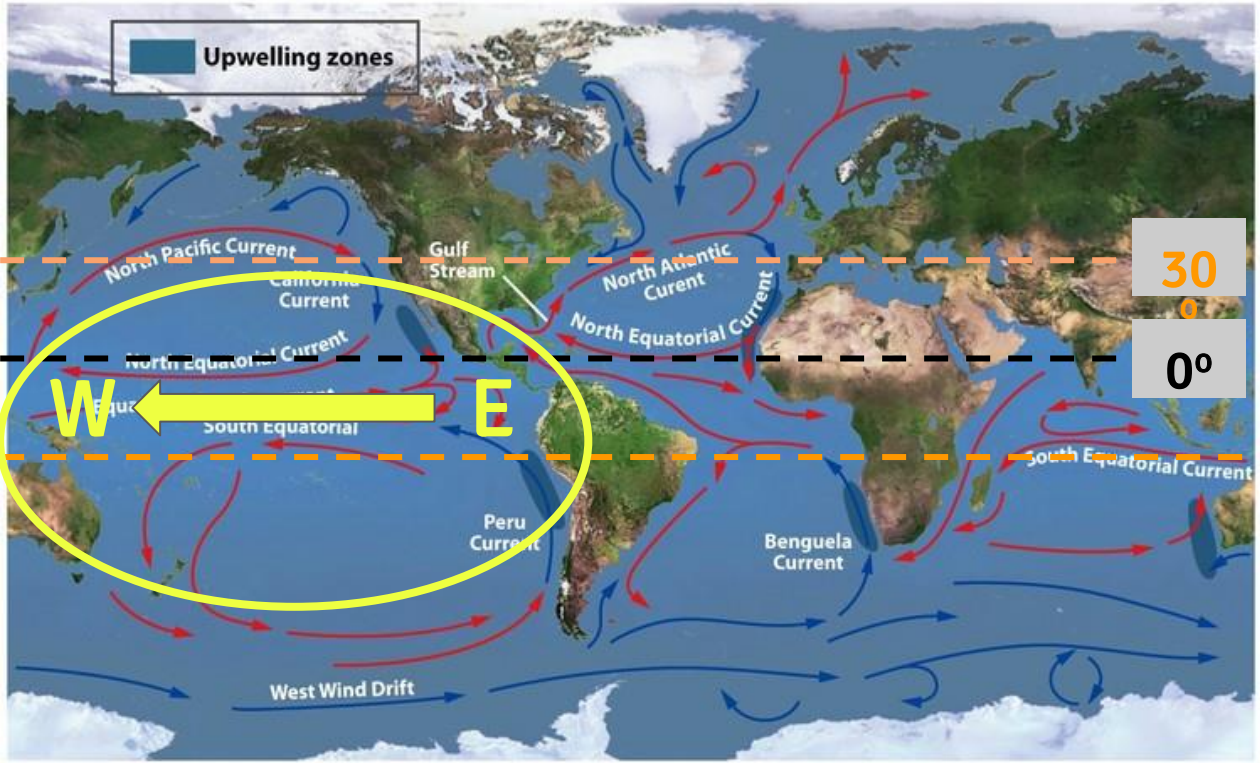
El Niño and La Niña are phenomena associated with changing ocean surface temperatures in the Pacific Ocean. These phenomena can cause global changes to rainfall, wind, and ocean circulation patterns.

ENG-2.C.2

El Niño and La Niña are influenced by geological and geographic factors and can affect different locations in different ways.

Global Ocean Surface Currents

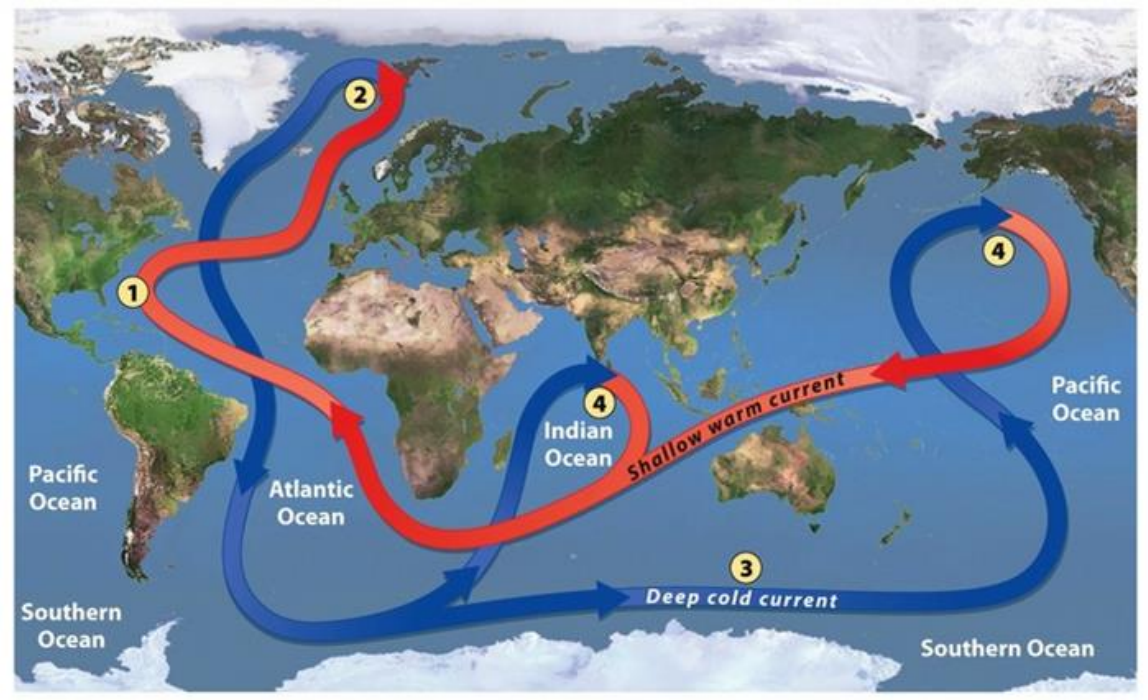
- **Gyers**: large ocean circ. patterns due to global wind
  - (clockwise in N hem, counterclockwise in S hem.)



- E→ W trade winds between 0-30° push eq. current E → W
- Westerlies between 30-60° push mid lat. currents W→ E
- **Upwelling Zones**: areas of ocean where winds blow warm surface water away from a land mass, drawing up colder, deeper water to replace it
  - Brings O_2 & nutrients to surface → productive fishing

Thermohaline Circulation

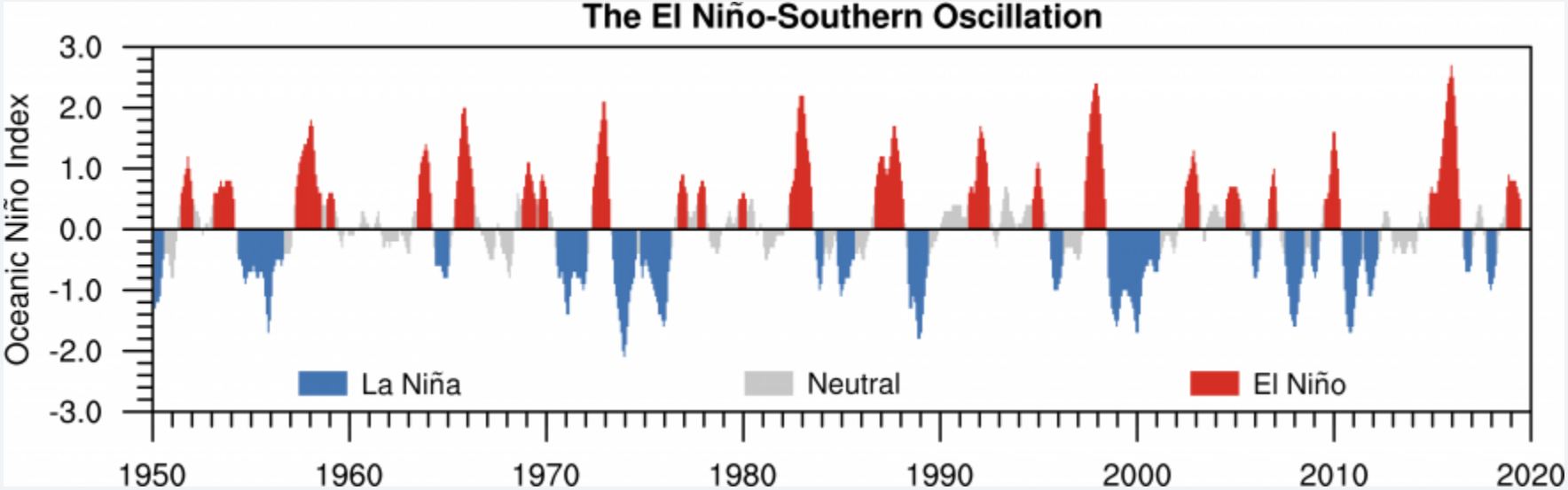
- Connects all of the world's oceans, mixing salt, nutrients, and temperature throughout

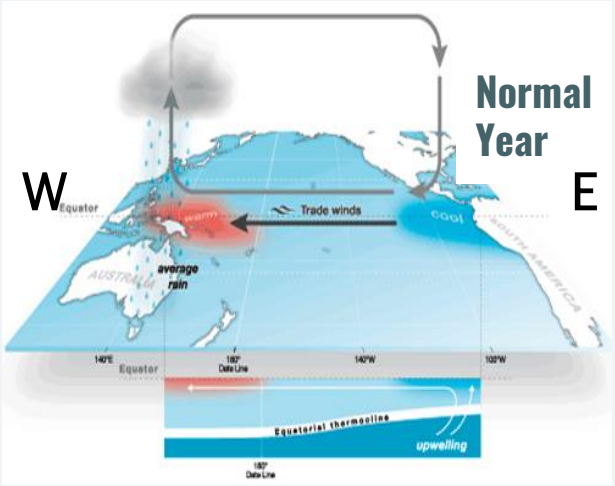


- Warm water from Gulf of Mexico moves toward North Pole
- Cools & evaporates as it moves toward poles
- Saltier & colder water @ poles, is more dense, making it sink
- Spreads along ocean floor
- Rises back up into shallow warm ocean current @ upwelling zones

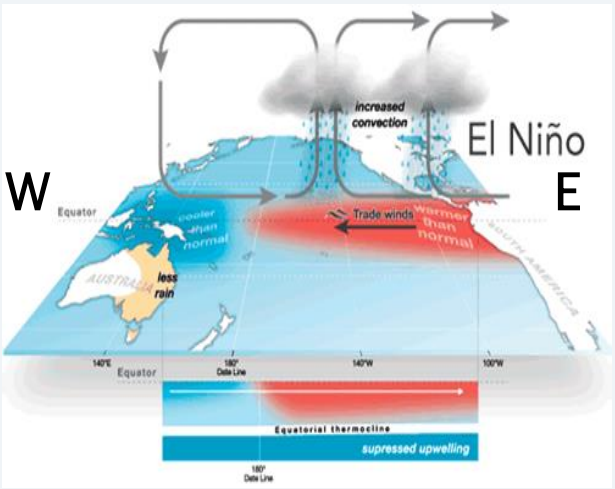
El Nino Southern Oscillation (ENSO)

- **ENSO**: pattern of shifting atmospheric pressure & ocean currents in the pacific ocean between South America and Australia/Southeast Asia
    - Oscillates, or shifts regularly from El nino (warmer, rannier) to La Nina (cooler, drier) conditions along coast of South America

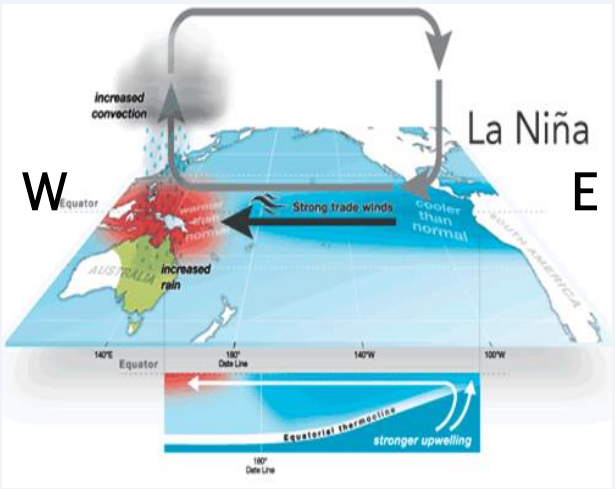




- **Trade winds blow eq. water W ← E**
- Cool H_2O upwelled off coast of SA (cool temp + good fi$herie$)
- Warm eq. current brings heat & precip. to Australia & SE Asia
- High pressure in east pacific (SA)
- Low pressure in west pacific (Australia & SE Asia)



- **Trade winds weaken, then reverse (W → E)**
- Warm eq. current brings heat & precip. to Americas (N & S)
- Suppressed upwelling off SA coast (damaging fi$herie$)
- Cooler, drier conditions in Australia & SE Asia
- H pressure in west pacific (Australia & SE Asia)
- L pressure in east pacific (SA)



- **Stronger than normal trade winds (W ← ← ← E)**
- **Increased upwelling** off SA coast brings cooler than normal conditions, extra good fi$herie$
- Warmer & rainier than normal in Australia & SE Asia

Effects of El Nino

- **Suppressed upwelling & less productive fisheries in SA**
- Warmer winter in much of N America
- Increased precip & flooding in Americas (W coast especially)
- Drought in SE Asia & Australia
- Decreased hurricane activity in Atlantic ocean
- Weakened monsoon activity in India & SE Asia

La Nina

- **Stronger upwelling & better fisheries in SA than normal**
- Worse tornado activity in US & Hurricane activity in Atlantic
- Cooler, drier weather in Americas
- Rannier, warmer, increased monsoons in SE Asia

Practice FRQ 4.9

Describe TWO environmental problems related to the conditions of an El nino event.

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.