Ecosystems 1.1
Objectives/EKs/Skills

LEARNING OBJECTIVE

ERT-1.A

Explain how the availability of resources influences species interactions.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ERT-1.A.1

In a predator-prey relationship, the predator is an organism that eats another organism (the prey).

ERT-1.A.2

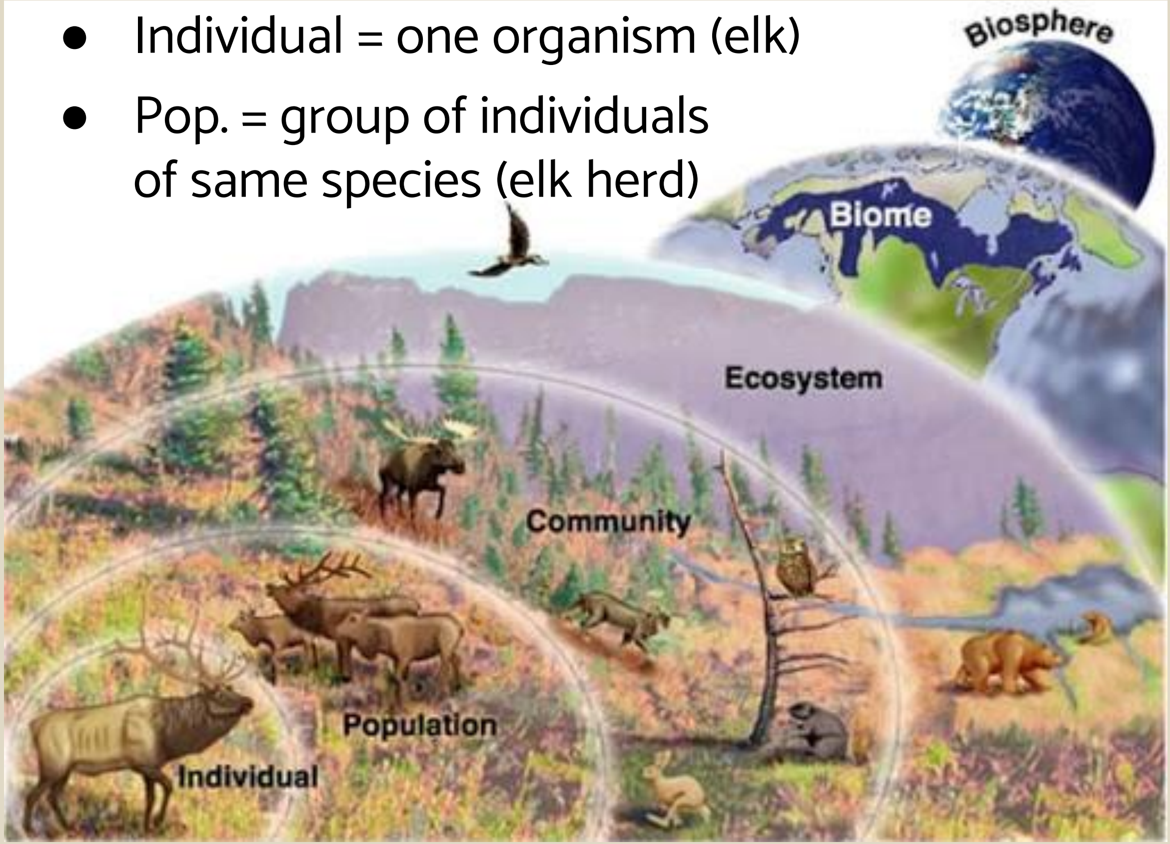
Symbiosis is a close and long-term interaction between two species in an ecosystem. Types of symbiosis include mutualism, commensalism, and parasitism.

ERT-1.A.3

Competition can occur within or between species in an ecosystem where there are limited resources. Resource partitioning—using the resources in different ways, places, or at different times—can reduce the negative impact of competition on survival.

Ecosystem Basics

- Individual = one organism (elk)
- Pop. = group of individuals of same species (elk herd)



- Community = all living organisms in an area
- Ecosystem = all living & nonliving things in an area (plants, animals, rocks, soil, water, air)

Biome = the plants and animals found in a given region (determined by climate)
Ex: (tropical rainforest)

Organism Interactions

Type of interaction	Species 1	Species 2
Competition	–	–
Predation	+	–
Mutualism	+	+
Commensalism	+	0

- **Competition**: organisms fighting over a resource like food or shelter; limits pop. size
- **Predation**: one organism using another for energy source (hunters, parasites, even herbivores)

- **Mutualism:** relationship that benefits both organisms (coral reef)
- **Commensalism:** relationship that benefits one organism & doesn't impact the other (birds nest in trees)

Predation (+/-)  

- **Herbivores:** (plant eaters) eat plants for energy (giraffe & tree)
- **True predators:** (carnivores) kill and eat prey for energy (leopard & giraffe)
- **Parasites:** use a host organism for energy, often without killing the host & often living inside host
  - Ex: mosquitoes, tapeworms, sea lamprey

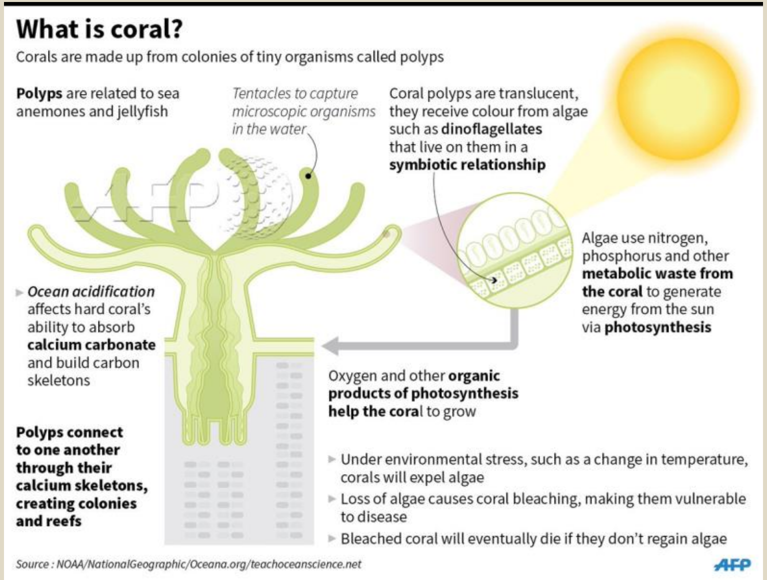
- **Parasitoids:** lay eggs inside a host organism; eggs hatch & larvae eat host for energy
  - Ex: parasitic wasps, bot fly

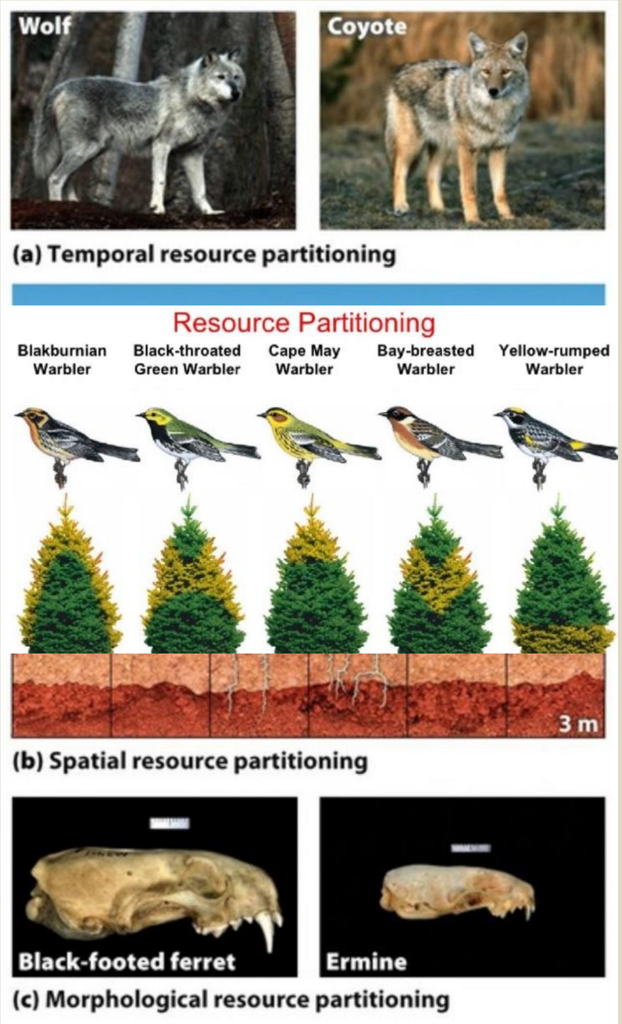
Symbiosis sym = together | bio = living | osis = condition

Any close and long-term interaction between two organisms of different species

- Mutualism (+/+), commensalism (+/0), and parasitism (+/-) are all symbiotic relationships

- **Mutualism:** Organisms of diff. species living close together in a way that benefits both
  - **Coral** (animals) provide reef structure & CO_2 for **algae**; algae provide sugars for coral to use as energy
  - **Lichen** = composite organism of fungi living with algae; algae provide sugars (energy) & fungi provides nutrients





(a) Temporal resource partitioning
(b) Spatial resource partitioning
(c) Morphological resource partitioning

Competition

Reduces pop. size since there are fewer resources available & fewer organisms can survive

- **Resource partitioning:** different species using the same resource in diff. ways to **reduce competition**
- **Temporal partitioning:** using resource @ different times, such as wolves & coyotes hunting @ different times (night vs. day)
- **Spatial partitioning:** using diff. areas of a shared habitat (diff. length roots)
- **Morphological partitioning:** using diff. resources based on diff. evolved body features

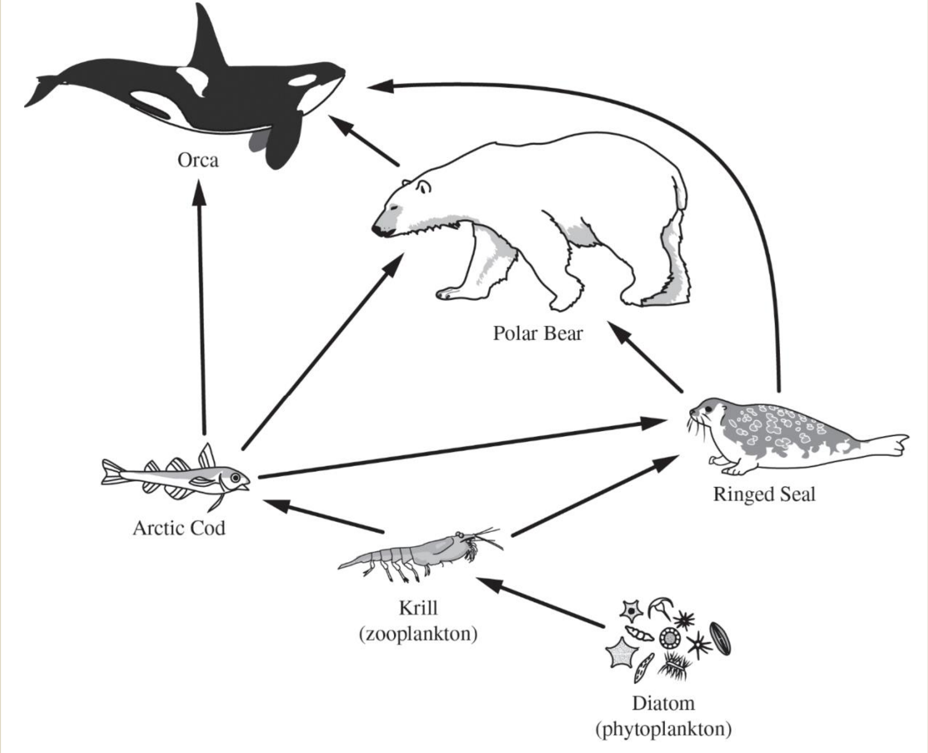
Practice FRQ 1.1

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.



Identify two organisms that compete for a shared food resource. **Describe** how resource partitioning could reduce the competition between the two organisms you identified.

1.2 Terrestrial (Land) Biomes

Objectives/Eks/Skill

LEARNING OBJECTIVE

ERT-1.B

Describe the global distribution and principal environmental aspects of terrestrial biomes.

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ERT-1.B.1

A biome contains characteristic communities of plants and animals that result from, and are adapted to, its climate.

ERT-1.B.2

Major terrestrial biomes include taiga, temperate rainforests, temperate seasonal forests, tropical rainforests, shrubland, temperate grassland, savanna, desert, and tundra.

ERT-1.B.3

The global distribution of nonmineral terrestrial natural resources, such as water and trees for lumber, varies because of some combination of climate, geography, latitude and altitude, nutrient availability, and soil.

ERT-1.B.4

The worldwide distribution of biomes is dynamic; the distribution has changed in the past and may again shift as a result of global climate changes.

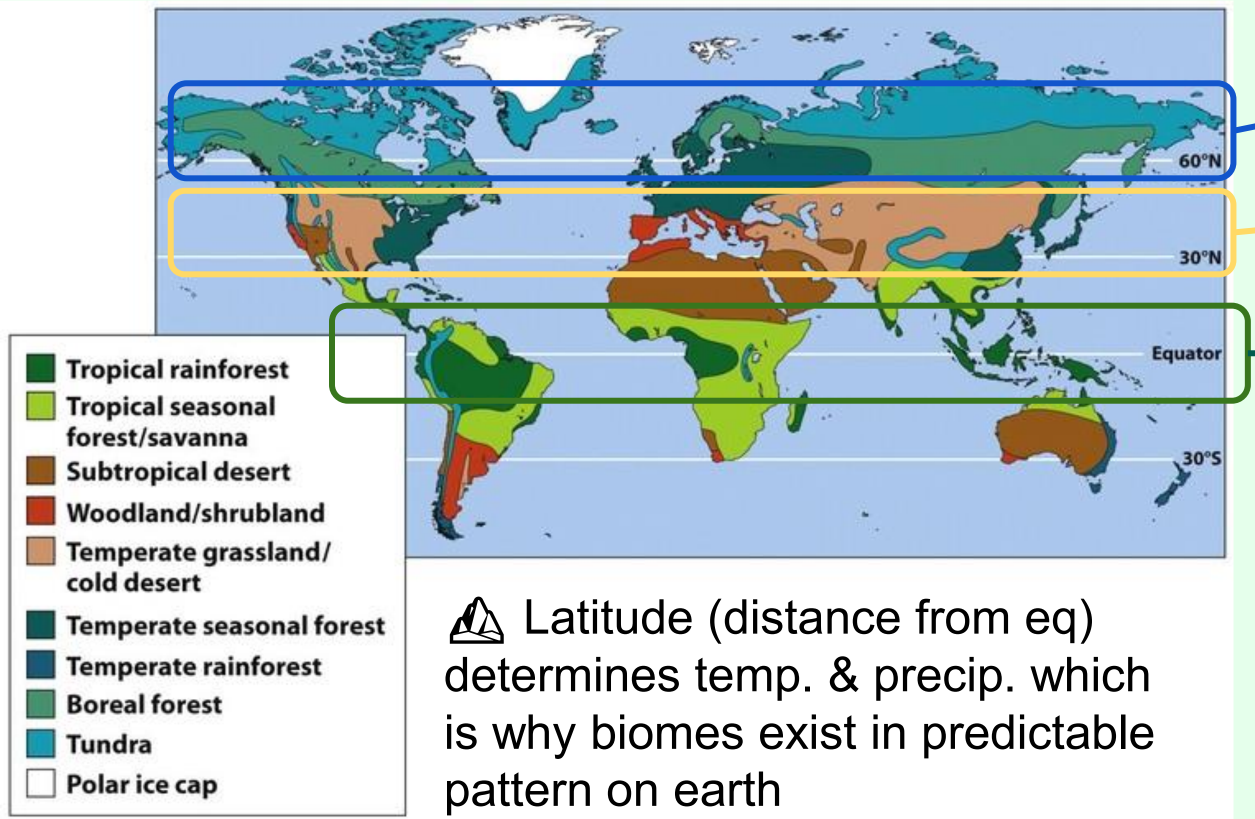
Biome: the plants & animals found in a region; based on yearly temp. + precipitation (climate)

Examples

The community of org. (plants & animals) in a biome are uniquely adapted to live in that biome

Ex: camels & cacti have water preserving traits for desert; shrubs & wildflowers store lots of energy in roots to recover quickly from fire in grasslands

Biome characteristics



⚠ Latitude (distance from eq) determines temp. & precip. which is why biomes exist in predictable pattern on earth

- Biome chart can also predict where on earth biomes are found

Biomes are defined by annual temp & precip. avg

Nutrient Availability

- **Tropical RF** = nutrient-poor soil (high competition from so many diff. plant species)
- **Boreal forest** = nutrient-poor soil (low temp. & low decomp. rate of dead org. matter)
- **Temp. forest** = nutrient-rich soil (lots of dead org. matter - leaves & warm temp/moisture for decomp.)

Plants need soil nutrients to grow, so availability determines which plants can survive in a biome

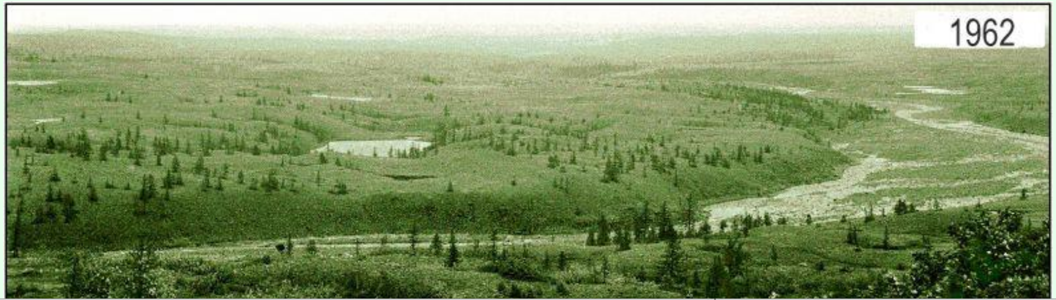
Ex: frozen soils of tundra don't allow nutrients in dead org. matter to be broken down by decomposers

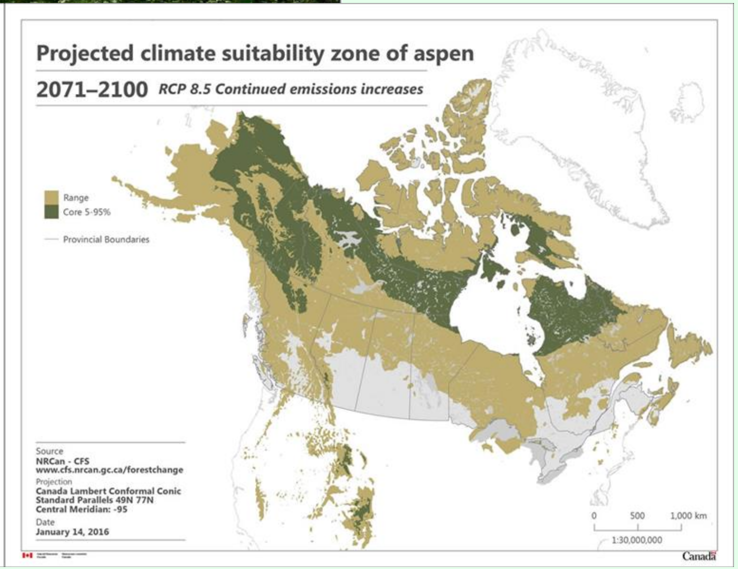
- Low soil nutrients
- Low water availability
- Few plants survive here

Shifting Biomes

Biomes shift in location on earth as climate changes

- Ex: warming climate will shift boreal forests further north as tundra permafrost soil melts & lower latitudes become too warm for aspen & spruce





Practice FRQ 1.2

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

Identify one characteristic of a biome and **explain** how that characteristic determines the community of organisms found in the biome.

1.3
Aquatic Biomes

Objective/EKs/Skill

LEARNING OBJECTIVE

ERT-1.C

Describe the global distribution and principal environmental aspects of aquatic biomes.

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ERT-1.C.1

Freshwater biomes include streams, rivers, ponds, and lakes. These freshwater biomes are a vital resource for drinking water.

ERT-1.C.2

Marine biomes include oceans, coral reefs, marshland, and estuaries. Algae in marine biomes supply a large portion of the Earth's oxygen, and also take in carbon dioxide from the atmosphere.

ERT-1.C.3

The global distribution of nonmineral marine natural resources, such as different types of fish, varies because of some combination of salinity, depth, turbidity, nutrient availability, and temperature.

Characteristics of Aquatic Biomes

Salinity

How much salt there is in a body of water, determines which species can survive & usability for drinking (Fresh water vs. estuary vs. ocean)

Depth

Influences how much sunlight can penetrate and reach plants below the surface for photosynthesis

Flow

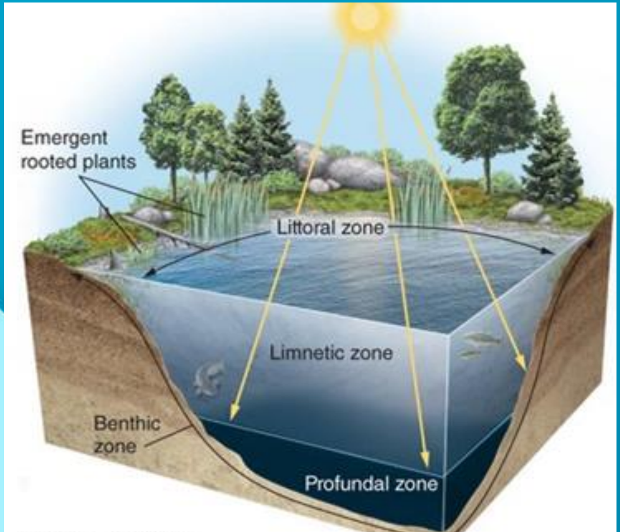
Determines which plants & organisms can survive, how much O_2 can dissolve into water

Temp.

Warmer water holds less dissolved O_2 so it can support fewer aq. organisms

Freshwater: Rivers & Lakes

- Rivers have high O_2 due to flow mixing water & air, also carry nutrient-rich sediments (deltas & flood plains = fertile soil)
    - Lakes = standing bodies of fresh H_2O (key drinking H_2O source)
        - **Littoral**: shallow water w/emergent plants
        - **Limnetic**: where light can reach (photosynth)
            - No rooted plants, only phytoplankton
        - **Profundal**: too deep for sunlight (no phots.)
        - **Benthic**: murky bottom where inverts (bugs) live, nutrient-rich sediments



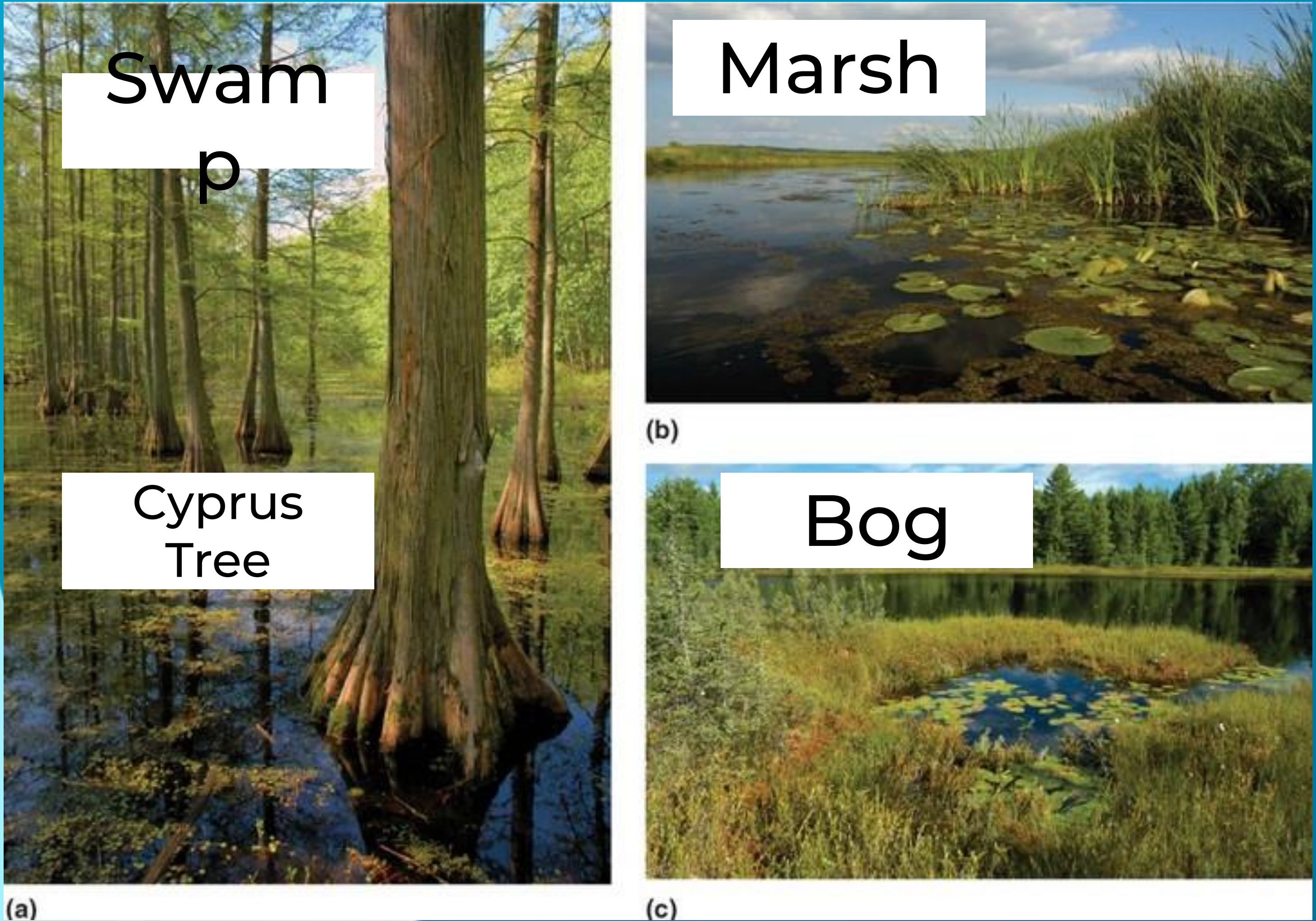
(b) Diagram of lake

Freshwater: Wetlands

- **Wetland**: area with soil submerged/saturated in water for at least part of the year, but shallow enough for emergent plants
  - Plants living here have to be ***adapted*** to living with roots submerged in standing water (cattails, lily pads, reeds)

Benefit$ of Wetland$

- ★ Stores excess water during storms, lessening floods
- ★ Recharges groundwater by absorbing rainfall into soil
- ★ Roots of wetland plants filter pollutants from water draining through
- ★ Highly plant growth due to lots of water & nutrients (dead organic matter) in sediments



Reeds &
cattails

Spruce &
sphagnum
moss

Estuaries: areas where rivers empty into the ocean

⛰ Mix of fresh & salt water (species adapt to this ex: mangrove trees)
⛰ High productivity (plant growth) due to nutrients in sediments deposited in estuaries by river

Salt Marsh:

- Estuary hab. along coast in temperate climates
- Breeding ground for many fish & shellfish species

Mangrove Swamps:

- Estuary hab. along coast of tropical climates
  - Mangrove trees with long, stilt roots stabilize shoreline & provide habitat for many species of fish & shellfish

Coral Reef

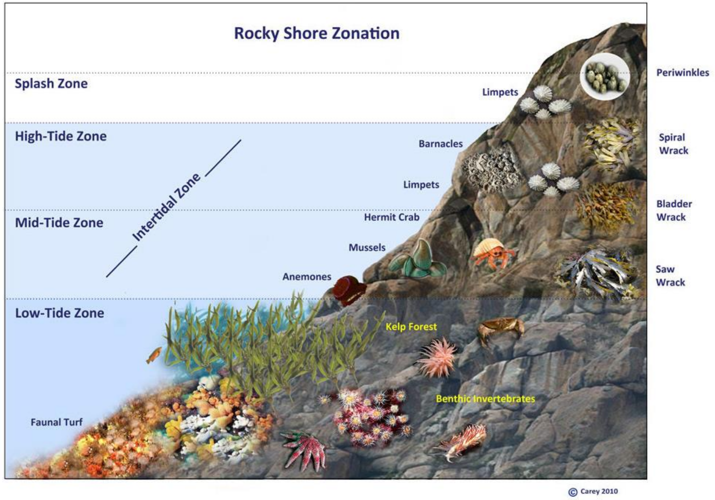
- Warm shallow waters beyond the shoreline; most diverse marine (ocean) biome on earth
- Mutualistic relationship between coral (animals) & algae (plants)
  - Coral take CO_2 out of ocean to create calcium carbonate exoskeleton (the reef) & also provide CO_2 to the algae
  - Algae live in the reef & provide sugar (energy) to the coral through photosynthesis

Both species rely on the other:

- Coral couldn't survive without energy from algae.
- Algae need the home of the reef & CO_2 from the coral

Intertidal Zones

- Narrow band of coastline between high & low tide
- Organisms must be adapted to survive crashing waves & direct sunlight/heat during low tide
  Ex: Barnacles, sea stars, crabs that can attach themselves to rocks
- Shells & tough outer skin can prevent drying out (desiccation) during low tides



Diff. organisms are adapted to live in diff. Zones

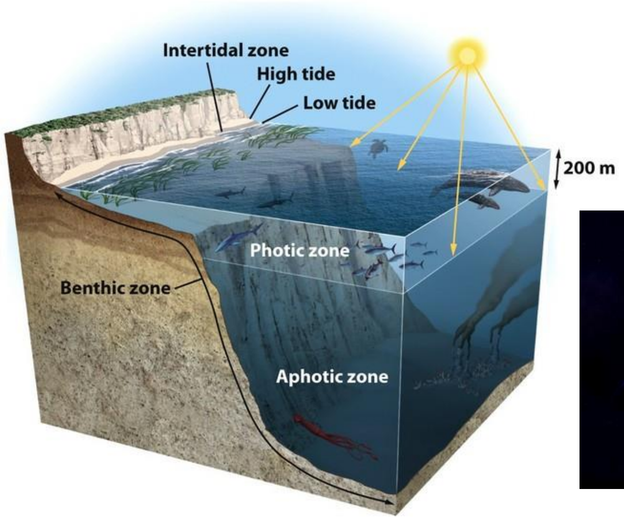
Ex: Spiral wrack (type of seaweed) curls up & secretes mucus to retain water during low tide

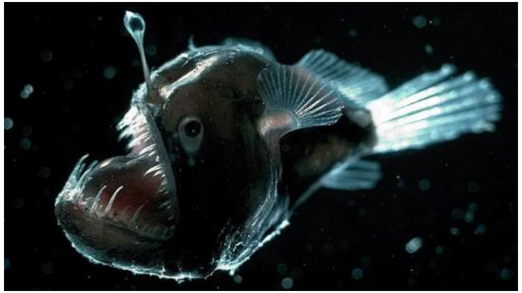
Open Ocean

- Low productivity/area as only algae & phytoplankton can survive in most of ocean

So large though, that algae & phytoplankton of ocean produce a lot of earth's O_2 & absorb a lot of atmospheric CO_2

- Photic zone = area where sunlight can reach (photosynthesis)
- Aphotic zone (abyssal) = area too deep for sunlight





Practice FRQ 1.3

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

Identify an organism found in an aquatic biome and **explain** how that organism is uniquely adapted to live in that biome.

1.4 Carbon Cycle

Objectives/EKs/Skills

LEARNING OBJECTIVE

ERT-1.D

Explain the steps and reservoir interactions in the carbon cycle.

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

ESSENTIAL KNOWLEDGE

ERT-1.D.1

The carbon cycle is the movement of atoms and molecules containing the element carbon between sources and sinks.

ERT-1.D.2

Some of the reservoirs in which carbon compounds occur in the carbon cycle hold those compounds for long periods of time, while some hold them for relatively short periods of time.

ERT-1.D.3

Carbon cycles between photosynthesis and cellular respiration in living things.

ERT-1.D.4

Plant and animal decomposition have led to the storage of carbon over millions of years. The burning of fossil fuels quickly moves that stored carbon into atmospheric carbon, in the form of carbon dioxide.

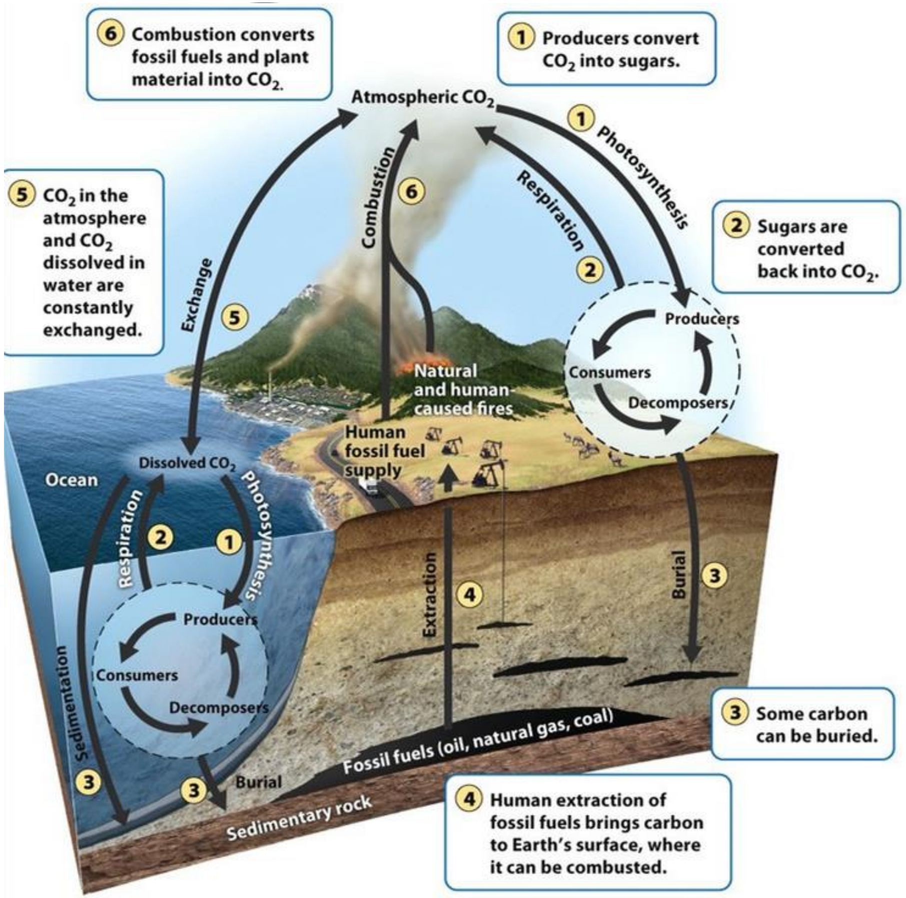
Carbon Cycle Overview

- Movement of molecules that contain Carbon (CO_2, glucose, CH_4) between sources and sinks

Some steps are very quick (FF combustion); some are very slow (sedimentation & burial)

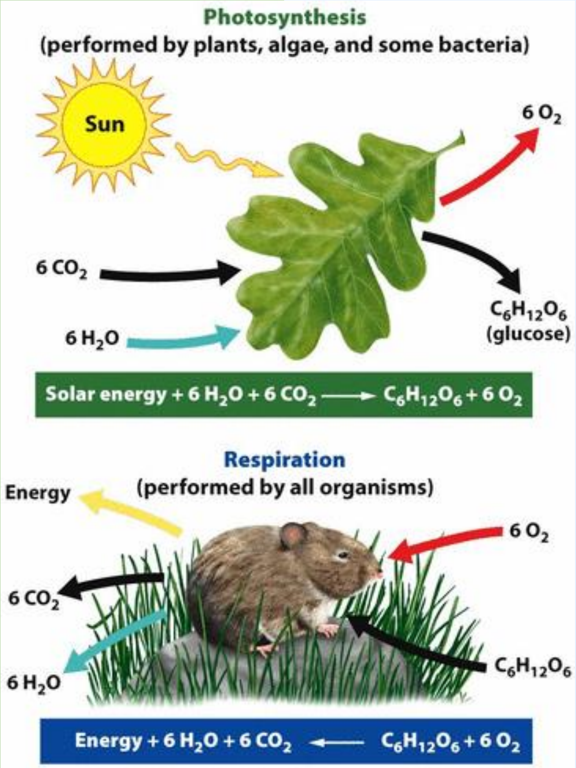
Leads to imbalance in which reservoirs or sinks are storing carbon

- Atmosphere is key C reservoir; increasing levels of C in atm. Leads to global warming
- **Carbon sink:** reservoir that take in more carbon than it releases
  - Ocean (algae & sediments), plants, soil
- **Carbon source:** reservoir that releases more carbon than it takes in
  - Fossil fuel (oil, coal, nat gas) combustion
  - Animal ag. (cow burps & farts = CH_4)
  - Deforestation, releases CO_2 from trees



Photosynthesis & Cellular Respiration

- Plants, algae, phytoplankton
- Removes CO_2 from the atmosphere & converts it to glucose
- Glucose = biological form of C & stored (chemical) energy in form of sugar
- CO_2 sink



- Done by plants & animals to release stored energy
- Uses O_2 to break glucose down & release energy
- Releases CO_2 into atmosphere
- CO_2 source (adds CO_2 to atm.)

Both processes are very quick

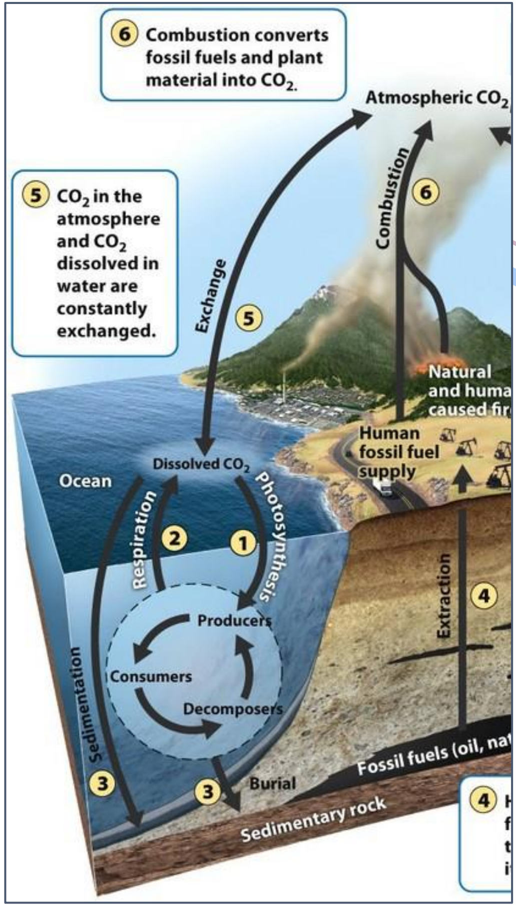
Cycle C between biosphere & atmosphere in balanced amount (no net C increase in atm.)

Ocean & Atmosphere

- **Direct exchange:** CO_2 moves directly between atmosphere & the ocean by dissolving into & out of ocean water at the surface

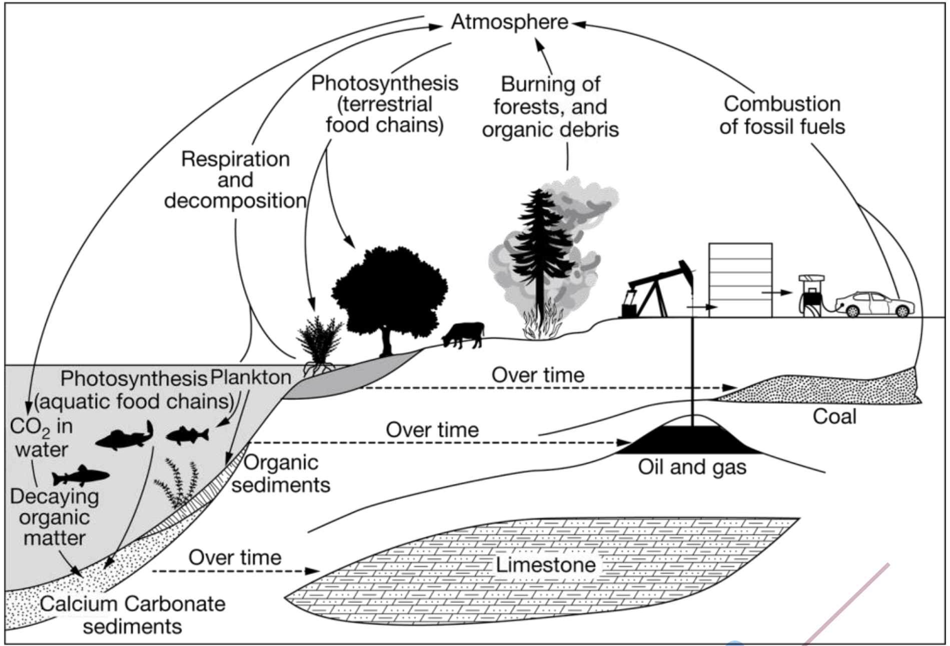
  Happens very quickly & in equal directions, balancing levels of CO_2 between atm. & ocean

- B/c of direct exchange, increasing atm. CO_2 also increases ocean CO_2, leading to ocean acidification
- **Algae & phytoplankton**: take CO_2 out of the ocean & atm. through photosynthesis
  - **Coral reef & marine org. with shells** also take CO_2 out of the ocean to make calcium carbonate exoskeleton
- **Sedimentation:** calcium carbonate precipitates out as sediment & settles on ocean floor
  - **Burial:** over, long, periods of time, pressure of water compresses C-containing sediments on ocean floor into sedimentary stone (limestone, sandstone) - long-term C reservoir



Burial, Extraction, & Combustion

- **Burial:** slow, geological process that stores C in underground sinks like sedimentary rock or fossil fuels
  - Sediments (bits of rock, soil, organic matter) compressed into sed. rock, or FF, by pressure from overlying rock layers or water
- **Fossil Fuels (FF)**: coal, oil, and Nat. gas are formed from fossilized remains of org. Matter. Ex: dead ferns (coal) or marine algae & plankton (oil)
- **Extraction & Combustion**: digging up or mining FFs & burning them as energy source; releases CO_2 into atm.

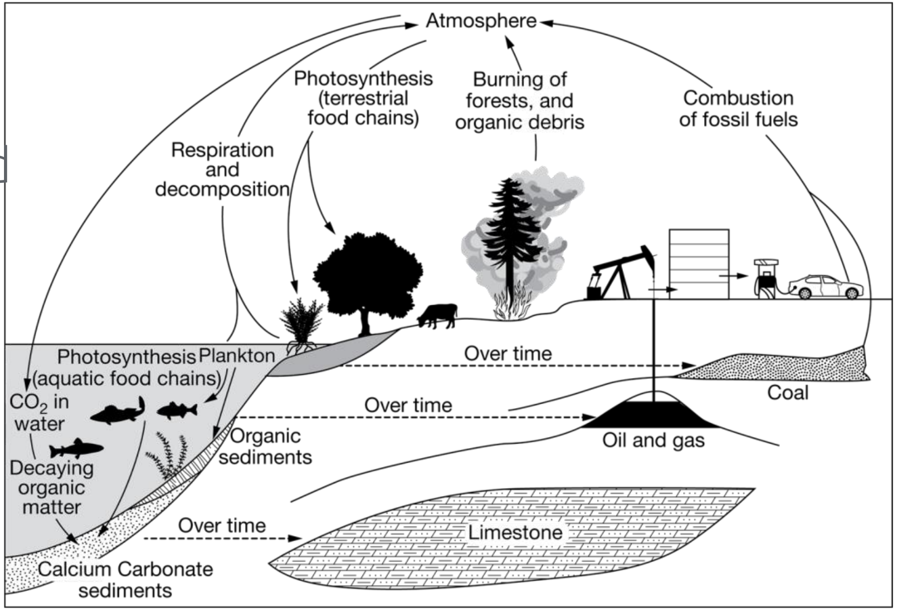


Burial (formation of FFs) takes far longer than **extraction** & **combustion**, which means they increase concentration of CO_2 in atmosphere

Practice FRQ 1.4

Identify one process in the diagram that happens quickly and one process that happens slowly.

Explain how the rate at which fossil fuels are transferred into the atmosphere, as shown in the diagram, has altered the carbon cycle during the past 250 years.



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

1.5
Nitrogen Cycle

Objective/EKs/Skill

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-1.E Explain the steps and reservoir interactions in the nitrogen cycle.	ERT-1.E.1 The nitrogen cycle is the movement of atoms and molecules containing the element nitrogen between sources and sinks.
	ERT-1.E.2 Most of the reservoirs in which nitrogen compounds occur in the nitrogen cycle hold those compounds for relatively short periods of time.
	ERT-1.E.3 Nitrogen fixation is the process in which atmospheric nitrogen is converted into a form of nitrogen (primarily ammonia) that is available for uptake by plants and that can be synthesized into plant tissue.
	ERT-1.E.4 The atmosphere is the major reservoir of nitrogen.

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

Nitrogen Cycle Overview

Mvmnt of N containing molecules between sources & sinks/reservoirs

Sources release N into atmosphere; sinks take N out of the atmosphere in increasing amounts

N reservoirs hold N for relatively short period of time compared to C cycle

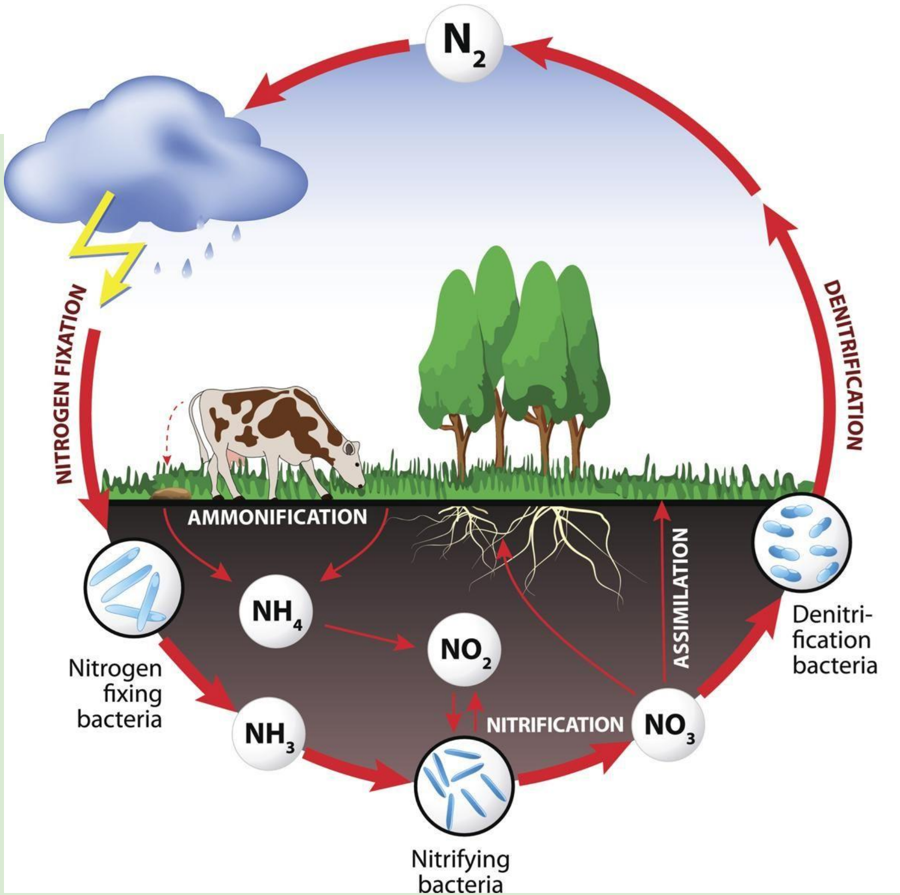
- **Ex: plants, soil, atmosphere**

Atmosphere = main N reservoir

N in atm. exists mostly as N_2 gas, not useable by plants or animals

N = critical plant & animal nutrient

All living things need N for DNA & amino acids to make proteins



Nitrogen Fixation

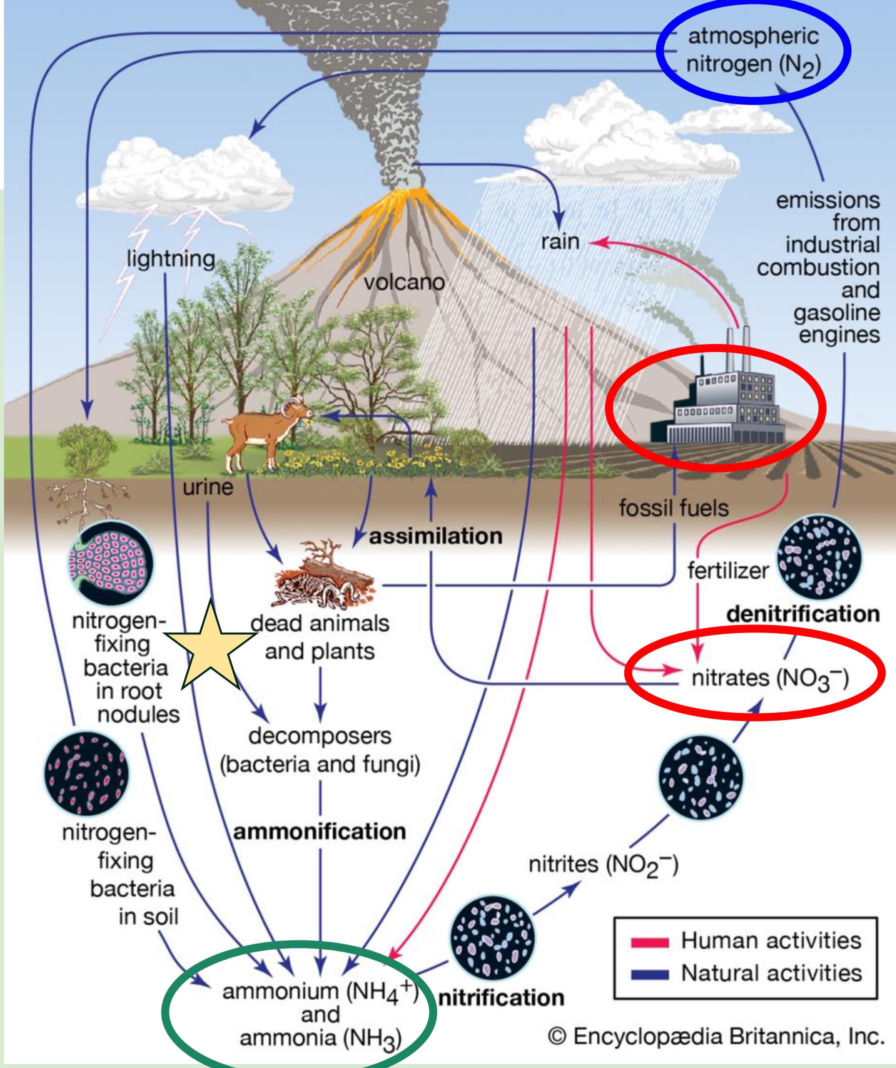
- Process of N_2 gas being converted into biologically available (useable by plants) NH_3 (ammonia) or NO_3^- (nitrate)

- **Bacterial fixation:** certain bacteria that live in the soil, or in symbiotic relationship with plant root nodules convert N_2 into ammonia (NH_3)

  Rhizobacteria live in root nodules of legumes (peas, beans) & fix N for them in return for amino acids from the plant

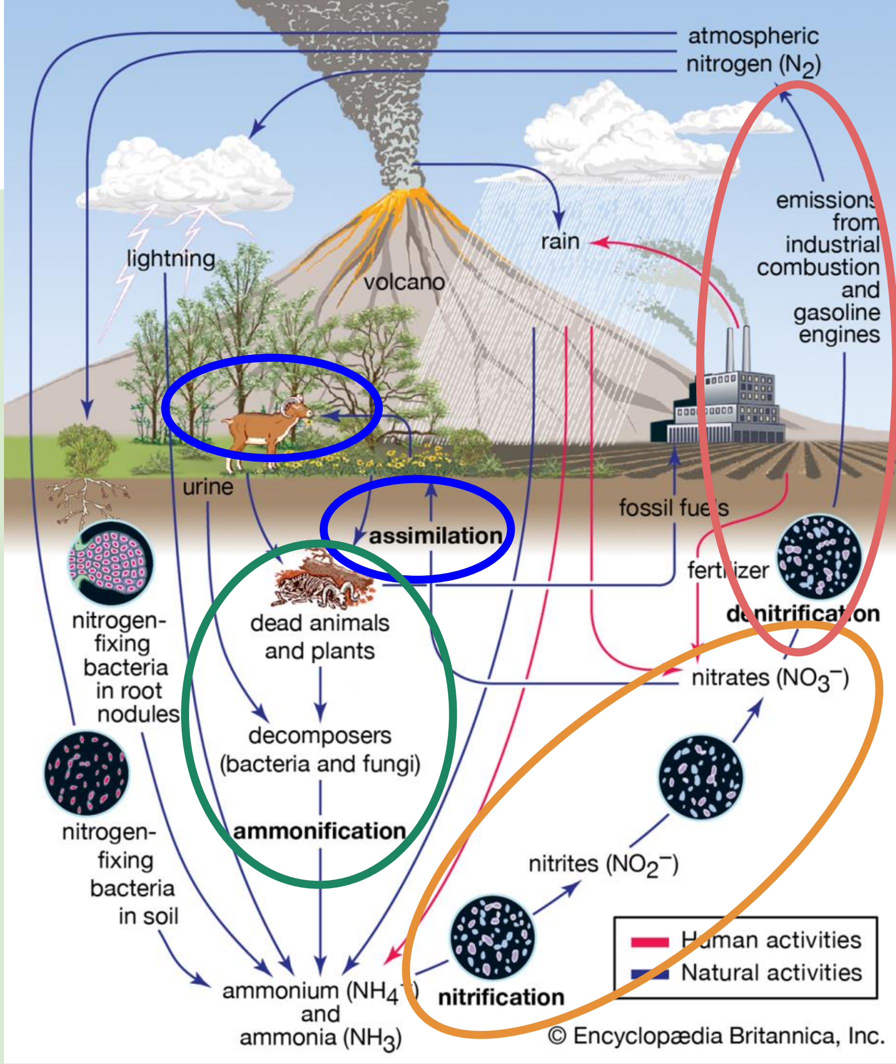
- **Synthetic fixation:** FF combustion converts N_2 gas into ammonia (NH_3)

  NH_3 is added to synthetic fertilizer and applied to agricultural soils (where it's converted into nitrate)



Other N Cycle Steps

- **Assimilation**: plants & animals taking N in and incorporating it into their body
  - Plant roots take in NO_3^- or NH_3 from soil; animals assimilate N by eating plants or other animals
- **Ammonification:** soil bacteria, microbes & decomposers converting waste & dead biomass back into NH_3 and returning it to soil
- **Nitrification:** conversion of NH_4 into nitrite (NO_2^-) & then nitrate (NO_3) by soil bacteria
- **Denitrification:** conversion of soil N (NO_3) into nitrous oxide (N_2O) gas which returns to atmosphere



Human Impacts on N Cycle

- **Climate:** N_2O (nitrous oxide) = greenhouse gas which warm earth's climate

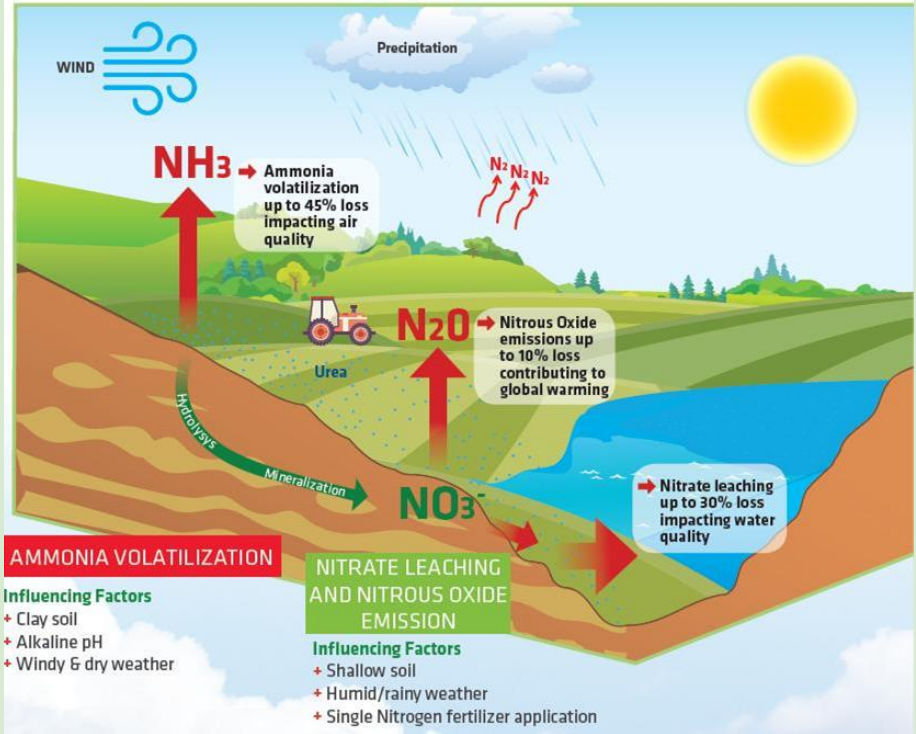
  Produced by denitrification of nitrate in agricultural soils (especially when waterlogged/over watered)

- **Ammonia volatilization:** excess fertilizer use can lead to NH_3 gas entering atm.

  NH_3 gas in atm causes respiratory irritation in humans & animals

- **Leaching & Eutrophication:** synthetic fertilizer use leads to nitrates (NO_3) **leaching**, or being carried out of soil by water

  Nitrates runoff into local waters, causing algae blooms that block sun & kill other aq. plants



Practice FRQ 1.5

Describe one chemical transformation that occurs in the natural nitrogen cycle and **explain** the importance of that transformation to an ecosystem.

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

1.6 Phosphorus Cycle

Objective/EKs/Skill

LEARNING OBJECTIVE

ERT-1.F

Explain the steps and reservoir interactions in the phosphorus cycle.

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

ESSENTIAL KNOWLEDGE

ERT-1.F.1

The phosphorus cycle is the movement of atoms and molecules containing the element phosphorus between sources and sinks.

ERT-1.F.2

The major reservoirs of phosphorus in the phosphorus cycle are rock and sediments that contain phosphorus-bearing minerals.

ERT-1.F.3

There is no atmospheric component in the phosphorus cycle, and the limitations this imposes on the return of phosphorus from the ocean to land make phosphorus naturally scarce in aquatic and many terrestrial ecosystems. In undisturbed ecosystems, phosphorus is the limiting factor in biological systems.

Phosphorus Cycle Basics

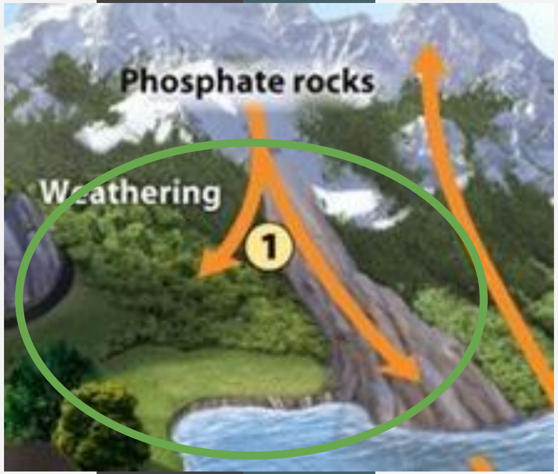
- Movement of P atoms & molecules b/w sources & sinks/reservoirs
  - Rocks & sediments containing P minerals = major reservoirs

P cycle is very slow compared to $C/H_2O/N$ cycles

- Takes a long time for P minerals to be weathered out of rocks & carried into soil/bodies of water
- No gas phase of P (doesn't enter atmosphere)
- B/c it cycles so slowly, it is a limiting nutrient, meaning plant growth in ecosystems is often limited by P availability in soil/water

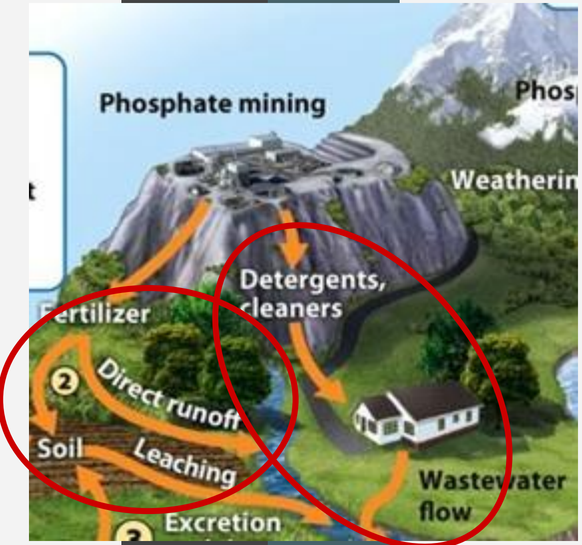
P is needed by all organisms for DNA, ATP (energy), bone & tooth enamel in some animals

Phosphorus Sources



Major <u>natural</u> source of P is weathering of rocks that contain P minerals.

- Wind & rain break down rock & phosphate (PO_4^{-3}) is released and dissolved into water; rain water carries phosphate into nearby soils & bodies of water
- Weathering is so slow that P is often a limiting nutrient in aquatic & terrestrial ecosystems



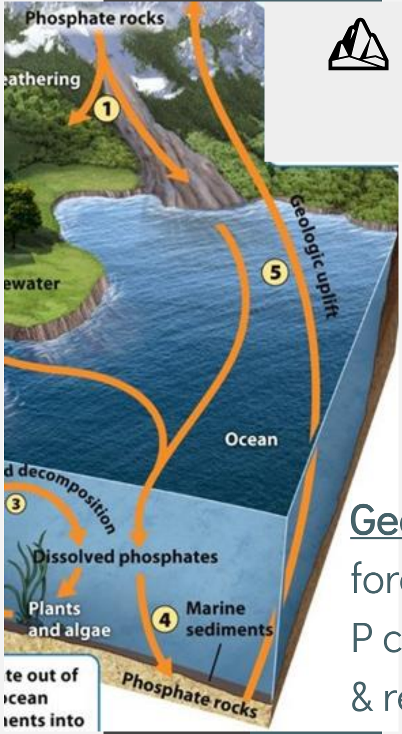
<u>Synthetic</u> (human) sources of P = mining phosphate minerals & adding to products like synthetic fertilizers & detergents/cleaners

- Synthetic fertilizers containing phosphates are added to lawns or ag. Fields; runoff carries P into nearby bodies of water
- Phosphates from detergents & cleaners enter bodies of water via wastewater from homes

Assimilation & Excretion/Decomp.

Just like N, P is absorbed by plant roots & assimilate into tissues; animals assimilate P by eating plants or other animals

Animal waste, plant matter & other biomass is broken down by bacteria/soil decomposers that return phosphate to soil



Assimilation & excretion/decomp form a mini-loop within P cycle just like assimilation & ammonification in N Cycle, photosynth & resp. in C cycle

Sedimentation & Geo. Uplift

Phosphate doesn't dissolve very well into water; much of it forms solid bits of phosphate that fall to the bottom as sediment (<u>sedimentation</u>)

P sediments can be compressed into sed. rock over long time periods by pressure of overlying water

<u>Geological uplift</u> = tectonic plate collision forcing up rock layers that form mountains; P cycle can start over again with weathering & release of phosphate from rock

Eutrophication (too much N & P)

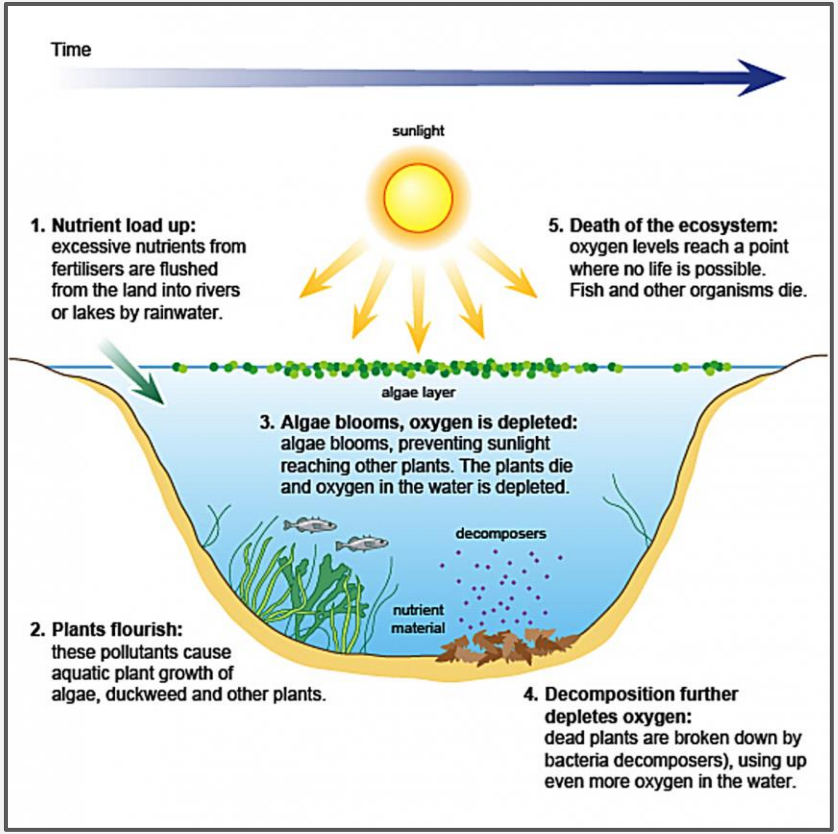
**Can occur from fertilizer runoff, human/animal waste contamination

B/c they're limiting nutrients in aq. ecosystems, extra input of N & P lead to <u>eutrophication</u> (excess nutrients) which fuels algae growth

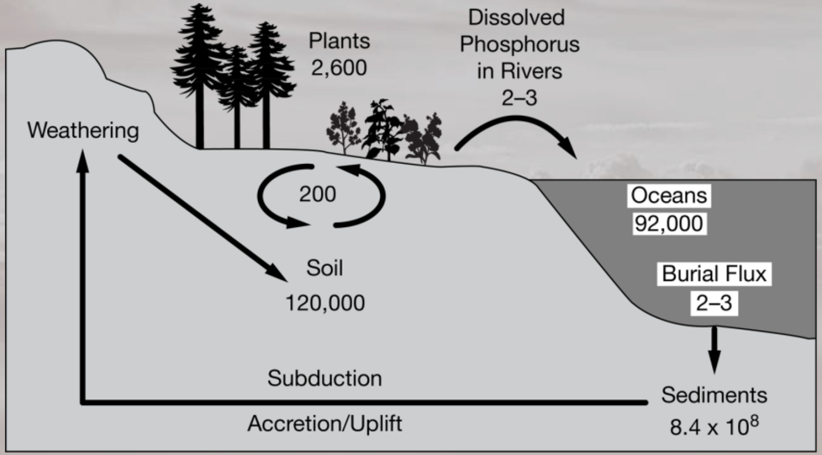
- Algae bloom covers surface of water, blocking sunlight & killing plants below surface
- Algae eventually die-off; bacteria that break down dead algae use up O_2 in the water (b/c decomp. = aerobic process)
- Lower O_2 levels (dissolved oxygen) in water kills aquatic animals, especially fish
- Bacteria use up even more O_2 to decompose dead aq. animals
- Creates pos. feedback loop: less O_2 → more dead org. → more bacterial decomposition → less O_2

Eutrophication (too much N & P)

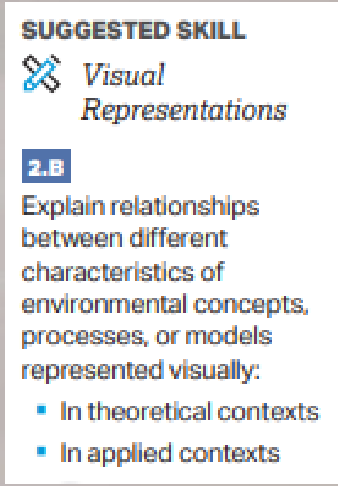
**Can occur from fertilizer runoff, human/animal waste contamination

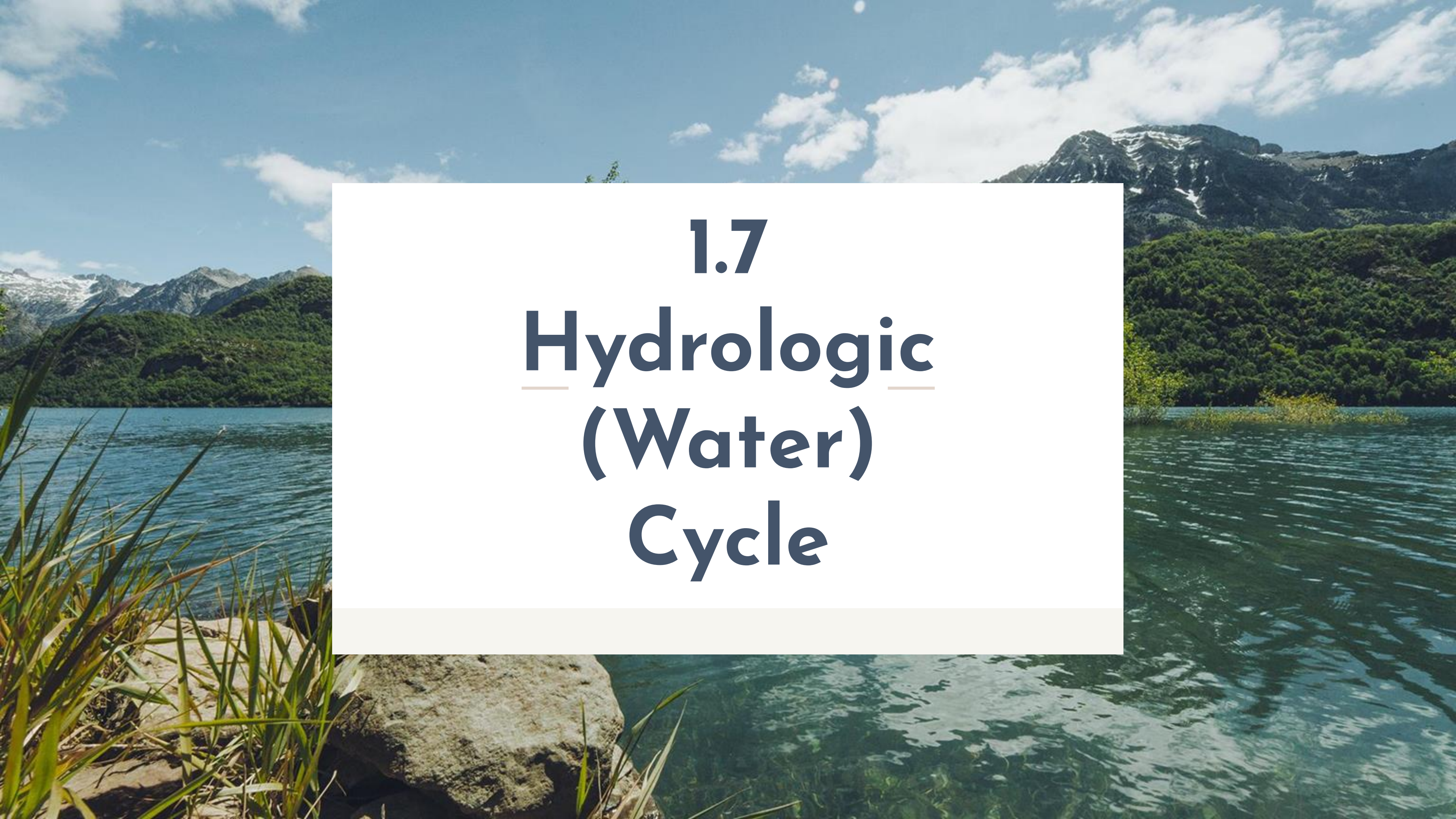


Practice FRQ 1.6



Choose 2 reservoirs depicted in the diagram above and describe how phosphorus moves from one to the other





1.7 Hydrologic (Water) Cycle

Objective/EKs/Skill

LEARNING OBJECTIVE

ERT-1.G

Explain the steps and reservoir interactions in the hydrologic cycle.

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

ESSENTIAL KNOWLEDGE

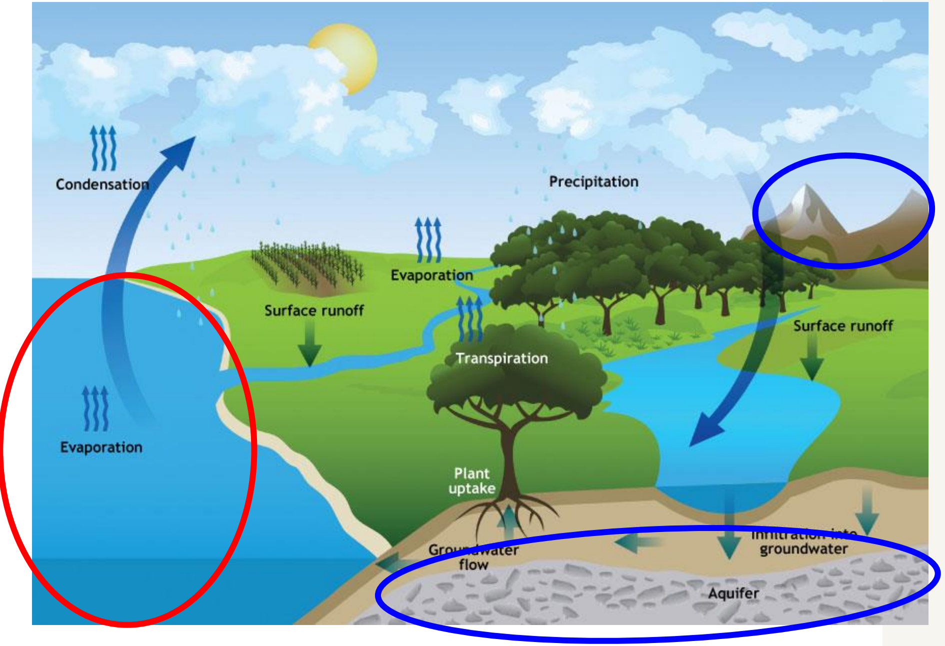
ERT-1.G.1

The hydrologic cycle, which is powered by the sun, is the movement of water in its various solid, liquid, and gaseous phases between sources and sinks.

ERT-1.G.2

The oceans are the primary reservoir of water at the Earth's surface, with ice caps and groundwater acting as much smaller reservoirs.

Water Cycle Overview



Movement of H_2O (in different states) b/w sources & sinks

- **State of matter (solid/liquid/gas) as well as where water is moving are key in H_2O cycle**

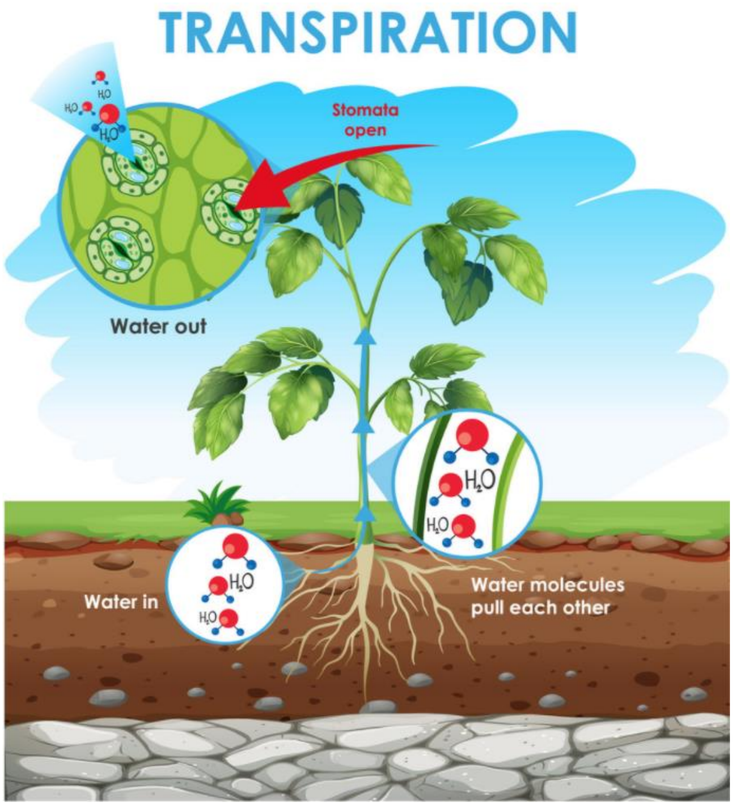
  Ex: precipitation = atm. (gas) → land or surface water (liquid)

- **Energy from sun drives the H_2O cycle**

  Ex: heat from sun causes liquid water in ocean to become a gas (evaporation) in atm.

- **Ocean = largest water reservoir**
- **Ice caps & groundwater are smaller reservoirs, but contain fresh, useable water for humans**

Evaporation & Evapotranspiration



2 main sources of water (processes that cycle it from liquid on earth back into the atmosphere)

Sometimes called "vaporization" since liquid water becomes water vapor (gas) in atm.

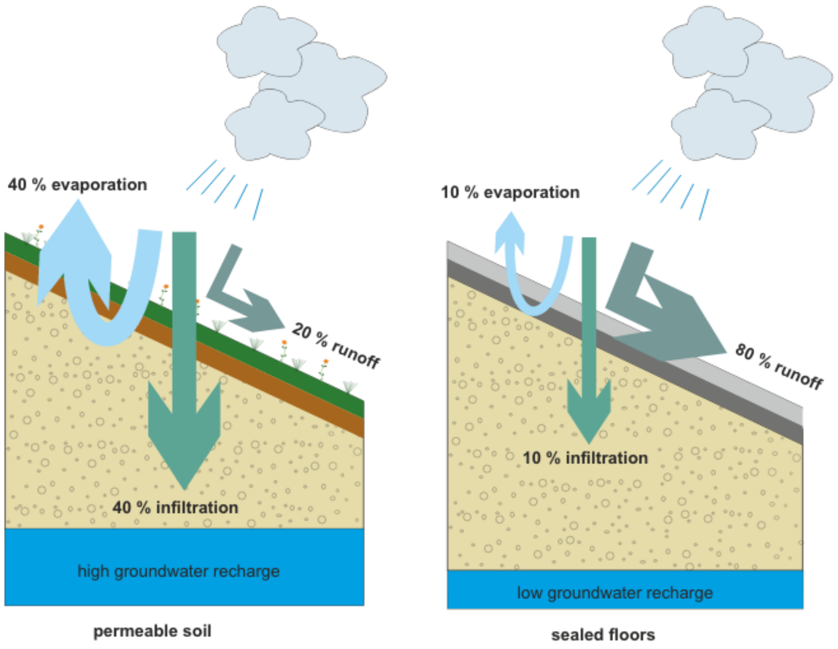
Transpiration: process plants use to draw groundwater from roots up to their leaves

- Leaf openings called stomata open, allowing water to evap. into atm. from leaf
- Mvmnt of H_2O out of leaf creates low H_2O potential in leaf, pulling H_2O up from roots

Evapotranspiration: amount of H_2O that enters atm. from transpiration & evap. combined

Both processes are driven by energy from the sun

Runoff & Infiltration



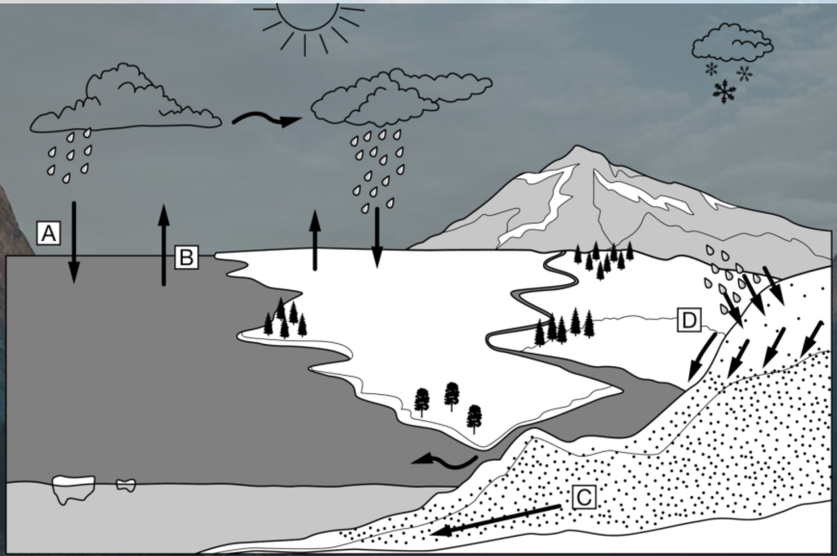
Precipitation (rain) either flows over earth's surface into a body of water (runoff) or trickles through soil down into groundwater aquifers (infiltration)

Groundwater (aquifers) & surface waters (lakes/rivers) are important freshwater reservoirs for humans & animals

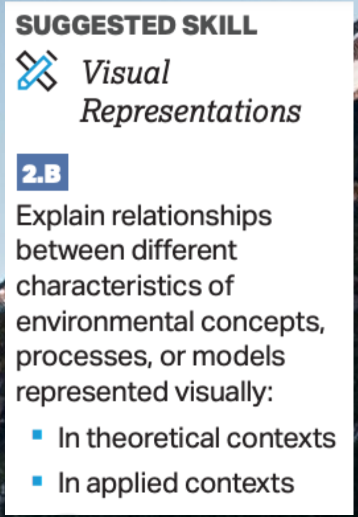
Precipitation recharges groundwater through infiltration, but only if ground is **permeable** (able to let water pass through)

Runoff recharges surface waters, but can also carry pollutants into water sources

Practice FRQ 1.7



Chose a processes from the diagram. **Identify** the process and **describe** how water is moving from one reservoir to another.



1.8

Primary Productivity

Objective/EKs/Skill

LEARNING OBJECTIVE

ENG-1.A

Explain how solar energy is acquired and transferred by living organisms.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ENG-1.A.1

Primary productivity is the rate at which solar energy (sunlight) is converted into organic compounds via photosynthesis over a unit of time.

ENG-1.A.2

Gross primary productivity is the total rate of photosynthesis in a given area.

ENG-1.A.3

Net primary productivity is the rate of energy storage by photosynthesizers in a given area, after subtracting the energy lost to respiration.

ENG-1.A.4

Productivity is measured in units of energy per unit area per unit time (e.g., kcal/m^2/yr).

ENG-1.A.5

Most red light is absorbed in the upper 1m of water, and blue light only penetrates deeper than 100m in the clearest water. This affects photosynthesis in aquatic ecosystems, whose photosynthesizers have adapted mechanisms to address the lack of visible light.

PP Basics

units: kcal/m^2/yr.

Energy area time

High PP = high plant growth = lots of food & shelter for animals

Ecosystems with high PP are usually more biodiverse (more div. of species) than ecosystems with low PP

Primary Productivity: rate that solar energy is converted into org. compounds via photosynthesis over a unit of time

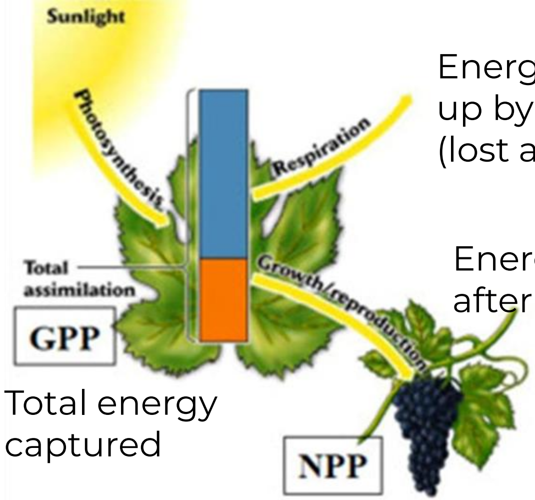
Aka: rate of photosynthesis of all producers in an area over a given period of time

Since photosynthesis leads to growth, you can also think of PP as the amount of plant growth in an area over a given period of time

Calculating PP

NPP = GPP - RL

Net Primary Productivity (NPP): The amount of energy (biomass) leftover for consumers after plants have used some for respiration



Energy used up by resp. (lost as heat)

Energy left after resp.

Total energy captured

Respiration loss (RL): plants use up some of the energy they generate via photosynthesis by doing cell. respiration (movement, internal transportation, etc.)

Think of RL as taxes plant needs to pay

Gross Primary Productivity (GPP): The **total** amount of sun energy (light) that plants capture and convert to energy (glucose) through photosynthesis

*Think of GPP as the **total** paycheck amount the plant earns*

Think of NPP as the actual amount of the plant's paycheck it keeps after taxes

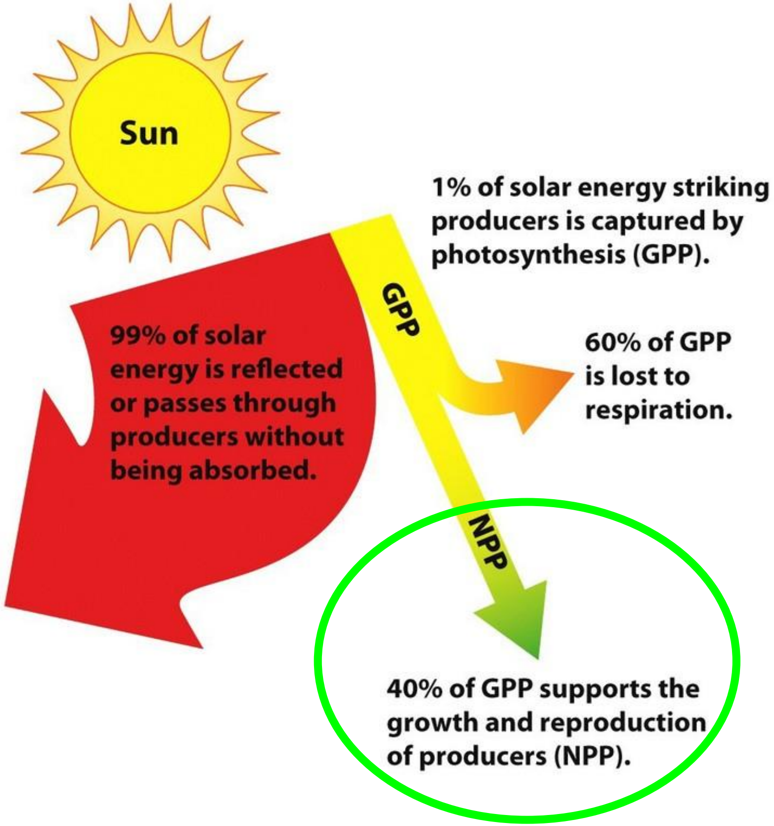
Ecological Efficiency

The portion of incoming solar energy that is captured by plants & converted into biomass (NPP or food available for consumers)

Generally, only 1% of all incoming sunlight is captured & converted into GPP via photosynthesis

Of that 1%, only about 40% (or 0.4% of total incoming solar energy) is converted into biomass/plant growth (NPP)

Some ecosystems are more efficient (higher NPP) than others



Trends in Productivity

The more productive a biome is, the wider the diversity of animal life it can support (high. biodiv.)

****Try to predict the most & least productive terrestrial and aquatic biomes ****

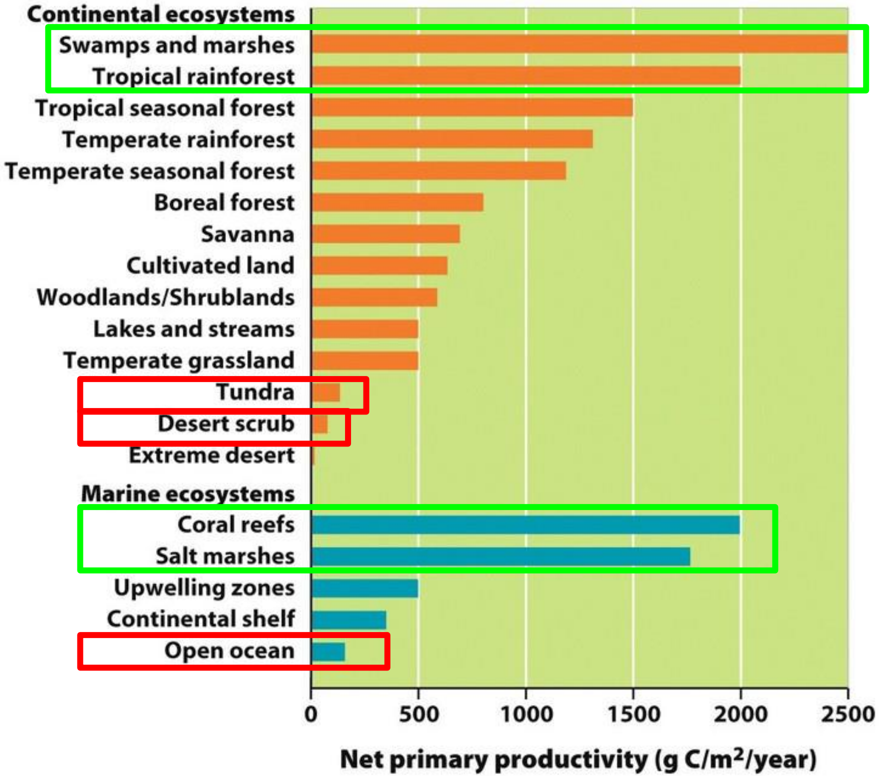
Water availability, higher temperature, and nutrient availability are all factors that lead to high NPP

Shortage of any of these three factors will lead to decreased NPP

Ex: Desert (low H_2O & nutrients)

Tundra (low temp & liquid H_2O)

Open ocean (low nutrients)



Practice FRQ 1.8

Describe the process of net primary productivity (NPP).

Describe the relationship between primary productivity and biodiversity.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

1.9 & 1.10 Trophic Levels & The 10% Rule

Objectives/EKs/Skills

LEARNING OBJECTIVE

ENG-1.B

Explain how energy flows and matter cycles through trophic levels.

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ENG-1.B.1

All ecosystems depend on a continuous inflow of high-quality energy in order to maintain their structure and function of transferring matter between the environment and organisms via biogeochemical cycles.

ENG-1.B.2

Biogeochemical cycles are essential for life and each cycle demonstrates the conservation of matter.

ENG-1.B.3

In terrestrial and near-surface marine communities, energy flows from the sun to producers in the lowest trophic levels and then upward to higher trophic levels.

LEARNING OBJECTIVE

ENG-1.C

Determine how the energy decreases as it flows through ecosystems.

SUGGESTED SKILL

Mathematical Routines

6.C

Calculate an accurate numeric answer with appropriate units.

ESSENTIAL KNOWLEDGE

ENG-1.C.1

The 10% rule approximates that in the transfer of energy from one trophic level to the next, only about 10% of the energy is passed on.

ENG-1.C.2

The loss of energy that occurs when energy moves from lower to higher trophic levels can be explained through the laws of thermodynamics.

Conservation of Matter & Energy

- **Matter & energy are never created or destroyed; they only change forms**

    Ex: Tree dies & the C/N/H_2O/P are returned to the soil & atmosphere

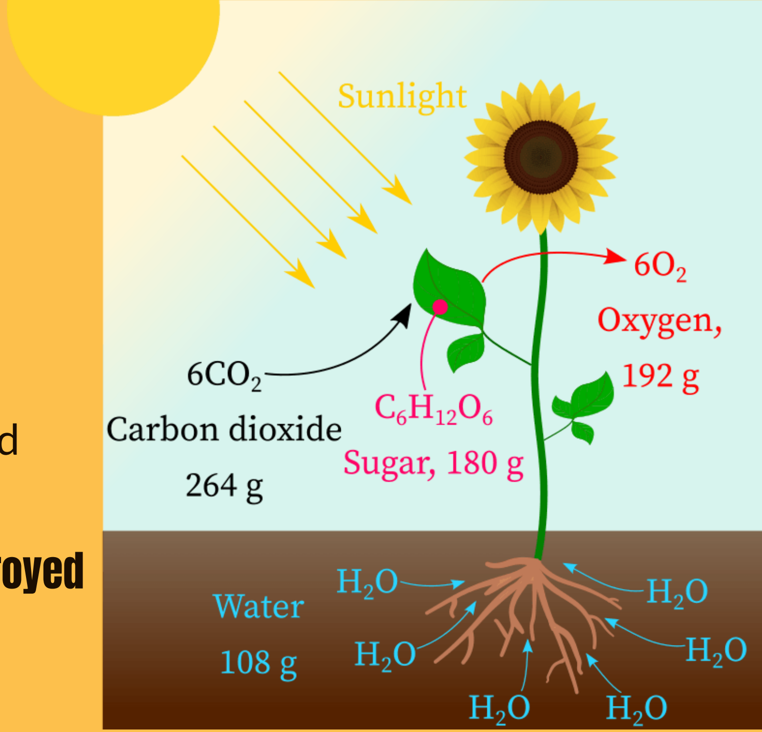
    Ex: Sun rays (light energy) hit leaves & are converted into glucose (chemical energy)

- **1st law of thermodynamics: energy is never created or destroyed**

    Biogeochem. cycles demonstrate conservation of matter (C/N/H_2O/P)

- **Food webs demonstrate conservation of energy**

    Ex: When a rabbit eats a leaf, the energy from the leaf (glucose) is transfered to the rabbit & stored as body tissue like fat/muscle



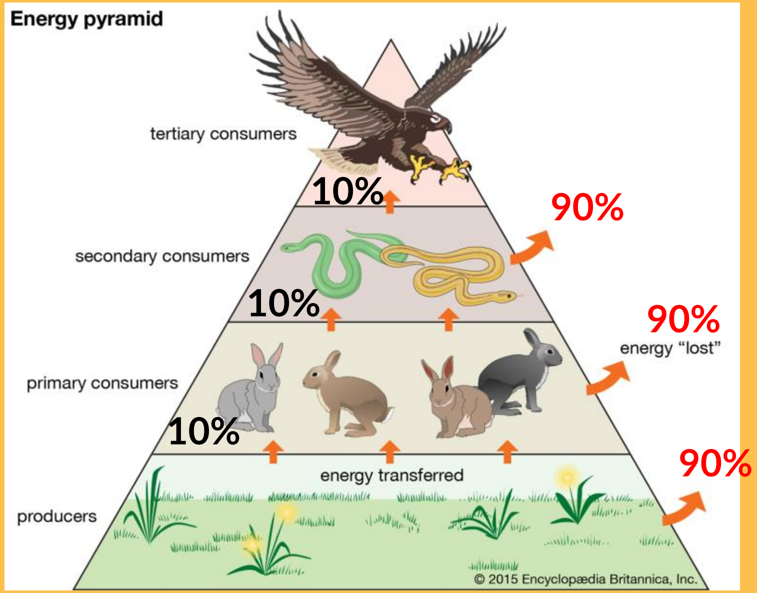
2nd Law of Thermodynamics

- **Each time energy is transferred, some of it is lost as heat**

  Applied to food webs: the amount of **useable** energy decreases as you move up the food chain (organisms use up most of it for movement, development, etc.)

- **Because *available* energy decreases with each step up the food chain, a trophic pyramid (trohp = nourishment or growth) is used to model how energy moves through an ecosystem**

- **10% Rule: in trophic pyramids, only about 10% of the energy from one level makes it to the next level; the other 90% is used by the organism & lost as heat**



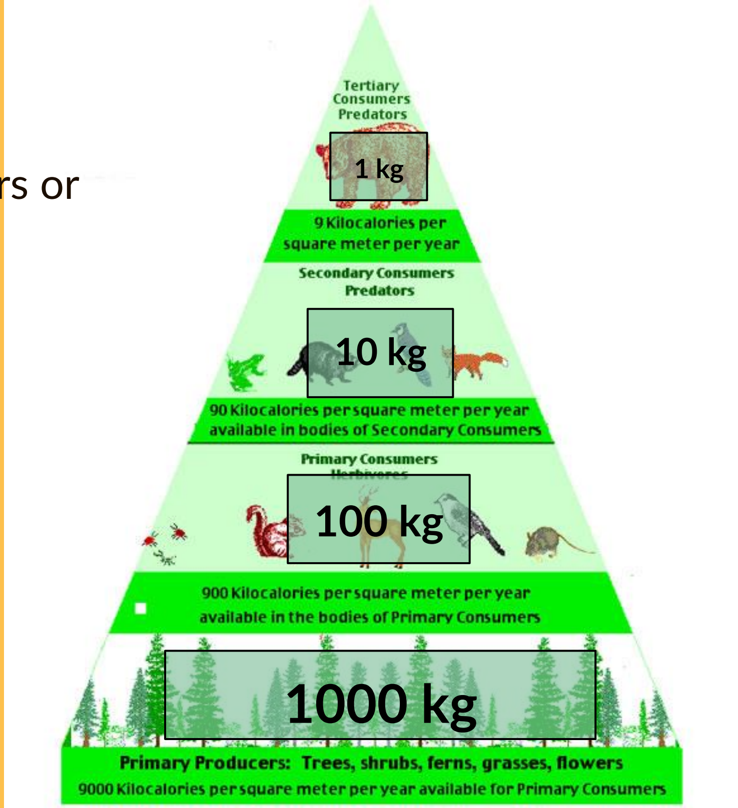
Trophic Levels & 10% Biomass

Tertiary Consumers: animals that eat secondary consumers or carnivores & omnivores (aka - top/apex predators)

Secondary Consumers: animals that eat primary consumers or herbivores (aka - carnivores & omnivores)

Primary Consumers: animals that eat plants (herbivores)

Producers (plants) “produce”- really convert sun’s light energy into chemical energy (glucose)

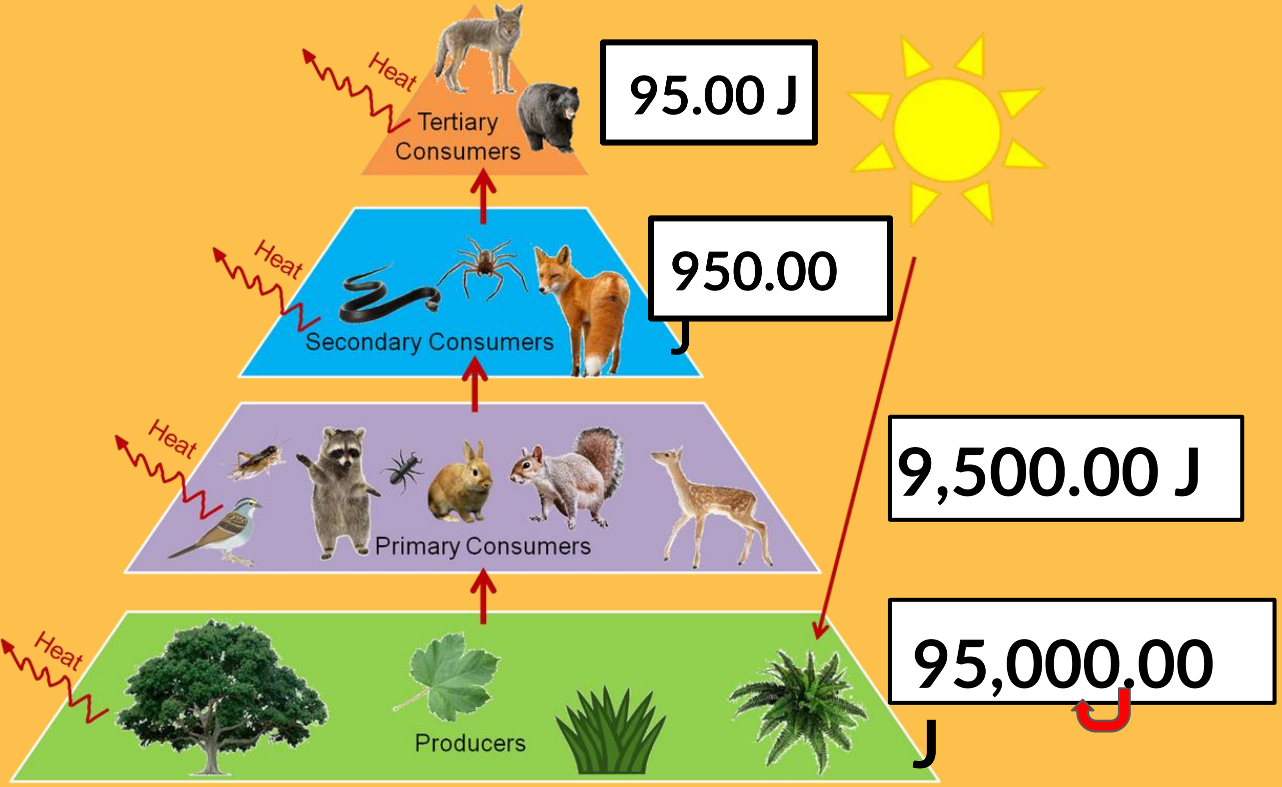


10% rule also applies to biomass (or mass of all living things at each trophic level)

Since energy is needed for growth & only 10% of energy transfers from one level to the next, only 10% of the biomass can be grown/supported

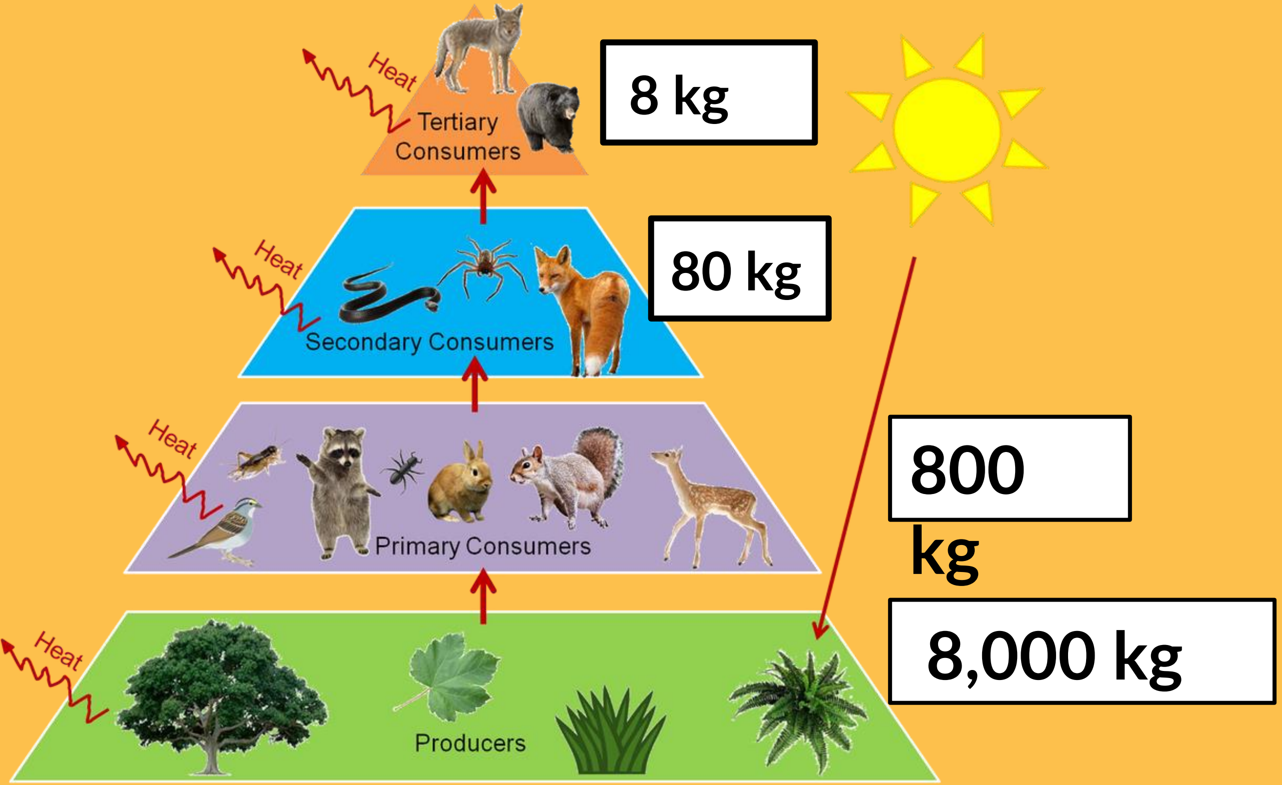
Calculating Biomass & Energy

- To calculate biomass or energy available at the next level up, move the decimal place one spot to the left (or divide by 10)



Calculating Biomass & Energy

Try calculating biomass



Practice FRQs 1.9 & 1.10

Explain why a relatively large forest can only support a small number of wolves.

Calculate the amount of energy available to a tertiary consumer in the following ecosystem.

100,000 J of energy produced by plants in the ecosystem (after respiration)

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

SUGGESTED SKILL

Mathematical Routines

6.C

Calculate an accurate numeric answer with appropriate units.

1.11
Food Chains and Food Webs

Objective/EKs/Skill

LEARNING OBJECTIVE

ENG-1.D

Describe food chains and food webs, and their constituent members by trophic level.

SUGGESTED SKILL

Visual Representations

2.A

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

ESSENTIAL KNOWLEDGE

ENG-1.D.1

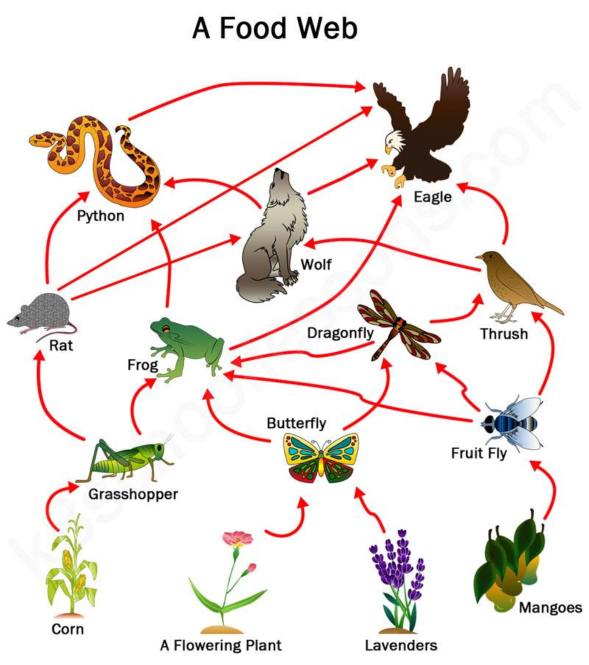
A food web is a model of an interlocking pattern of food chains that depicts the flow of energy and nutrients in two or more food chains.

ENG-1.D.2

Positive and negative feedback loops can each play a role in food webs. When one species is removed from or added to a specific food web, the rest of the food web can be affected.

Food Web Basics

Shows how matter & energy flow through an ecosystem, from organism to organism

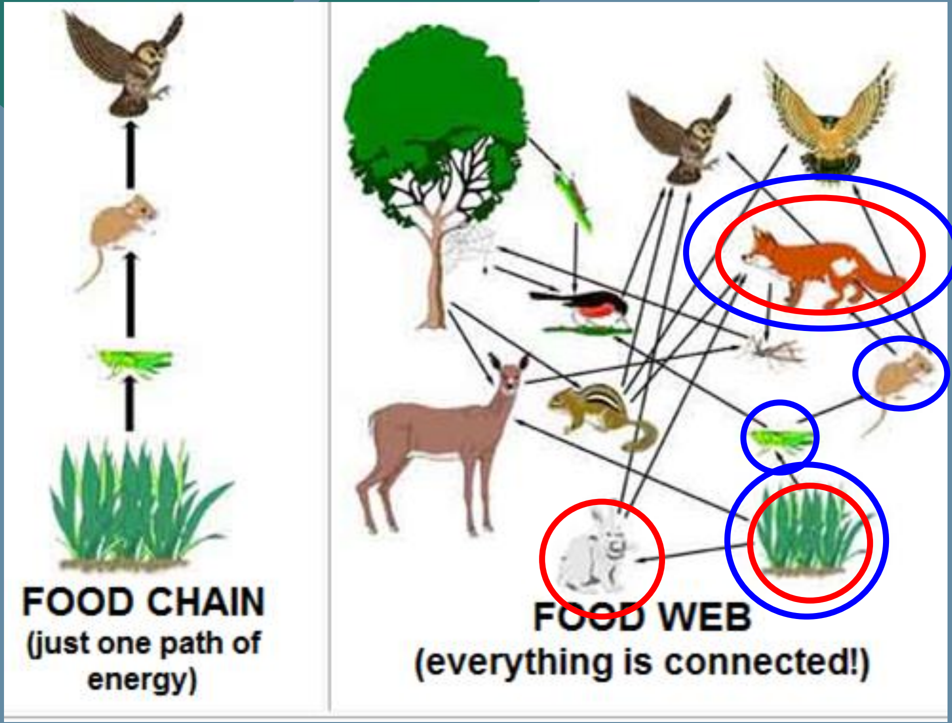


When one organism preys on (eats) another, the matter (C/N/H_2O/P) and energy (glucose, muscle tissue, etc.) are passed on to the predator

Arrows in food webs indicate direction of energy flow (point to the org. taking in the energy)

Food Web vs. Chain

Food chains just show one, linear path of energy & matter



Food webs have <u>at least 2</u> different, interconnected food chains

Webs show that organisms can exist at different trophic levels

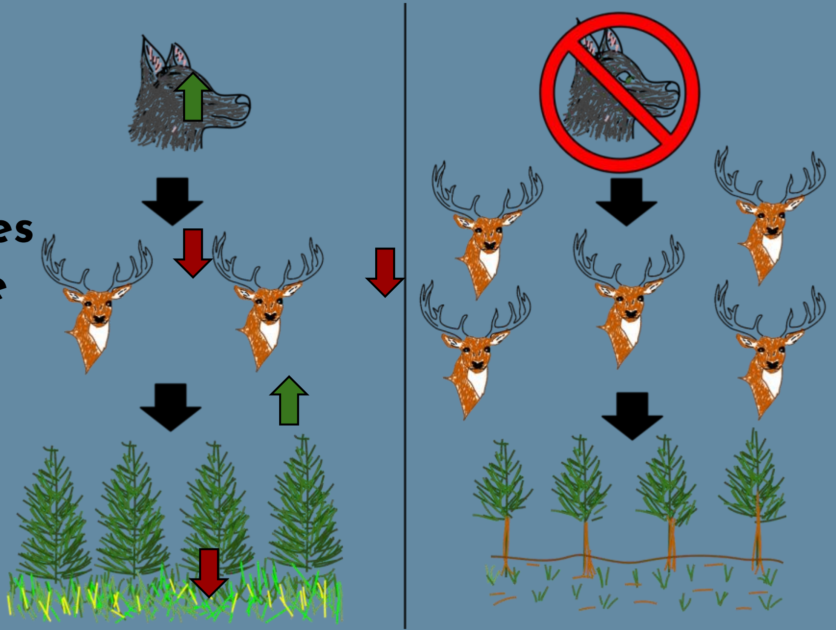
grass → hare → owl (sec. cons.)

grass → grasshopper → robin → owl (tert. cons.)

Interactions & Trophic Cascade

- **Food webs show how increase or decreases in pop. size of a given species impact the rest of the food web**

  Ex: <u>Increase in python pop.</u>
  - Decrease in frog & rat pops.
  - Increase in grasshopper pop.
  - Decrease in corn



Trophic cascade: removal or addition of a top predator has a ripple effect down through lower troph. Levels

Ex: decline in wolf pop. = increase in deer pop. which leads to overgrazing & decline in trees

SUGGESTED SKILL

Visual Representations

2.A

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

Practice FRQ 1.11

Describe one direct effect that a decline in the frog population would have on the food web.

Identify an organism that is both a secondary and tertiary consumer