Unit 9 - Global Change

LEARNING OBJECTIVE

STB-4.A

Explain the importance of stratospheric ozone to life on Earth.

ESSENTIAL KNOWLEDGE

STB-4.A.1

The stratospheric ozone layer is important to the evolution of life on Earth and the continued health and survival of life on Earth.

STB-4.A.2

Stratospheric ozone depletion is caused by anthropogenic factors, such as chlorofluorocarbons (CFCs), and natural factors, such as the melting of ice crystals in the atmosphere at the beginning of the Antarctic spring.

STB-4.A.3

A decrease in stratospheric ozone increases the UV rays that reach the Earth's surface. Exposure to UV rays can lead to skin cancer and cataracts in humans.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

9.1 - Objective/EKs/Sk

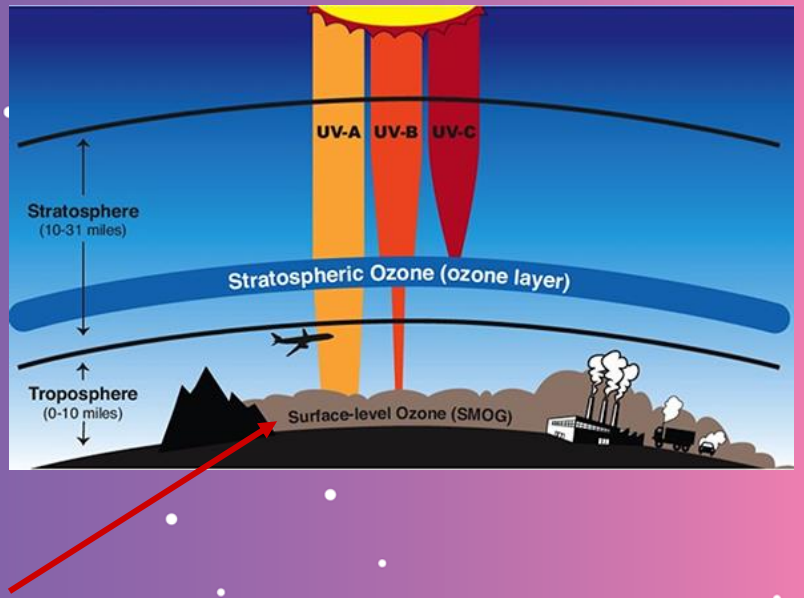
9.1 & 9.2 - Stratospheric Ozone Depletion and Reducing Ozone Depletion

Stratospheric Ozone & Life on Earth

⚠ **Ozone in the stratosphere absorbs UV-C and much of UV-B radiation**

- Without ozone layer, life on land would not be possible since UV-B & C radiation causes significant tissue damage & mutates DNA
- Human health benefits of stratospheric ozone:
  - Prevention of skin cancer & cataracts
  - UV-B & C mutate DNA (skin cancer) & cause oxidative stress in eyes (cataracts)

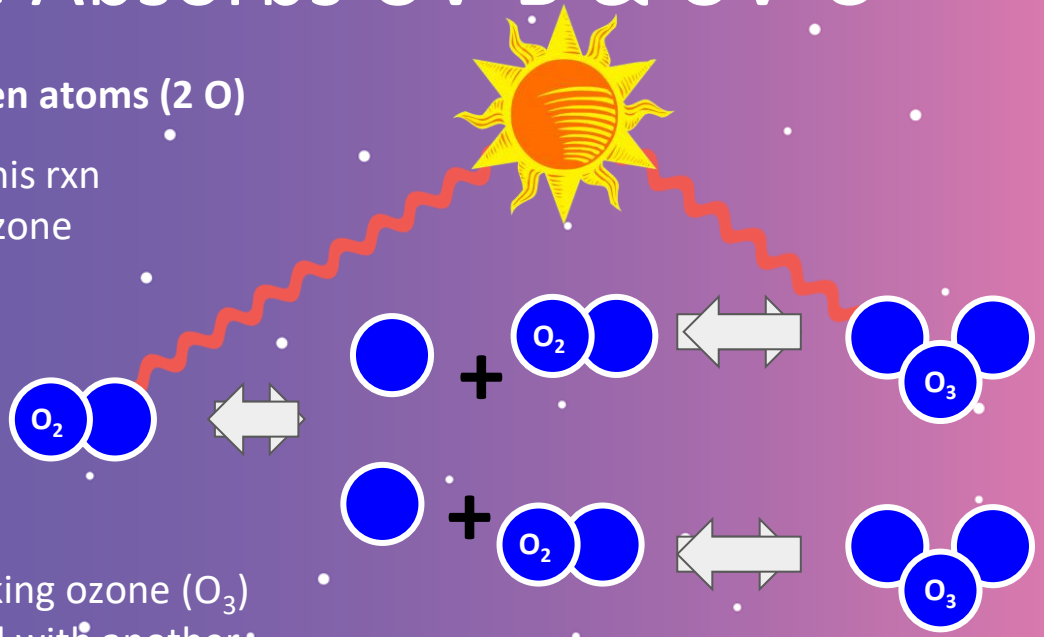
⚠ **Remember: tropospheric = respi. Irritant, damaging to plant tissue & precursor to photochemical smog**



How Ozone Absorbs UV-B & UV-C

UV-C breaks O_2 into two free oxygen atoms (2 O)

- When a free oxygen atom from this rxn combines with an O_2 molecule, ozone (O_3) is formed

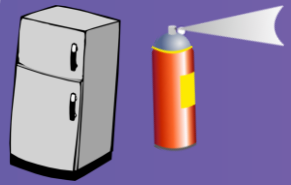


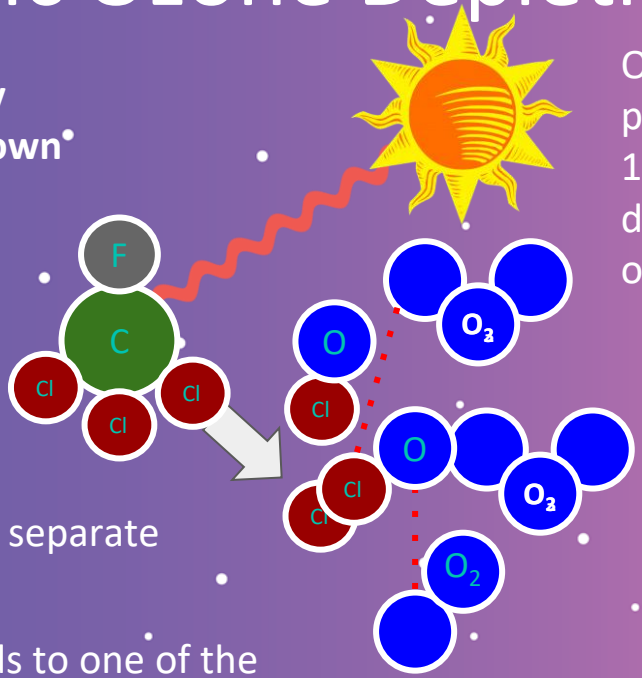
- UV-C also reverses the rxn by breaking ozone (O_3) into O_2 and O, which can then bond with another free O to form O_2
- Continued formation & break down of O_3 in stratosphere absorbs all UV-C & much UV-B radiation (protecting org. on earth)

Anthropogenic Ozone Depletion

⚠ CFCs (chlorofluorocarbons) are a primary anthropogenic (human) cause of O_3 breakdown

- Used as refrigerant chemicals and propellants in aerosol containers (hair spray, febreeze, etc.)





One single Cl atom persists in atm. for 50-100 years and can destroy up to 100,000 ozone molecules

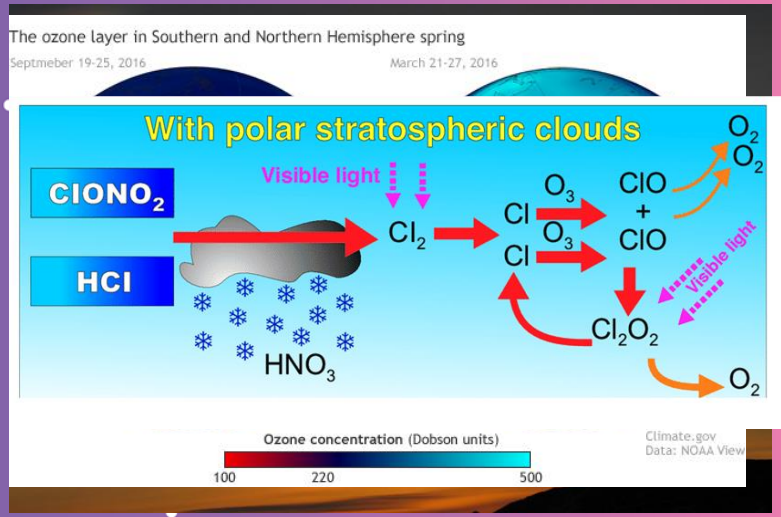
- UV radiation causes free chlorine atom to separate from CFCs
  - Highly electroneg. chlorine atom bonds to one of the oxygen atoms of ozone (O_3) converting it into oxygen (O_2)
  - Free O atom then bonds to O from chlorine monoxide to form O_2 and free Cl atom to go break down more O_3

Natural Ozone Depletion

⚠Antarctica spring melt forms polar stratospheric clouds (PSC)

- Clouds made of water & nitric acid (HNO_3) that can only form in consistent -100^0 F temp. range found above antarctica
- In presence of PSCs, chlorine nitrate ($ClONO_2$) and hydrochloric acid (HCl) react & give off Cl_2
  - Cl_2 is photolyzed (broken by sun) into 2 free Cl atoms

⚠Remember what Cl atoms due to ozone from CFCs (break O_3 down into O_2 over and over)



SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-4.B Describe chemicals used to substitute for chlorofluorocarbons (CFCs).	**STB-4.B.1** Ozone depletion can be mitigated by replacing ozone-depleting chemicals with substitutes that do not deplete the ozone layer. Hydrofluorocarbons (HFCs) are one such replacement, but some are strong greenhouse gases.

9.2 - Objective/EKs/Skill

9.2 - Reducing Ozone Depletion

⚠ **Main way to reduce anthropogenic O_3 depletion is phasing out & replacing CFCs**

- **Montreal Protocol (87')** was a global agreement to phase CFCs out of production in refrigerators, aerosols and other uses
  - Replaced with HCFCs (CFCs with hydrogen added)
  - HCFCs still deplete O_3 and act as GHGs, but to a lesser degree than CFCs
  - Not a permanent solution, but a temporary transition option
    - (phase out in dev. Nations after 2020, developing nations have until 2030)

- *Replacement for HCFCs is HFCs (still GHGs, but not O_3 depleting since they don't contain Cl)

  **Replacements for HFCs are HFOs (just HFCs with C-C double bonds that shorten atm. Lifetime & GWP)

Practice FRQs 9.1 & 9.2

SUGGESTED SKILL

Environmental Solutions

7.B

Describe potential responses or approaches to environmental problems.

SUGGESTED SKILL

Concept Explanation

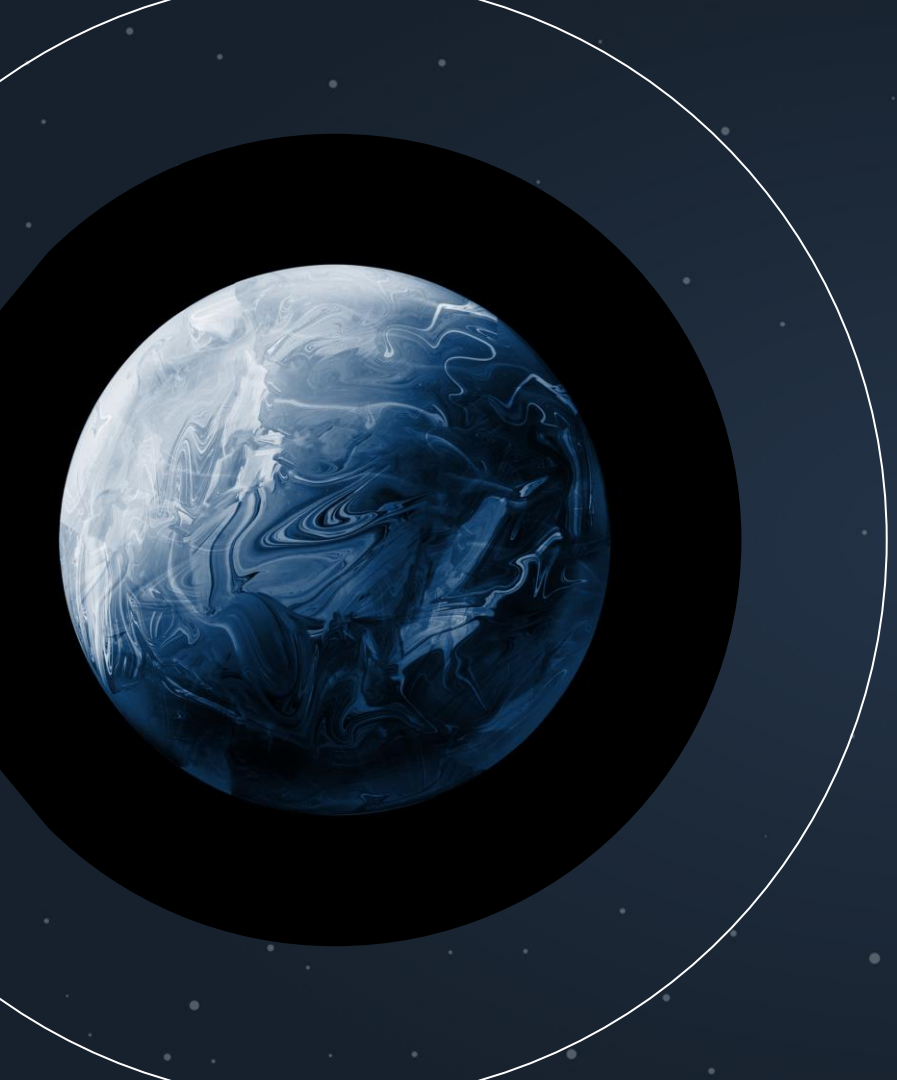
1.A

Describe environmental concepts and processes.

Describe how stratospheric ozone protects organisms on earth from UV radiation.

Describe how CFCs deplete stratospheric ozone.

Explain how the Montreal Protocol decreased ozone depletion.



9.3 THE GREENHOUSE EFFECT

OBJECTIVES/EKS/SKILL

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
STB-4.C Identify the greenhouse gases.	**STB-4.C.1** The principal greenhouse gases are carbon dioxide, methane, water vapor, nitrous oxide, and chlorofluorocarbons (CFCs). **STB-4.C.2** While water vapor is a greenhouse gas, it doesn't contribute significantly to global climate change because it has a short residence time in the atmosphere. **STB-4.C.3** The greenhouse effect results in the surface temperature necessary for life on Earth to exist.
STB-4.D Identify the sources and potency of the greenhouse gases.	**STB-4.D.1** Carbon dioxide, which has a global warming potential (GWP) of 1, is used as a reference point for the comparison of different greenhouse gases and their impacts on global climate change. Chlorofluorocarbons (CFCs) have the highest GWP, followed by nitrous oxide, then methane.

SUGGESTED SKILL

Concept Explanation

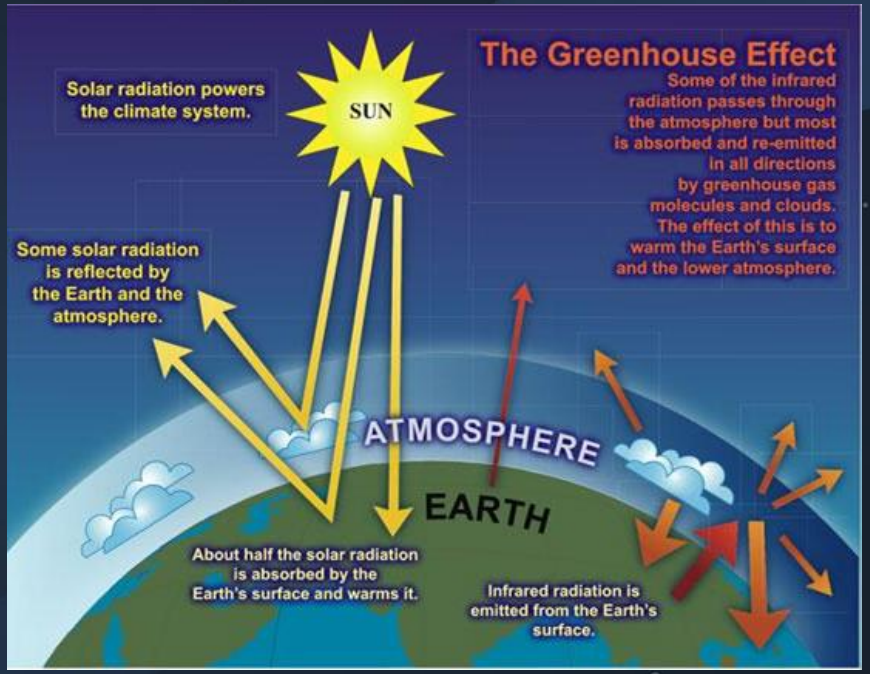
1.B

Explain environmental concepts and processes.

SOLAR RADIATION

⚠ **Not all incoming solar radiation reaches earth's surface**

- 26% reflected back into space by clouds & atm.
- 19% absorbed by atm. & clouds & radiated out into space & down to earth
- The rest reaches earth's surface where it can be absorbed or reflected (depending on the albedo of the surface it strikes)
    - Darker, lower albedo surfaces absorb sunlight & release infrared radiation (which we feel as warmth)
    - Lighter, higher albedo surfaces reflect sunlight, directly back out into space, or into clouds/GHGs that absorb it



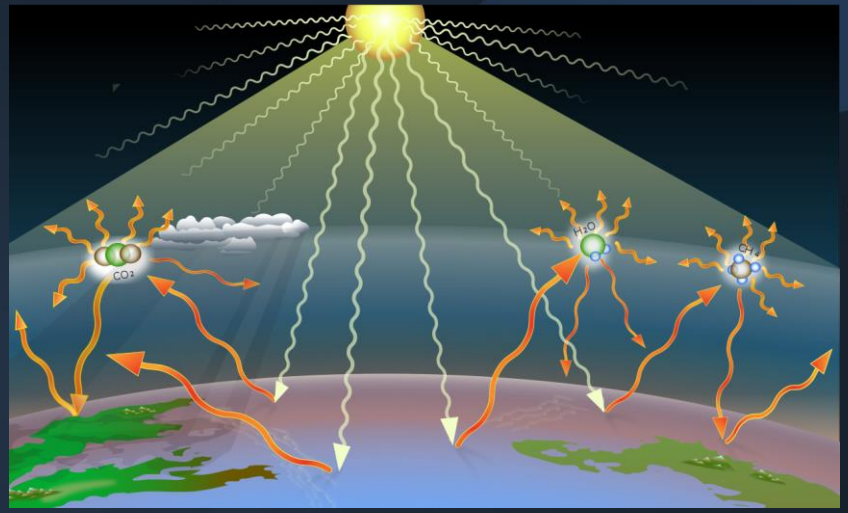
THE GREENHOUSE EFFECT

⛰Gases in earth's atmosphere trap heat from the sun & radiate it back down to earth

- Without greenhouse effect, earth would be too cold to support life

How it works:

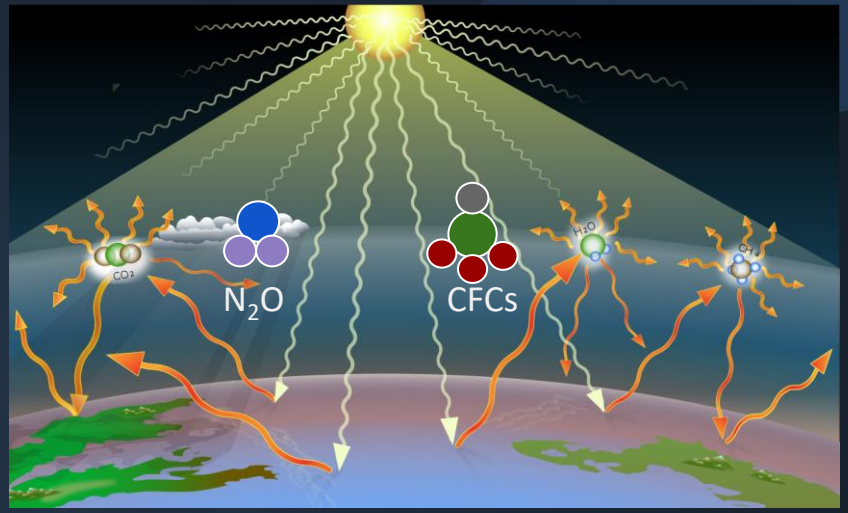
- Solar radiation (light waves like UV & visible light) strike earth's surface, heating it
- Earth's surface releases infrared radiation
- Greenhouse gases absorb infrared radiation & radiate it both out into space and back toward earth
- Portion coming back to earth is the "greenhouse effect"



GREENHOUSE GASES & SOURCES

Most important Greenhouse Gases (GHGs) are:

- **CO_2** - FF comb, decomposition, deforestation
- **Methane (CH_4)** - natural gas extraction & combustion, animal agriculture, anaerobic decomp. (especially permafrost thaw)
- **Nitrous oxide (N_2O)** - agricultural soils (denitrification of nitrate, especially in overwatered, over fertilized soils)
- **CFCs/HCFCs/HFCs** - refrigerants, blowing agents in aerosol products



***Water vapor (H_2O)** - *evaporation & transpiration from plants*

Technically a GHG by definition, but doesn't drive atm. temp change (other way around - temp. Controls atm. H_2O vapor level)

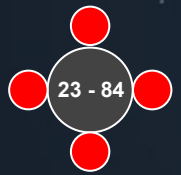
GLOBAL WARMING POTENTIAL (GWP)

⚠ **Measure of how much a given molecule of gas can contribute to the warming of the atmosphere over a 100 year period, relative to CO_2**

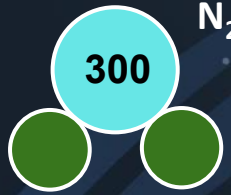
⚠ **Based on 2 factors:**

1) **Residence time:** how long molecule stays in the atmosphere
2) **Infrared absorption:** how well the gas absorbs & radiates Infrared radiation (IR)

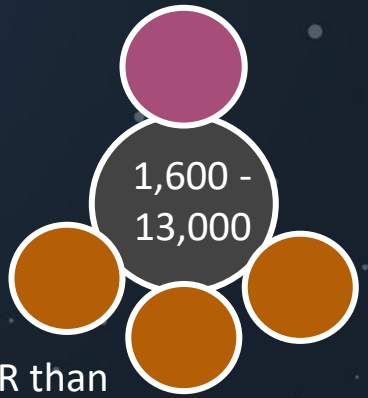
CO_2 has a GWP of 1 (all other gases are measured in relation to CO_2)



Methane (CH_4) remains in atm. around 12 yrs, absorbs more IR than CO_2



N_2O remains in atm. around 115 yrs, absorbs **much** more IR than CO_2



CFCs remain in atm 50-500 yrs, absorb **much, much, much more** IR than CO_2

PRACTICE FRQ 9.3

Explain how greenhouse gases in the atmosphere contribute to the heating of earth's climate.

Identify a greenhouse gas that has a GWP greater than 1. **Explain** why this greenhouse gas has a higher GWP than 1.

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

9.4
Increase in Greenhouse Gases

Objective/EKs/Skill

SUGGESTED SKILL

Visual Representations

2.C

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

LEARNING OBJECTIVE

STB-4.E

Identify the threats to human health and the environment posed by an increase in greenhouse gases.

ESSENTIAL KNOWLEDGE

STB-4.E.1

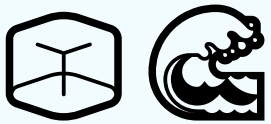
Global climate change, caused by excess greenhouse gases in the atmosphere, can lead to a variety of environmental problems including rising sea levels resulting from melting ice sheets and ocean water expansion, and disease vectors spreading from the tropics toward the poles. These problems can lead to changes in population dynamics and population movements in response.

Why Sea Level Is Rising

Thermal Expansion

- Water molecules move slightly further apart when they're heated
- All the water molecules of ocean moving slightly apart leads to sea level rising

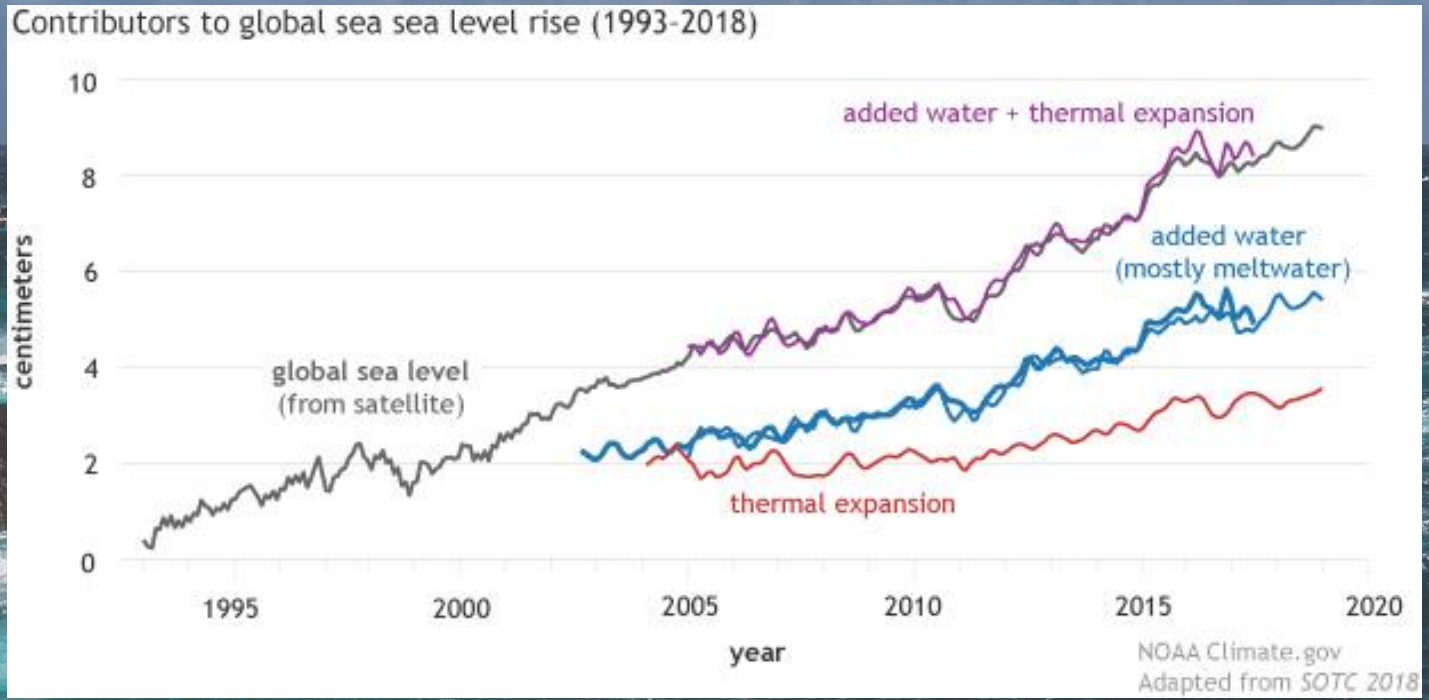
- Increased greenhouse gases lead to a warmer climate & more melting of continental ice sheets (Antarctica) and glaciers
- This water flows into the ocean and leads to sea level rise



Melting Ice Sheets & Glacial Ice

**NOTE: Sea ice (such as N polar ice) melt does NOT cause sea level rise, only land-based ice sheets and glaciers*

Why Sea Level Is Rising

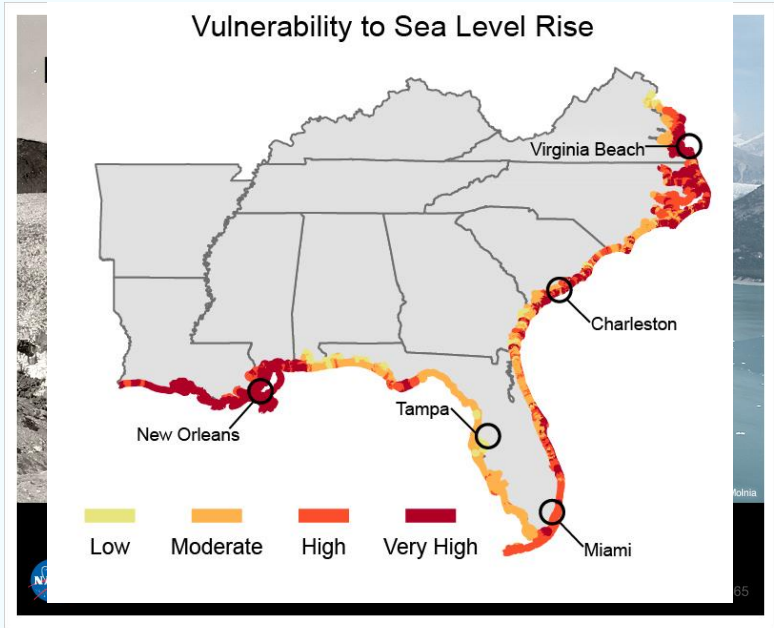


Env. Impacts of Sea Level Rise

- **Flooding of coastal ecosystems like estuaries (mangroves, salt marshes)**
  - Loss of species that depend on arctic and tundra ecosystems (polar bears, penguins, reindeer)
  - Loss of thaw-freeze cycle that glaciers go through, depriving surrounding ecosystems and human communities of water source

Human Impacts

- **Relocation of coastal human populations**
  - Increase in flood frequency = higher insurance and repair costs, lost property
  - Saltwater intrusion (salt water pushing into ground water & contaminating wells)
  - Refugees forced to move inland



Disease Vectors

Vectors

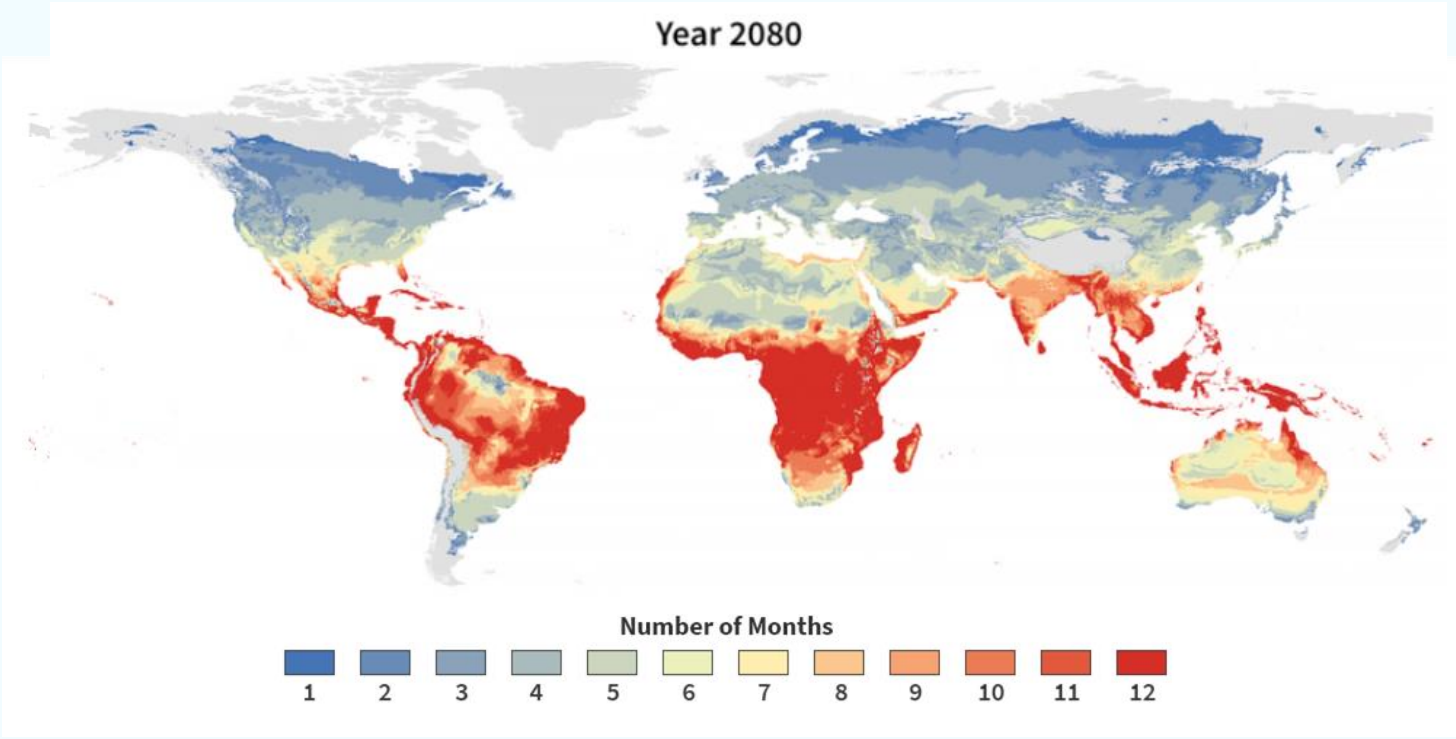
- Living organisms (usually mosquitoes, ticks, fleas) that can transmit diseases from human to human or animal to human
  - Ex: malaria, Zika, West Nile, dengue fever, cholera

- Warmer temperatures allow insect-transmitted diseases to spread to parts of the world previously too cold
- As the insect vectors expand their range further from equators, toward poles, new human pops. are at risk

Expanded Range

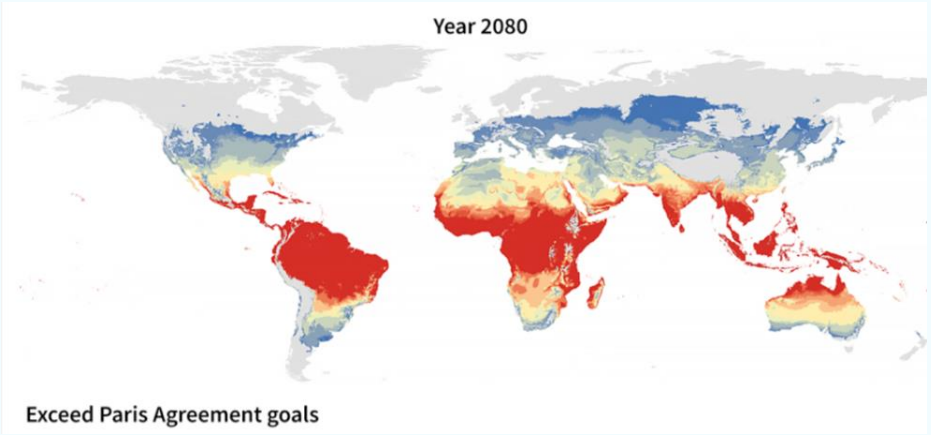
Current *Aedes aegypti* range

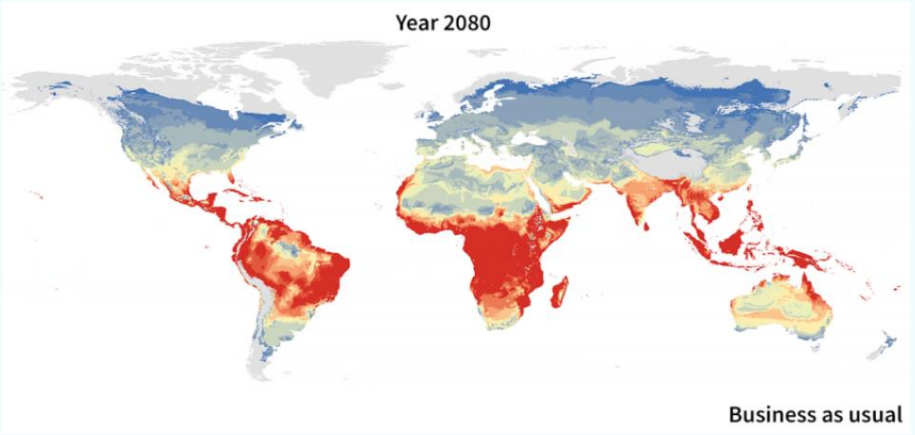
Vector for dengue fever, Zika virus, yellow fever



Projected *Aedes aegypti* range

Vector for dengue fever, Zika virus, yellow fever





Practice FRQ 9.4

SUGGESTED SKILL

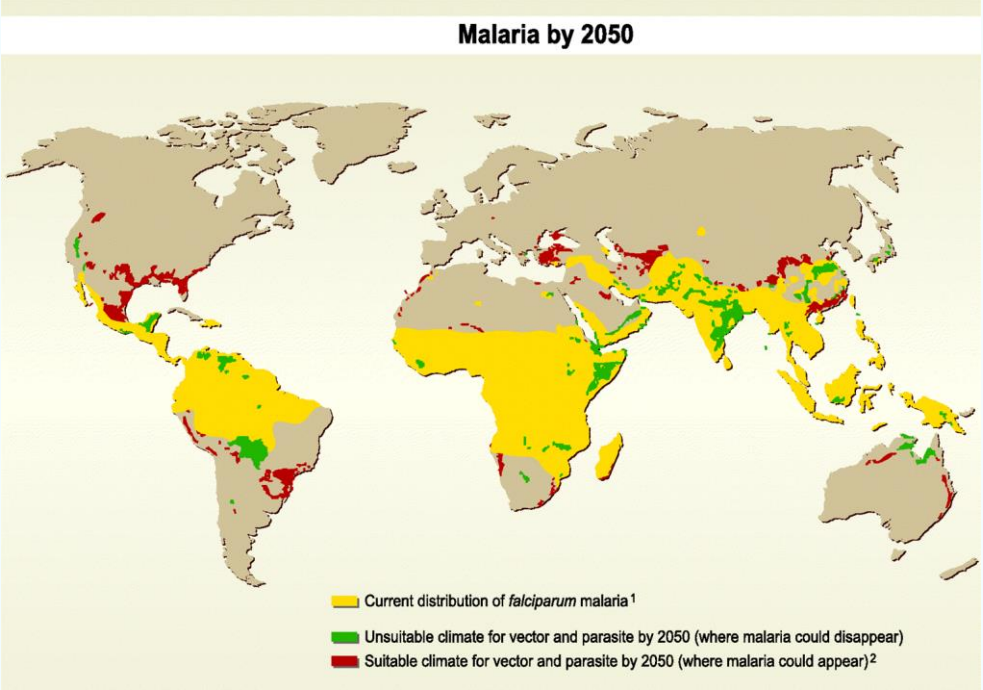
Visual Representations

2.C

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

Identify a region where malaria rates may increase by the year 2050.

Explain how climate change may contribute to this increase in malaria in this region.



9.5 (pt. 1)
Global Climate Change

Objective/EKs/Skill

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.1

The Earth has undergone climate change throughout geologic time, with major shifts in global temperatures causing periods of warming and cooling as recorded with CO_2 data and ice cores.

STB-4.F.2

Effects of climate change include rising temperatures, melting permafrost and sea ice, rising sea levels, and displacement of coastal populations.

STB-4.F.3

Marine ecosystems are affected by changes in sea level, some positively, such as in newly created habitats on now-flooded continental shelves, and some negatively, such as deeper communities that may no longer be in the photic zone of seawater.

STB-4.F.4

Winds generated by atmospheric circulation help transport heat throughout the Earth. Climate change may change circulation patterns, as temperature changes may impact Hadley cells and the jet stream.

SUGGESTED SKILL

Data Analysis

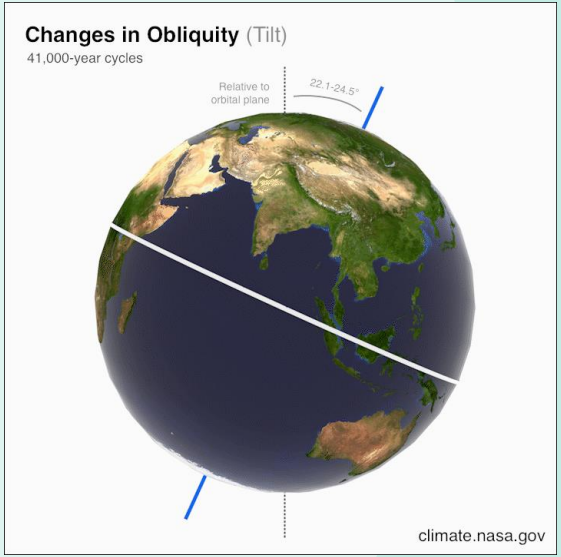
5.D

Interpret experimental data and results in relation to a given hypothesis.

Historic Climate Change

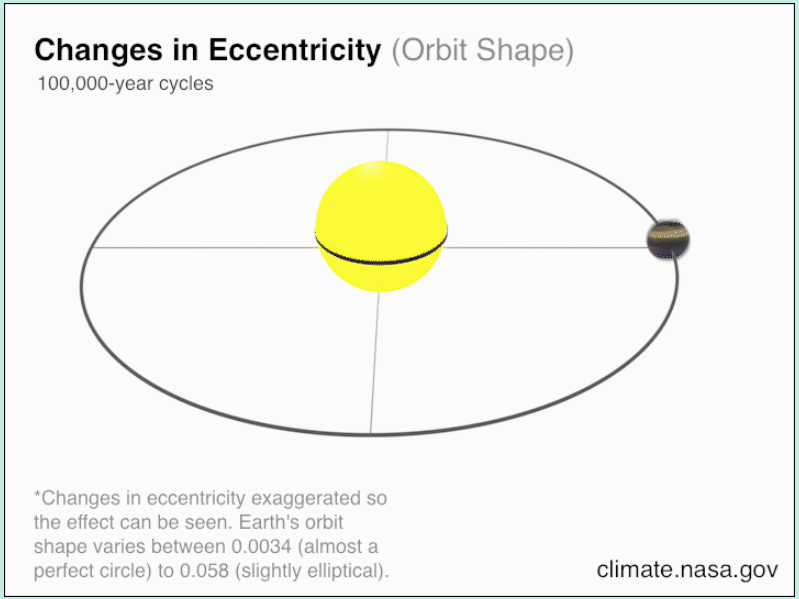
Earth's climate has varied over geologic time, largely due to variations in earth's orbit around the sun

- Varies in **obliquity** (~40,000 yrs.) exposing northern latitudes to higher insolation at different times



Leads to predictable variation in Earth's climate called Milankovitch Cycles

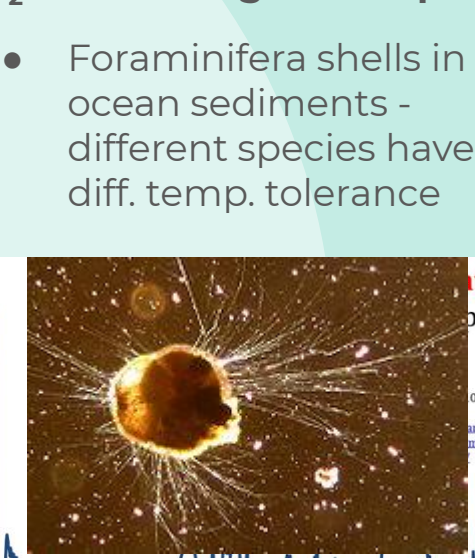
- Varies in **eccentricity** (~100,000 yrs.) bringing it closer to and further from the sun at different times
  - More eccentric = further from sun

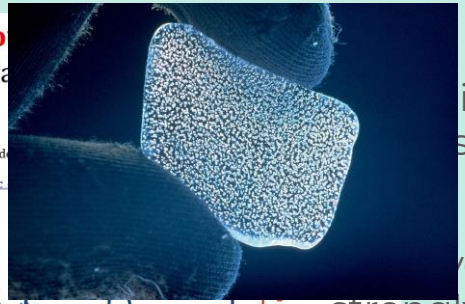


Earth's Historical Climate

Scientists have measured and estimated earth's historical temperature and CO_2 levels using 3 main pieces of evidence

- Foraminifera shells in ocean sediments - different species have diff. temp. tolerance
- Air bubbles in ice cores that contain ancient atmospheric gas (CO_2 levels)
- ^{16}O vs. ^{18}O isotope concentrations in ancient ice (↑ ^{18}O = ↑ temp.)





ice ages, followed by warmer
s occur roughly every 100,000 years

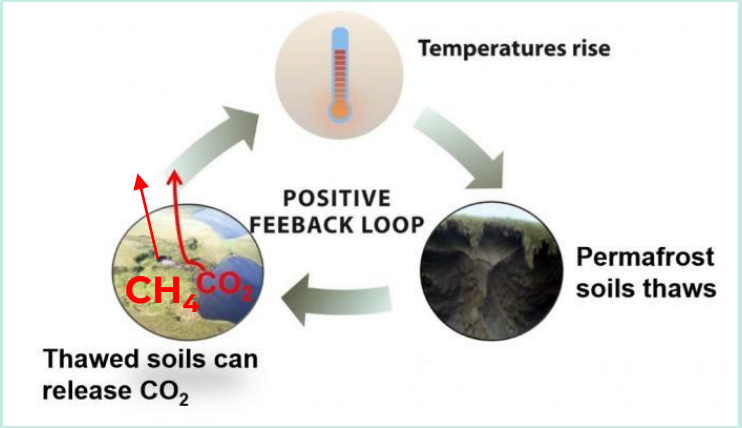
vels are
strongly correlated
with temperature,
but causality isn't
fully understood

Effects of Climate Change

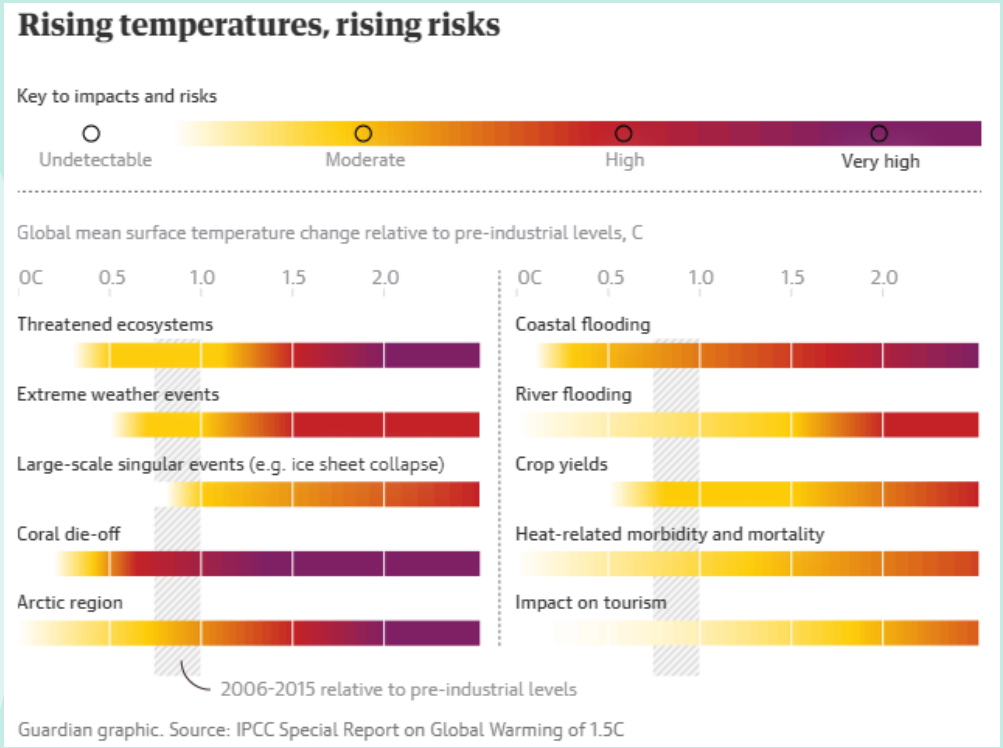
Rising Temperature - habitat/species loss, drought, soil desiccation, heat waves, increased precipitation in some regions

Rising Sea Level - due to glacial, continental ice sheet melt + thermal expansion

Melting of Permafrost - permanently frozen tundra soils that begin to thaw & release methane & CO_2 from anaerobic decomposition



Risks of Global Warming to 2.0º C

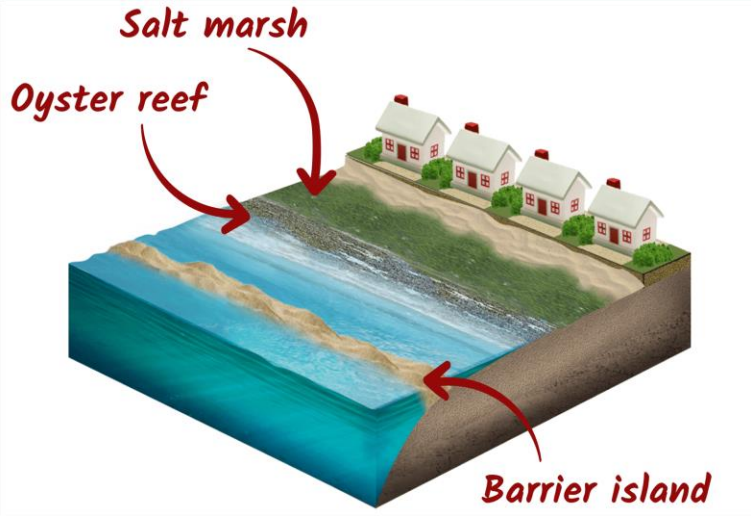


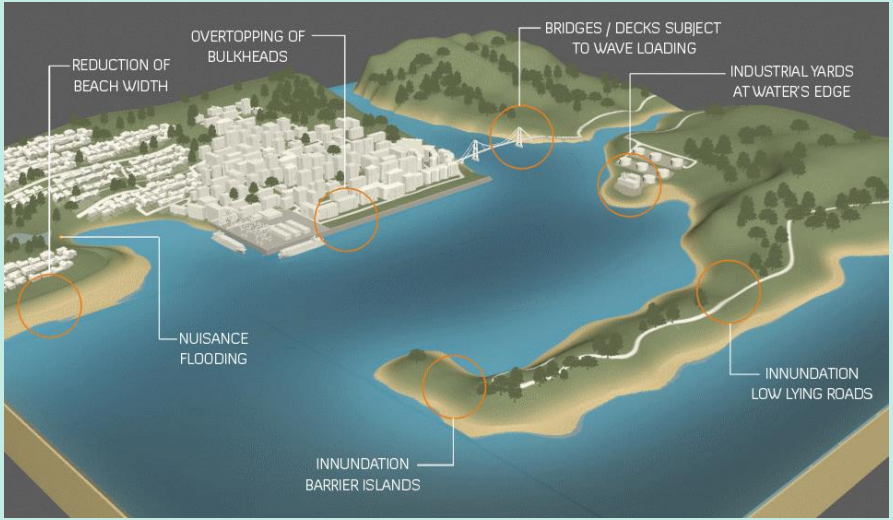
Impact on Coastal Communities

Property loss, damage, potential relocation: Coastal communities, especially poorer ones that can't build up may need to relocate inland

- Seawalls or other barriers can be built higher, but this just delays eventual flooding

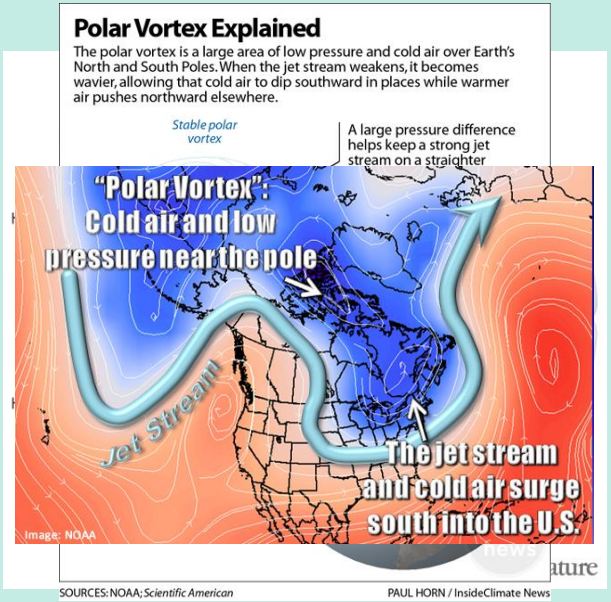
Loss of barrier islands: islands that buffer coastal communities/ecosystems from wind & waves may be lost as sea level rises





Impact on Atmospheric Currents

- **Widening & weakening of hadley cell:** as temp. diff. between equator and poles decreases, air ascending and expanding from equator travels further before sinking
  - This shifts subtropical zones (dry, desert biomes) toward the poles and expands the tropics
  - Regions between 30^0 and 60^o may experience drier climate as cool, dry, descending air from hadley cell shifts north & south
- **Weakened, destabilized Jet Stream**: as arctic warms faster than other areas of earth, temp. difference between equator & poles weakens
  - Because temperature & pressure diff. between polar & subtropical regions is what drives the polar jet stream, less diff. between them means weaker, wobblier jet stream
    - Leads to extreme cold spells in eastern US & dry spells in western US



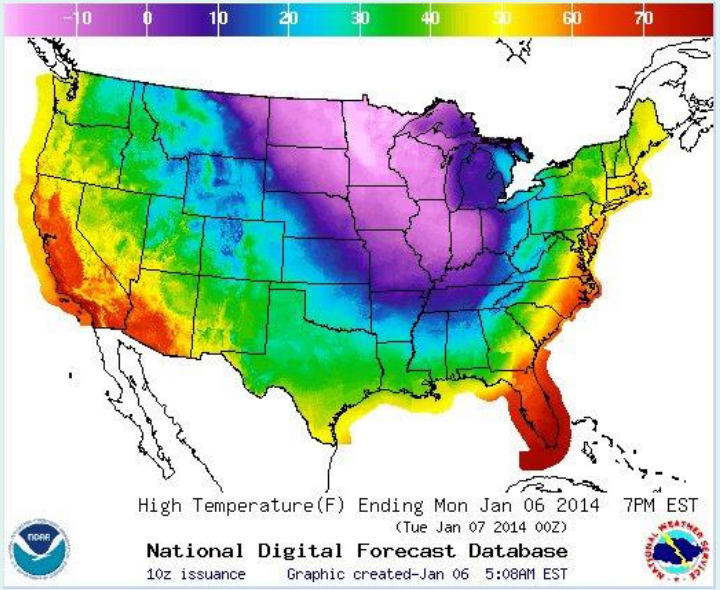
Practice FRQ 9.5

SUGGESTED SKILL

Data Analysis

5.D

Interpret experimental data and results in relation to a given hypothesis.



Explain how the data above support the hypothesis that a destabilized polar jet stream caused the cold spell seen in the midwest.

9.5 (pt. 2)
Global Climate Change

Objective/EKs/Skill

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.5

Oceanic currents, or the ocean conveyor belt, carry heat throughout the world. When these currents change, it can have a big impact on global climate, especially in coastal regions.

STB-4.F.6

Climate change can affect soil through changes in temperature and rainfall, which can impact soil's viability and potentially increase erosion.

STB-4.F.7

Earth's polar regions are showing faster response times to global climate change because ice and snow in these regions reflect the most energy back out to space, leading to a positive feedback loop.

STB-4.F.8

As the Earth warms, this ice and snow melts, meaning less solar energy is radiated back into space and instead is absorbed by the Earth's surface. This in turn causes more warming of the polar regions.

STB-4.F.9

Global climate change response time in the Arctic is due to positive feedback loops involving melting sea ice and thawing tundra, and the subsequent release of greenhouse gases like methane.

STB-4.F.10

One consequence of the loss of ice and snow in polar regions is the effect on species that depend on the ice for habitat and food.

SUGGESTED SKILL

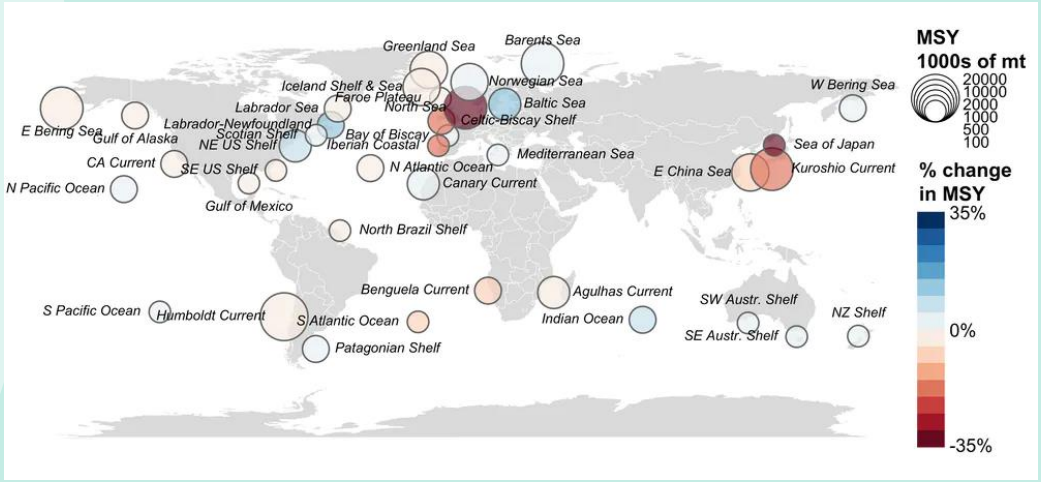
Data Analysis

5.D

Interpret experimental data and results in relation to a given hypothesis.

Impact on Marine Ecosystems

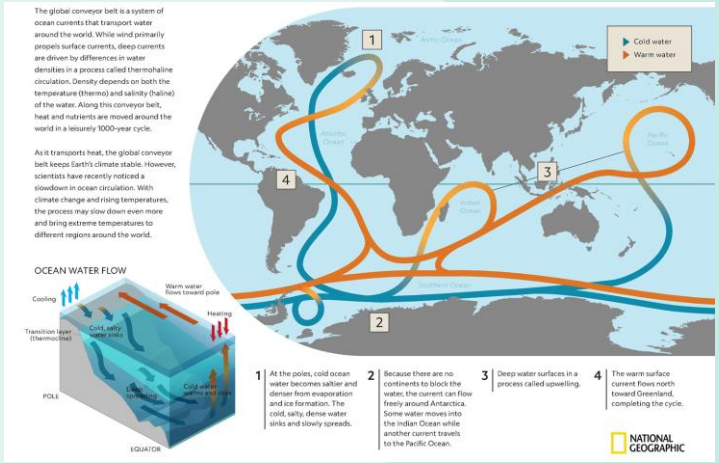
- **Altered range of marine ecosystems:** some new marine habitats will be formed by rising sea level flooding coastline
    - Some areas of ocean will become too deep to receive sunlight & photic zone will shift up, further from ocean floor
- **Altered ranges for organisms**: warm water holds less O_2, so many fish populations have declined, or migrated to cooler waters

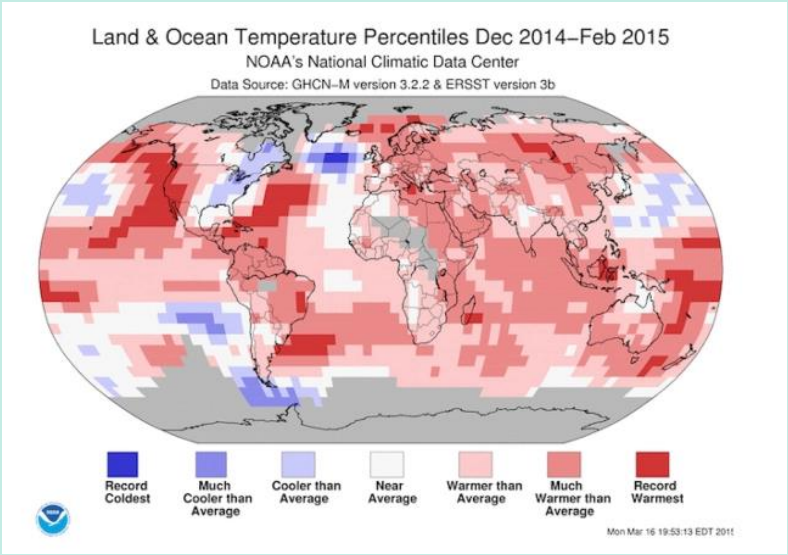


Impact on Ocean Circulation

Suppression of thermohaline circulation: global ocean current that redistributes heat from the equator, salt, and nutrients by mixing ocean waters could slow or stop altogether

- Ice melt from Greenland → especially cold, fresh water buildup in north atlantic
- Freshwater is less dense than salt, preventing it from sinking
- This cold north atlantic slows warmer Gulf Stream waters, cooling Europe & slowing global thermohaline circulation



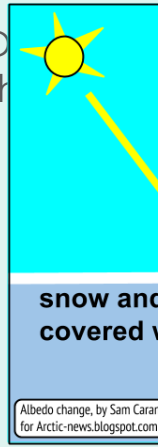


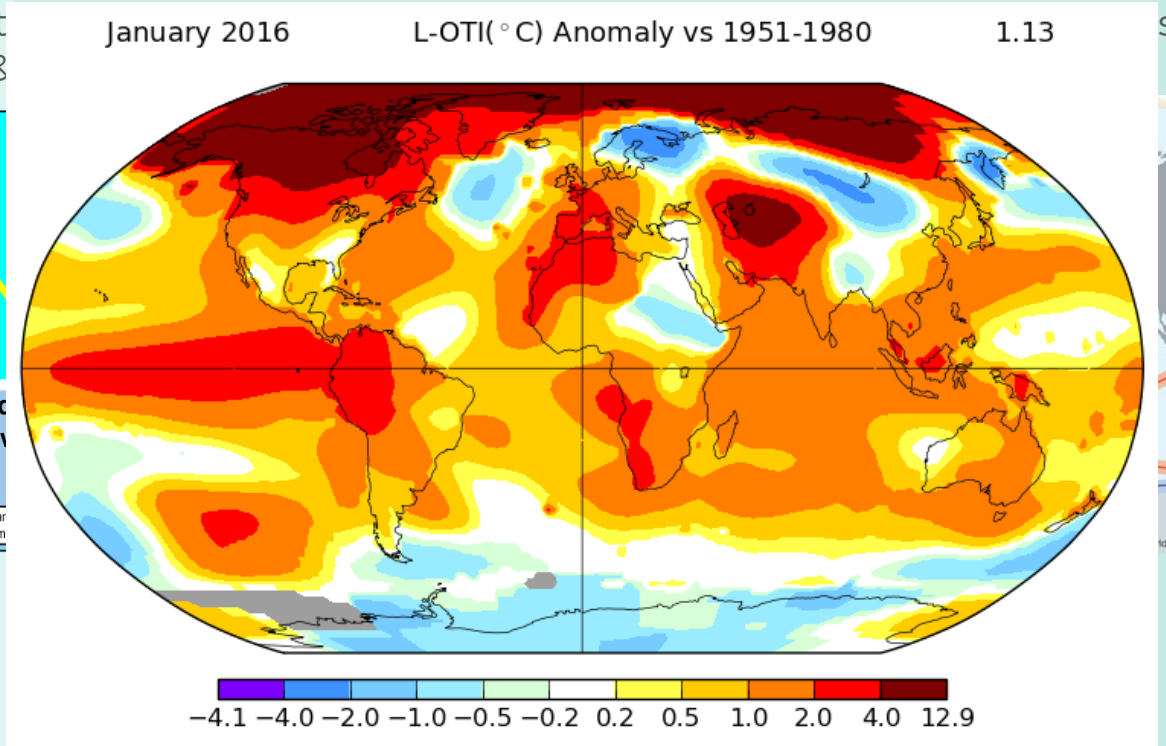
Unequal Global Warming

Polar regions of earth are warming faster than other regions (polar amplification)

- Especially the arctic (N pole) because there is more land & less water to absorb heat
  - Melt
    ice &
- D
  th

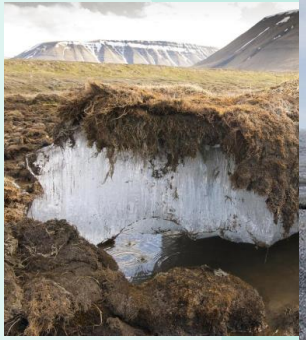
sunlight than

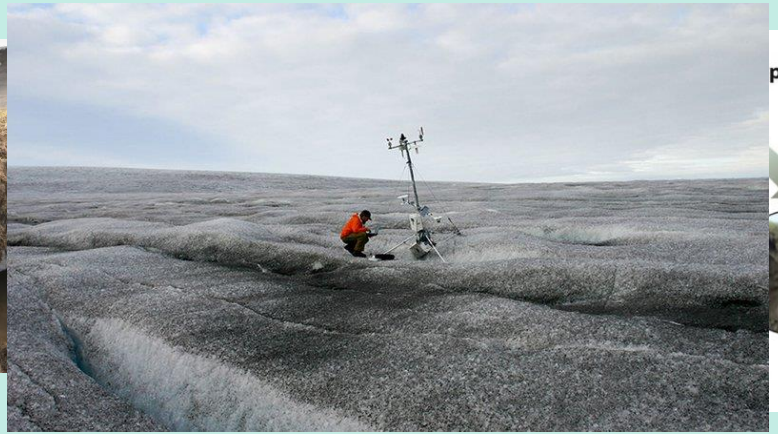


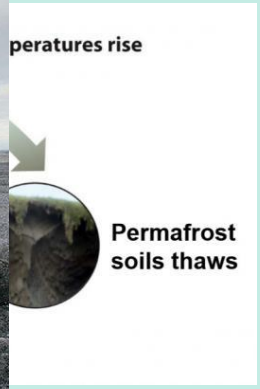


Unequal Global Warming

Melting of Permafrost - permanently frozen tundra soils that begin to thaw & release methane & CO_2 from anaerobic decomposition





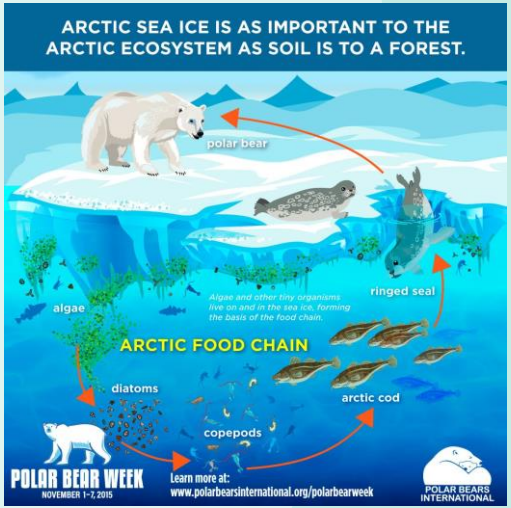


- Air pollution adds soot & other PM to atmosphere, distributed to poles by atmospheric circulation
    - Darker, soot/PM covered ice absorbs even more heat due to lower albedo

Impact on Polar Ecosystems

Arctic sea ice loss = habitat loss

- Seals use it for resting and find holes for breathing
- Algae grow on ice, forming base of arctic food web
- Polar bears use ice for hunting seals at breathing holes



9.6
Ocean Warming

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

Objective/EKs/Skill

LEARNING OBJECTIVE

STB-4.G

Explain the causes and effects of ocean warming.

ESSENTIAL KNOWLEDGE

STB-4.G.1

Ocean warming is caused by the increase in greenhouse gases in the atmosphere.

STB-4.G.2

Ocean warming can affect marine species in a variety of ways, including loss of habitat, and metabolic and reproductive changes.

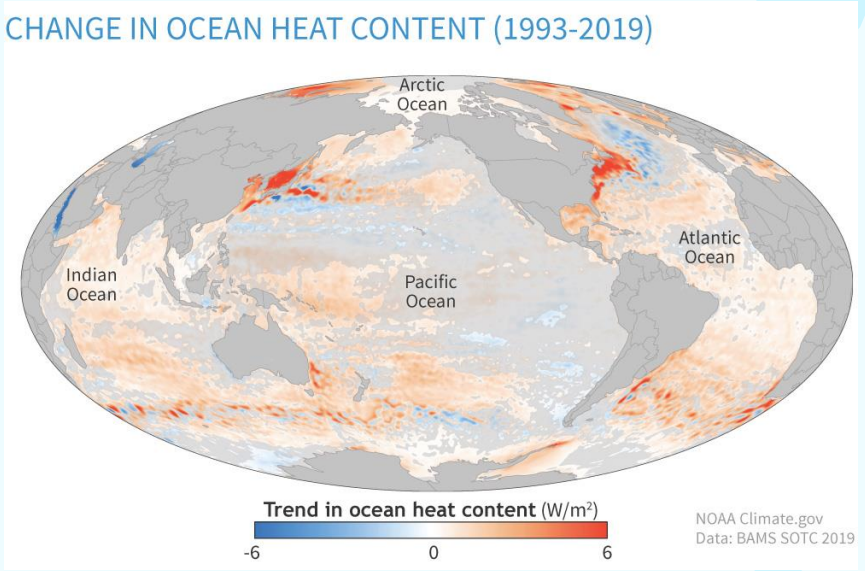
STB-4.G.3

Ocean warming is causing coral bleaching, which occurs when the loss of algae within corals cause the corals to bleach white. Some corals recover and some die.

Atmospheric Warming ⟷ Ocean Warming

As the atmosphere warms, heat is transferred to the ocean

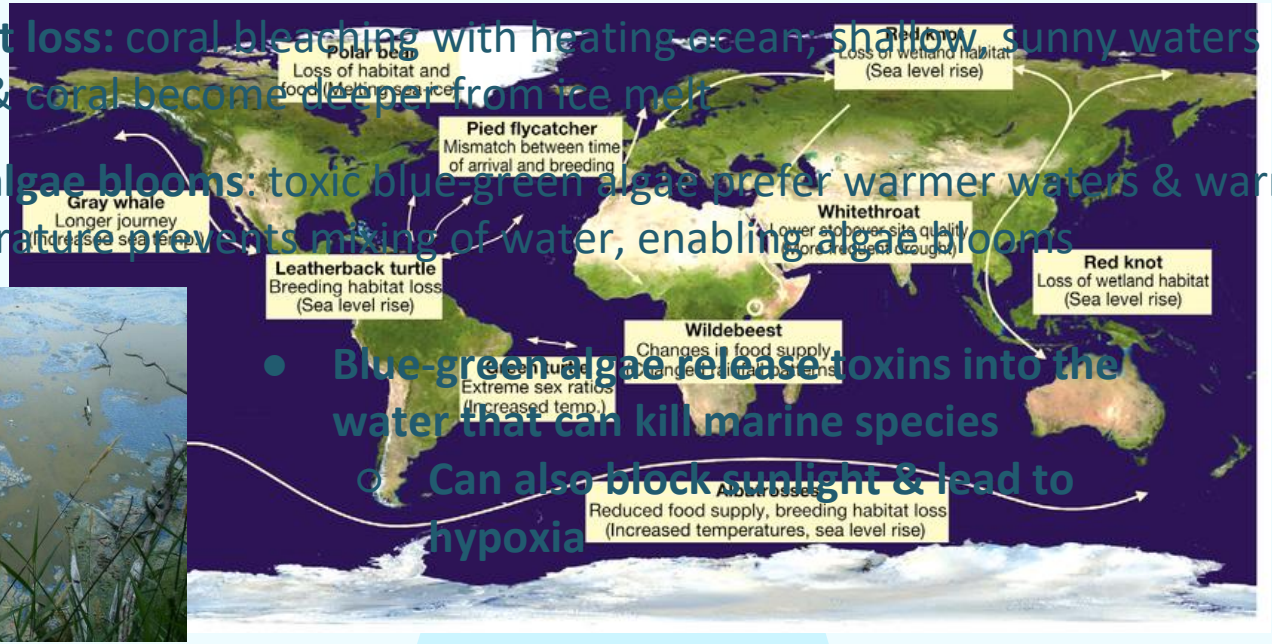
- Ocean absorbs heat radiated back to earth by greenhouse gases
- Oceans absorb much of earth's heat due to high specific heat of water (est. 90% of earth's warming from past 50 yrs. occured in oceans)
- Thermohaline circ. distributes heat absorbed at surface to depths & other areas of earth
    - Heat absorbed by ocean can transfer back to atmosphere for decades



Effects on Marine Species

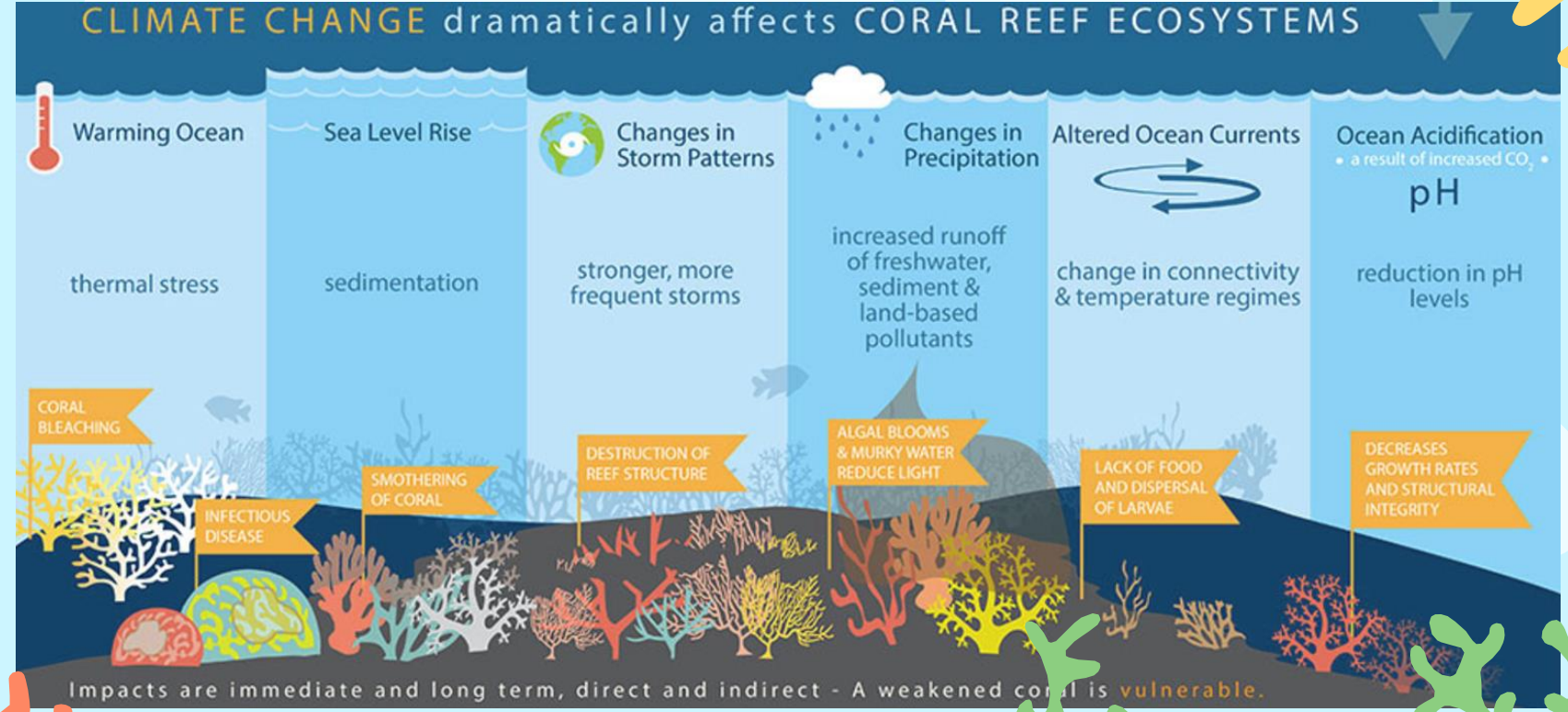
Warmer water holds less O_2; causing resp. stress or suffocation

- Migratory routes and mating seasons can be altered, especially for whales
  - Reproductive timing, often tied to temp. change, can be disrupted (fish esp.)
- **Habitat loss:** coral bleaching with heating ocean; shallow, sunny waters ideal for algae & coral become deeper from ice melt
- **Toxic algae blooms**: toxic blue-green algae prefer warmer waters & warm temperature prevents mixing of water, enabling algae blooms



- **Blue-green algae release toxins into the water that can kill marine species**
  - **Can also block sunlight & lead to hypoxia**

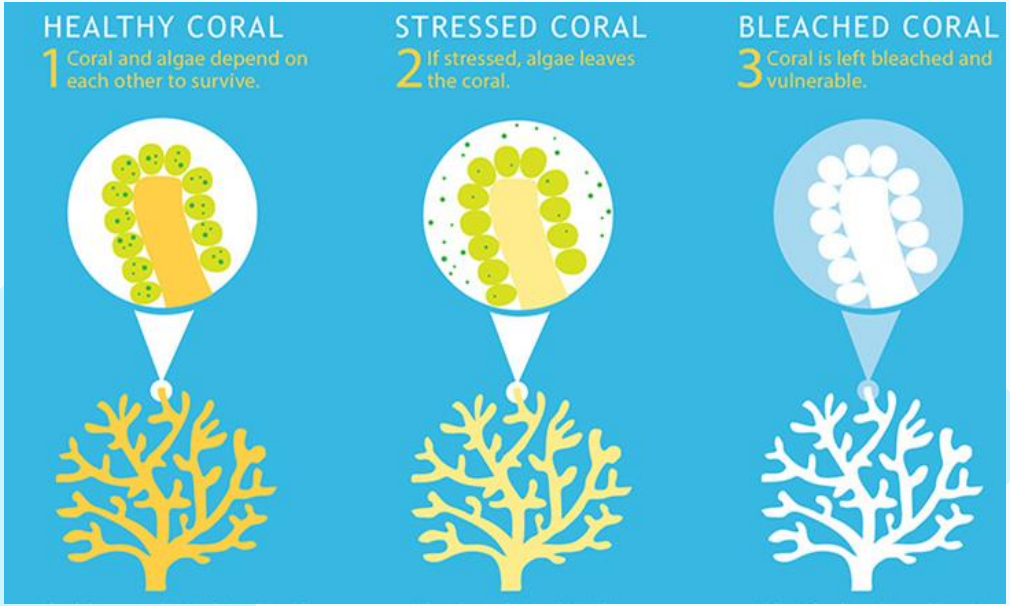
Climate Change & Coral Reef



Coral Bleaching

⛰ Coral reef = mutualistic relationship between coral & photosynthetic algae called zooxanthellae; algae supply sugar & coral supply CO_2 + detritus (nutrient containing org. matter.)

- Algae have narrow temp. tolerance and leave the reef when temp. rises
    - Pollutants from runoff (sediment, pesticides, sunscreen) can also force algae from reef
- Coral lose color & become stressed and vulnerable to disease without algae (main food source)



SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

Practice FRQ 9.6

Describe one climate change-related threat to coral reef ecosystems.

Describe one climate change-related threat to a marine species other than coral.

9.7

Ocean Acidification

SUGGESTED SKILL

Concept Explanation

1.C

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

Objective/EKs/Skill

LEARNING OBJECTIVE

STB-4.H

Explain the causes and effects of ocean acidification.

ESSENTIAL KNOWLEDGE

STB-4.H.1

Ocean acidification is the decrease in pH of the oceans, primarily due to increased CO_2 concentrations in the atmosphere, and can be expressed as chemical equations.

STB-4.H.2

As more CO_2 is released into the atmosphere, the oceans, which absorb a large part of that CO_2, become more acidic.

STB-4.H.3

Anthropogenic activities that contribute to ocean acidification are those that lead to increased CO_2 concentrations in the atmosphere: burning of fossil fuels, vehicle emissions, and deforestation.

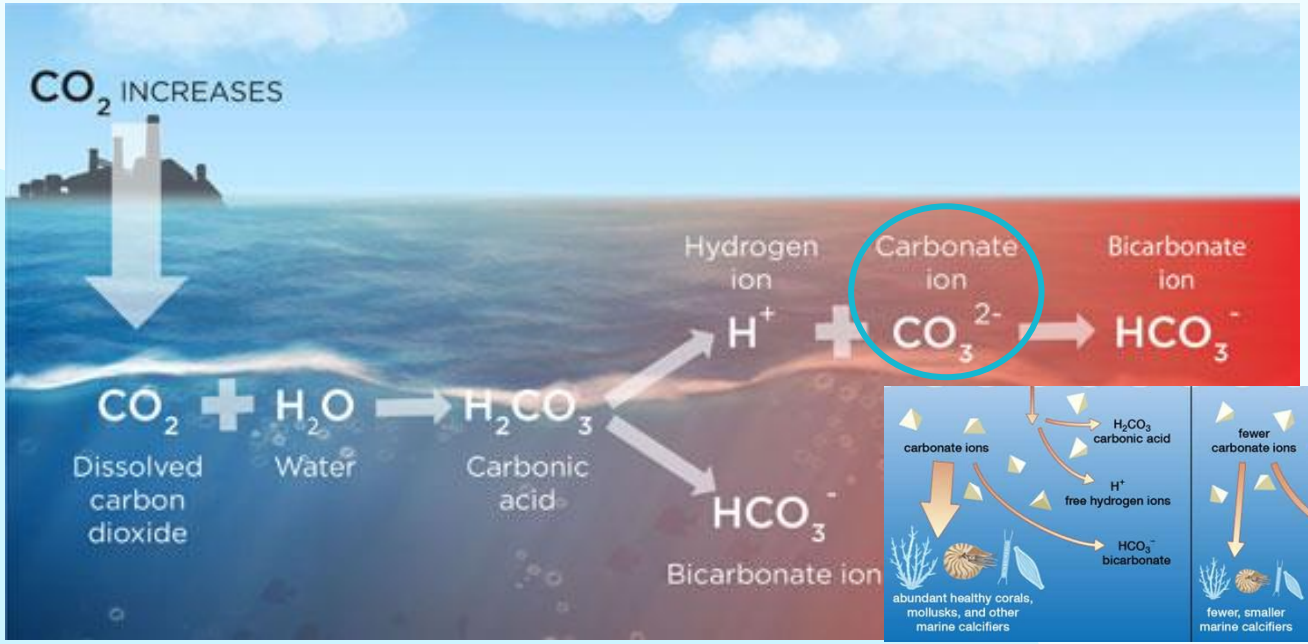
STB-4.H.4

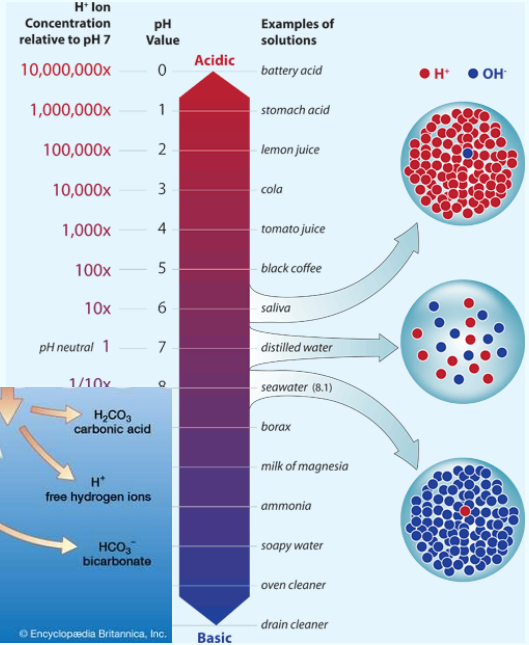
Ocean acidification damages coral because acidification makes it difficult for them to form shells, due to the loss of calcium carbonate.

Ocean Acidification

Increased CO_2 in atmosphere → increased ocean CO_2 (direct exchange)

- CO_2 combines with ocean water to form carbonic acid (H_2CO_3)
- Carbonic acid dissociates into Bicarbonate ion (HCO_3^-) and H^+ ion

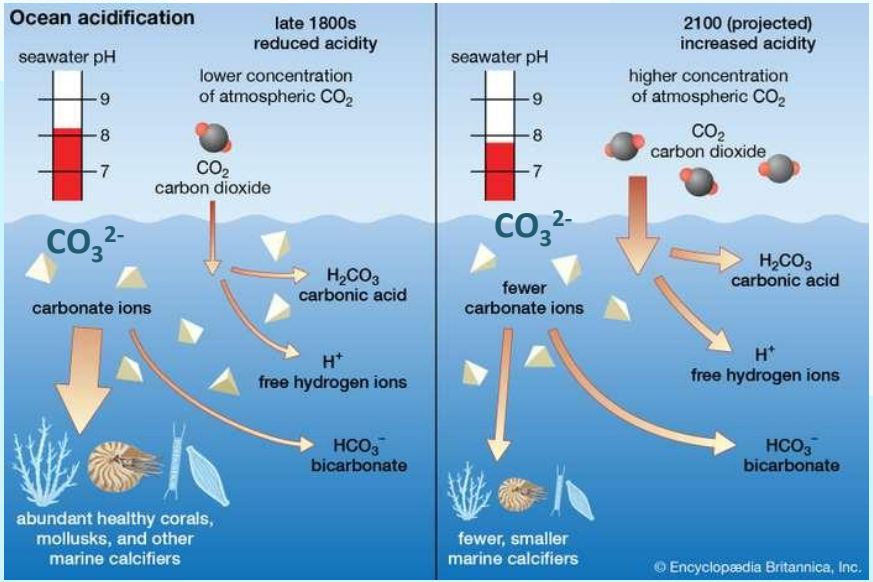




Calcium Carbonate & Marine Organisms

Marine org. that make shells use calcium (Ca^{+}) and carbonate (CO_3^{2-}) ions to build their calcium carbonate shells (calcification)

- CO_2 increase & ocean acidification makes carbonate ions less available
  - Carbonic acid → increased H^+ ions which bond w/carbonate to form Bicarbonate (HCO_3^-)



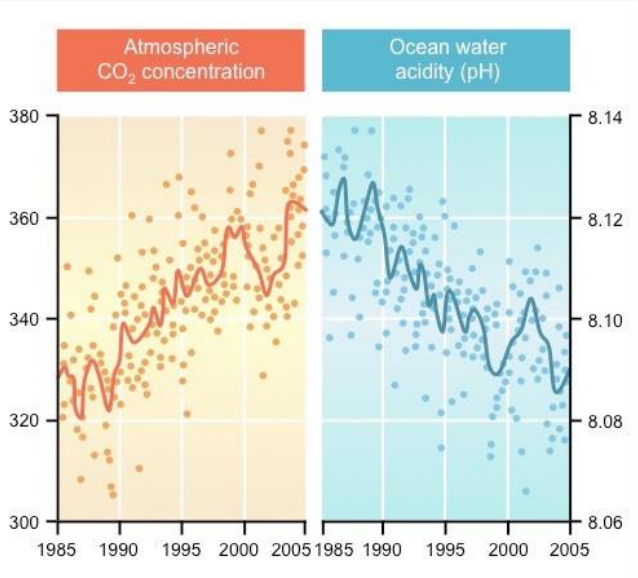
Marine shells breakdown as pH decreases and carbonate ions are less soluble in ocean water

Fewer carbonate ions = less calcification; weaker shells of coral, mollusks, and urchins

Climate Change & Ocean Acidification

⛰ Anthropogenic causes for ocean acidification: fossil fuel combustion (CO_2), deforestation (CO_2), and coal/gas combustion (NO_x/SO_x → acid precip.)

- CO_2 increase directly correlated with ocean acidification
  - Inverse relationship b/w atm. CO_2 & ocean pH (low pH = more acidic)



Ocean pH has decreased from 8.2 to 8.1 in past 150 years; could decrease to 7.8 by 2100

**pH = log scale so 8.2 to 8.1 = 30% decrease*

SUGGESTED SKILL

Concept Explanation

1.C

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

Practice FRQ 9.7

Identify a human activity that leads to ocean acidification. **Explain** how ocean acidification can threaten marine organisms.

9.8
Invasive Species

SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

Objective/EKs/Skills

LEARNING OBJECTIVE

EIN-4.A

Explain the environmental problems associated with invasive species and strategies to control them.

ESSENTIAL KNOWLEDGE

EIN-4.A.1

Invasive species are species that can live, and sometimes thrive, outside of their normal habitat. Invasive species can sometimes be beneficial, but they are considered invasive when they threaten native species.

EIN-4.A.2

Invasive species are often generalist, r-selected species and therefore may outcompete native species for resources.

EIN-4.A.3

Invasive species can be controlled through a variety of human interventions.

Invasive Species Basics

⚠ **Species not native to an area, introduced often by human transport**

- No natural predators to control pop.
- Highly competitive (aggressive feeders or fast growers) for resources
- Can thrive in their non-native habitats

r-selected, generalists

R-selected and generalist species are more likely to be invasive

- High biotic potential & low parental care
- Highly adaptable
- Diverse habitat & food needs

Invasive Species To Know

Zebra Mussel

- Transported by ship ballast water
- Aggressive filter feeders, eating algae many other species rely on
- 1 mil. eggs/yr.
- Clog intake pipes

Kudzu Vine

- Planted to limit soil erosion in southern US
- Grows very rapidly
- Outcompetes natives for sunlight; growing over them
- No herbivore control in US

Asian Carp

- Brought in to control algae growth in aquatic farms
- Escaped to Mississippi river; outcompete native fish for food and space
- Decreases fishery production & value

Invasive Species To Know

Emerald Ash Borer

- Spread by wood packing materials of ships/planes & fire wood
- Larvae laid in bark, eat their way into phloem
- Disrupts tree nutrient transport, killing them
- Expanding range due to global warming

Cane Toad

- Introduced to eat cane beetles causing sugarcane crop loss in Australia
- Became invasive due to huge appetite
- Drove declines in other amphibians and small reptiles

Pythons (FL)

- Brought to Florida as pets, released into wild by owners
- Decimated mammal populations in Everglades ~90-95%
- Aggressive hunters with no natural predators

Controlling invasives

Invasives estimated to cost US $120 billion/year (2005 est.)

- Lost ag. productivity, tourism, property value decline, fishery decline, control and removal costs

Control/Removal Methods

- Laws preventing transport of invasives (firewood for emerald ash borer)
  - Removal of hosts (dead ash trees for EAB) to reduce spread
- Careful boat cleaning & inspection (zebra mussels)
- Introduction of natural predator (biological control)
  - Chinese wasps to kill emerald ash borer
- Physical removal (hunting pythons, detaching z. mussels, pulling plants out, cutting trees down)

SUGGESTED SKILL

Environmental Solutions

7.E

Make a claim that proposes a solution to an environmental problem in an applied context.

Practice FRQ 9.8

Identify a specific example of an invasive species and **propose a solution** to limit the spread of that invasive species.

9.9
Endangered Species

SUGGESTED SKILL

Environmental Solutions

7.D

Use data and evidence to support a potential solution.

Objective/EKs/Skill

LEARNING OBJECTIVE

EIN-4.B

Explain how species become endangered and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.B.1

A variety of factors can lead to a species becoming threatened with extinction, such as being extensively hunted, having limited diet, being outcompeted by invasive species, or having specific and limited habitat requirements.

EIN-4.B.2

Not all species will be in danger of extinction when exposed to the same changes in their ecosystem. Species that are able to adapt to changes in their environment or that are able to move to a new environment are less likely to face extinction.

EIN-4.B.3

Selective pressures are any factors that change the behaviors and fitness of organisms within an environment.

EIN-4.B.4

Species in a given ecosystem compete for resources like territory, food, mates, and habitat, and this competition may lead to endangerment or extinction.

EIN-4.B.5

Strategies to protect animal populations include criminalizing poaching, protecting animal habitats, and legislation.

How Species Become Endangered

Poaching

- Poachers hunt exotic species for fur, tusks, horns
- May also be over harvested or hunted for food
- Removed from wild & sold as pets

Invasives

- Invasives can outcompete natives for resources (food, water, sun, space)
- Zebra mussels have endangered 30 native mussel species in US rivers

Special food/habitat needs

- Niche specialists are more prone to endangerment due to specific food/habitat needs
- Less tolerant of changing climate, habitat loss, wildfires, deforestation, urbanization, etc.

Climate Change

- Shifts habitats of many species
  - Migration to new habitat is harder with fragmentation/loss
- Changes in temp/preeip. can occur too rapidly for some species to migrate or adapt

Protecting Endangered Species

Poaching Prevention

- Hiring of armed guards to monitor populations and prevent poaching
- Laws that punish poaching severely, with stiff fines or jail time

Legislation

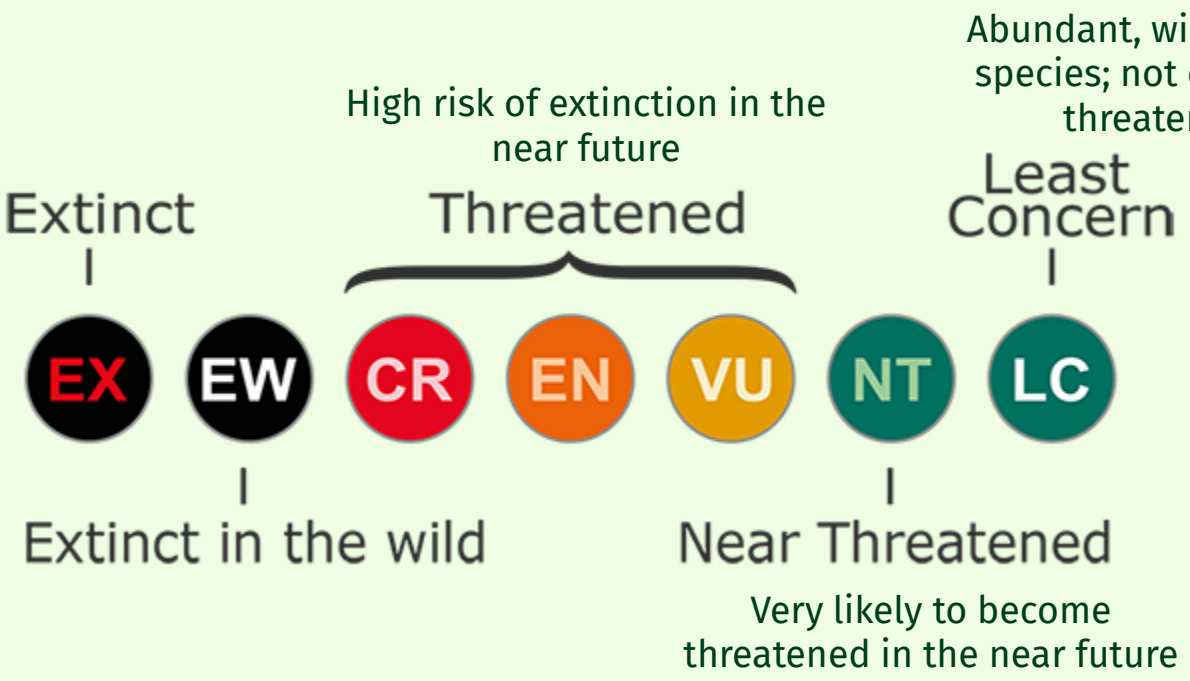
CITES: International agreement for countries to set up agencies to monitor import and export of endangered species (as specified by IUCN Red List)

Endangered Species Act: US law giving USFWS power to designate species as endangered or threatened, monitor trade, and purchase land critical to these species' habitats

Protect Wildlife Habitats

- Designating areas with important habitats as:
  - National parks
  - Wildlife preserves
  - Animal sanctuaries
- Prevention of
  - Hunting, development, fragmentation, deforestation
- Allows species to breed and reestablish population size

IUCN Red List



Endangerment by Taxon

Especially vulnerable to climate change due to biphasic life (relying on water and land) and highly permeable skin

Amphibians

Mammals

Birds

Threatened by changing ocean temperature and pH (ocean acidification from increasing atm. CO_2 levels)

Warm Water Coral

Conifers

Threatened by disease and warming temperatures expanding insect pest ranges

Coniferous forests sequester 3X as much CO_2 as temperate or tropical forests

Specialists vs. Generalists

Most likely to be endangered or become extinct

Least likely to be endangered or become extinct

Specialists

- Less likely to move to new habitat
- Less likely to adapt to new conditions
- Disadvantaged by rapidly changing habitat conditions

Generalists

- More likely to move to new habitat
- More likely to adapt to new conditions
- Advantaged by rapidly changing habitat conditions

Competition & Endangerment

Shenandoah salamander: endangered species, limited to ranges on only three specific mountains due to fiercely territorial red-backed salamander

VS

Red-backed Salamander Classified as “least concern” by IUCN. Guards rock habitats from other salamander species, preventing range expansion

- **Interspecific competition:** competition for resources (food, nest sites, water) amongst members of different species
  - Can cause species to become threatened, especially when combined with general habitat fragmentation or loss due to human land use
  - Can further threaten species already vulnerable to habitat disruption due to climate change

SUGGESTED SKILL

Environmental Solutions

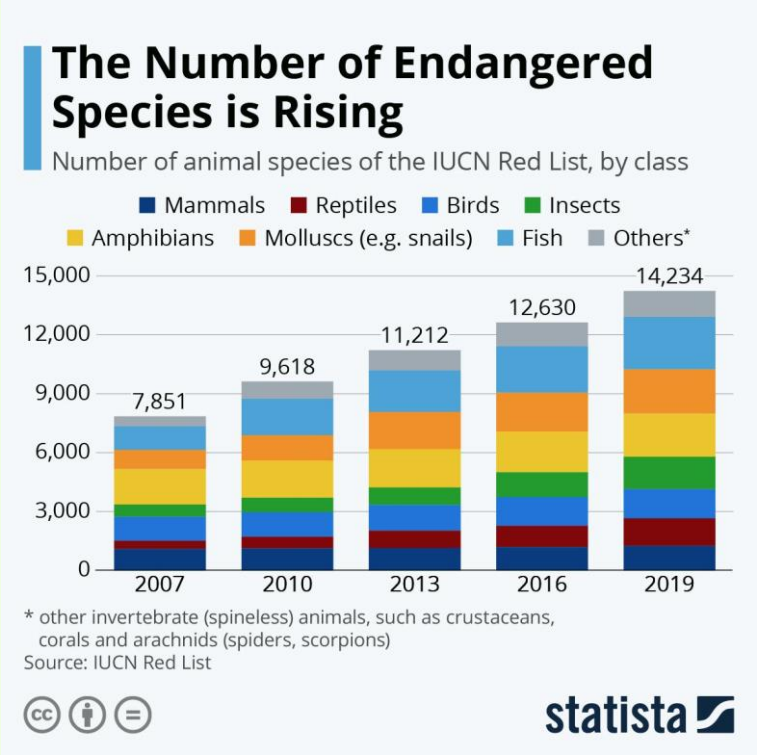
7.D

Use data and evidence to support a potential solution.

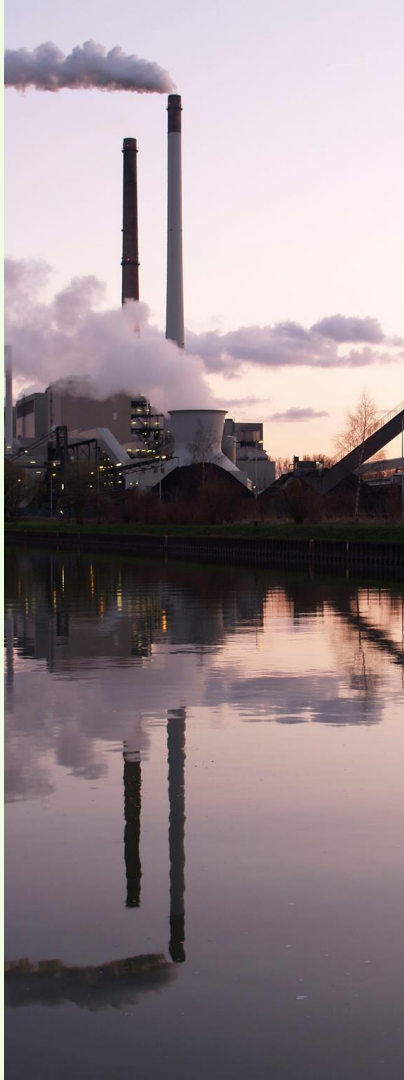
Practice FRQ 9.9

The US FWS proposes 2 action plans to reduce threats to endangered species in the US.
Plan #1 focuses on regulating surface water pollutants with stricter laws while Plan #2 focuses on purchasing and preserving more intact forest ecosystems.

Justify plan #1 or plan #2 as being more effective in reducing threats to endangered species



9.10
Human Threats to Biodiversity



Objective/EKs/Skill

SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
EIN-4.C Explain how human activities affect biodiversity and strategies to combat the problem.	**EIN-4.C.1** HIPPCO (habitat destruction, invasive species, population growth, pollution, climate change, and over exploitation) describes the main factors leading to a decrease in biodiversity. **EIN-4.C.2** Habitat fragmentation occurs when large habitats are broken into smaller, isolated areas. Causes of habitat fragmentation include the construction of roads and pipelines, clearing for agriculture or development, and logging. **EIN-4.C.3** The scale of habitat fragmentation that has an adverse effect on the inhabitants of a given ecosystem will vary from species to species within that ecosystem. **EIN-4.C.4** Global climate change can cause habitat loss via changes in temperature, precipitation, and sea level rise. **EIN-4.C.5** Some organisms have been somewhat or completely domesticated and are now managed for economic returns, such as honeybee colonies and domestic livestock. This domestication can have a negative impact on the biodiversity of that organism.

HIPPCO

Habitat Fragmentation/Loss

Deforestation (lumber, cities, roads)
Wetland draining (ag, urbanization)
River water level decreased by dams

Invasive Species

Invasives such as z. mussel and kudzu vine outcompete native species for food/space, lowering populations

Population Growth

Human pop. growth drives hab. loss
Urbanization, ag. expansion to feed more people remove/fragment hab.

Pollution (Pollutants)

Oil spills reduce marine org. pop. sizes
Pesticides (glyphosate, atrazine) kill non-target species

Climate Change

Shifts biomes & therefore species habitat ranges, can change temp. & precip. patterns too rapidly for a species to adapt or migrate, causing pop. decline or extinction

Over Exploitation

Excessive hunting or poaching (faster than reproductive rate) leads to pop. decline & potential extinction

Habitat Fragmentation

Roads & Pipelines

Roads & oil/gas pipelines fragment habitats; disrupt movement & lead to fatal collisions with vehicles

Agricultural & Urban Land Use

Clearing forest/grassland for ag. fields or urbanization fragments those habitats.

Logging

Both removal of trees & construction of logging roads to transport lumber fragment forest ecosystems

⚠ **Breaking of larger, continuous habitats into smaller, isolated patches; disrupts breeding, hunting, migration**

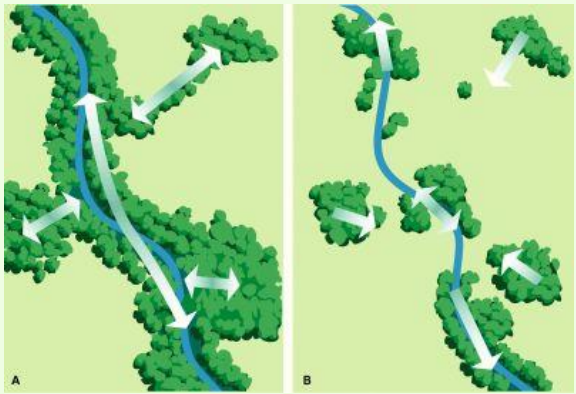
Metapopulations

⚠ **Some species are more disrupted by fragmentation than others**

- Large predators needing large hunting space
- Smaller populations of large k-selected mammals may struggle to find mates

⚠ **Habitat Fragmentation creates smaller, isolated subpopulations**

- Smaller subpopulations have less genetic diversity, are more prone to inbreeding depression, and are less resilient to env. disturbance or disease
- **Metapopulations** are mostly isolated, subpopulations connected by **habitat corridors;** this can allow some gene flow (mating between populations) and improve genetic diversity



Edge Effect

"**Edge habitat**" where two ecosystems such as forest-grassland or ocean-river (estuaries) meet have diff. characteristics than the middle of each ecosystem

- Some species thrive in the edge habitat & biodiversity is often higher in edge habitats due to diversity of food, shelter, and nutrient resources
- Edge habitats can expand range of potentially disruptive species (ex: brown headed cowbird) that thrive in grassland-forest edge
    - Brood parasite that leaves its eggs in the nests of songbirds for them to raise, unknowingly

Climate Change

Temperature change

Warming temp. can shift biomes

- Boreal forest & temperate coniferous forests may shift northward; tundra may decrease

Precipitation change

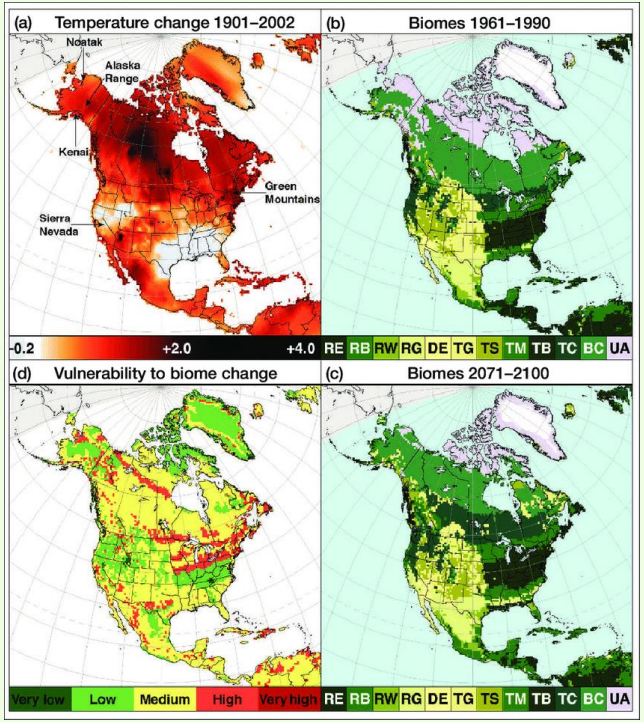
Warming global. temp. will decrease precipitation in some areas, leading to soil desiccation and desertification

- Will increase in some areas, expanding tropical ecosystems

Sea level rise

Estuary habitats (salt marshes, mangroves) become fully submerged & more saline; coastal ecosystems become flooded

⚠ Climate change can shift the range of habitats, or increase/decrease their range altogether



Biodiversity & Domestication

⚠ Domestication of species for agriculture generally decreases genetic and species biodiversity

Crops

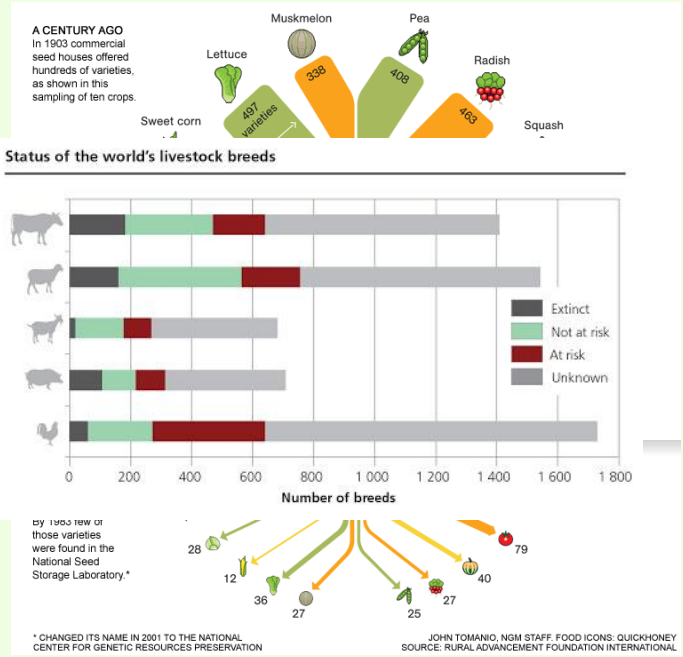
Fewer plant species are grown as selective breeding and GM results in only the highest yield species

GM use and selective breeding also lead to less genetic diversity in crops, making them more vulnerable to disease or environmental disruptions

Livestock

Historically, there have been over 8,000 breeds of the 11 species most commonly eaten by humans

- Breeds were uniquely adapted to local climate
- Many breeds are now extinct, or at risk due to selection for only highest productivity



Mitigating Biodiversity Loss

Protecting & Connecting Habitats

Protecting important habitats by creating national parks, nature preserves, or preventing them from being developed

Connecting fragmented habitats with **wildlife corridors** enables movement/breeding

Sustainable Land Use

Urban growth boundaries, infill, and building up (not out) to reduce urban sprawl can preserve existing habitats

Expanding parks, urban gardens, green roofs can provide habitat for many species

Sustainable agriculture, lowering meat consumption can reduce ag. land needs, preventing hab. loss

Restoring Lost Habitats

Replanting clear-cut forests
Reestablishing prairies on old ag. fields or golf courses

Practice FRQ 9.10

SUGGESTED SKILL

Environmental Solutions

7.C

Describe disadvantages, advantages, or unintended consequences for potential solutions.

Describe ONE economic disadvantage and advantage of preserving a piece of land as a wildlife preserve.