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Climate

- Average weather patterns in an area over time
- Temp and rainfall used to define climate
- Climate fluctuates from year to year
- Compare the fluctuations to average climate
- RevSeal changes that are occurring
- Other factors influence temp and rainfall
- Amt of energy from sun that reaches Earth’s surface
- Topography of the region

Biosphere

- Sum of locations where life exists on Earth
- Includes some of the ocean’s deepest areas
- Extends upwards into the atmosphere
- Dependent on the climate of the planet

Global warming

- Increase in average global temperatures since the 1980s
- Many factors determine Earth’s average temp
- Was challenging to determine a baseline average
- Amt of radiation from the sun is determined by the sun cycle (11 years)
- Planet activity influences the average temp over time
- Planet activity = volcanic eruptions
- Rate is accelerating

Causes of climate change

- Greenhouse gases
- Gases in our atmosphere trap heat near the Earth’s surface
- Some of these are essential to life
- Making the Earth warm enough for living organisms
- Greenhouse effect

- Solar energy strikes Earth
- Some reflected back into space (deflected by ice and snow)
- Majority strikes oceans and darker covered planet portions
- Solar energy absorbed and gradually released back into the atmosphere as heat
- Water and CO2 trap some of this energy and re-release it slowly back into the atmosphere
- We do not need large amounts of GHGs to achieve this
- Temperatures in the lower atmosphere and on the Earth's surface are affected the most due to large amounts of GHGs
- CO2
- Produced through natural events
- Fires, volcanic activity, cellular respiration
- One of the most important GHGs
- Causes of increases
- Increases in fossil fuels (oil and coal)
- Changes in agricultural practices
- Deforestation
- Natural causes = forest fires, volcanoes
- Methane
- Naturally produced from decomposition of organic matter
- Powerful GHG able to retain/release 30x amt of heat
- Causes of increases
- Increase in livestock which produce methane
- Increase in production of agricultural products like rice which release methane
- Landfill size increase

Evidence of climate change

- Oceans
- CO2 dissolves easily in water and interacts with H2O by forming H2CO3
- Carbonic acid increases the hydrogen ions in the water
- An increase in H+ ions decreases the pH (acidic ocean)
- Decrease carbonate CO3
- Carbonate is used by sea creatures to make their shells
- Less carbonate = less carbs, lobsters, and clams
- Drastically affects the ecosystem
- Surface temperatures increasing

- Water acts as a heat sink (temp storage of heat energy)
- Glaciers and sea ice
- Glaciers decreasing
- Ice sheets decreasing
- Greenland loses 270 gigatons of ice per year
- Antarctica loses 150 gigatons of ice per year
- 1 gigaton can fill over 400,000 Olympic-sized pools
- The Arctic ice cap
- Vulnerable to changes in global temperatures due to location over open water
- Extreme weather events
- Includes droughts, heat waves, extreme precipitation events
- Unclear if tornadoes are connected to climate change
- Influenced by an increase in global temperatures
- Temp in USA has increased by 12 F
- Projected to increase by 25 F by 2050

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The Carbon Cycle

Both CO2 and methane contain carbon. This is the same carbon that is found in the organic nutrients we eat

Carbon: an element

- The nucleus of an element contains protons and neutrons
- Protons: positively charged subatomic particles
- Neutrons: neutrally charged subatomic particles
- Atomic # = # of protons in an atom
- Atomic mass = # of protons + # of neutrons in an atom
- Electrons are located in electron shells
- Negatively charged particles that have almost no mass
- **of electrons = # of protons**
- Electrons determine the chemical reactivity of an element

Chemical reactivity

- Electrons determine the chemical reactivity of an element
- Electrons in the outer shell interact with atoms of other elements to form chemical bonds
- Carbon prefers to form 4 chemical bonds at a time

Electron shell of carbon

- The inner shell has space for 2 electrons
- All other shells have space for 8 electrons
- Carbon has space for 4 electrons

Chemical bonds

- Ionic
- donate/accept electrons
- Covalent
- Share electrons

Carbon cycle

- Carbon cycle between abiotic geologic and atmospheric reservoirs and biotic organisms
- Carbon is found in the oceans, underground in fossil fuels, and the atmosphere
- Carbon sinks
- Reservoir for long-term storage
- Animals release CO2 into the atmosphere during cellular respiration via the breakdown of organic nutrients for energy
- Carbon source

Photosynthesis

- Series of chemical metabolic reactions used by plants to produce their own food
- The majority of photosynthesis occurs in the leaves
- Mesophyll cells house the cellular machinery for photosynthesis
- Chloroplasts: organelle responsible for chemical reactions
- Thykaloids: disc-like structures containing chlorophyll (a pigment)
- Grana: stacks of thylakoids
- Stroma: space between grana stacks of thylakoids

Solar energy strikes the planet as photons traveling at different wavelengths

Sunlight has both a wave and a particle nature

Photosynthesis organisms use only a small portion of the EM spectrum referred to as visible light

Photosynthesis

- light-dependent reactions
- Captures energy from the sun and transfers it to ATP and NADPH
- Occurs in the thylakoid of the chloroplasts
- Uses the photosynthetic pigments
- light-independent reactions
- Uses energy from light-dependent reactions to convert CO_2 into carbohydrates
- Occurs within the stroma of the chloroplast
- Also called the Calvin cycle

Light-dependent reactions

- Chlorophyll absorbs energy from the sun
- Energizes electrons forming high-energy particles
- Found in the photosystems (I and II) of the thylakoid
- Electrons are passed to a series of proteins on the thylakoid membrane
- Electron transport chain which produces an H^+ gradient
- NADP reductase which transfers electrons to $NADP^+$ to produce NADPH
- Electrons lost are replaced by photolysis
- Water is broken down, releasing electrons, hydrogen ions, and oxygen
- Some of the high-energy electrons are used to produce ATP
- $NADP^+$ accepts some high-energy electrons to produce NADPH

Light-independent reactions

- ATP and NADPH fuel Calvin cycle reactions
- Uses CO_2 to produce Glyceraldehyde 3-phosphate (G3P)
- 3 steps
- Carbon fixation
- Electrons from NADPH and ATP are used to reduce CO_2
- Ribulose 1,5-biphosphate is regenerated
- The remaining 1 molecule of G3P from the 3 turns of the Calvin cycle is used to make carbohydrates
- Requires 6 turns of the Calvin cycle
- ADP and $NADP^+$ are returned to the light-dependent reactions

Fossil fuels

- Fuel sources formed in the earth from plant and animal remains
- Includes oil, natural gas, coal, and shale

- Methane is a large component of natural gas
- Formed by submerging organic material over long periods of time and subjecting them to the heat and pressure of Earth’s crust

Formation of coal

- Plants and animals lived in swampy ecosystems
- As the organisms died, they became covered by the low-oxygen environment of the swamp preventing their decay
- Over time, they were covered by dirt and exposed to intense pressure and heat forming coal
- Remains of organic material
- Burning of fossil fuels releases CO2 into the atmosphere
- The US produces ~79% of its energy from fossil fuels

Until the late 19th century, fossil fuels were only released slowly into the atmosphere

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Impact on Human Health and Ecosystems

Disease

- Vector
- Something that moves an infectious agent from one organism to another
- Bacteria
- Viruses
- Insects
- Mosquitoes
- Expanded range
- Dengue fever
- West Nile
- Chikungunya
- Zika
- Ticks
- Lyme disease

Impacts of drought and heat waves on human health

- Western USA

- Input of water into the ecosystem occurs only seasonally
- Snow melts in the mountain regions
- Monsoon season in the southwest
- In 2022, 90% of the West was experiencing a drought
- Effects of drought
- Limited access to water
- The concentration of pollutants in the drinking water supply
- Disruption in agriculture
- Loss of food security
- Heat-related deaths
- It mainly affects economically disadvantaged populations and the elderly
- Disruption of the forest
- Increase in forest fires -> decrease in air conditions

Long-term adaptation

- The biological world around you exists due to adaptation throughout time of climate conditions in that region
- Conditions have historically changed slowly
- Climate change is occurring at a much faster pace
- Result: pace of extinction is disrupted

Bramble Cay Melomys

- The first mammal to go extinct due to climate change
- Not observed since 2009
- Cause: increase in sea surface levels and altered vegetation due to climate change

The loss of one species can have severe consequences on the whole community

TABLE 1.1

Invasive species

- Resilient and more tolerant of change
- Species that have been introduced outside of its natural range usually due to human actions
- Unintentional or intentional transport of plants, animals, or other organisms while traveling
- Negatively impact the biodiversity and structure of the community
- Zebra and Quagga Mussel
- Native to the seas of Russia and Ukraine

- Found in the Great Lakes of the US in 1988
- Outcompete native species for food
- Attach to native mussels and kill them
- Gypsy (spongy) moth
- Native to Eurasia
- Brought to the US in the 1860s by entrepreneurs interested in making silk
- Eats the leaves and needles of trees and destroys forests
- Lionfish
- Native to Indonesia
- Top-level predator
- Accidentally introduced into Florida
- Prey up to 30 different species of small reef fish
- Compete with snappers and groupers for food
- Wooly adelgids
- Native to East Asia
- Infect hemlock trees
- Loss of dense canopy of hemlock trees
- Erosion has increased
- Loss of cooler, darker, moist shelter for amphibians, newts, birds, and other larger animals like deer and moose
- Salamanders cannot tolerate this change and thus numbers have decreased
- Loss of forest cover from local streams
- Temperature of rivers/streams increased
- Less suitable for trout

Our planet’s climate is changing on a global scale

Biome

- Global terrestrial ecosystem characterized by temperature and precipitation
- Includes the climate and the type of organisms living in the area
- The ecosystem includes biotic and abiotic factors

Impact on weather patterns

- average temperatures have increased by 1.98 F or 1.1 C
- Average precipitation has increased by 4%
- Regional
- The rate of extreme precipitation events increasing

- Droughts increasing

Coral bleaching

- Corals are symbiotic organisms
- Provide algae a place to live on the coral
- Algae provide the coral with food as photosynthetic organisms and color
- The relationship is temperature dependent
- At higher temperatures, the coral becomes stressed and evicts the algae
- Without algae, the coral dies and turns white
- 50% of corals lost

Ocean Acidification

- Zooplankton are reduced in numbers
- Fish populations are more susceptible to disease
- Shellfish cannot calcify their shells

Terrestrial Biome

- A decrease in precipitation and an increase in temperature leads to the formation of a desert biome
- Deforestation and poor agricultural practices can convert a grassland into a desert

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**Carbon Footprint

- Calculation of the amount of carbon directly or indirectly released into the atmosphere
- Measured in tonnes of CO2
- Measure of an individual’s impact on climate change
- Measuring carbon footprint
- Energy usage
- How much?
- What kind?
- Alternative energy choices (includes clean renewable energy)
- A term used to describe an energy source that does not require the use of fossil fuels
- Clean energy
- Renewable energy sources
- Includes solar and wind
- Solar

- Sun energy
- can be installed on a large scale for industrial use
- It can be installed in a single home for individual use
- Wind
- Turbines
- The scale ranges from individual use to massive wind forms or offshore turbines
- Pros: can be used anywhere
- Cons: expensive
- Includes geothermal, biofuel, and hydroelectric
- geothermal energy
- Energy generated by the Earth
- Use of underground heat generated by the Earth to produce steam
- Common in areas with significant tectonic or volcanic activity
- Ranges from individual use to large-scale purposes
- Pros: cleans
- Cons: limited to localized sources
- Nuclear power
- Splitting apart atom nucleus
- Usually uranium
- The energy released is used to create boiling or pressurized water in order to power a turbine
- Pros: does not directly use fossil fuels
- Cons: uses radioactivity to not referred to as clean
- Transportation
- Method of commuting?
- Food choices
- Buying locally?
- Beef
- Cows are one of the largest biotic contributors to climate change
- Requirement for land = deforestation
- Methane producers
- Waste disposal/recycling

Most advantages are focusing on the development of cleaner alternative energy sources which is preventative measures

CO2 dioxide removal technology

- Focus on lowering the current level of carbon dioxide
- Geoengineering
- development of technology focused on altering Earth’s environment to combat climate change
- Also called climate engineering
- Two forms
- CO2 removal
- Solar radiation management
- Tech focuses on reflecting a portion of solar energy before it reaches the Earth
- This prevents solar energy from entering and being trapped by the greenhouse gases in the atmosphere
- speculative
- CO2 removal
- Reforestation
- Carbon sinks in soil and oceans
- Carbon sequestration project
- The ORCA in Iceland
- Genetic engineering of plants and animals
- Genetic engineering
- Engineer trees or plants to increase CO2 consumption
- Engineer plants to be drought-resistant
- Challenges
- Funding
- Development takes time
- Acceptance of the general public
- It is difficult to predict the effects of these technologies

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