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Place Based Science & Climate Change Lessons for Middle and High Schoolers

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Learning Goals:
- Understand basic drivers and function of weather
- Be able to identify different cloud types and what they mean
- Understand how winds are created and how to use Beaufort Scale

Rationale: Understanding how weather works can help us predict our local weather patterns based on the environmental and atmospheric variables around us. Also, understanding why the weather is the way it is in our locality and how that affects our surrounding environments.

Materials:
- Cloud chart
- Beaufort scale
- Journals

Background info:

Precipitation — “Bringer of Life”
1. Why is precipitation important?
   Water is life. Precipitation determines whether land is desert, grassland, or forest. Average annual precipitation and temperature (along with soil type) are the most important factors in producing tropical, temperate, or polar deserts, grasslands, and forests.

2. How do you measure precipitation?
   Rain gauges measure precipitation. Precipitation amount is always recorded as the amount that falls over a given period (generally 24 hours)
   a. Cirrocumulus: fair but cold weather
   b. Cirrus: fair weather, but if they build up larger over time and are followed by cirrostratus clouds, there may be a warm front on the way.
   c. Cirrostratus: come 12-24 hours before precipitation
   d. Cumulonimbus: thunderstorm clouds, expect heavy precipitation.
   e. Altocumulus: if you see altocumulus clouds on a warm, humid morning, there might be a thunderstorm by late afternoon.
   f. Altostratus: a storm with continuous rain or snow might be on its way. Occasionally, rain falls from an altostratus cloud. If the rain hits the ground, then the cloud has become a nimbostratus.
   g. Stratus: light mist or drizzle.
   h. Stratocumulus: light rain.
1. What is wind?
Because the earth’s surface is unevenly heated it causes differences in air temperature. As air is heated, it rises. Cooler air falls. This creates wind.

2. Why is wind important to the earth as an environment?
- The wind transports seeds to generate plants and trees!
- Gives rise to ocean currents.
- Transports water vapor from the ocean to the land.
- Affects the rate of evaporation from the ocean.
- Produces energy for human use.

3. How do you measure wind speed?
Beaufort Scale: A written scale that allows you to judge the speed of wind anywhere, anytime. This scale can be based on anything the wind moves (trees or flags).

Optional wind speed activity:
- Use Beaufort scale to measure wind speed and direction. Use trees, grass, leaves to observe
- NOTE: Always record where wind is coming from, i.e. if the wind is blowing to the northwest it is coming from the southeast, so record south easterly winds.
Air Pressure

1. What is air pressure?
All air is pulled toward the earth by gravity. The pull is the greatest at sea level. On land, air pressure varies because of changes in landscape. As the gravitational pull on air increases, the density increases. The increase in density is what we feel as air pressure.

2. Why is air pressure important to measure?
Meteorologists measure air pressure to forecast storms or anticipate changes in the weather because the pressure is directly related to precipitation, wind, clouds, etc.

Fact:
The atmosphere itself is incredibly heavy. This weight creates intense pressure. It exerts about 15 pounds per square inch on the earth’s surface. The reason people are not crushed by this pressure is that we have air inside us, in our blood, tissues, and cells, exerting an equal outward pressure that balances the inward pressure of the atmosphere. That is why our ears pop when we drive down a mountain; our bodies are trying to adjust to the change in pressure.

Activities:
1. Discuss different types of weather and how we observe them
   a. Cloud types
   b. Wind speed
   c. Precipitation
2. Ensure they can check and record information
3. Incorporate daily weather checks into your daily routine:

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4. Encourage them to hypothesize, analyze, and observe
   a. What are the birds doing?
   b. Are there bugs out in large numbers or missing?
5. Write down observations in journal

Discussion Q’s:
1. Why would you want to predict weather?
2. Why would you want to know air pressure? Precipitation? Wind speed and direction? Cloud forms?
3. What else could we monitor to predict?
4. Why is it hard to make exact predictions?
5. Do we see any patterns in the weather?
6. How is weather different in the mountains versus the valley?

Reflection:
- Come back to checking the weather periodically or everyday.

**Introduction to Climate Change**
Learning Goals:
1. Define climate change
2. Be able to delineate between weather and climate.
3. Understand how the greenhouse effect works & how humans burning fossil fuels effects that cycle
4. Be able to name major global effects from climate change

Background information:

1. Climate change: A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels

- Weather: The short term, local atmospheric conditions.
- Climate: Long term averages of atmospheric conditions over a given area.

The dog represents weather, the person represents climate

The Greenhouse Effect: Earth’s Energy Budget
- Sunlight passes through the atmosphere. Clouds, ice caps and other light-colored surfaces reflect some light back into space, but most of the incoming energy reaches the planet’s surface. The Earth radiates heat back toward space. Greenhouse gases in the atmosphere absorb that heat, bouncing some back to the Earth’s surface and releasing some into the atmosphere
Greenhouse gases: carbon dioxide, methane, nitrous oxide. Need these to keep earth livable, but with increased levels, layer thickens and more heat is trapped, thus increasing our annual global temperatures. *Refer to pie chart later in the lesson for most common sources of human made CO₂

Effects of Climate Change:
1. Changing precipitation patterns affect water resources quantity and quality, some regions will experience increased precipitation while others will experience more severe and more frequent droughts. What do you think is happening in Missoula?
2. Many species face extinction. Move, adapt, or die are the three options for species.
3. Increased forest fires
4. Sea level rise from melting land ice (i.e. Greenland). Coral bleaching.
5. As temperatures continue to increase, these global effects get more severe and set-off positive feedback loops.
   a. Positive feedback loops: A disturbance/change to a system that amplifies a greater change, moving that system away from equilibrium.
   b. Example: Melting sea ice - When the oceans warm, sea ice melts, because ice has a higher albedo than ocean water, the ocean absorbs more sunlight, therefore warming at an ever higher/faster rate, melting more and more sea ice.
6. These are also in conjunction with the other effects humans have had on our global ecosystems such as habitat fragmentation and pollution.

Materials:
- Graphs and visuals are super helpful for this lesson.
- Real world or localized examples are important.

Activities: (Can be done at a later time)
1. “Move, Adapt, Or Die” Naturalist Activity (Find below)
Closing/Reflection:
- Why is it important to learn about climate change?
- What are ways we can minimize our own and our societies greenhouse gas emissions?
- How could addressing climate change also benefit human society and nature?

**Addressing Climate Change**

**Learning Goals:**
- What sectors contribute the most ghgs to the atmosphere?
- Is individual or collective action more important?
- In what ways are climate justice and social justice connected?
  - Developed countries contribute the most greenhouse gases, but will feel the least effects from climate change.
  - Developed countries have the monetary resources and governmental stability to address threats from climate change, whereas less developed countries do not.
  - There are many intersections between climate injustices and human injustices
- What can we do?
  - Promote solutions that benefit the planet and the people
    - Like making green low cost housing
    - Increase bike lanes in poor communities
    - Installing renewable energy in rural communities
    - Empower people to address these issues within their own communities
    - Push developed nations to transition their energy sources and provide funds to at risk countries

**Rationale:** We can't uncouple the often scary science from the social, political, and philosophical questions of climate change.

**Information:**

1. What of these sectors do individuals produce versus companies or governments?
2. What surprises you about this chart?
3. What are some examples of each area that you use or know of?
4. How do they emit ghgs?
   - Electricity/Heat production: coal and gas power plants
   - Agriculture: deforestation, industrial agriculture
   - Industry: combination of electricity and transportation
   - Transportation: gas combustion engines
Physical Solutions:
1. Transition to green energy (what is green energy vs non-renewable energy?)
2. Protect carbon sinks by preventing deforestation and improve agricultural land use.
3. Reduce our reliance on cars
   - Public transportation, bike, etc..
4. Green cities
   - Energy efficient
   - Powered by renewables
   - Local agriculture
   - City planning for sustainability
5. Carbon sequestration

Socio-cultural Solutions:
- Move away from consumer culture
- Localizing our food systems and communities
- Focusing on sustainability and not uninhibited growth

What are some good ways your community addresses climate change? What more could they be doing? (Brainstorm some individual and collective actions we could do in Missoula county to reduce our carbon footprints)
- Individual
  - Bike, take the bus, buy local food, and save energy around your house.
  - Attend/organize a march or advocacy group, vote for people that want to address climate change, push for changes at your school/school district/community level

Closing:
- Part of addressing climate change involves creating a more equitable global community. It will be hard but worth it!

Move, Adapt, or Die?

1. Split into groups of 3. Give each group a species card.
2. Have them brainstorm how climate change is affecting the area they are in (can give some background info here if needed.)
   a. How will precipitation change?
   b. How will the temperature change?
c. More wildfires?
3. Then have them address the following questions:
   a. How will these change affect the habitat of your species?
   b. Will these changes affect any of the food sources of your species?
   c. Will these changes enhance threats to your species like fires or disease?

4. What roles/ benefits would the ecosystem lose without our species?

5. Can your species adapt or move? Is it likely your species will survive?

**Grizzly Bear**

Habitat: Nomadic in large expanses of the northwest, hibernate in dens in winter

Characteristics: Top of the food chain, eats a variety of plants: nuts, berries, fruit, leaves, and roots

Threats: Habitat loss/fragmentation
Whitebark Pine

Habitat: Subalpine - timberline zones in the Rocky Mountains (5,900-9,500 ft.), like cold snowy, moist climates

Characteristics: Conifer, rely on Clark’s Nutcracker to cache seeds to reproduce, very drought tolerant,

Threats: White pine blister rust, fire exclusion, bark beetles.

Mayfly

Habitat: Nymph stage in fresh waterways

Characteristics: Feed on algae and plants.

Threats: Eaten by fish, birds, bats, and predatory insects.

Rainbow Trout

Habitat: Native to cool, clear rivers and lakes west of the Rocky Mountains.

Characteristics: Eat crustaceans, insects, and small fish.

Threats: Warm water, water pollution
**Pika**

Habitat: Talus slides, boulder fields, rock rubble near meadows. Usually at high elevation but mid-elevation possible if suitable rock cover and food plants present within the Mountains of North America.

Characteristics: Feed on hay, grasses, and flowers. Store large amounts of food in

Threats: Predators, barriers to migration.

**Silvery Lupine**

Habitat: grasslands, ponderosa pine woodlands, on rocky prairie hillsides and on subalpine ridges

Characteristics: Perennial, can grow well on dry sites. Fix nitrogen into soil.
Answers:

**Grizzly Bear**: Quickly changing ecosystems threaten many grizzly bear food sources, but because bears can eat a wide variety of foods they will most likely be able to adapt their diets as it warms.

**Whitebark pine**: Less late season moisture, more pine beetles, cannot move range higher because they are already so high up. Very threatened, likelihood of extinction.

**Mayfly**: Need cool clean water for nymph stage, but can adapt and live in a variety of ecosystems. Adaption is likely.

**Rainbow trout**: Stressed by warming rivers. Threatened.

**Pika**: As high alpine environments heat up, pika become stressed. Hard to adapt quickly to increasing temperatures. Can’t migrate to higher and cooler elevations. Possible extinction.

**Silvery Lupine**: Resilient due to ability to grow in dry sites and established on a wide range of places. Likely adaptation and survival.
Learning goals:
- Be able to identify the watershed you are in
  - Locate the main stem, tributaries, headwaters, mouth, and boundaries on map
  - Characterize the movement of water

Materials:
- Watershed maps
Background Information:

1. How are these rivers fed?
   Snow, rain

2. How does precipitation reach these places?
   The water cycle!
   Earth continuously recycles water.
   Evaporation: when water is heated it turns from liquid -> gas
   Transpiration: Plants release water into the atmosphere as a byproduct of photosynthesis
   Condensation: Cool air causes gases to turn to liquid or solid water
   Precipitation: When liquid or solid water is heavy enough to fall to earth’s surface
Runoff: Snowmelt or rain that is not absorbed into the ground flows into streams, rivers, and lakes. (Makes our watershed!) Groundwater: Water stored in the ground. I.e. aquifers.

3. Water is renewable resource. What does that mean?
4. Only 2% of the world’s water is freshwater

Activities:
1. Water is Life: Exploration along a river or lake
   a. What do you notice about plant life along rivers versus communities farther away?
1. Which is more lush?
2. Why?

2. Water Cycle Charades
   a. Split into 2 groups use the charades list provided. Give a group a word to act out, give them a minute to coordinate. Have them act it out for the group to guess. Switch roles and repeat!

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<tr>
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<td>Evaporation</td>
<td>Groundwater</td>
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<td>Transpiration</td>
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</tbody>
</table>

Closing:
- What is your favorite body of water and why?
- What is the coolest thing about the waterway you are near right now?

Climate Change and Water

Learning goals:
- Explain how a warming climate effects the water cycle
- Explain the local impacts of climate change to the Flathead valley
- Understand ways in which we can address climate change

Background Info:
1. What is climate change?
   a. Our planet is heating up (1°C so far)
   b. This increase makes weather more extreme and unpredictable
   c. Species (including us humans) may find they are no longer suited to their environment
2. How is it caused?
   a. Burning fossil fuels (coal, oil, and gas)
      i. Act as atmospheric blanket and trap heat: the greenhouse effect
b. Farming: 1.5 billion cows farting methane!
c. Deforestation: forests store carbon and plants absorb CO₂ to grow that is released when cut down for farmland, roads, development, and mines

3. What changes are happening on earth as it warms?
   a. Changing rainfall patterns
   b. Change in seasons
   c. Melting sea ice
   d. Rising sea levels

- Climate change affects the water cycle through
  - Increased temperatures
  - Rising sea levels
  - Alters precipitation patterns
  - Melting glaciers and sea ice
  - Warmer water

Activities:
1. Materials
   - For each group of 2-4 students: An envelope containing the 16 glacier photos printed from the Glaciers: Then and Now - Image Pairs

2. Directions
   A. Explain what glaciers are, how glaciers grow and retreat, and the two types of glaciers: continental and valley (or alpine) glaciers. Discuss the climate conditions that are necessary for a glacier to grow (snowy winters and cool summers). Discuss the climate conditions that are necessary for a glacier to shrink (warmer).
   B. In groups of three or four, have them try to match the glacier images from the past and present. (Note: Do not share the key with students until they have matched pairs.)
   C. Give 5 minutes to compare their matches to those made by the other groups.
D. Discuss the images and reveal the correct matches.
E. Discuss what is similar and different about pair of images.

3. Discuss as a class how the "then" and "now" photos were similar and different, and hypothesize about the reason for change in glaciers.
   ● What stayed the same? What changed?
   ● Do all the glaciers in this sample follow the same pattern? Are they growing, retreating, or staying the same?
   ● What climate conditions encourage glacier growth and glacier retreat?
   ● What might account for glacier retreat today?
   ● As glaciers get smaller, how might this affect the Earth? How might it affect humans?

Closing:
- What are the likely impacts to the water in our area?
  - Dry late summer rivers
  - Spring flooding
  - Warmer rivers: less fish and macroinvertebrates

- What can we do to reduce the impacts from climate change?
  - Reduce our reliance on fossil fuels
    - Avoid driving cars: Bike or take the bus
    - Consume better made goods, consume less
    - Reduce our use of energy: turn lights off, less heat and air conditioning
  - Eat locally grown food
  - Plant trees, fight deforestation
  - Protect our waterways! Water is life!
  - Connect with nature and protect what you love
    - Give an example of a place you love enough to fight for
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