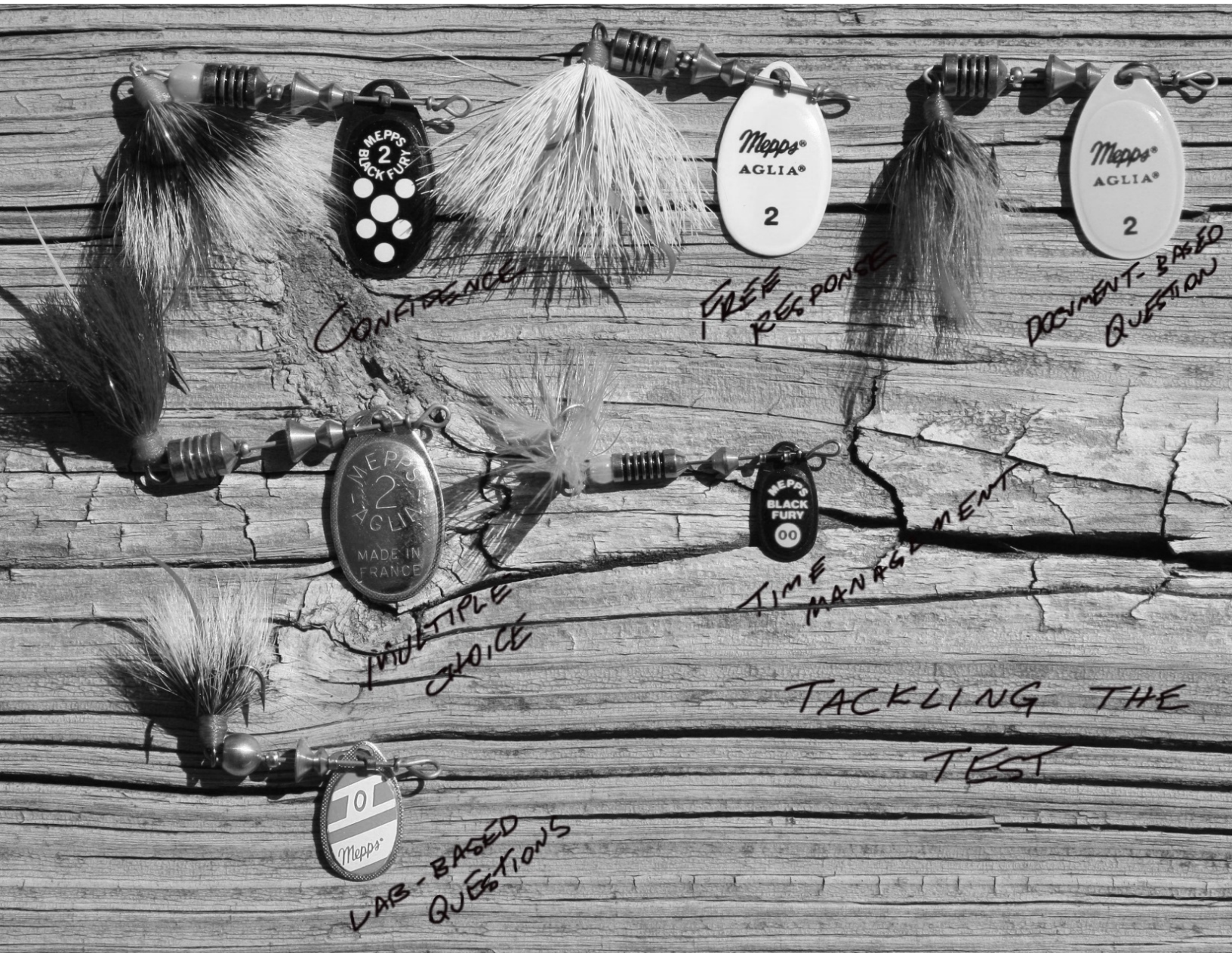
Advanced Placement

ENVIRONMENTAL SCIENCE

Biogeography + Climate Change



NATIONAL MATH + SCIENCE INITIATIVE

Student

2014

Biogeography and Climate Change

Biogeography is the study of species distribution and their environments currently and throughout geologic time. Species and communities vary along geographic gradients of latitude, elevation, and habitat.

Weather and Climate

Weather is a short-term atmospheric condition in an area. They include:

1. **Temperature**
2. **Humidity**
3. **Precipitation**
4. **Cloud cover**

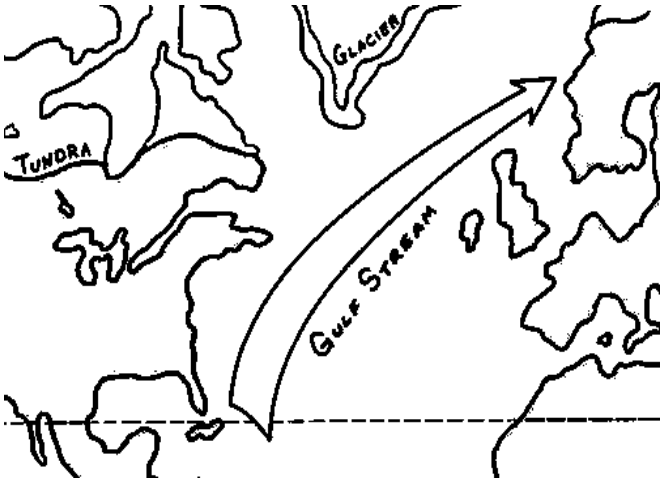
Due to the uneven heating of the earth's surface, masses of air that are warm or cold, wet or dry, and contain air at high or low pressure are constantly moving across the land and sea. Weather is most dramatic along the boundaries between these air masses called **fronts**. A warm front is a boundary where the warm air is moving into a cold air mass. A cold front is when the cold air mass is advancing and is often associated with severe weather.

Climate is a region's general pattern of atmospheric condition over a long period of time (at least 30 years). The two major factors contributing to a region's climate is **average temperature** and **average precipitation**. These two factors are ultimately determined by air circulation, water circulation, latitude and altitude.

Global air circulation is determined by four factors:

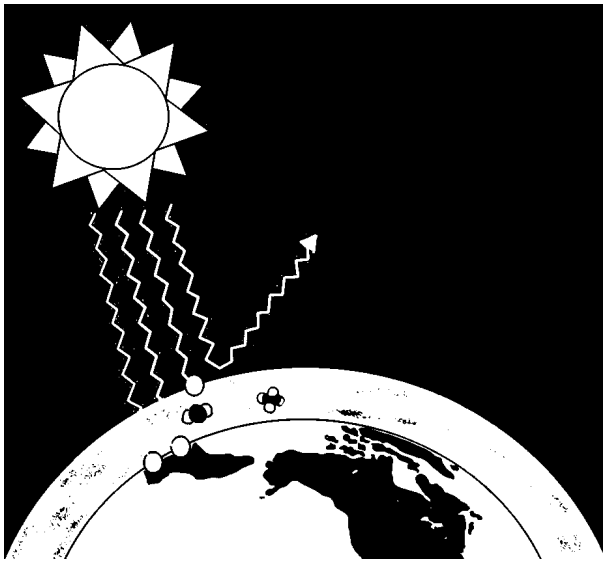
1. **Uneven heating** of Earth's surface
2. **Seasonal changes** due to the tilt of Earth
3. Prevailing winds influenced by the **Coriolis Effect**
4. Heat from the sun evaporating ocean water and transferring heat from the oceans to the atmosphere creating cyclical **convection cell**.

The redistribution of heat by both air and water influence the climate of regions (especially coastal) and in turn the vegetation. Water circulation or ocean currents redistribute the heat received from the sun from one area to another. The differences in water density and heat create both warm and cold ocean currents. The **Gulf Stream** is driven largely by wind, but as it branches into the North Atlantic Drift, it is largely **thermohaline** circulation driven. Currents also help redistribute nutrients and dissolved oxygen. These two factors greatly influence aquatic communities.



El Niño/Southern Oscillation (ENSO)
As wind moves away from landmasses, water is swept away from coastal regions. This results in an upwelling of cold, nutrient-rich waters from below. These nutrient-rich waters support large populations of producers (**phytoplankton**), which in turn support large populations of consumers. El Niño/Southern Oscillation is the result of these winds weakening or even reversing. The upwelling along the North American and South American coasts are suppressed stifling primary productivity. This leads to a decline in fish populations. El Niño impacts weather over two-thirds of the planet. Climate shifts can affect **El Niño** and **La Niña** phenomena, which leads to drought or excessively rainy monsoon seasons.

Greenhouse Effect
Greenhouse gases are those compounds existing in a vapor phase, both naturally occurring and manmade, that store thermal energy or let solar energy reach the surface of the Earth and/or then prevent its radiation back into space. Carbon dioxide (**CO_2**), methane (**CH_4**) and water vapor (**H_2O**) are good examples of greenhouse gases.



The **greenhouse effect** occurs on Earth much like the microclimate of a greenhouse. Incoming solar energy is partially reflected, but Earth absorbs much of the energy. This energy transforms water in the oceans from liquid to vapor phase and this vapor represents stored energy. The water vapor along with other gases trap thermal energy near the surface of the Earth leading to rising temperatures which in turn leads to greater evaporation of water, which causes more heat entrapment. This is an example of a **positive feedback mechanism**. **Anthropogenic** (manmade) greenhouse gases include CO_2, **nitrous oxide** and ground level (tropospheric) ozone and CFC's. These also serve to trap energy near the surface of the Earth.

The increase of atmospheric concentrations of CO_2 and other greenhouse gases is well documented. Impacts and consequences of global warming are already evident. There are many consequences such as increased mean temperature, which has led to a **rapid retreat of alpine glaciers and the continental glaciers** of Greenland and Antarctica, as well as reduction of pack ice in the northern hemisphere. **Sea level rises in two ways: increased water from glaciers and thermal expansion.** The melting of the great ice sheets continues to cause increased water in the oceans where it then undergoes thermal expansion. The melting also means lowering Earth's surface **albedo**. Less reflection of sunlight (more absorption) due to the loss of ice further increases temperatures.

A reduction of anthropogenic emissions, namely CO_2, could slow down the effects of an "intensified greenhouse effect" on the climate. Since most carbon dioxide emissions are the result of combustion of fossil fuels, one way to reduce them is to **improve efficiency**. Moving away from internal combustion engines towards electric powered vehicles would enable the

sequestration of CO_2 emissions at the power plant. Minimizing deforestation and planting trees is another method of sequestering carbon. Through the process of photosynthesis, carbon dioxide is removed from the atmosphere and "fixed" in the form of carbon compounds in woody plants where it is temporarily removed from the atmosphere.

The most important treaty regarding CO_2 emission limits was the **Kyoto Protocol**, which was held in Kyoto, Japan during 1997. The purpose was to establish a timeline to cut carbon dioxide emissions produced by 160 nations. Developing countries argued that they should not be bound by the caps and eventual reduction because the problem was one, which was rooted in emissions produced by industrialized nations. Industrialized nations viewed the parameters of the protocol as costly to markets and detrimental to industrial productivity. The industrialized nations also argued that if they were held to the protocol and the developing nations were not, no reduction in worldwide CO_2 would be realized and the industrialized nations would bear the cost of an ineffective program.

Other Factors

Other topographic features can create local and regional climates different from the general climate of a region.

The **rain shadow effect** creates dry climates on the leeward side of mountain ranges. As warm, moist air flows over mountains, it cools and condenses. This leads to precipitation on the windward side of the range before it passes over the top. The leeward side remains dry in the "rain shadow." The Atacama Desert is the driest on Earth due in large part to the "rain shadow" cast by the Andes Mountains. In the western United States, the Cascades and the Sierra Nevada create rain shadows.

Urbanization also creates a local climate that often differs from the regional climate. It generally is warmer (**urban heat island**) than its surroundings. Cities absorb much less water than the surrounding rural areas. The increased temperature and redirection of water often lead to a change in vegetation that affects the biological community.

Biodiversity

Climate greatly influences **biodiversity**. Biodiversity refers to the variation of life. It can include species, genetic, and ecosystem variation.

Intact ecosystems provide a cornerstone of our existence because they provide **ecosystem services**. Bacteria decompose our waste. Phytoplankton and terrestrial plants provide our oxygen. When we suffer loss of biodiversity, ecosystem services operate less effectively, which is detrimental to all life.

Habitat loss has resulted by humans' ability to modify environments for our use coupled with meeting the needs of an **exponential population growth rate**. Examples include the loss of wetlands, forests, grasslands, **riparian** areas and estuaries due to industrialization and urbanization. **Overuse, overharvest** and **overexploitation** are exemplified by the elimination of salmon fisheries because of excessive harvests. Cropland has also been overused by repeat

planting of the same crop year after year which depletes the soil of nutrients and leads to topsoil loss by erosion.

Pollution of water and air with chemical waste from industrial sources has rendered areas of the world so toxic that shellfish growing there are unfit for consumption, if they are able to survive at all. The introduction of **non-native species (invasive)** into areas has led to the loss of native species. These non-native species typically occupy niches lacking natural predation found in their native environment allowing them to out-compete native species. **Endangered species** serve as barometers of our effects on the environment. Currently, amphibians are of notable scientific interest. Scientists view them as **indicator species** serving as as an early warning system. They are in decline worldwide.

Humans historically modify the natural environment. This has brought ecological disaster many times. Great advances in health care have enabled more of us (**lower infant mortality**) to live longer and in turn require greater consumption of natural resources. Over the course of Earth's history there has always been **background extinction**, which is the natural loss of species over time. This is to be contrasted against catastrophic **mass extinctions**, which occur quickly (geologically speaking). The last mass extinction occurred at the end of the Cretaceous Period, 65 million years ago, when a large asteroid slammed into Earth off the coast of the Yucatan Peninsula. However, many scientist fear that we may currently be in the middle of a mass extinction event created by our own hands.

The value of diversity and richness is multifold. Intact ecosystems may offer scientific, pharmaceutical (aspirin), industrial and agricultural solutions that may benefit mankind. The concept of "maintenance through conservation" is a topic known as **conservation biology.** If a locality is selected for conservation biology such a portion of forest in Costa Rica this is "on site" or "**in situ"** conservation. Zoos are therefore and example of "off site" or **"ex situ"** conservation. Relevant laws and treaties include the **Endangered Species Act of 1973** and **CITES (**Convention on International Trade in Endangered Species of Wild Flora and Fauna).