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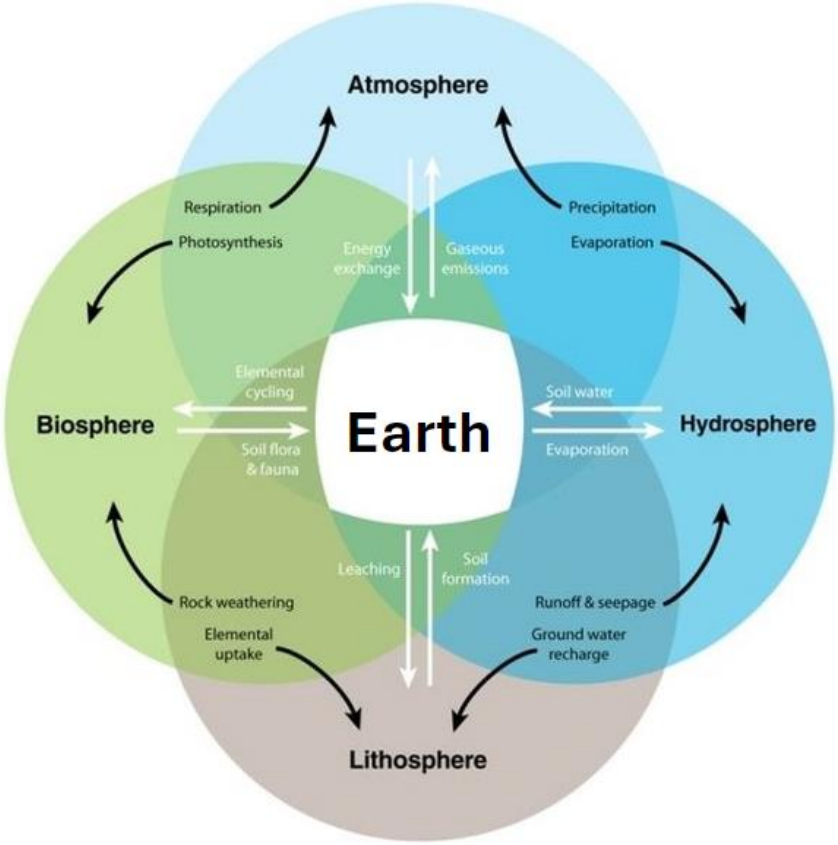
Earth Spheres and Interconnectedness

Earth is said to be made up of 4 systems on Earth that contain important processes that keep Earth the way we know it.

The 4 spheres are:

1. The Atmosphere (The gases in all of Earth's upper layers)
2. The Hydrosphere (The cycle of water on Earth)
3. The Lithosphere (rocks and dirt)
4. The Biosphere (All biological life)

Processes such as photosynthesis, precipitation, and elemental cycling allow for all the spheres to be interconnected, meaning they directly affect each other.



These spheres are also connected to systems found in space, but we will focus on Earth to better understand how to be custodians of our world to preserve it for years to come.

The **atmosphere** is a layer of gases that are held near a planet by gravity. Earth's atmosphere has 5 layers that contain many gases that affect both the atmosphere itself, as well as the other spheres. The 5 layers in the following order from the ground:

- Troposphere (8-15 km). The layer makes up the air we breathe. Most of Earth's weather happens in this layer. This is also where most human airplanes and other flying inventions operate. In this layer, temperature decreases the higher we go, as we are getting further away from the heat on Earth.
- Stratosphere (15-60 km). The temperature increases the higher we go, due to ultraviolet radiation from the sun. Most of this UV radiation is absorbed by a layer of **ozone** O_3 before reaching the lower layer.
- Mesosphere (60-120 km). The middle layer. It gets colder as you rise. That's it.

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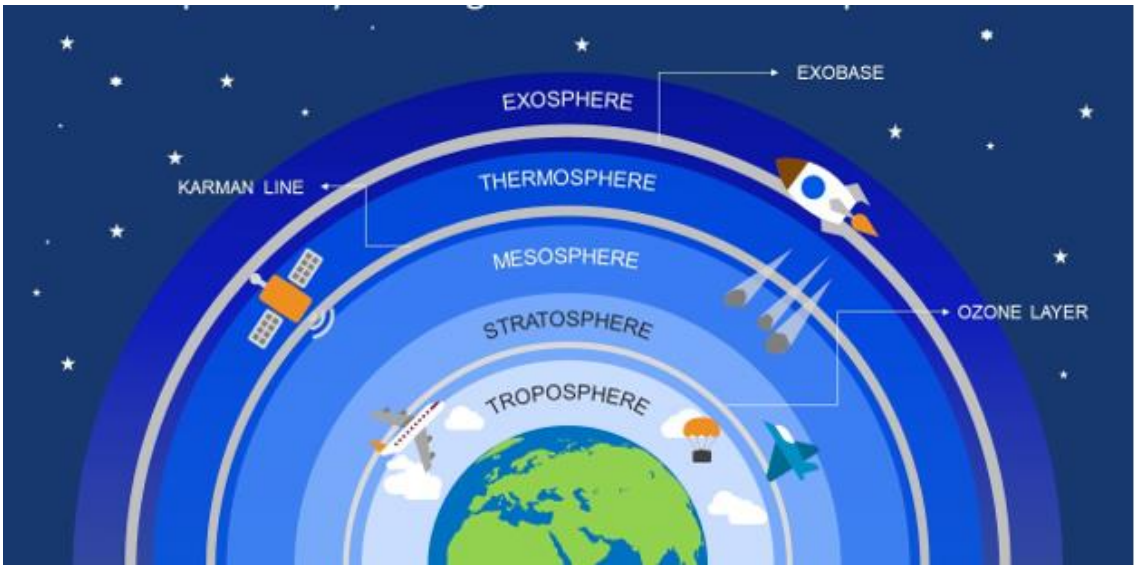
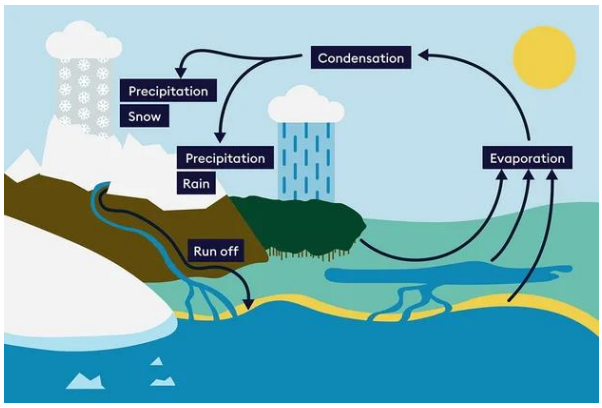
- Thermosphere (120-600 km). This is the largest layer of Earth's atmosphere. Contains the **Karman Line**, which is the altitude where space starts.
- Exosphere (600+ km). The last two layers contain many orbiting man-made satellites.



We will see later that ozone is incredibly important for setting Earth's temperature and climate.

The **hydrosphere** is the cycle of water on Earth. It is <u>very</u> complex, as water travels around Earth in many forms. It is so large that the word "**cryosphere**" has been created to describe the sphere where water is frozen in glaciers, icebergs and other reserves to split this large sphere up. We will look at the basic cycle that most people should know about.

1) As sunlight warms bodies of water like oceans, lakes, and seas, water will heat up and **evaporate** into a gas.
2) As the water rises, it cools down as it is away from Earth's heat, **condensing** the water from gas to vapor. This process forms clouds.



3) As the cloud travels, it will encounter areas of low pressure and fall back down to work during **precipitation**. This can be rain, snow, or similar weather.
4) Water will run off downhill and **collect** in bodies of water, ready to be evaporated again (or enter the biosphere).

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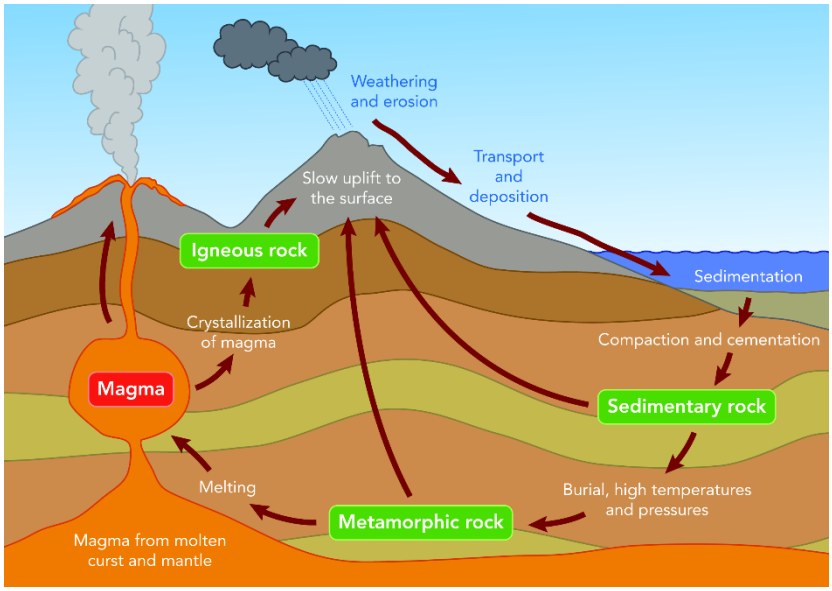
The **Lithosphere** is based on the topmost layer of the Earth's crust. This sphere encompasses how rocks and minerals move around our ecosystems.



If you wish to learn more about this cycle, take Earth Science 11. However, the main players in the cycle are:

- **Igneous rocks** are rocks that form under high pressure and temperature and are brought to the surface.
- The igneous rocks break down (weathering) on the surface into small, fine powder rocks (**sedimentary rocks**). These settle on the bottoms of lakes, rivers, and oceans.
- The Sedimentary rocks get buried and with pressure turn into **metamorphic rocks**, ready to repeat the cycle by melting into igneous rocks.

The **Biosphere** is the most complicated. It involves all life on the planet and can be viewed on both a small (ecosystem) and large (biome) scale.

An **ecosystem** is a community of living organisms living in and with their physical surroundings. Ecosystems are greatly impacted by changes to their composition.

We have seen how carbon, nitrogen, and water enter and leave the biosphere, but keep in mind that many other elements and energy are also involved in the sphere.

<u>Abiotic vs Biotic</u>

Each ecosystem is made of abiotic factors and biotic factors. **Abiotic** factors are parts of the environment that are not alive. They are mostly found in the lithosphere, atmosphere, and hydrosphere. We often think about abiotic factors with reference to how they affect life in the environment. **Biotic** factors are parts of the environment that are alive. Basically, this refers to the biosphere and includes all life in the environment, including microscopic organisms like bacteria.

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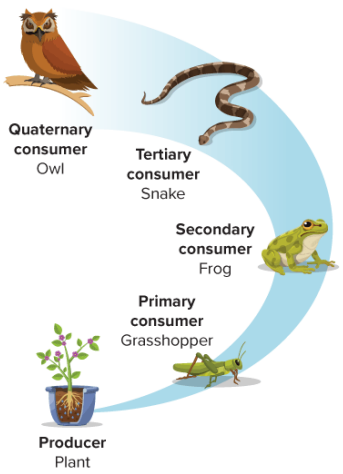
Food Webs and Food Chains

Food Chains are diagrams that show how energy flows between organisms in an ecosystem. **Food Webs** are different, as they show multiple food chains interacting with each other.

Food Chain



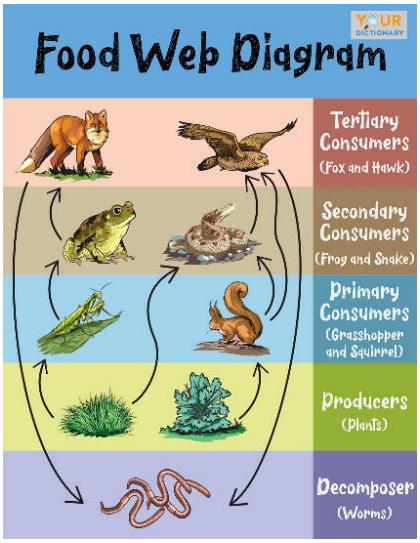
Basic layout of a food chain:
All (if not most) food chains start with some form of plant life making food. Plants are called **producers**, as they are the organisms that make the food/chemical energy from scratch using the sun.

Animals in the food web are made up of a mix of:

- **Carnivores** – Animals that eat other animals
- **Herbivores** – Animals that almost exclusively eat plants for food
- **Omnivores** – Animals that eat either plants or animals

Some animals (herbivores or omnivores) will eat plants/producers, moving the energy up a hierarchal chain.

- The animals/organisms that directly eat plants are called **primary consumers**. Example: Deer, insects, …
- The animals that eat mostly primary consumers are called **secondary consumers**. Example: Snakes, Rats
- The animals that eat secondary consumers are called **tertiary consumers**. Example: Foxes, Hawks
- (not always included) The animals that eat tertiary consumers are called **quaternary consumers**. They are at the top of the food chain. Example: Humans and Bears



Typically, large organisms are at the top of the food chain, being more powerful but requiring more food to maintain themselves and survive.

Decomposers are organisms that break down all life in each part of the food chain into nutrients for producers.

The food chain is affected by many changes to Abiotic and Biotic factors. If a predator or prey population changes, or if an entirely new predator or prey is introduced, other pre-

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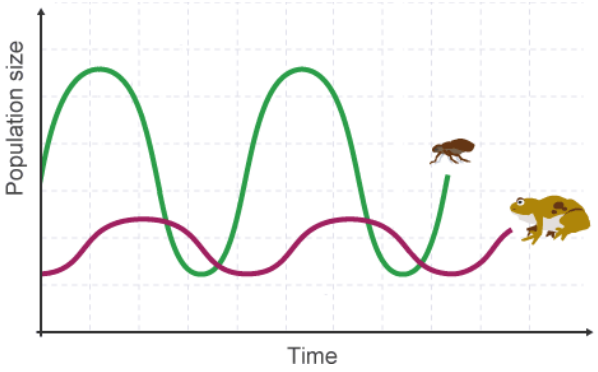
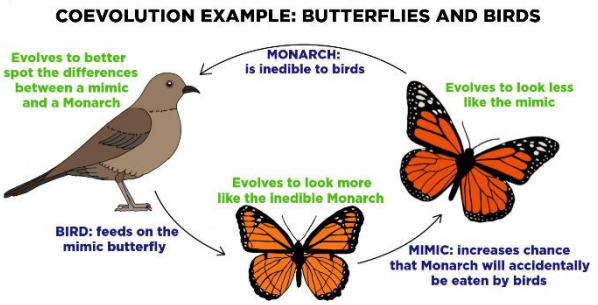
existing populations will change, sometimes resulting in extinction or ecosystem destabilization. Additionally, abiotic factors like ice-ages, mudslides, earthquakes, pollution,… can have large impacts.

Organisms that have an effect that forever alters the ecosystem if they are removed are called **keystone species**.

In the picture, you can see that when there are more flies, the frog population has more food and increases. When that happens, the fly population decreases from hunting, resulting in a decrease in frogs from starvation. This relationship can be disrupted by numerous factors.



Evolution: Over a long period of time, predators may gain mutations (changes to their DNA that result in changes to the animal/plant) to catch and eat their prey easier. At the same time, prey can also gain mutations to avoid being caught and consumed.



Population increase events, mass death events, or extinction:

When a species gains or loses many of its members, it disrupts the food chains. Increasing a population will increase the amount it hunts, lowering the prey's population and leading to many other effects. Decreasing a population does the opposite, but leads to more, often unpredictable results.

In Yellowstone Park, wolves were nearly hunted to extinction. Wolves are the main predator of elk/deer. With less wolves came more deer, and because elk/deer are herbivores, more of the plant life was eaten. This damaged the habitats for songbirds, lowering their numbers. Songbirds eat mosquitos, so their numbers increased. This affected many more things, but you can see the effects of an extinct species are massive.

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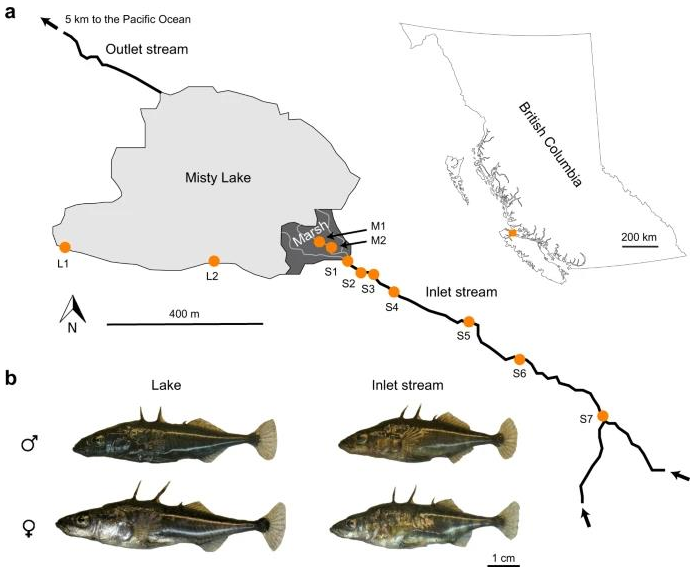
Invasive species: This is when species are moved from one ecosystem to another ecosystem that is not normally home to the new species. Depending on the species, it has the potential to have no predators, but affect the number of animals (population) of other species in the area.

Example: You have probably seen lots of purple loose strife in marshes and dikes. It is from Europe and Asia and has the ability to outcompete native plant life here. It also changes the water quality and fish habitats, damaging aquatic life populations. It was probably brought here in 1869ish.

Example: Snakehead fish have been brought to BC by humans. They have no predator that hunts them and are vicious consumers that devastate pre-existing organisms in the area. All snakeheads have been removed so far, and this must remain the case to maintain BC ecosystems.

Geological changes: Sometimes changes to the local geology can divide or combine ecosystems, resulting in big changes. They can also change the natural habitats of organisms.

In British Colombia, Stickleback fish have evolved in many ways. After the glaciers receded, they evolved from fish that cycle from salt to fresh water throughout the year, into fish that mainly live in freshwater lakes and streams. They evolved different eating habits and started hunting different prey, increasing the population of their old prey and decreasing the population of the new prey. Misty lake is a great example of this.



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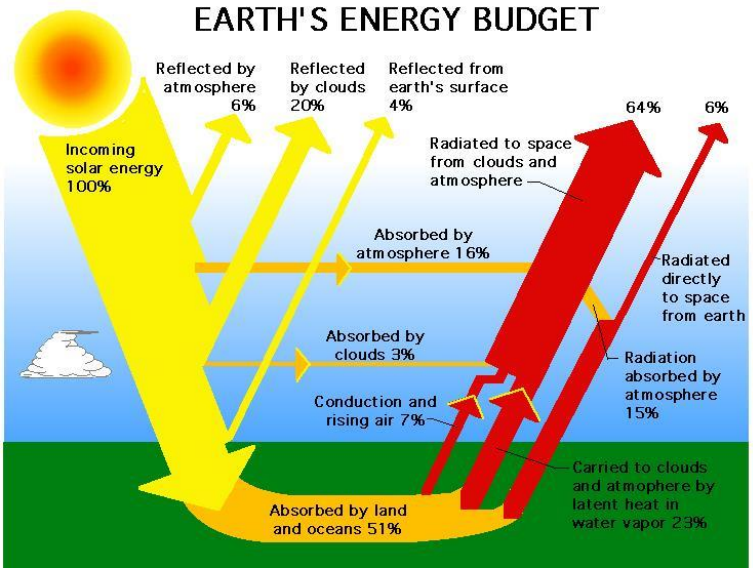
The sun as an energy source

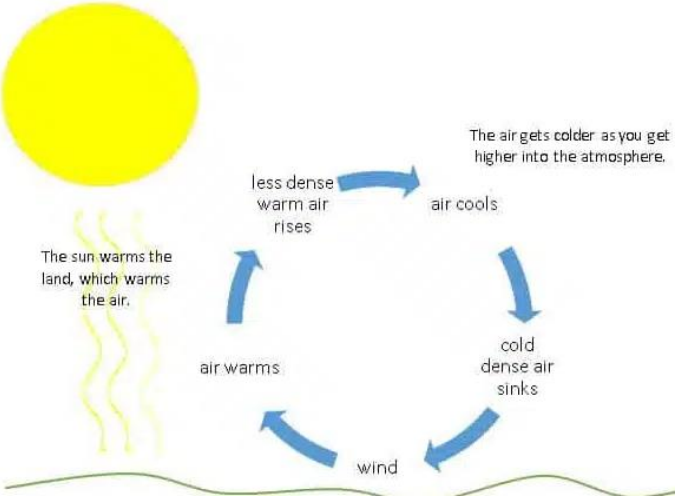
The sun is the “battery” of Earth. It provides the vast majority of energy in the environment through various ways.

We often call the distribution of solar energy on Earth the Energy Budget. The diagram shows where energy from the sun goes on Earth.



Keep in mind that some of the energy does not reach the planet, as it is reflected by the atmosphere or the surfaces of Earth. Surfaces that have light colours/shades (like the white from snow and ice) are said to reflect more light and have a high **albedo effect** (the ability to reflect light).

On the other hand, once on Earth, some energy is kept on Earth by **greenhouses gases** in the atmosphere, like carbon dioxide, ozone, and nitrogen compounds.



<u>Ways the sun powers Earth:</u>

1. By heating the water, allowing for evaporation to drive the hydrosphere.

The sun drives the weather and currents on Earth using Convection currents (from Science 8!). This is where water and air heats up and rises, but is then cooled and fall back down to be heated again.

2. Heating the water also drives the water currents and lithosphere’s air currents on Earth. This means the sun plays a large role in the weather.
3. By providing light energy for photosynthesis, giving the source of chemical energy used in the biosphere (stored in sugar).
4. By heating the land, making it habitable for organisms. And more!

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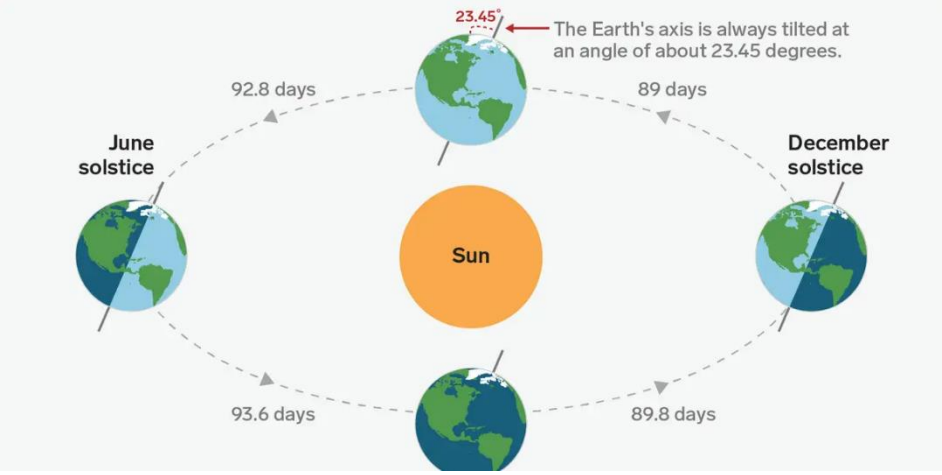
Other planets in the solar system receive too much or too little of the sun's energy to make them hospitable. As astronomers say, Earth exists in the **Goldilocks' Zone** (not too hot, not too cold, just right!).

Since Earth is always tilted at different angles towards the sun, some places receive different amounts of energy at different times of the year, leading to different weather and climate. This leads to the Northern hemisphere and Southern hemisphere having the opposite seasons to each other (when one is winter, the other is summer).

The time when Earth is fully tilted to one hemisphere is called a solstice (there are 2 since it will tilt back).

Due to the equator of Earth being in the center and always being the same distance from the sun, its temperature remains similar throughout the year.



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A **biome** (yes, like Minecraft) is a large area that shares similar weather, temperature, geology, and many times similar biological life.

Some of Earth's Biomes include:

- Desert – Areas with low precipitation (rain). Can be cold or hot. Usually lower plant life.
- Permafrost – Places on Earth covered in ice most of (if not, all of) the year. Turns out it is pretty cold. It also has very low annual precipitation.
- Rainforest – Places with a lot of rain. Often have a lot of plant life. Can be hot (tropical) or moderate temperature (Temperate). The Vancouver area is Temperate Rainforest.
- Grassland – Areas that remain warm, but have seasonal wet and dry time periods.
- Boreal Forest – Cold winters, warm summers, and moderate precipitation. It often has tall trees like pine.
- Tundra – Average temperature of 0°C, but extremely cold winters and warm summers. Low amounts of precipitation.