Step 9 Life on Earth

Here is a review of the main concepts of this step!

1 A terrestrial planet

The Earth is a terrestrial planet, meaning it is composed of rock with a solid surface, unlike the giant planets made mostly of hydrogen, helium, and water. It is the largest and densest of the four terrestrial planets in the Solar System, with the strongest magnetic field and active plate tectonics. Known as the "blue planet," the Earth is unique for its surface water, covering 70% of the planet, divided into salt water and fresh water, with varied landmasses making up the remaining 30%. The surface of the planet is continuously reshaped by plate tectonics and erosion, causing geological features like mountains, volcanoes, and canyons to form and evolve.

2 Water

Water is common in the universe, predominantly as ice, while liquid water is rare and essential for life. On Earth, water exists naturally in all three states: solid, liquid, and gas, covering about 70% of the planet. Only 3% of Earth's water is fresh, with 77% of that frozen. Water's unique properties make it a universal solvent crucial for life processes. The Earth's water cycle maintains a constant total amount of water, transitioning between liquid, vapor, and ice through six processes: evaporation, condensation, precipitation, surface runoff, infiltration, and transpiration. This cycle ensures the continuous movement and purification of water.

3 The atmosphere

The atmosphere is a layer of gases around Earth, stretching up to 600 km high and held by gravity. It provides essential things for life: oxygen to breathe, carbon dioxide for plants, nitrogen for soil, and water vapor for rain. The atmosphere keeps liquid water on Earth and supports life.

Greenhouse gases like ozone, water vapor, carbon dioxide, methane, and nitrous oxide trap heat from the Sun, warming the planet. This is called the greenhouse effect, which helps keep temperatures stable between day and night. The ozone layer also blocks harmful UV rays from the Sun. The upper atmosphere protects Earth from meteorites and solar wind.

The atmosphere has four layers:

1. **Troposphere:** From the surface up to 15 km, where weather happens and temperature decreases with height.
2. **Stratosphere:** From 15 to 50 km, stable with increasing temperatures due to the ozone layer.
3. **Mesosphere:** From 50 to 85 km, where temperatures drop again and contains metals like iron.
4. **Thermosphere:** Up to 600 km, with very high temperatures and ionized (electrically charged) particles.

4 The ozone layer

The ozone layer was discovered in 1913 by French physicists Charles Fabry and Henri Buisson and studied further by British meteorologist Gordon Miller Bourne Dobson. It is in the lower stratosphere and contains a lot of ozone. The thickness of the ozone layer varies, being thinner near the equator and thicker near the poles, and it changes with the seasons. Ozone is very reactive and can cause damage to rubber, plants, and human lungs when found near the Earth's surface.

Ozone is crucial for protecting life on Earth by shielding it from harmful ultraviolet (UV) radiation from the Sun. Ozone, a form of oxygen with three atoms (O3), forms when UV radiation or electrical discharges split oxygen molecules (O2) into individual atoms that recombine to form ozone.

Ozone depletion and recovery

Ozone depletion became a concern when scientists found that chlorine and bromine compounds, like chlorofluorocarbons (CFCs), destroy ozone in the stratosphere. These compounds release radicals that can break down over 100,000 ozone

molecules, reducing the layer's ability to block UV radiation. This led to the discovery of the ozone hole over Antarctica. The Montreal Protocol, starting in 1987, restricted and eventually banned CFC production, slowing ozone layer depletion. Recent satellite data shows the Antarctic ozone hole has been shrinking since the early 2000s.

5 The inner structure of the Earth

Earth, with a diameter of 12,756 km, has four layers:

1. **Inner core:** A 1,200 km wide solid iron ball with sulfur and nickel. Extremely hot but solid due to high pressure.
2. **Outer core:** A 2,200 km thick layer of liquid iron, sulfur, and nickel, generating the Earth's magnetic field.
3. Mantle: A 2,900 km thick layer of solid silicate rock that flows slowly due to heat, causing rock to rise and sink.
4. **Crust:** The thin, outermost layer made of silicate rock, 8-40 km thick, broken into moving plates that form mountains and seafloors. Only the crust can be directly studied, while deeper layers are understood through indirect methods like earthquake analysis.

6 Earthquakes

Earthquakes result from the movement of tectonic plates along faults in Earth's crust, releasing stored energy as seismic waves. These waves shake the ground and are recorded by seismographs to determine location, magnitude, and depth.

- **Cause:** Stress buildup along faults leads to sudden plate movement.
- **Effects:** Seismic waves cause ground shaking and potential damage.
- **Measurement:** Magnitude (energy release) and intensity (ground effects) are measured using scales like Richter and Mercalli.
- **Phases:** Earthquakes may have foreshocks before and aftershocks after the

main event.

Understanding earthquakes helps assess their impact and plan for safety and infrastructure resilience.

7 Volcanic eruptions

Volcanic eruptions occur when molten rock (magma) and gases escape through openings on Earth's surface, known as volcanoes. Eruptions can be explosive, propelling material high into the air, or effusive, with gentler flows of lava. The causes of eruptions include tectonic plate movements creating space for magma, plate collisions forcing crust to melt and rise as magma, and hot spots heating magma, causing it to rise due to reduced density.

- **Types of volcanoes:**
  - **Active:** Currently erupting or expected to erupt soon.
  - **Dormant:** Not currently erupting but may in the future.
  - **Extinct:** No longer erupting and unlikely to erupt again.
- **Structural variations:**
  - **Shield volcanoes:** Large with a broad, shield-like shape formed by flowing lava. Eruptions are typically gentle due to runny basaltic magma.
  - **Composite** (Stratovolcanoes): Characterized by steep slopes and explosive eruptions. Viscous andesitic magma traps gas bubbles, leading to violent explosions and ash clouds.
  - **Caldera volcanoes:** Formed by collapse after explosive eruptions empty the magma chamber. Rhyolitic magma creates viscous lava and poses significant hazards like ash fall, pyroclastic surges, and tsunamis.

Understanding volcano types and eruption styles helps assess volcanic hazards and mitigate risks to populations and infrastructure.

8 Tsunamis

Tsunamis are large ocean waves triggered by underwater earthquakes, volcanic eruptions, or landslides. They travel at speeds up to 805 km/h (500 mph) across deep ocean waters with minimal energy loss due to their long wavelengths. As tsunamis approach shallower coastal regions, they slow down and increase in height. The initial retreat of seawater (drawdown) before a tsunami hits is a crucial warning sign. Tsunamis often arrive as a series of waves, with subsequent waves potentially larger than the first. Waiting for official safety announcements after the first wave is essential to prevent harm from subsequent waves in vulnerable coastal areas. Understanding tsunami behavior helps communities prepare and respond effectively to mitigate risks and save lives.

9 Other extreme natural events

Natural disasters such as floods, hurricanes, landslides, avalanches, and droughts, in addition to volcanic eruptions and earthquakes, are increasingly severe due to human-induced climate change. Over the past 50 years, human activities have warmed the planet, causing polar ice caps to melt and intensifying extreme weather events. The impact of these disasters is measured by loss of life, economic damage, and community resilience. While technology improves forecasting for storms and weather-related disasters, earthquakes, landslides, and volcanic eruptions can still occur unexpectedly.

Flooding often results from heavy rainfall overwhelming natural watercourses, exacerbated by storm surges from tropical cyclones or high tides coinciding with elevated river levels.

Hurricanes, known as typhoons or cyclones depending on location, are large rotating systems of air around a low-pressure center. They bring destructive winds, heavy rainfall, and storm surges, primarily occurring between June and November in the Northern Hemisphere over warm tropical waters.

Heat waves, increasingly common due to climate change, involve prolonged periods of abnormally high temperatures. High-humidity heat waves, characterized by persistently high night-time temperatures, pose significant health risks. Conversely, low-humidity heat waves contribute to drought conditions, facilitating wildfires.

Understanding these events is crucial for communities to prepare, mitigate risks, and respond effectively to safeguard lives and infrastructure.