Chapter 3
Ecosystem Ecology

Ecosystem Ecology Examines Interactions Between the Living and Non-Living World

- **Ecosystem-** A particular location on Earth distinguished by its particular mix of interacting biotic (living) and abiotic (non-living) components.

- Abiotic components such as sunlight, temp, soil, pH, water, nutrients (highly dependent on *climate factors*)

Ecosystem Boundaries

- Some ecosystems, such as a caves and lakes have very distinctive boundaries. However, in most ecosystems it is difficult to determine where one ecosystems stops and the next begins.
- Scientists might define a **terrestrial ecosystem** as the *range of a particular species of interest* (ex) area where wolves roam or using topographic features

Figure 3.2a
Environmental Science

Figure 3.2b
Environmental Science

Large vs. Small ecosystems

Ecosystem Processes

- Even though it is helpful to distinguish between two different ecosystems, **ecosystems interact with other ecosystems.**

- Changes in one ecosystem could/can ultimately have a far-reaching effect on the next ecosystem and/or global environment.

Food Web:

Solar energy

Producers

Consumers

Decomposers

(ex. bacteria and fungi)

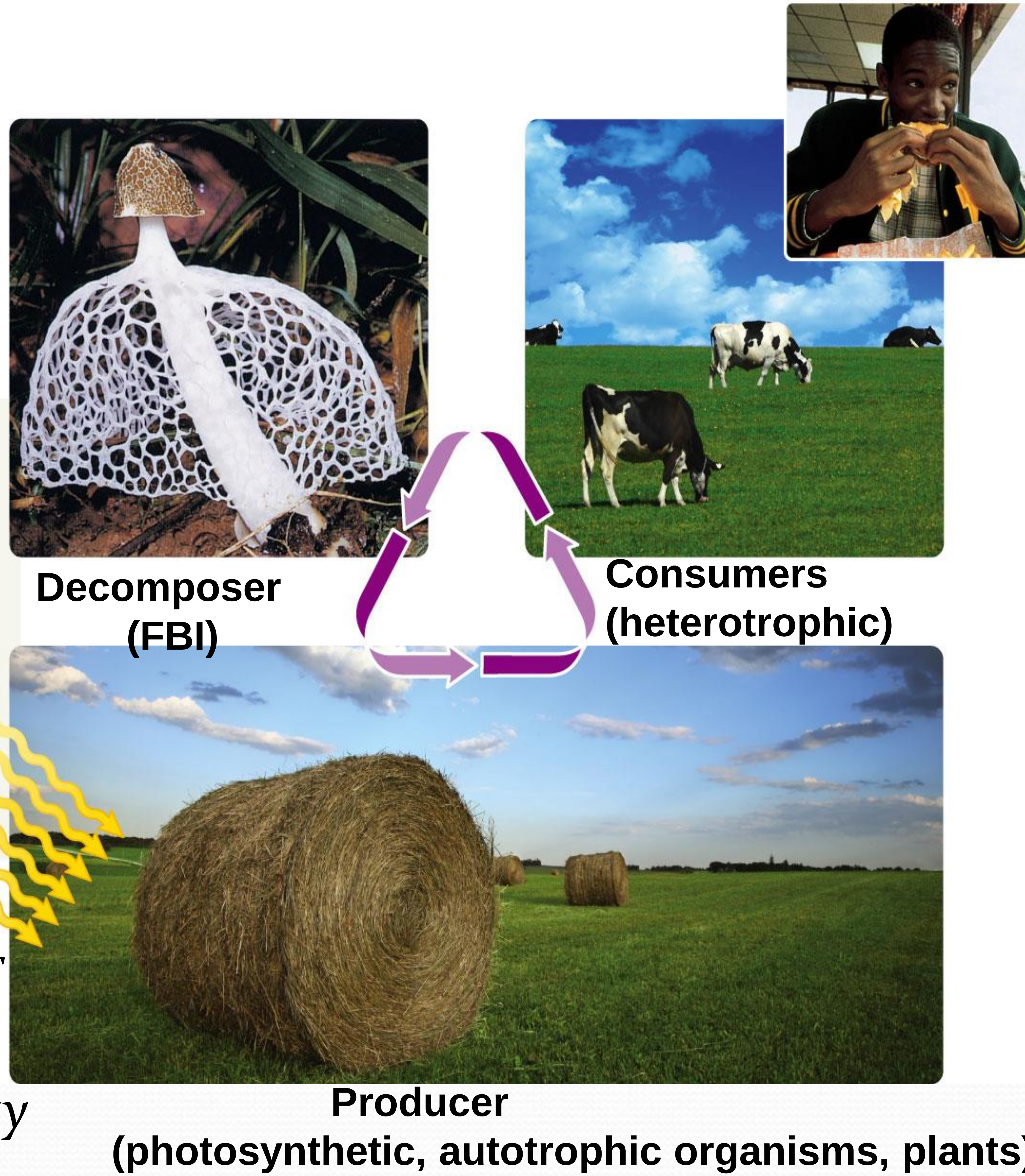

Fig. 1-6, p. 5

Interdependence:
all organism are a part of a network that *depend on one another for energy* and raw material

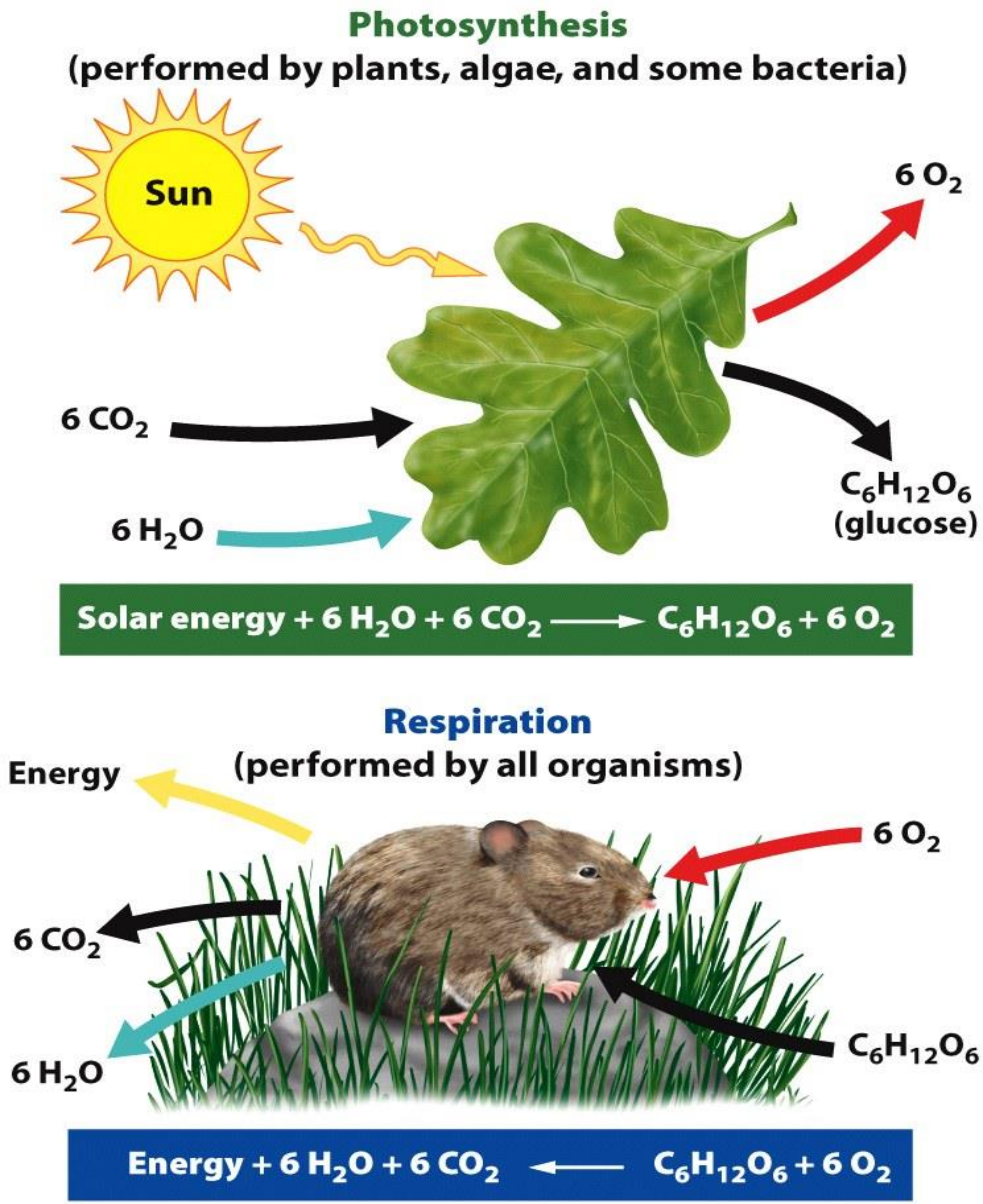

Figure 3.4
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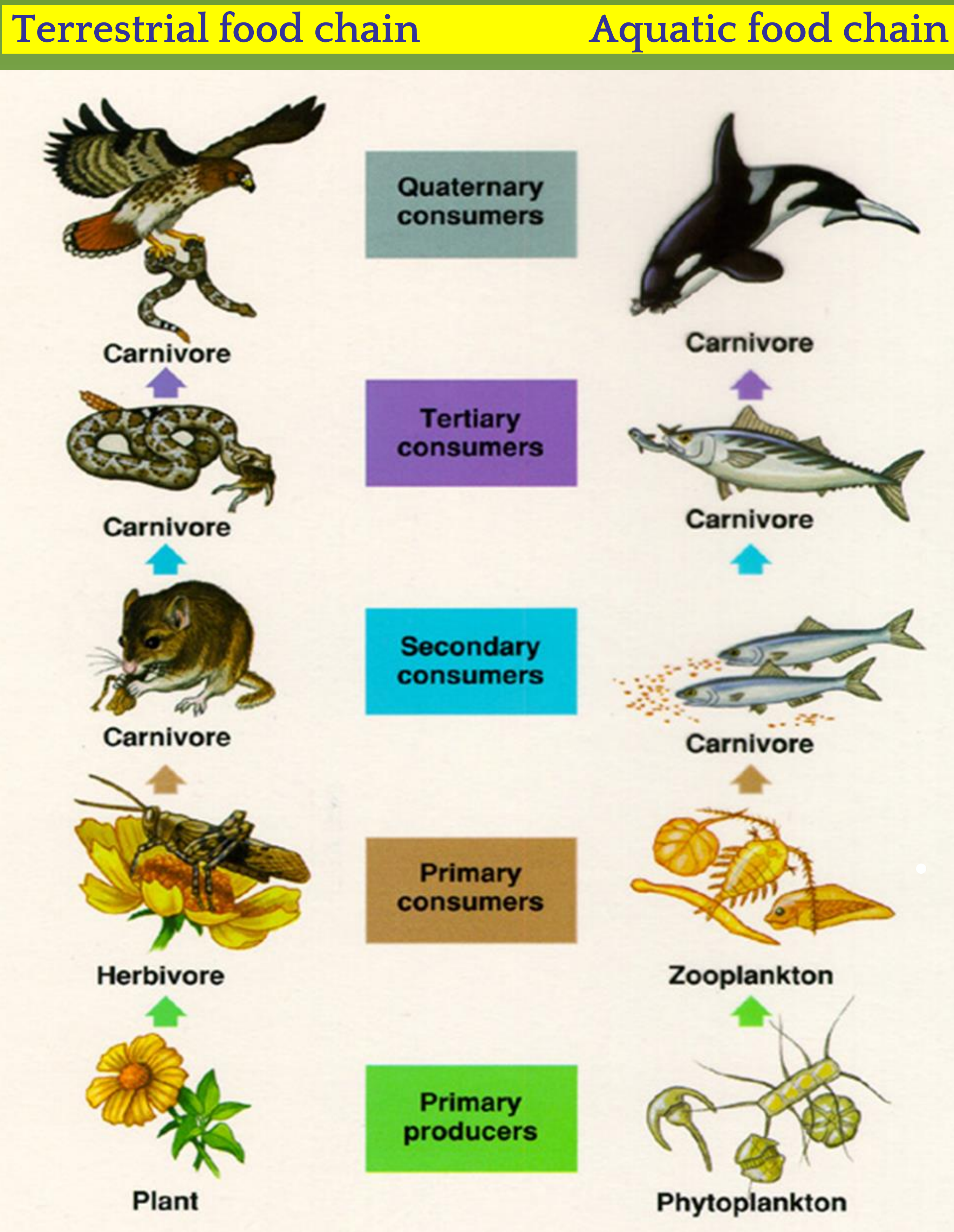
Photosynthesis is the process in which producers use solar energy to convert “waste” to beneficial components to our atmosphere

Cellular respiration is the process by which other organisms gain energy from eating the tissues of producers

Photosynthesis work antagonistically to cellular respiration (opposites)

Energy Flows through Ecosystems



Tertiary/Quaternary Consumers (*carnivores*)- obtain energy by consuming other organisms - eat secondary consumers (meat).

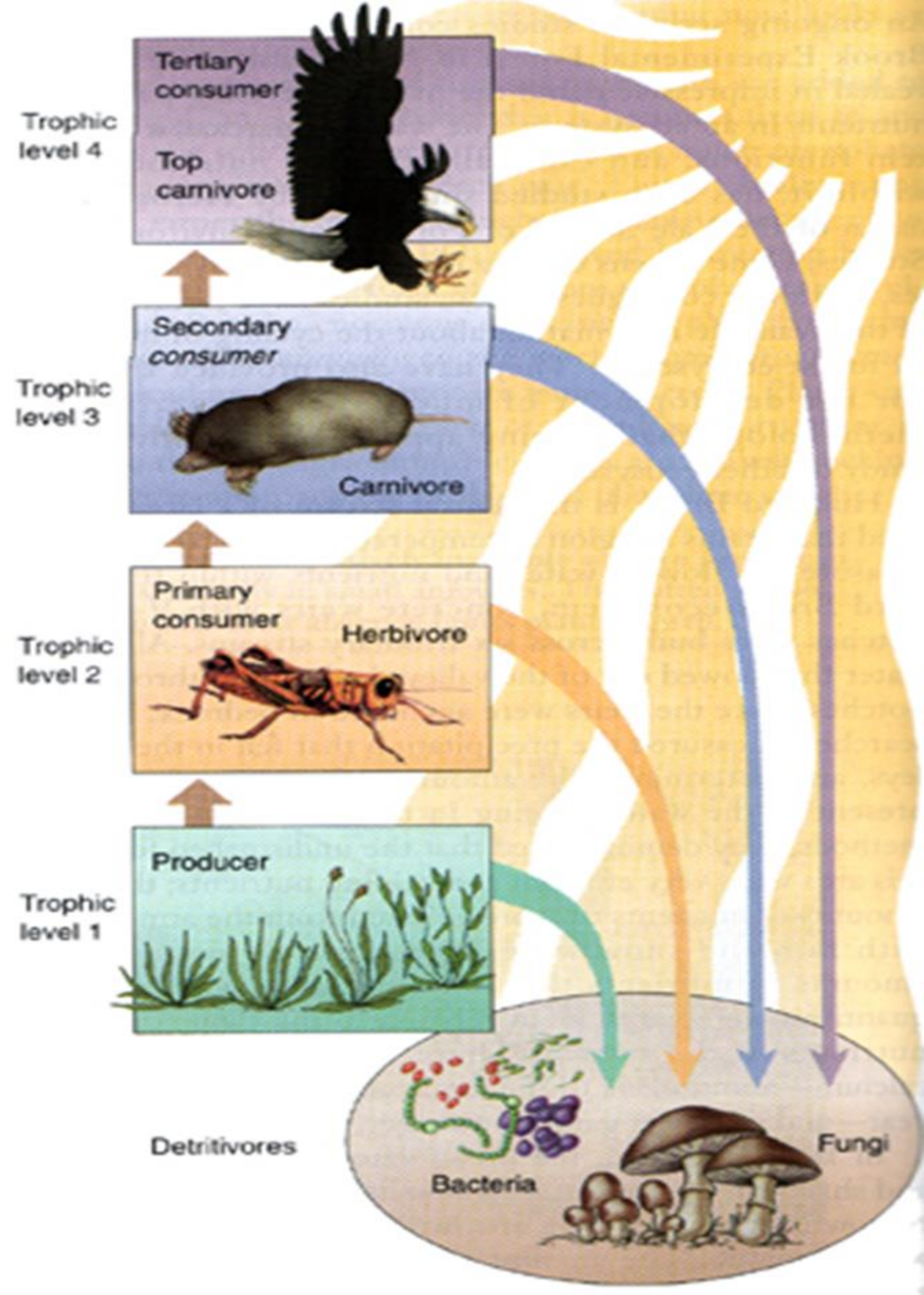
Secondary Consumers (*Omnivores*)- obtain their energy by eating primary consumers (meat or vegetation)

Primary Consumers (*herbivores*)- consume producers.

Producers (*autotrophs*) are able to use the suns energy to produce usable energy through the process called photosynthesis

- **Food Chain-** The *sequence* of consumption from producers through tertiary consumers.

- **Trophic levels** are successive levels of *organisms consuming one another.*



Each trophic level eventually produces dead individuals and waste products that FEED other organisms….(organisms that feed on dead/decaying masses)

1. **Scavengers** – carnivores that consume on dead organisms (animals) ex. Vultures

- 2. **Detritivores –** organisms that specialized in breaking down dead tissues and waste products into smaller particles ex. Beetles

- 3. **Decomposers –** complete breakdown process by recycling the nutrients from dead tissues and waste back to the ecosystem ex. Fungi & Bacteria

***w/o these organisms there would be no way of recycling organic matter and energy to the ecosystems (bodies would just build up)

Food Web- A more realistic type of food chain that takes into account the complexity of nature

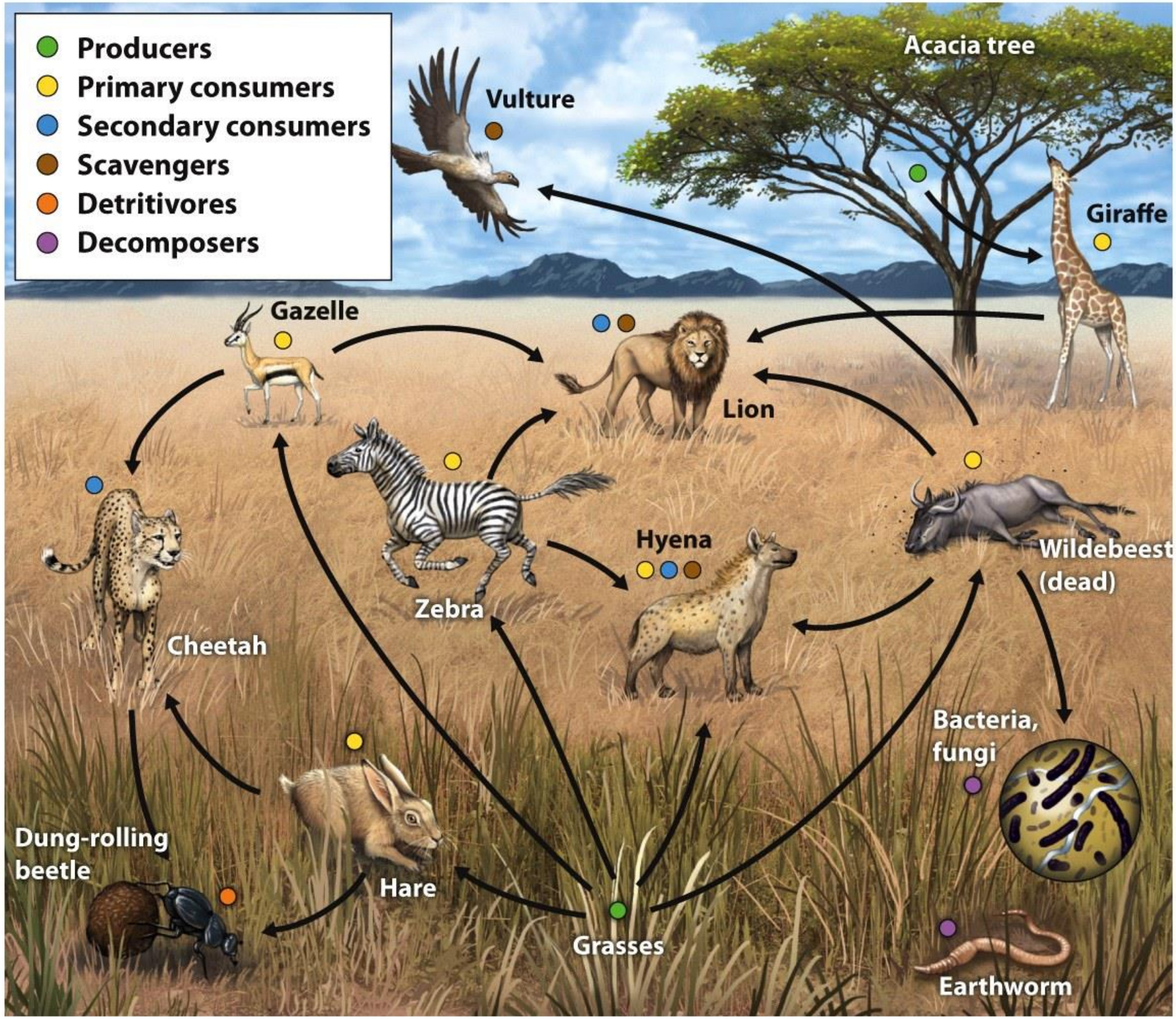


Figure 3.6
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Ecosystem Productivity

- **Amt. of energy available in an ecosystem determines how much life can be supported (varies from ecosystem to the next)**

- **Gross primary productivity** (*GPP*)- The TOTAL amount of solar energy that the producers in an ecosystem capture via photosynthesis over a given amount of time.

- **Net primary productivity** (*NPP*)- The energy captured (GPP) minus the energy respired by producers. (establishes the RATE at which living mass is produced over time)

Take home salary Salary

NPP = GPP – respiration by producers

Total amount of solar energy that reaches the producers is only 1%, converted into chemical energy. Most of the solar energy is lost from the ecosystem as heat that returns to the atmosphere.

Out of the 1%, 60% used to fuel the producers respiration.

40% can be used to support the producers growth & development

Measuring NPP is used to measure the change in an ecosystem. New system is more or less productive from pervious system.

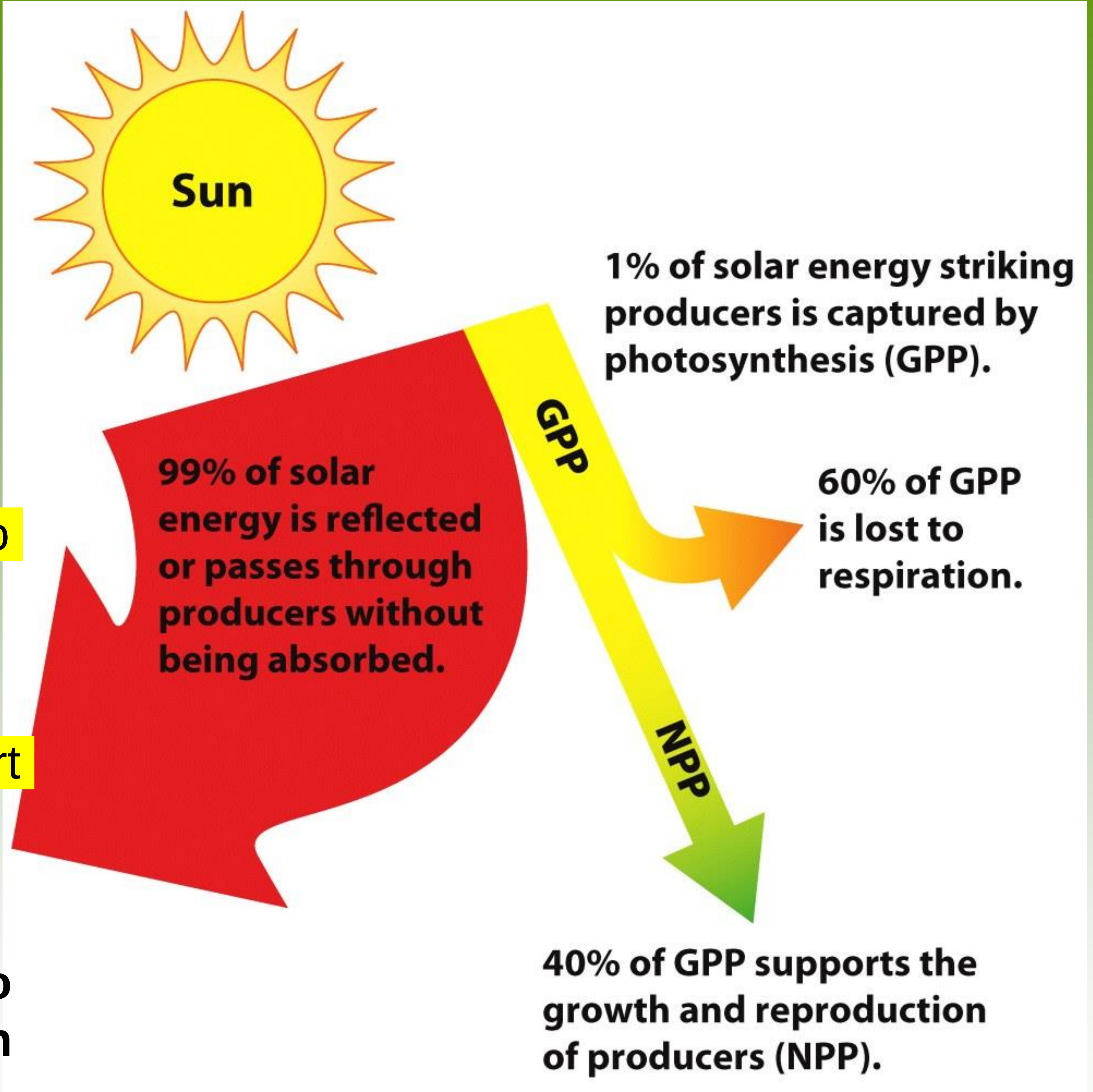

Figure 3.7
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Energy Transfer Efficiency and Trophic Pyramids

- **Biomass-** The energy in an ecosystem is measured in terms of biomass (total mass of all living matter in a specific area)

- **Standing crop-** The amount of biomass present in an ecosystem at a particular time.

- **Ecological efficiency-** The proportion of consumed energy that can be passed from one trophic level to another. (fairly low)

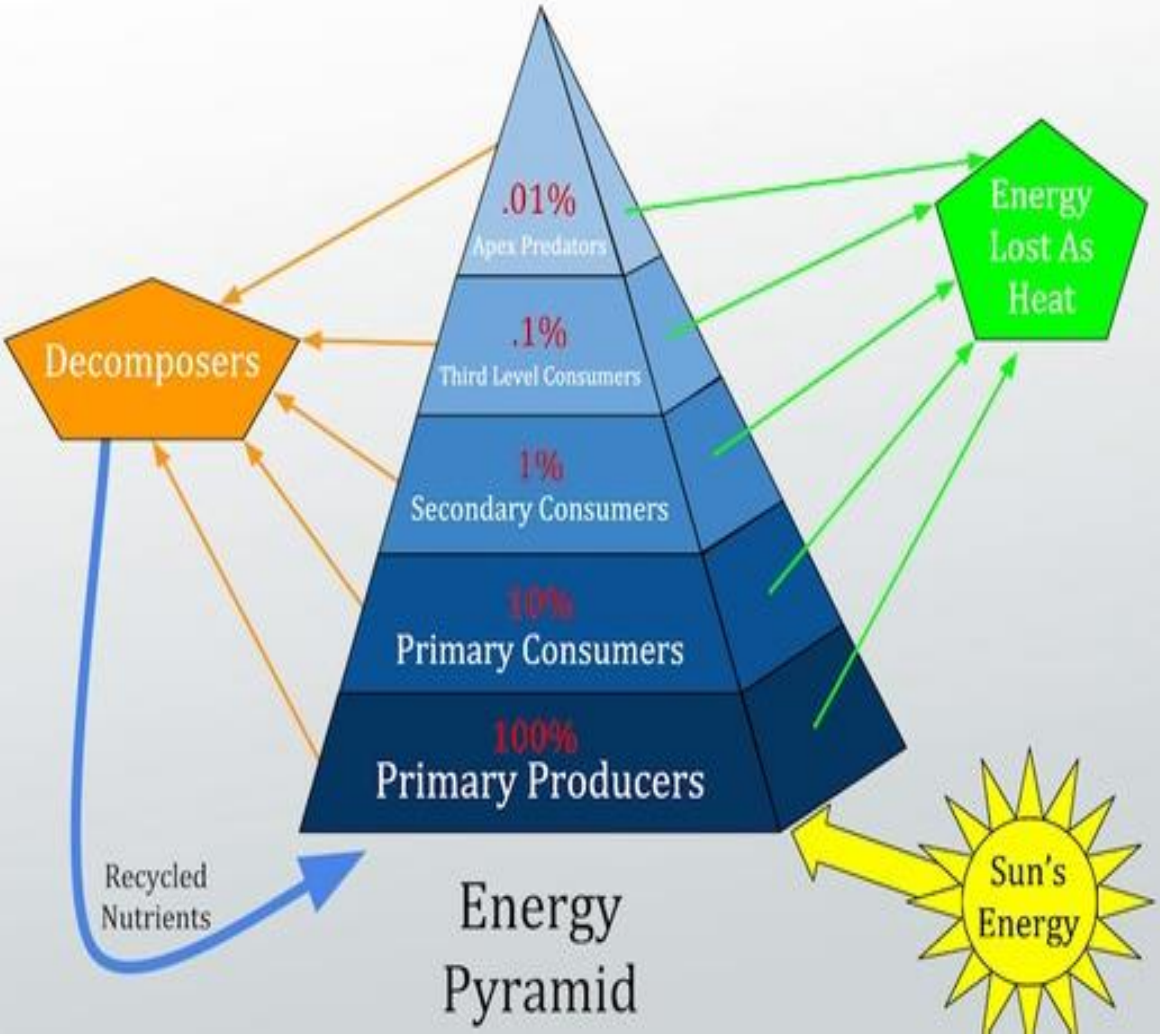
Energy Flow and the 10% Rule

- **Trophic pyramid-** The representation of the distribution of biomass among trophic levels.

- ***total biomass available at a given trophic level, only about 10% can be converted into energy at the next higher tropic level **(divided by 10 as you go up the food pyramid – useable energy**)

- Most energy (and biomass) is found at the producer trophic level an DECREASE as we move up the food pyramid. (determines the population sizes for the various species)

ENERGY PYRAMIDS AND FOOD CHAINS



Matter cycles through the biosphere

- **Biosphere-** The combination of all ecosystems on Earth.
  - Region of our planet where life resides
  - 20km (12 miles) thick
  - **Energy flows** through the biosphere, energy from the sun enters, moves among living and non-living components, ultimately emitted into space (open system – energy, closed system - matter)
- **Biogeochemical cycles-** The movement of matter (*pools*) within and between ecosystems involving biological, geologic and chemical processes. Process that move matter btwn pools are known as *Flows*.

The Hydrologic Cycle

- **The movement of water through the biosphere.**
- Water is the universal solvent (dissolving) and transporting the chemical elements for living organism.

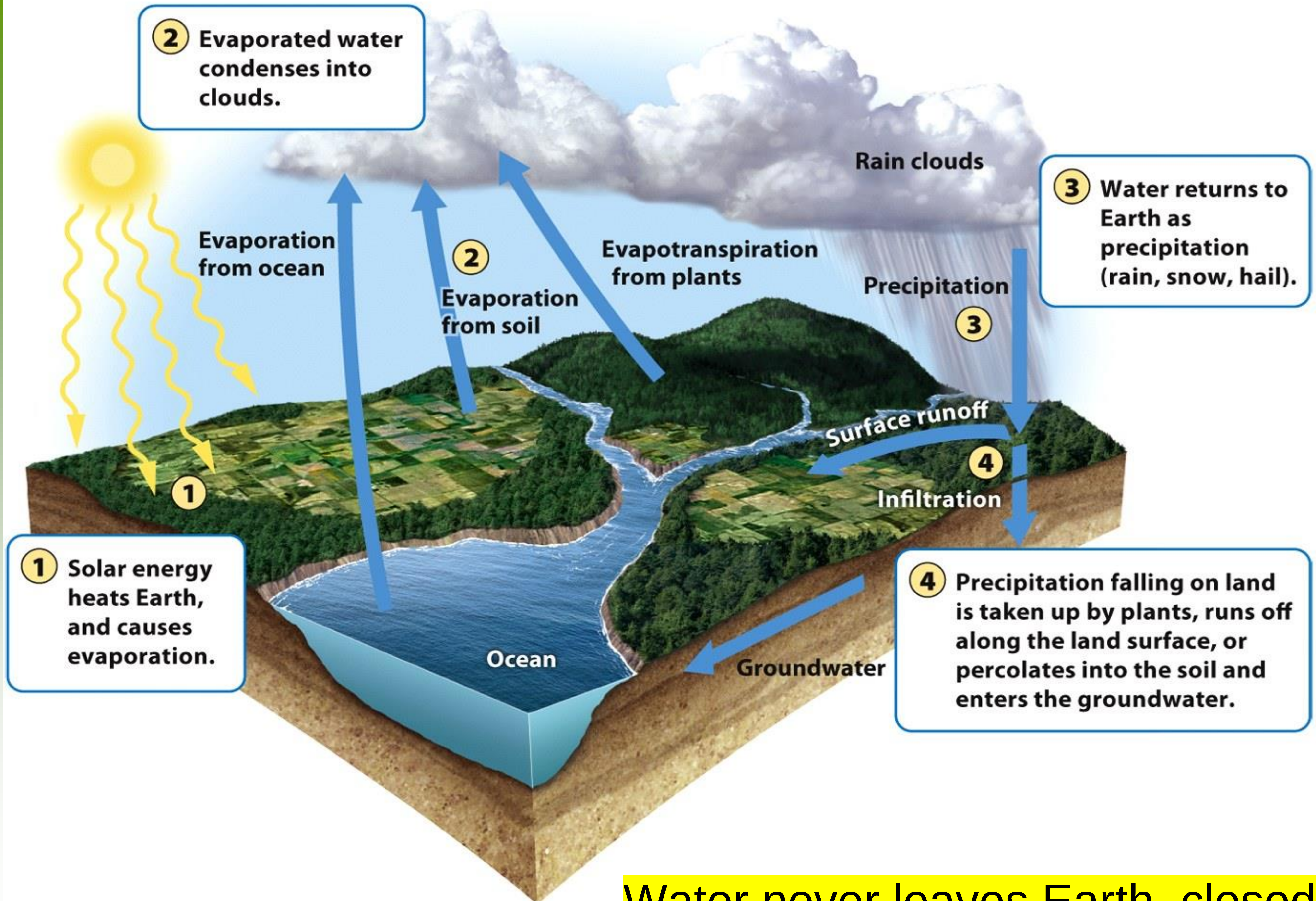


Figure 3.10
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Water never leaves Earth, closed system (matter)

The Hydrologic Cycle

- **Transpiration-** The process where plants release water from their leaves into the atmosphere.

- **Evaporation –** process where bodies of water release water into the atmosphere.

- **Evapotranspiration-** The combined amount of evaporation and transpiration.

- **Runoff-** When water moves across the land surface into streams and rivers, eventually reaching the ocean.

Human Activities on Water cycle

1. Harvesting trees from a forest can reduce evapotranspiration due to reduce biomass, results in runoff/percolation (water seeps down into soil/rock due to gravity) increase

2. Clear-cutting mountain tops can lead to erosion and flooding

3. Paving land to build roads, buildings and homes reduces the amt. of percolation, increasing runoff and evaporation

4. Diverting water from one area to another based on where water is in demand (irrigation, industrial uses, drinking water)

The Carbon Cycle

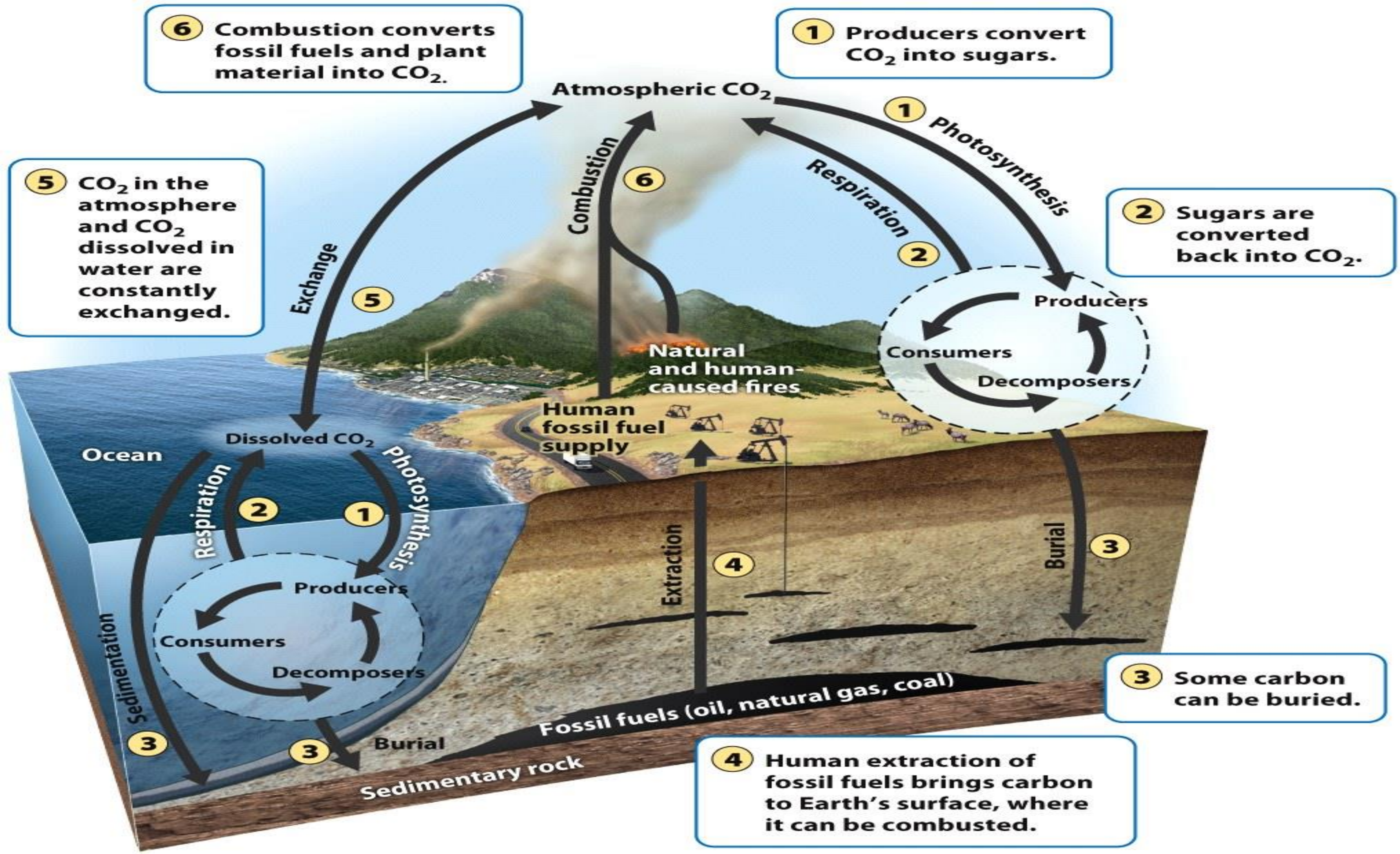

Figure 3.11
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4 pathways

1.We eat the food and produce carbon dioxide and water through cellular respiration *(biological).*

2.Carbon dioxide is released from Earth through ocean (large amts) vents (cracks in ocean floors), forest fires and volcanic eruptions *(geochemical*).

3. Decomposers release carbon dioxide when breaking down dead material *(biogeochemical).*

4. We release carbon monoxide through fossil fuels (gasoline), tree harvesting and factories into the environment *(human activities).*

- In photosynthesis, organisms use carbon dioxide along with water and sunlight (solar energy) to produce carbohydrates (food), oxygen.

Processes that drive Carbon Cycle

1. **Photosynthesis** – producers take up CO_2, some carbon is returned to the atmosphere when organisms respire or death (decomposition)

2. **Respiration/Decomposition/Combustion** – organic molecules are broken down to produce CO_2, water, & energy. Respiration and decomposition are biotic processes and Combustion occurs abiotically

3. **Exchange** – btwn the atmosphere and oceans. CO_2 mixes with Ca^{++} ions in the ocean forming Calcium Carbonate (forming limestone and dolomite rock thru sedimentation and burial)

4. **Sedimentation** – (slow process) small amts of Calcium Carbonate sediment formed over millions of years to produce the largest carbon pool.

5. **Extraction** – removal of fossil fuels from the Earth, process involving combustion, releases CO_2 into the atmosphere or into the soil as ash (carbon)

The Nitrogen Cycle

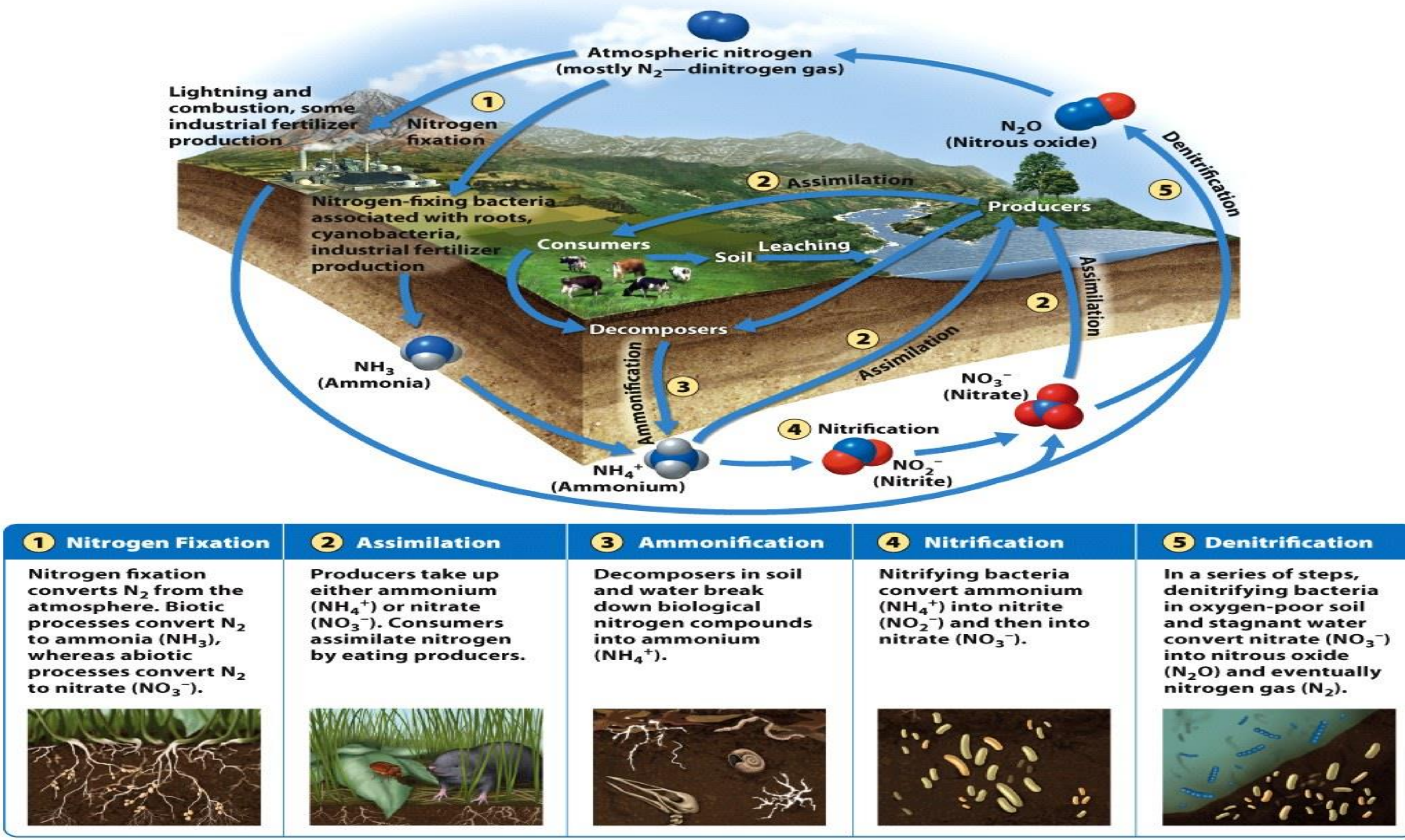

Figure 3.12
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Nitrogen gas (78%) is in the atmosphere (lightning, volcanoes) , Oxygen gas (21%)

- Bacteria (legumes) in the soil absorb the gas (N2) and convert it into another form of nitrogen called ammonia (NH3) in a process called **nitrogen fixation**. (convert nitrogen gas into ammonia). Abiotic processes convert N2 to Nitrate.

- **Assimilation** - Producers take up the ammonium or nitrate….consumers get nitrogen by eating producers.

- **Ammonification** – Decomposers and water break down biological nitrogen into Ammonium (NH4+)

- *After nitrogen fixation-* **Nitrification** is the process when bacteria in the soil convert ammonia (from dead material) into nitrite then to nitrate (plants can use and we can eat)

- *Last step-* Dead organisms contain nitrogen, decomposers (bacteria, O2 poor-soil) break down the material (nitrate) and release that nitrogen (N2O to N2 into the atmosphere **Denitrification**

Human Activities on Nitrogen cycle

- Adding nitrogen to soils in **fertilizers reduces the number of species in that area** up to 48% because some species could survive under low-nitrogen rich conditions.

- Favored colonization by new species that are better adapted to soil with higher fertility (**intro. to new species in environment**).

- Changes in conditions are likely to cause a change in biodiversity as well!!!

The Phosphorus Cycle

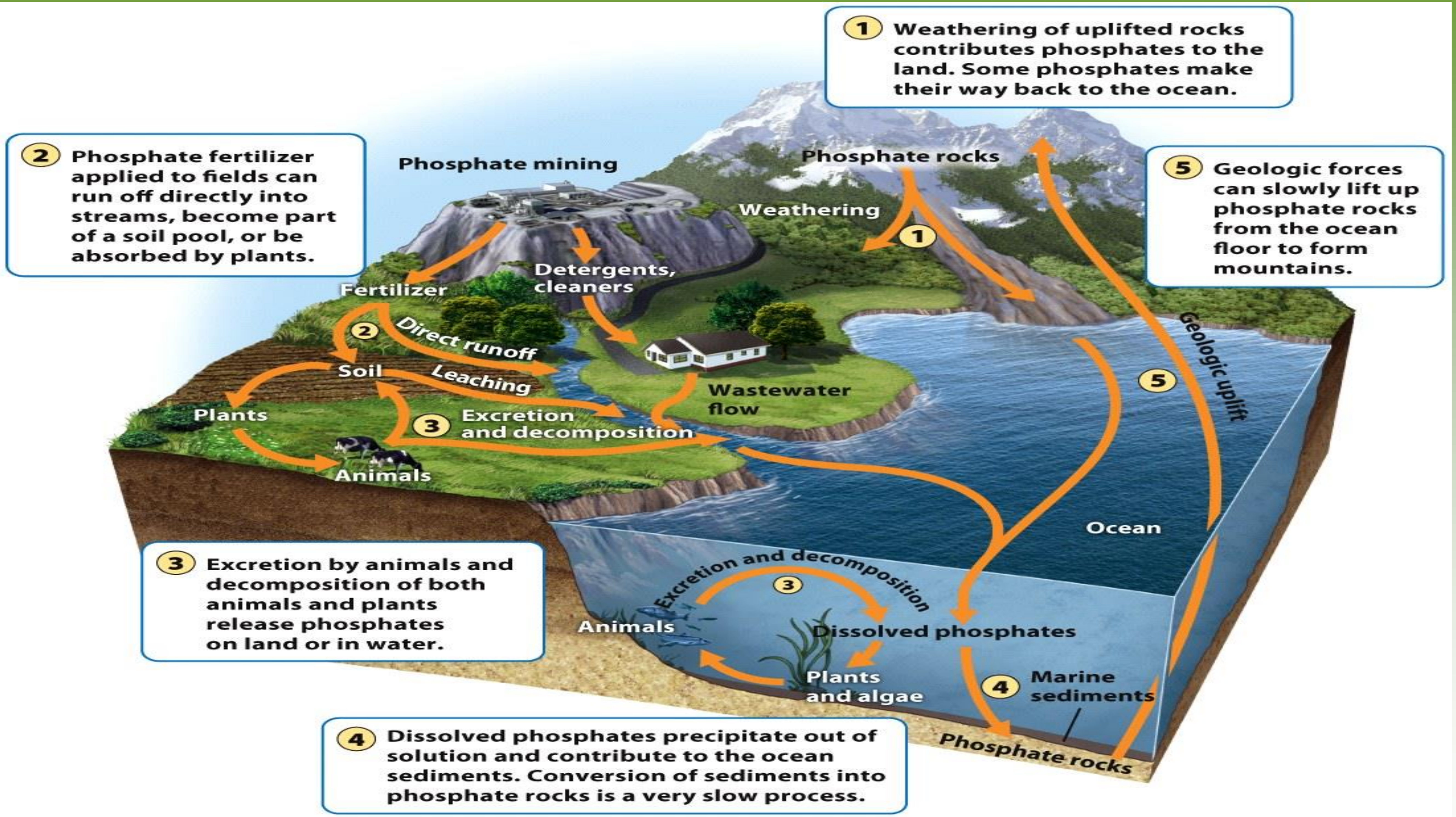

Figure 3.13
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Phosphorus (like nitrogen) are important components of DNA and RNA and ATP. Second (behind nitrogen) macromolecule important for the success of agricultural yields. Commonly added to fertilizer like nitrogen.

Unlike nitrogen, Phosphorus does not have gaseous components…not very soluble in water, sediments on ocean floor

Cycle begins with the weathering or mining of phosphate rock and use of phosphate fertilizer, which releases phosphorus in the soil and water (**derived from rock and decomposed vegetation**)

Taken up by producers and moves thru food web

Phosphorus can precipitate out of the solution and form sediments, over time can transform into new phosphate rock.

Excess Phosphorus

- Small inputs of **leached** (movement of macromolecule through soil with water) phosphorous can greatly increase the growth of organisms such as algae.

- **Algae bloom** – quickly increase the amt of biomass (algae) in a phosphorous-limited aquatic ecosystem.

  - The algae eventually dies, causing massive amount of decomposition, which consumes large amts of oxygen.

- Resulting in **Hypoxic** (low-oxygen) conditions that kill fish and other aquatic organisms (Hypoxic Dead Zones).

Ecosystems respond to disturbance

- **Disturbance-** An event caused by physical, chemical or biological agents that results in changes in population size or community composition.

- **Natural disturbances** include: hurricanes, ice storms, tsunamis, tornadoes, volcanic eruptions, forest fires…etc

- **Anthropogenic disturbances** include: human settlement, clear-cutting, agriculture, air pollution, mining…etc

- How an ecosystem can resist the impact or recover (affects on the flow of energy and matter)

Figure 3.15a
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Before Hurricane Katrina 2001

2 days after Hurricane Katrina 2005

Figure 3.15b
Environmental Science

Watershed Studies

Watershed- All of the land in a given landscape that drains into a particular stream, river, lake or wetland.

Soil in each watershed is underlain by impenetrable bedrock, no deep percolation of water, **all precipitation is either evapotranspiration or runoff**.

Figure 3.16
Environmental Science

Resistance versus Resilience

- **Resistance-** A measure of how much a disturbance can affect its flows of energy and matter.
- **Resilience-** The rate at which an ecosystem returns to its original state after a disturbance.
  - Resilience of an ecosystem ensures that it will **continue to provide benefits to humans**. This greatly depends on species diversity.
- **Restoration ecology**- A new scientific discipline that is interested in restoring damaged ecosystems

The Intermediate Disturbance Hypothesis

- The intermediate disturbance hypothesis- states that ecosystems experiencing intermediate levels of disturbance are more diverse than those with high or low disturbance levels.

Species diversity is highest at intermediate levels of disturbances. Species at both extreme can persist.

Rare disturbances favor best competitors, outcompetes other species.

Frequent disturbances eliminates most species expect those that have evolved to live under conditions

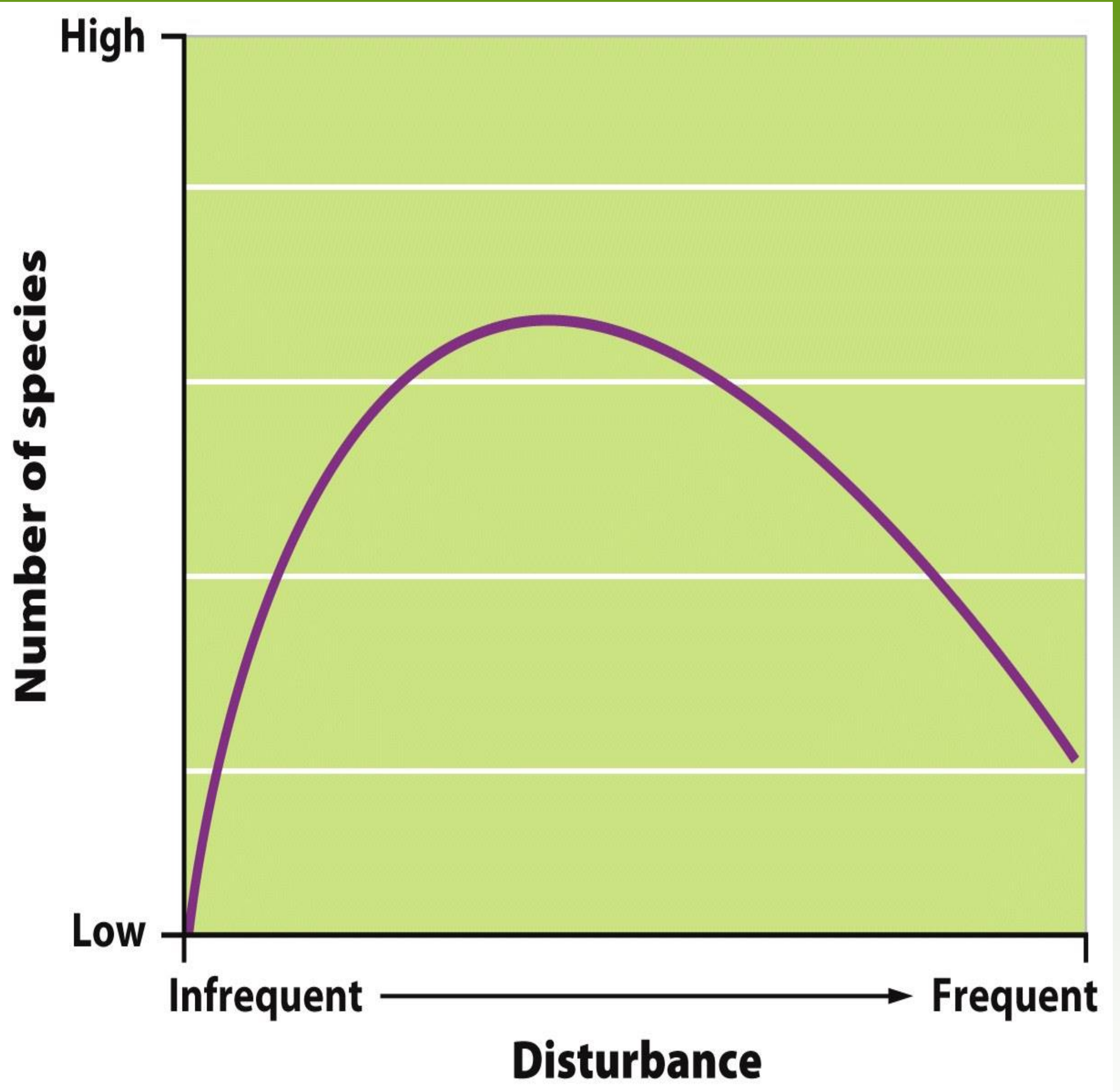

Figure 3.19
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Instrumental Values of Ecosystems

- **Provisions**- Goods that humans can use directly.
- **Regulating services-** The service provided by natural systems that helps regulate environmental conditions.
- **Support systems-** The support services that natural ecosystems provide such as pollination, natural filters and pest control.

Cultural services- Ecosystems provide cultural or aesthetic benefits to many people.

- **Intrinsic value** – species' worth independent of any benefit it may provide to humans. *Morals values of an animal's life.*