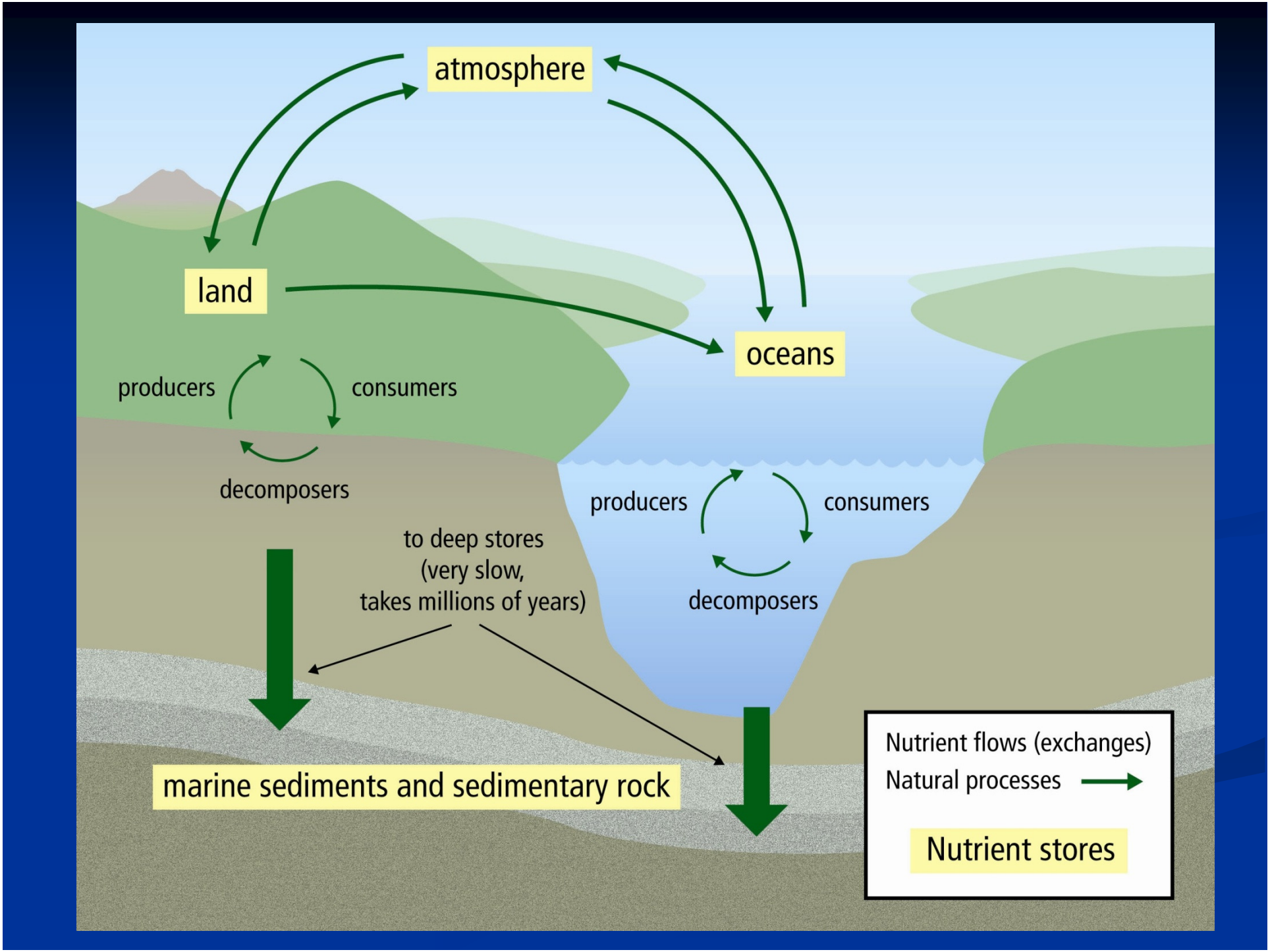
2.2 Nutrient Cycles in Ecosystems

Nutrient cycles – the flow of nutrients IN and OUT of the land, ocean, atmosphere and deep rock.

The health of our ecosystems depends on the balance of:

Carbon, Nitrogen, Phosphorous, Hydrogen and Oxygen

C N P H O


atmosphere
land
oceans
producers
consumers
decomposers
producers
consumers
decomposers
to deep stores
(very slow,
takes millions of years)
marine sediments and sedimentary rock
Nutrient flows (exchanges)
Natural processes
Nutrient stores

CARBON CYCLE

A. Carbon Facts:

- Carbon is found in all living matter.
- Places that carbon is found are called stores or sinks

Short-term Stores

- living things in water & on land
- rotting tissue of plants/animals
- atmosphere (air)
- ocean (dissolved in the water)

Long-term Stores

- underground (oil, gas, natural gas and coal)
- sedimentary rock (limestone)
- ocean floor (old shells)

B. How Carbon Changes Form:

1. Photosynthesis (in plants, algae and cyanobacteria)

$$CO_2 + H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + O_2$$

2. Cellular respiration (in cells of all living things)

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O + \text{ENERGY}$$

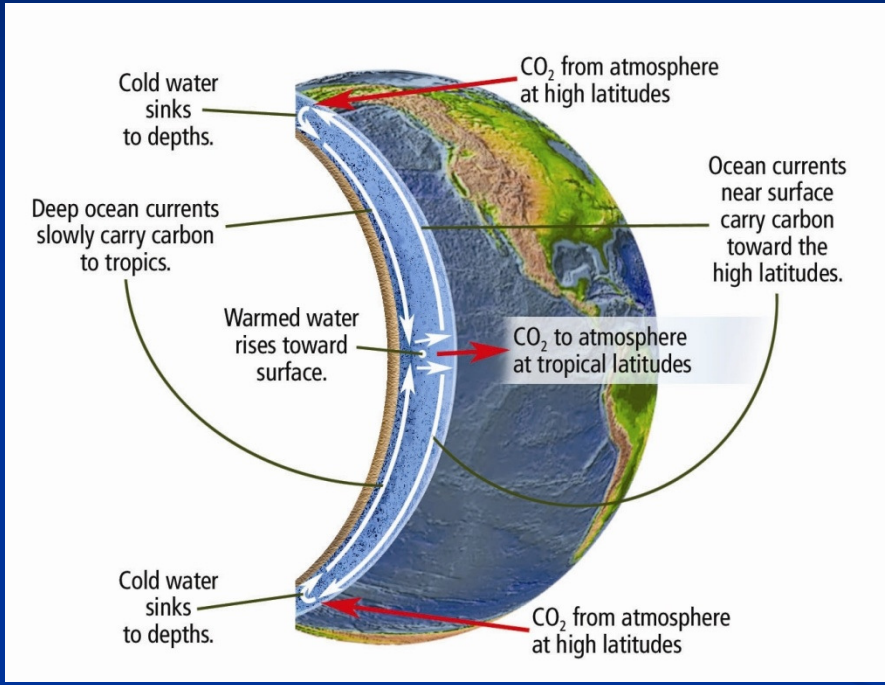
(energy is used for growth, repair etc.)

3. Decomposition (rotting) – done by bacteria/fungi

cellulose → CO_2

4. : Ocean mixing: moves CO_2 around the world

- CO_2 sinks in cold ocean waters → flows to the warm equator and evaporates into the air.



5. Combustion: (burning, engines, volcanoes, forest fires)

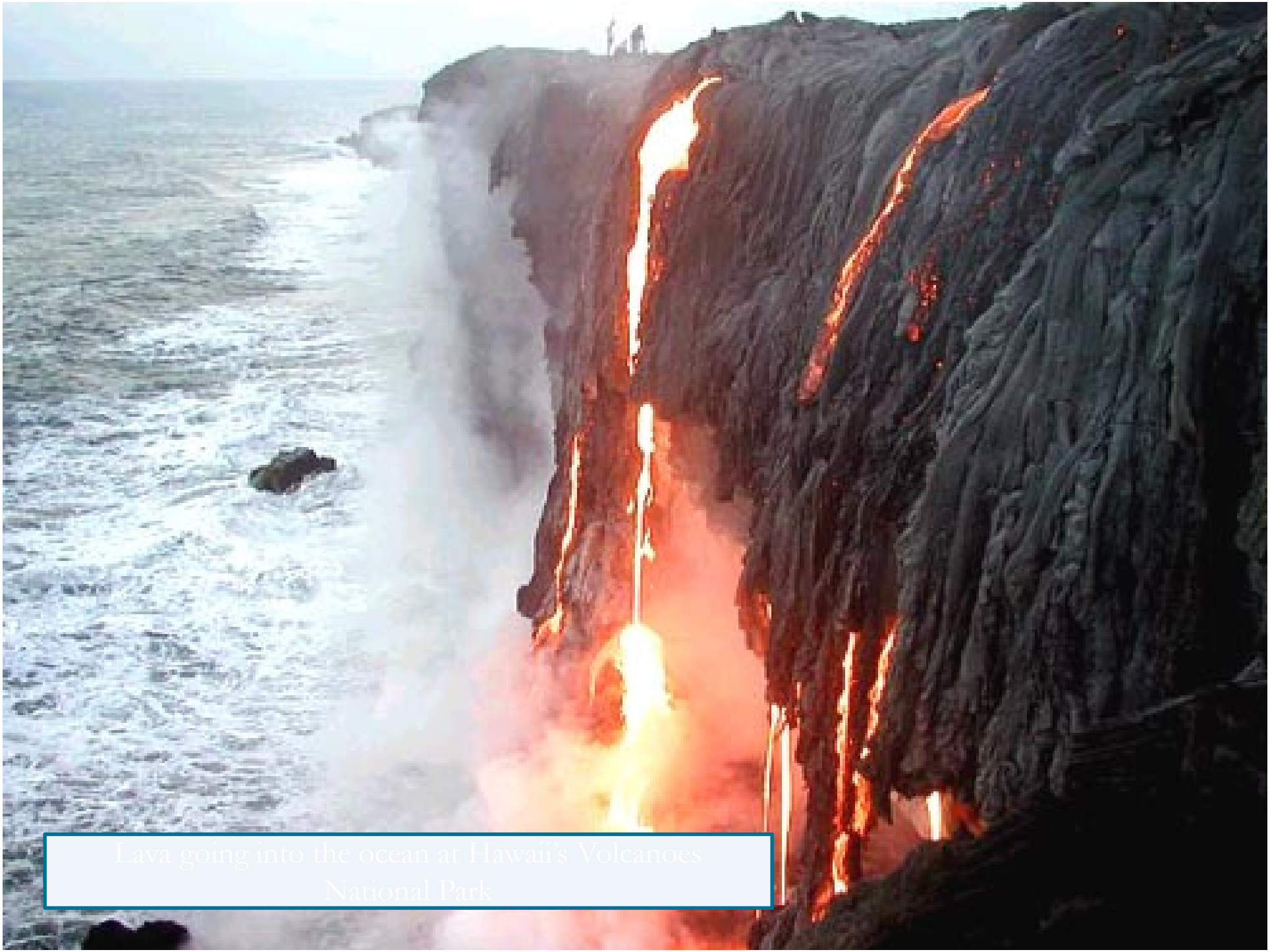
fossil fuels + O_2 → CO_2 + H_2O + ENERGY

(oil, gas, natural gas, coal)

VOLCANIC ERUPTIONS

- Sometimes CO_2 is released from volcanoes!

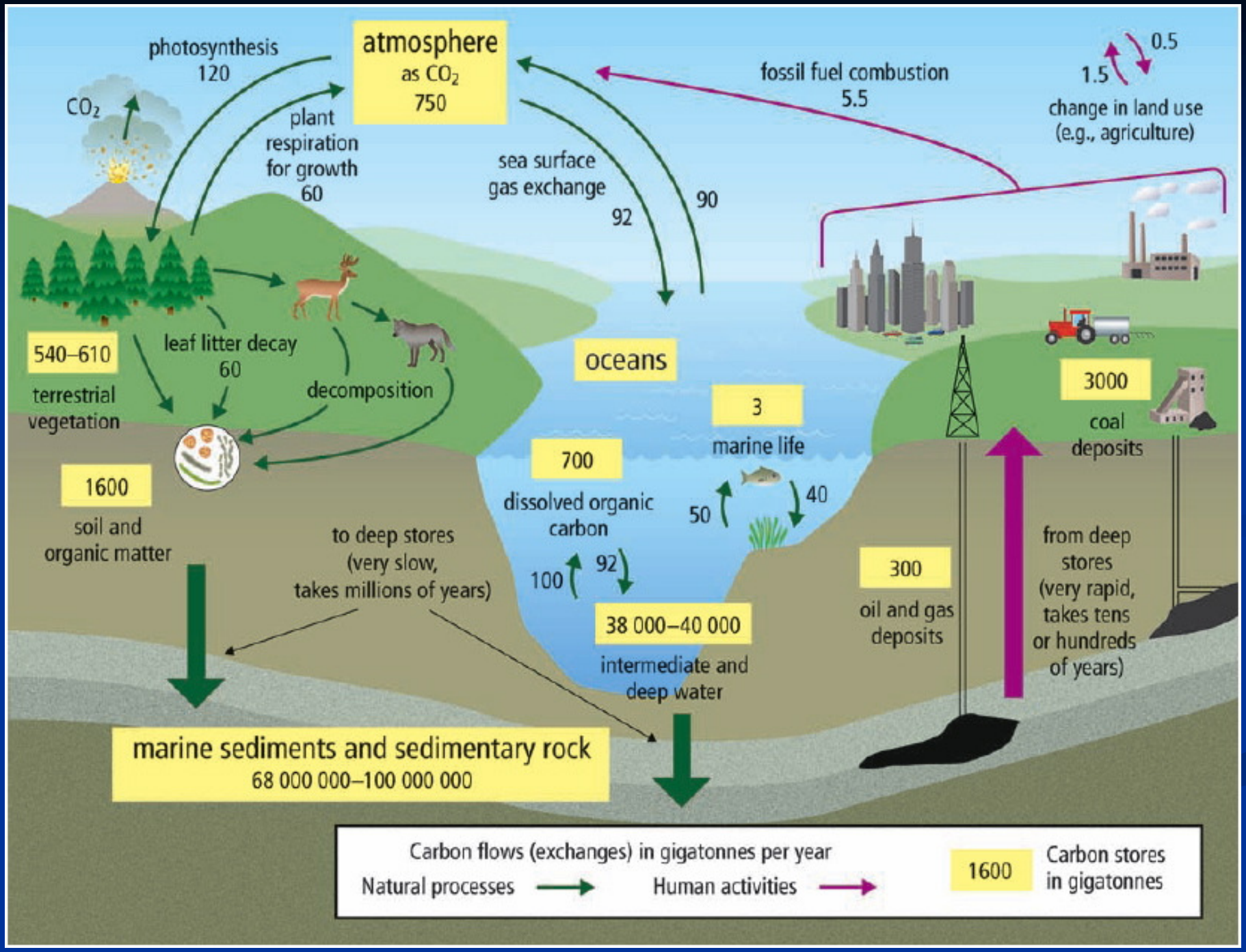
MAGMA =
Molten sedimentary rock



Lava going into the ocean at Hawaii's Volcanoes National Park

FOREST FIRES

- CO_2 is rapidly released during forest fires


atmosphere
as CO_2
750
photosynthesis
120
CO_2
plant
respiration
for growth
60
sea surface
gas exchange
92
90
fossil fuel combustion
5.5
1.5
0.5
change in land use
(e.g., agriculture)
540–610
terrestrial
vegetation
leaf litter decay
60
decomposition
oceans
3
marine life
700
dissolved organic
carbon
50
40
100
92
38 000–40 000
intermediate and
deep water
1600
soil and
organic matter
to deep stores
(very slow,
takes millions of years)
300
oil and gas
deposits
3000
coal
deposits
from deep
stores
(very rapid,
takes tens
or hundreds
of years)
marine sediments and sedimentary rock
68 000 000–100 000 000
Carbon flows (exchanges) in gigatonnes per year
Natural processes
Human activities
1600
Carbon stores
in gigatonnes

Human Activities & CO_2

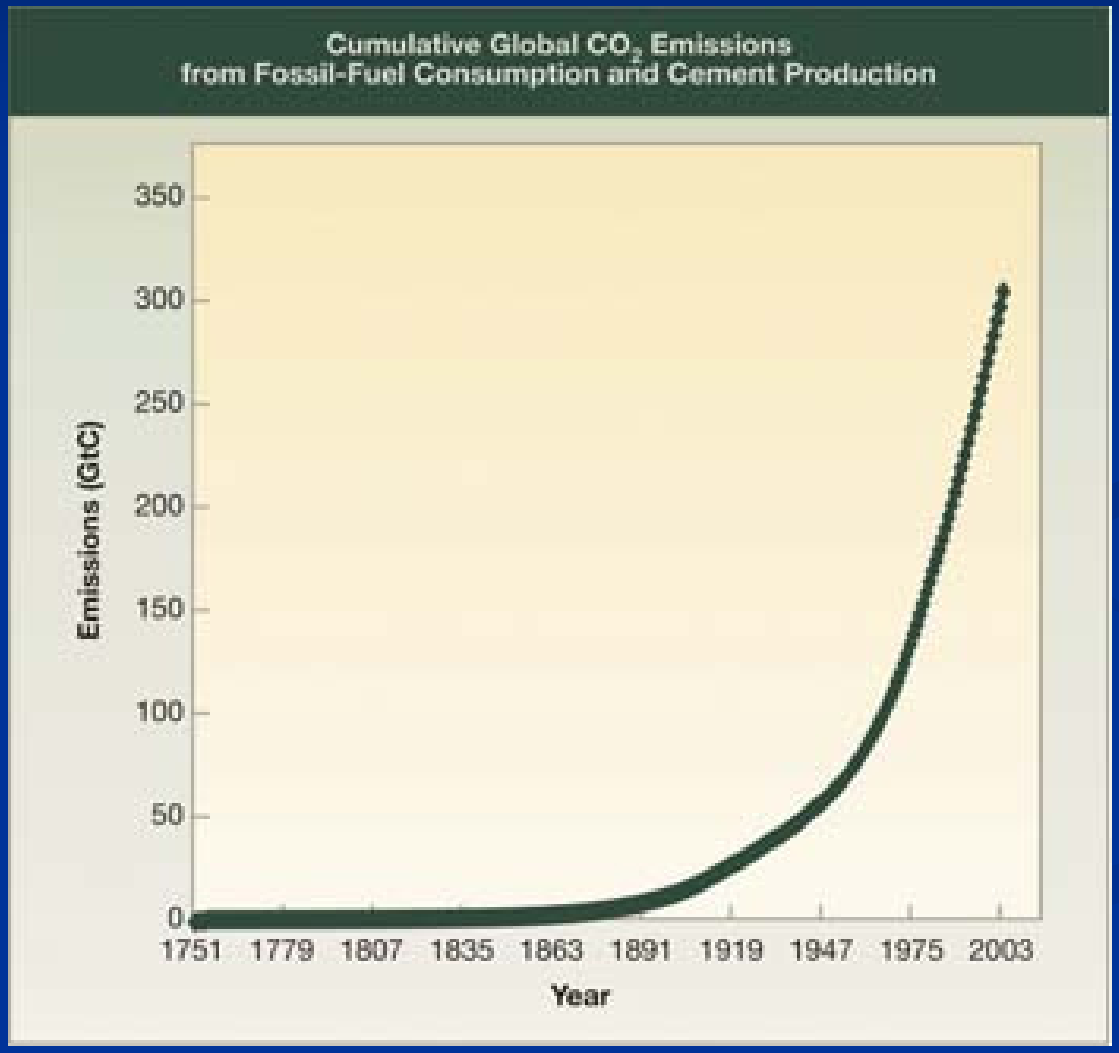
1. Burning Fossil Fuels

- CO_2 in atmosphere has increased 30% in past 160 years.
- In the 160,000 years before that, it only increased 1-3%.
- Carbon is removed from long-term storage as we mine coal & drill for oil and gas.
- CO_2 is also a greenhouse gas, (traps heat in atmosphere)

2. Removing Trees

- Trees absorb CO_2, so when they are cut down, CO_2 is released into the air.
- Other crops don't remove as much CO_2

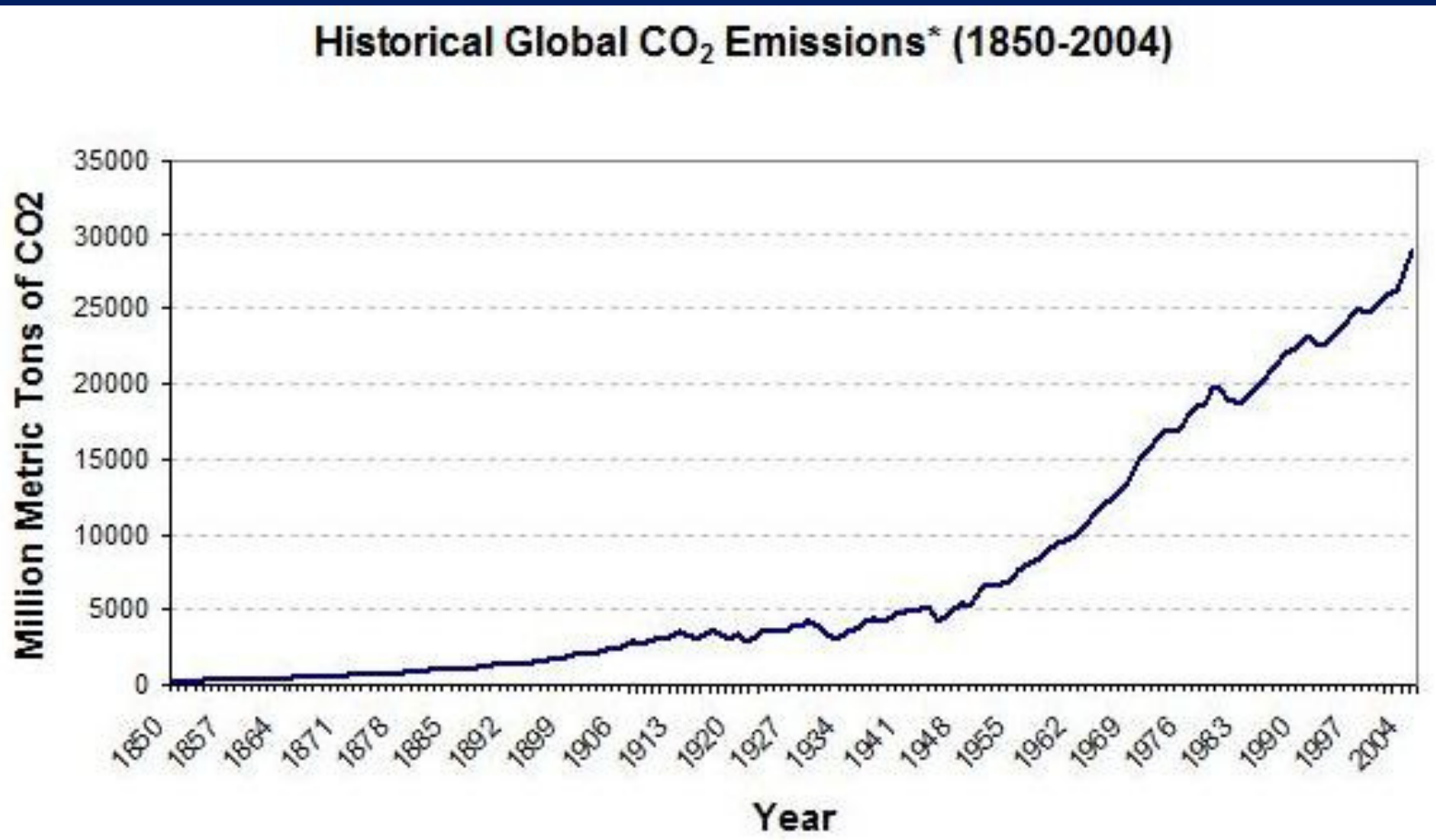
CO_2 on the rise in the atmosphere



- For the past 160 000 years, the increase in CO_2 was 1-3 %
- Since 1850, the increase has been 30%

Scientists estimate that carbon stores in the atmosphere will rise by at least 1/3 by the end of the century.

Burning Fossil Fuels (oil, gas, coal)



*from Fuel Burning, Cement Manufacture, and Gas Flaring

Source: Marland et. al (2007) Global, Regional, and National CO_2 Emissions. In Trends: A Compendium of Data on Global Change. CDIAC U.S.A.

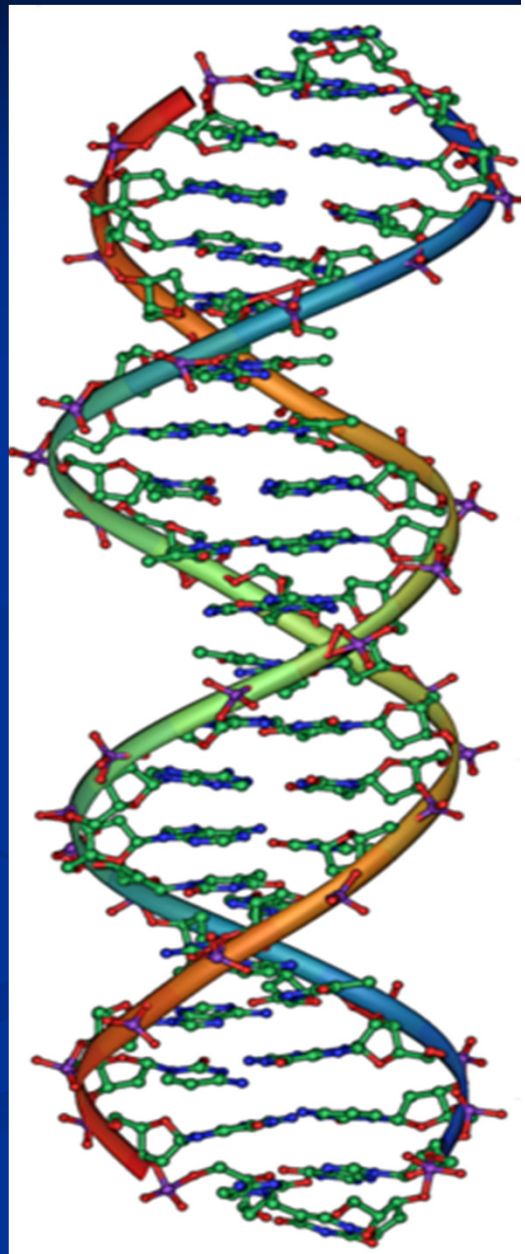
Nitrogen Cycle

A. Nitrogen Facts

- Makes up DNA & proteins (muscle function).
- Help plants grow.

Where Nitrogen is Found:

- Atmosphere (78% is N_2)
- Oceans
- Organic matter in soil
- Lakes, marshes, organisms



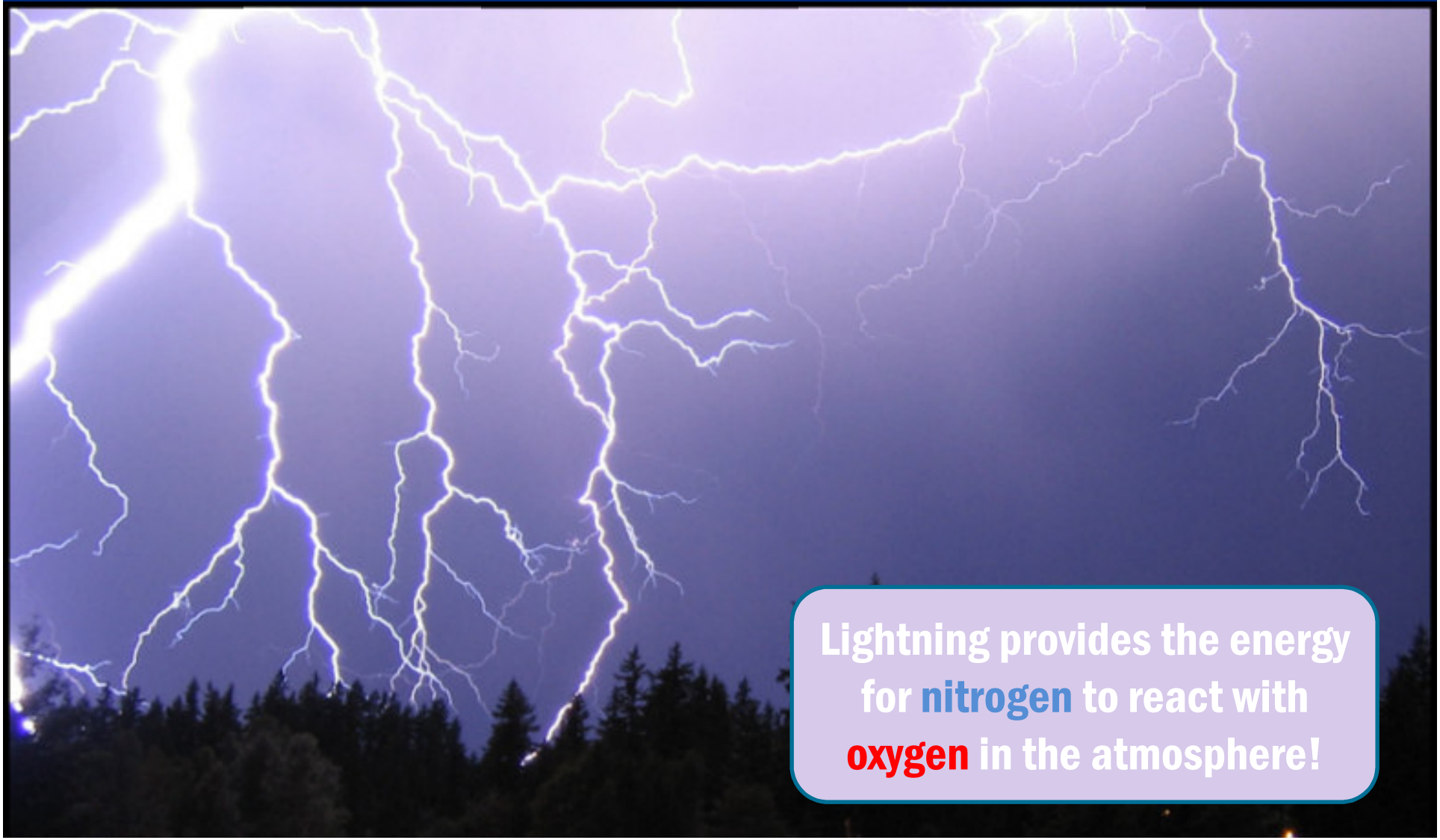
B. How Nitrogen Changes Form:

- N_2 is not usable by plants or animals, so it has to be converted to other forms.
- Plants can use NO_3^- (nitrate) and NH_4^+ (ammonium)

1. Nitrogen Fixation

- Lightning changes N_2 (nitrogen gas) → NO_3^- (nitrate). Rain washes nitrate into soil. (small amount)
- Bacteria in soil (*rhizobium*) & cyanobacteria in water change N_2 (nitrogen gas) → NH_4^+ (ammonium). (more)

$N_2 \longrightarrow NO_3^-$



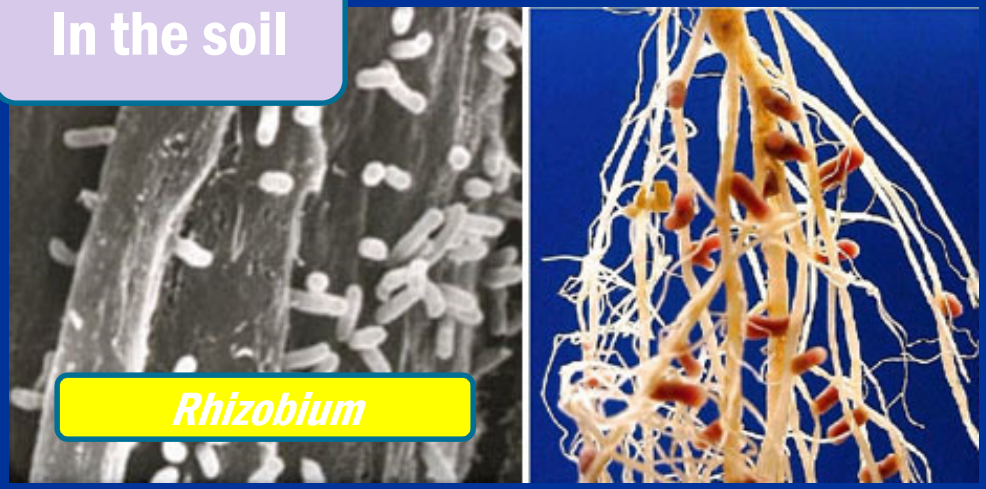
Lightning provides the energy for nitrogen to react with oxygen in the atmosphere!

N_2 → NH_4^+

Nitrogen-fixing bacteria in the soil can convert ("fix") N_2 to ammonium.

Nitrogen-fixing cyanobacteria in water can also do this!

In the soil



Usually live on roots of legumes and other plants.

In the water

Video

2. Nitrification (done by nitrifying bacteria).

   NH_4^+ (ammonium) → NO_2^- (nitrite) → NO_3^- (nitrate)

3. <u>Uptake</u>

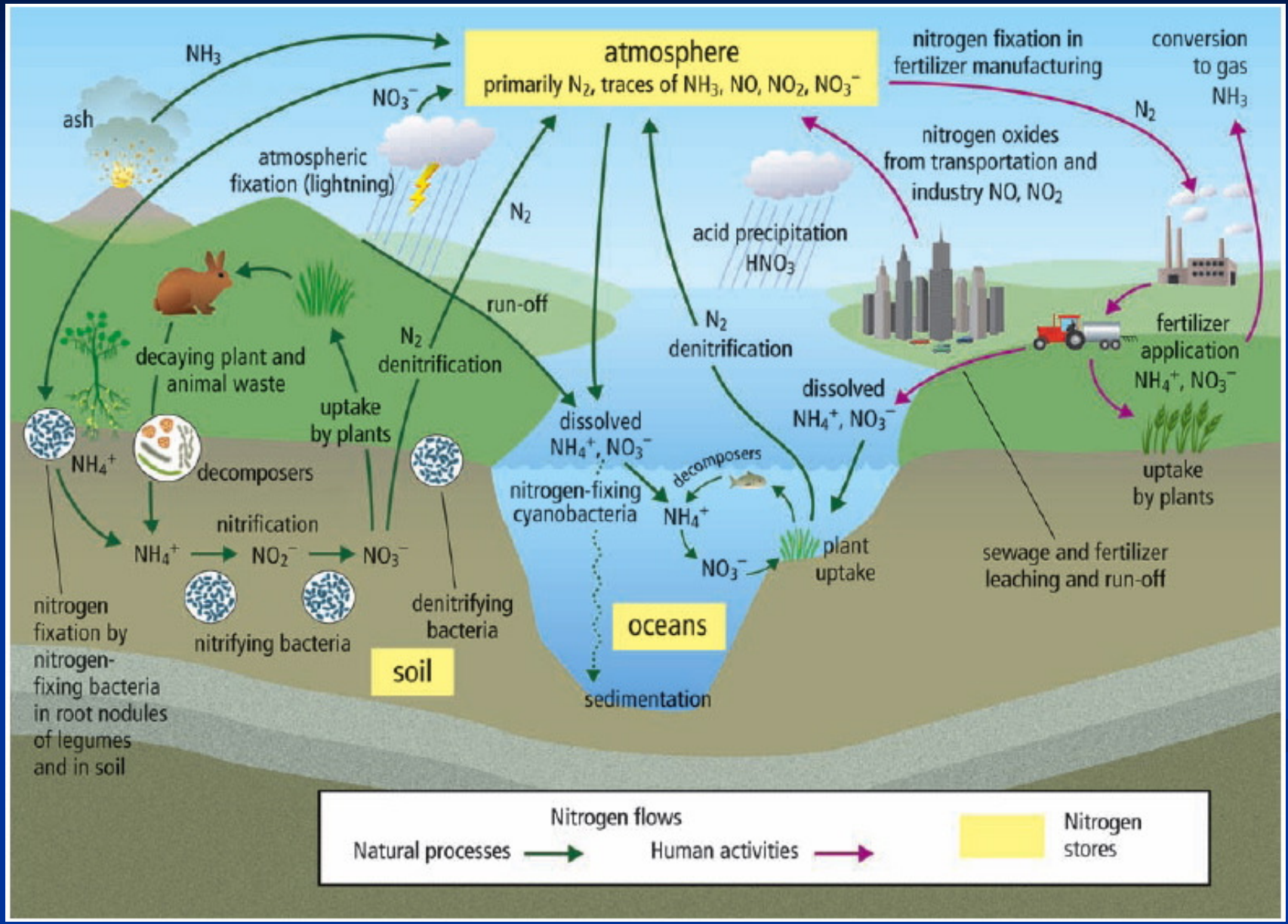
   NO_3^- is sucked into plants & used for growth.

   Herbivores eat plants & use N for making proteins & DNA.

4. Denitrification (done by denitrifying bacteria & volcanic eruptions)

   NO_3^- → N_2

Nitrogen Cycle



C. Human activities affect the nitrogen cycle.

The amount of nitrogen in the ecosystem has doubled in 50 y. due to:

1. Burning fossil fuels & sewage treatment.
   - NO & NO_2 are byproducts
2. Land-clearing by burning.
   - acid rain is formed which contains nitric acid (HNO_3).
3. Overfertilization

- NH_4^+ & NO_3^- leach into soil & waterways.
  - huge growth in aquatic algae = eutrophication
- These algal blooms use up all CO_2 & O_2, block sunlight & produce neurotoxins which poison and kill many aquatic organisms.

The Phosphorous Cycle

Phosphorous Facts

- Phosphorous is a part of the molecule that carries energy in cells (ATP).
- Phosphorous helps root growth, stem strength and seed production.
- In animals, phosphorous is important for strong bones.

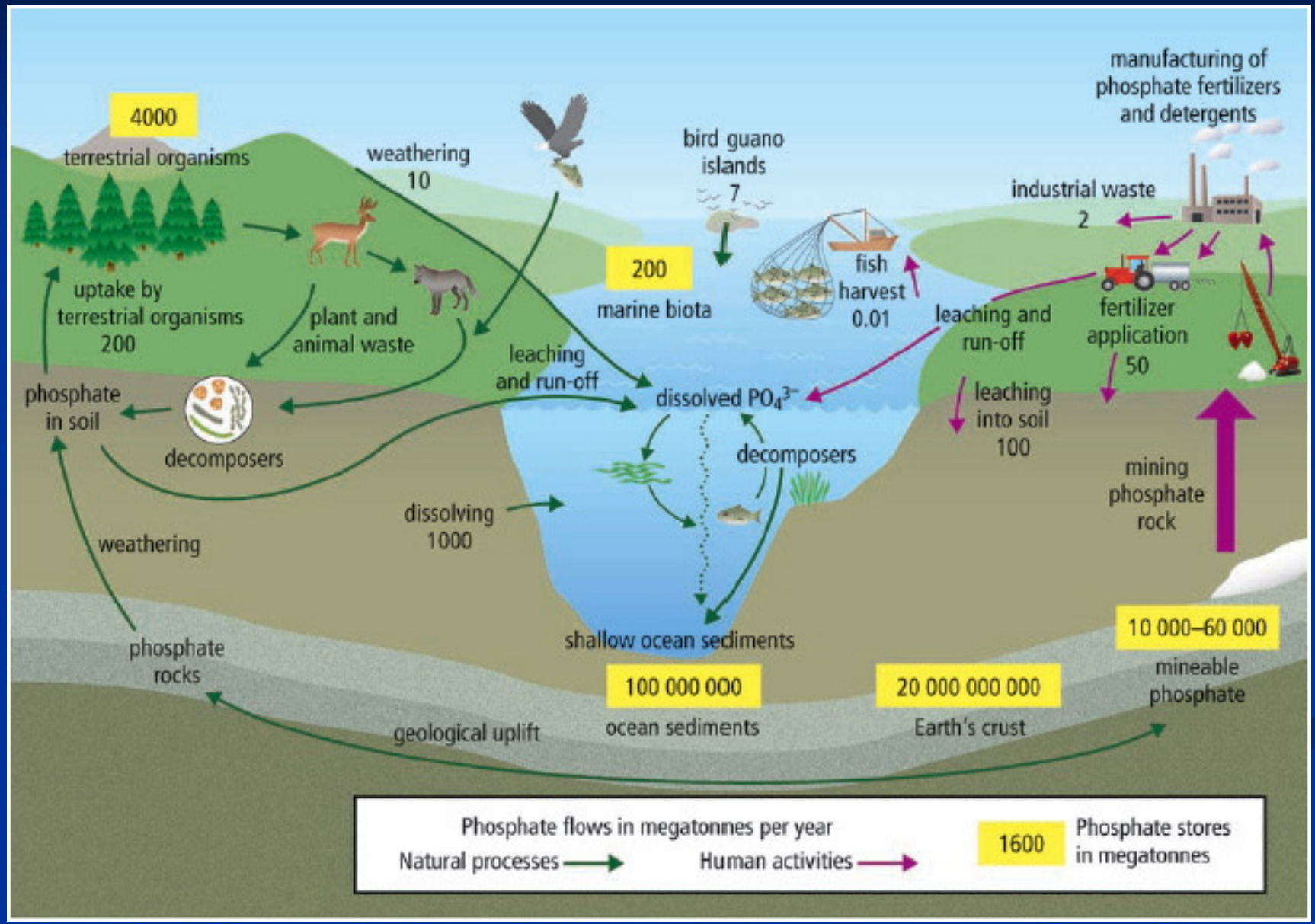
Where Phosphorous is Found:

- Not in atmosphere, but in phosphate rocks (PO_4^{3-}, HPO_4^{2-}, H_2PO_4) and sediments on the ocean floor.

B. How Phosphorous Changes Form.

1. Weathering *(breaking down rock into smaller pieces).*
   a) Chemical weathering:
      acid rain or lichens releases phosphates (PO_4^{3-})
   b) Physical weathering
      wind, water and freezing release the phosphates.
2. Uptake: plants suck up PO_4^{3-}, then are eaten by animals.
3. Decomposition: Bacteria break down organic matter & phosphorous is returned to soil.
4. Geologic Uplift: when rocks under the ground are pushed up → mountains → weathering.

The Phosphorous Cycle



C. Human activities affect the Phosphorous Cycle.

1. Mining: increases P in ecosystems quickly.

2. Slash-and-burn forest practices: turns P into ash, which runs into waterways.

How Changes in Nutrient Cycles Affect Biodiversity

Any significant changes to any of these nutrients (C, H, O, N or P) can greatly impact biodiversity.

1. Carbon cycle changes → climate change & global warming.
2. Too much nitrogen can allow certain plant species to out-compete other species.
3. Decreased levels of phosphorous → slow growth of algae (important producers).

Take the Section 2.2 Quiz