Science 1206

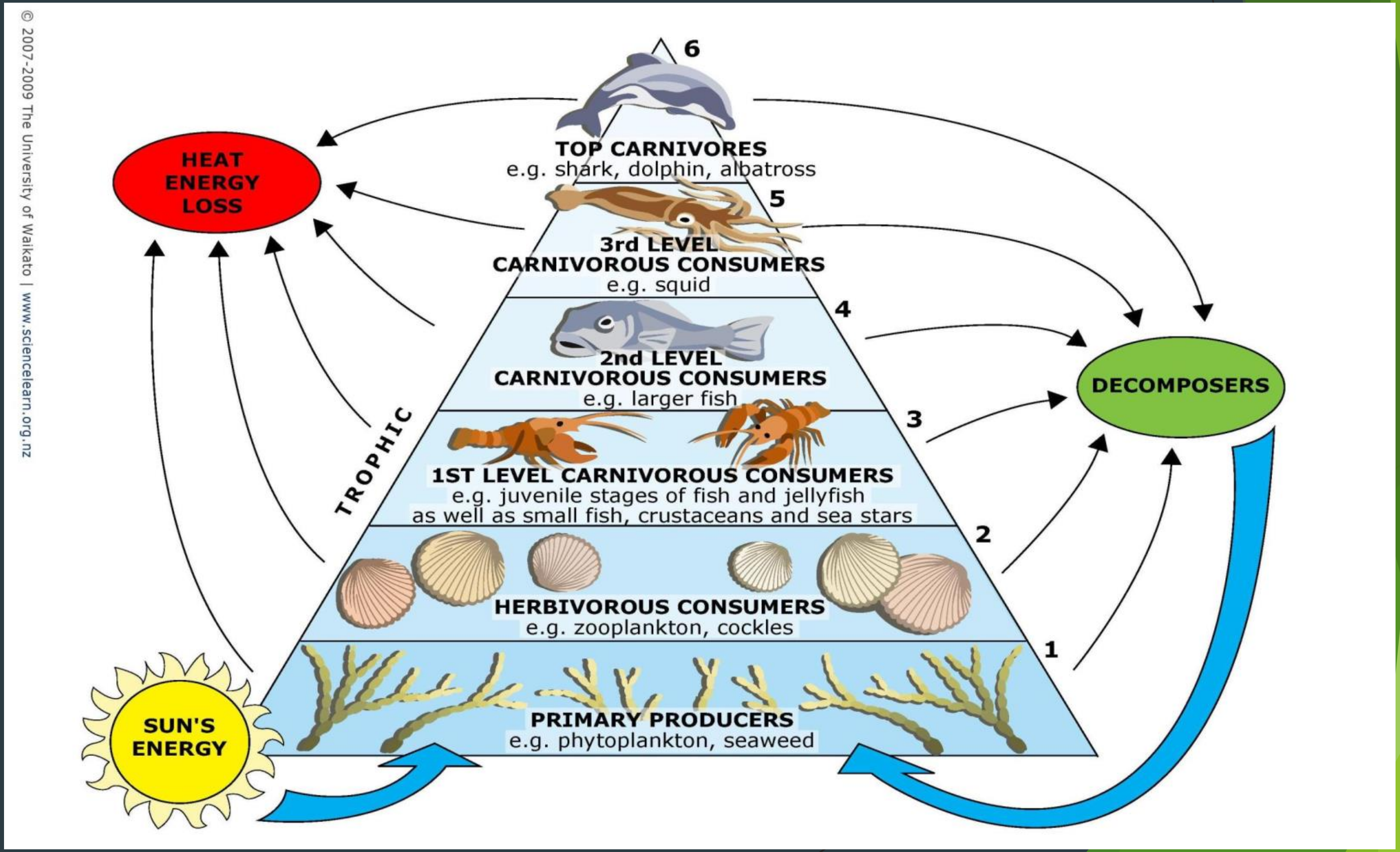
Unit 4: Sustainability of Ecosystems

ECOLOGY

What we learned in Grade 7

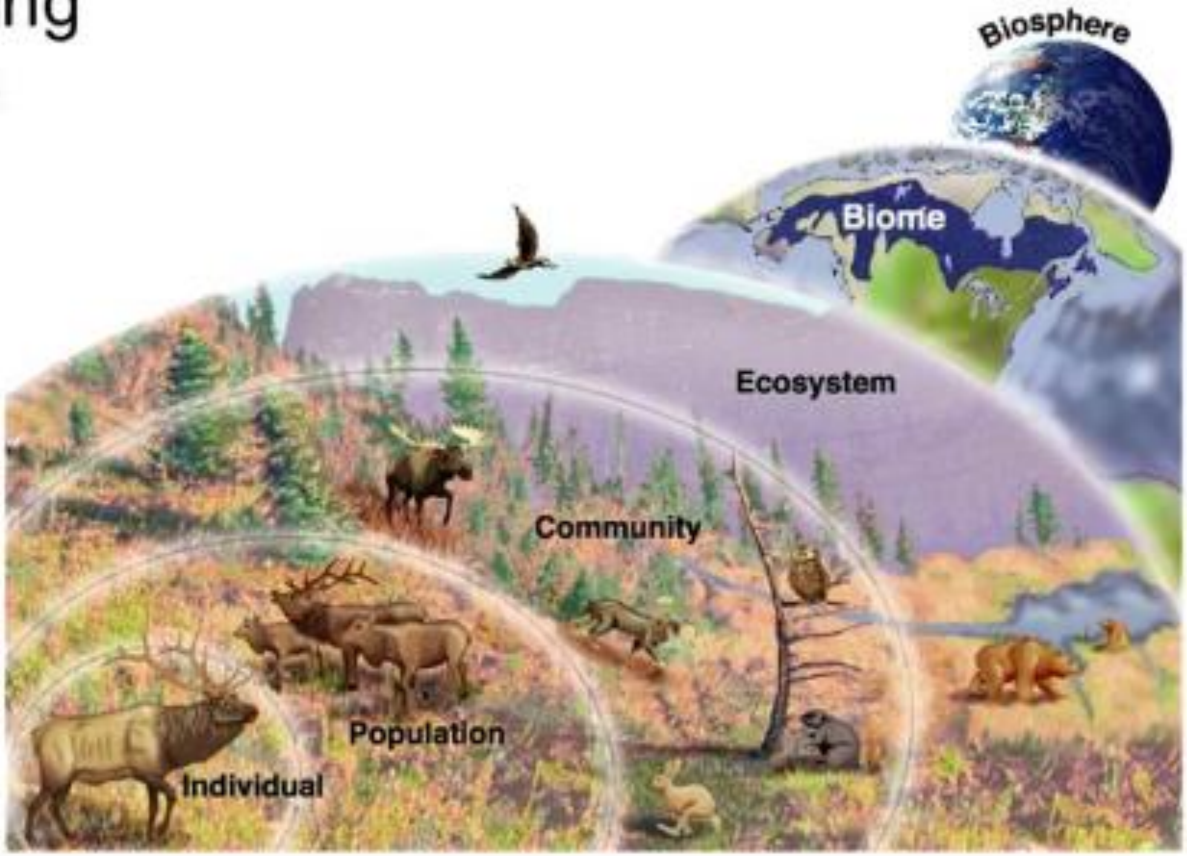
1. Biotic vs Abiotic
2. Levels of Organization
3. Habitat and Niche
4. Energy and Feeding

Ecology—the scientific study of **interactions** between different **organisms** and between organisms and their **environment** or surroundings



Levels of Organization

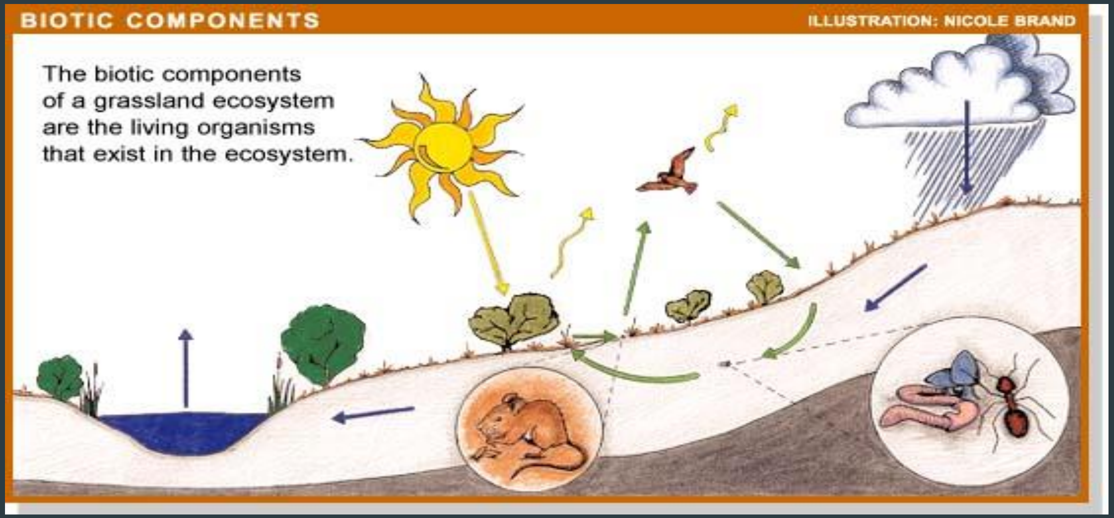
- Ecologist study organisms ranging from the various levels of organization:
  - **Species**
  - **Population**
  - **Community**
  - **Ecosystem**
  - **Biome**
  - **Biosphere**



Levels of Ecological Organization

- **Biosphere:** Earth, supports life
- **Biome:** group of ecosystems with similar climate (Tundra, Grasslands, Deciduous Forrest)
- **Ecosystem:** All Biotic & Abiotic factors existing together in a given area (forest, ocean, park)
- **Community:** multiple groups of organisms living in the same ecosystem (only organisms;)
- **Population:** all the organisms of the same group or species
- **Organism:** an individual of a type of species

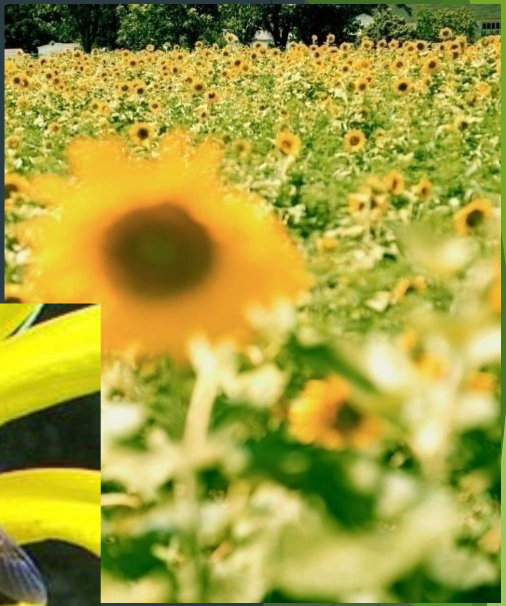
<u>Biotic Factor</u>—*living* factors that influence an ecosystem



<u>Abiotic Factor</u>—*non-living* factors that influence an ecosystem

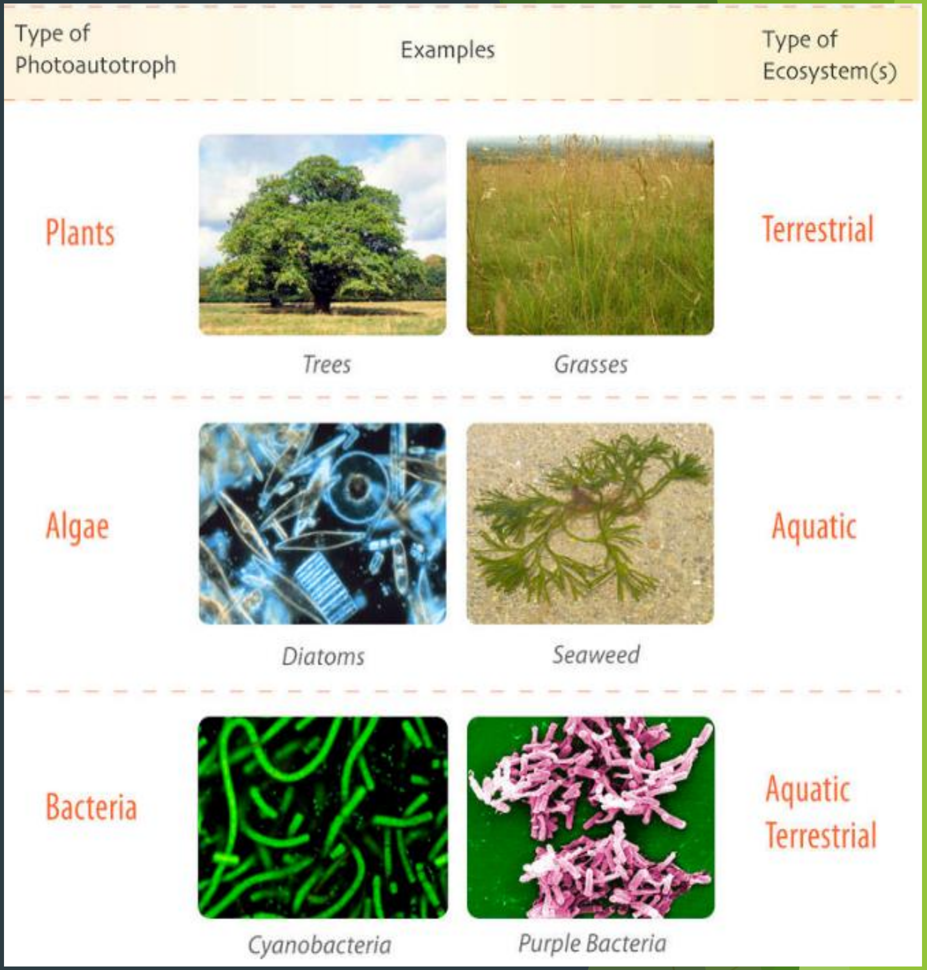
<u>Niche</u> - the unique **<u>role</u>** that an organism has in its ecosystem, "job"

<u>Habitat</u>- the environment in which an organisms lives, "address"



Producers

- **Autotrophs** –an organism that produces complex organic compounds (such as sugars) from simple substances present in its surroundings, generally using energy from light (**photosynthesis**) or inorganic chemical reactions (chemosynthesis).
- Because **autotrophs** produce their own food, they are sometimes called **producers**.
- **Primary producers** – the first producers of energy-rich compounds that are later used by other organisms.
- Most engage in the process of photosynthesis, they use the energy of the sun to convert **CO_2** and **water** into **glucose** and **O_2**.



Type of Photoautotroph	Examples		Type of Ecosystem(s)
Plants	Trees	Grasses	Terrestrial
Algae	Diatoms	Seaweed	Aquatic
Bacteria	Cyanobacteria	Purple Bacteria	Aquatic Terrestrial

Consumers

- **Consumers** – organisms that consume other organisms for energy and nutrients.
- **Heterotrophs** – can not make their own food; acquire energy from other organisms by ingesting them.
- Heterotrophs are also Consumers!!!!

Different Types of Heterotrophs

There are many types of Heterotrophs

1) **Carnivores** – kill and eat other animals.

   a. **Predator** - kills and consumes it's prey.

   b. **Scavenger** – consumes the carcasses of dead animals.

2) **Herbivores** – eat plants.

3) **Omnivores** – diets include both plant and animal matter.

4) **Decomposers** – break down organic matter.

   a. **Detritivores** – feed on detritus (small pieces of decaying matter) by grinding them into smaller pieces (earthworms and snails are examples).

   b. **Saprobes**- organisms such as fungi and bacteria that chemically break down organic matter.

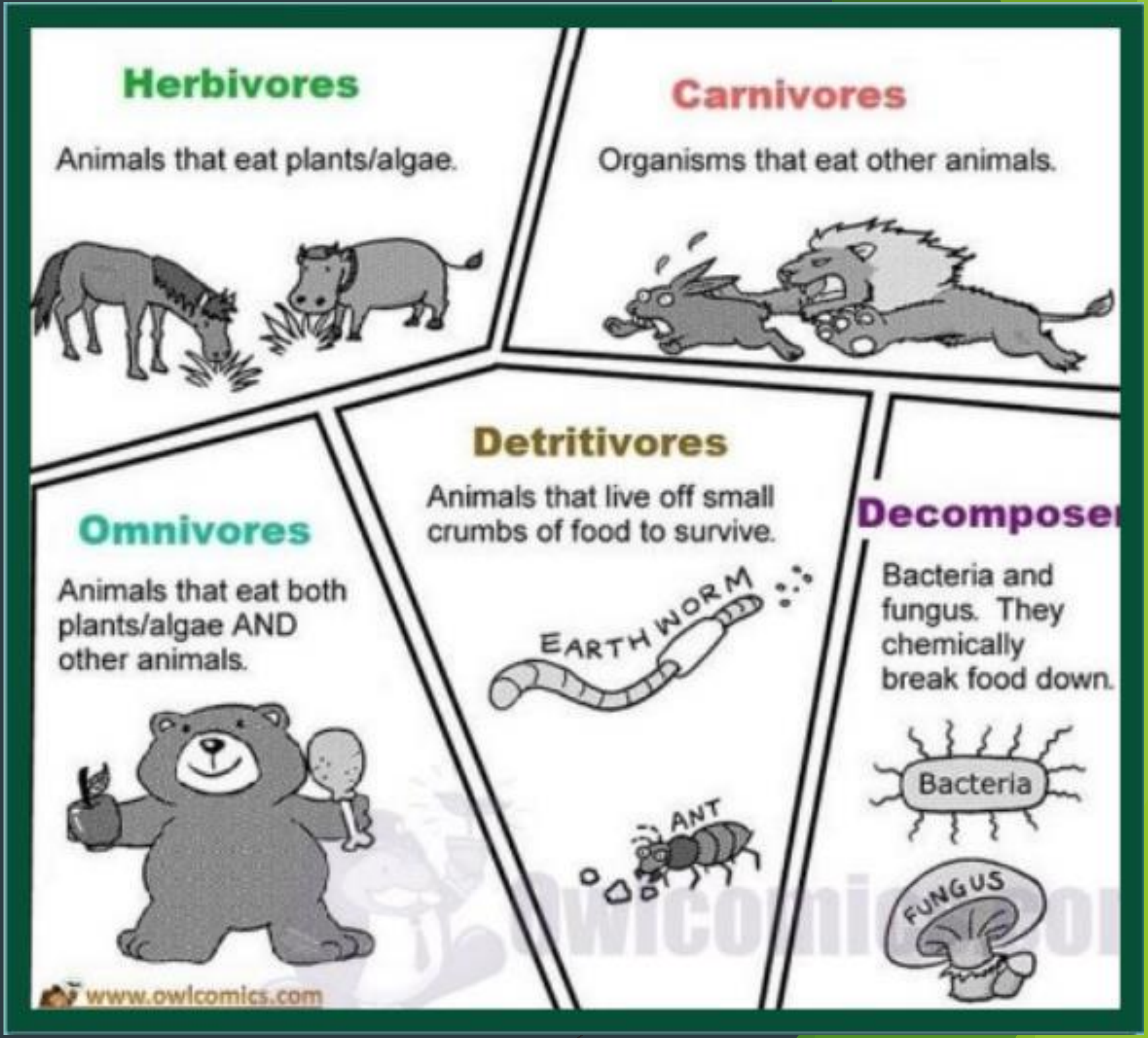
Types of Consumers

- Herbivores
  - Only eat plants

- Carnivores
  - Only eats animals

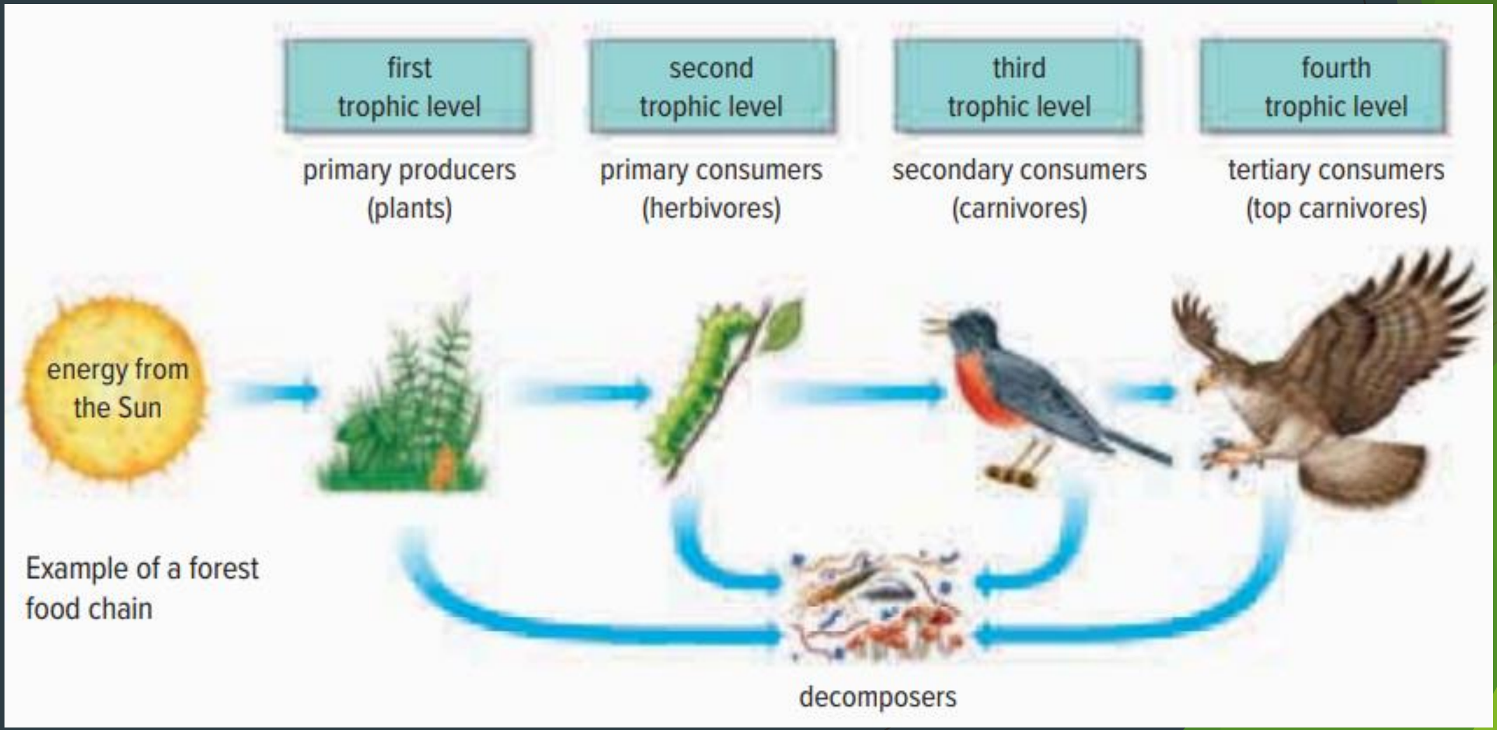
- Omnivores
  - Eats both plants & animals

- Scavengers
  - Eat bodies of dead organisms

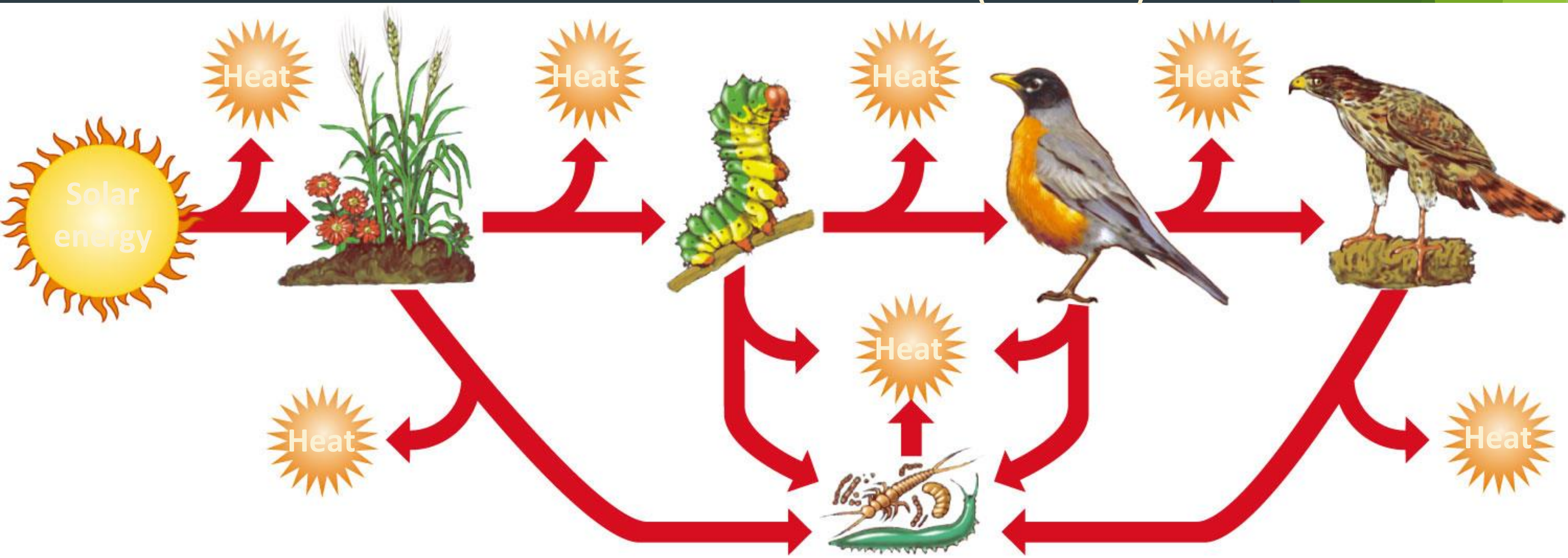


Herbivores
Animals that eat plants/algae.
Carnivores
Organisms that eat other animals.
Detritivores
Animals that live off small crumbs of food to survive.
Omnivores
Animals that eat both plants/algae AND other animals.
Decompose
Bacteria and fungus. They chemically break food down.
EARTHWORM
ANT
Bacteria
FUNGUS
www.owlcomics.com

- Consumers may be **primary**, **secondary**, or **tertiary** based on the level at which they feed.
- A caterpillar is a primary consumer since it is located in the **second trophic level** and feeds on **producers** (located in the **first trophic level**).
- The robin is a **secondary consumer** since it is located in the **third trophic level** and feeds on primary consumers.
- The hawk is a **tertiary consumer** since it is located in the **fourth trophic level** and feeds on secondary consumers.



First Trophic Level	Second Trophic Level	Third Trophic Level	Fourth Trophic Level
Producers (plants)	Primary consumers (herbivores)	Secondary consumers (carnivores)	Tertiary consumers (top carnivores)

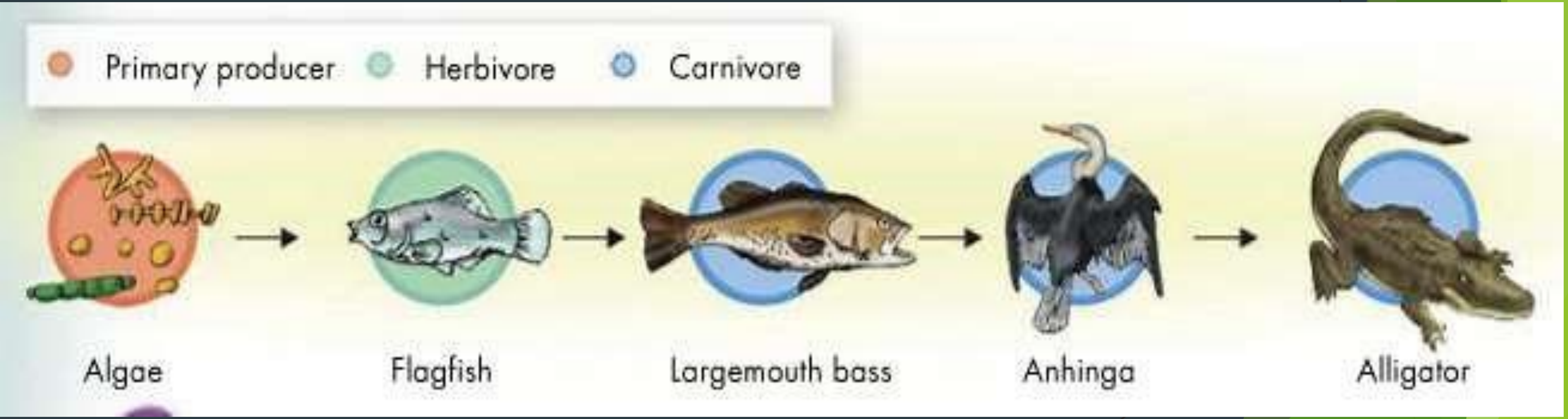


Decomposers and detritus feeders

Energy Flow in Ecosystems

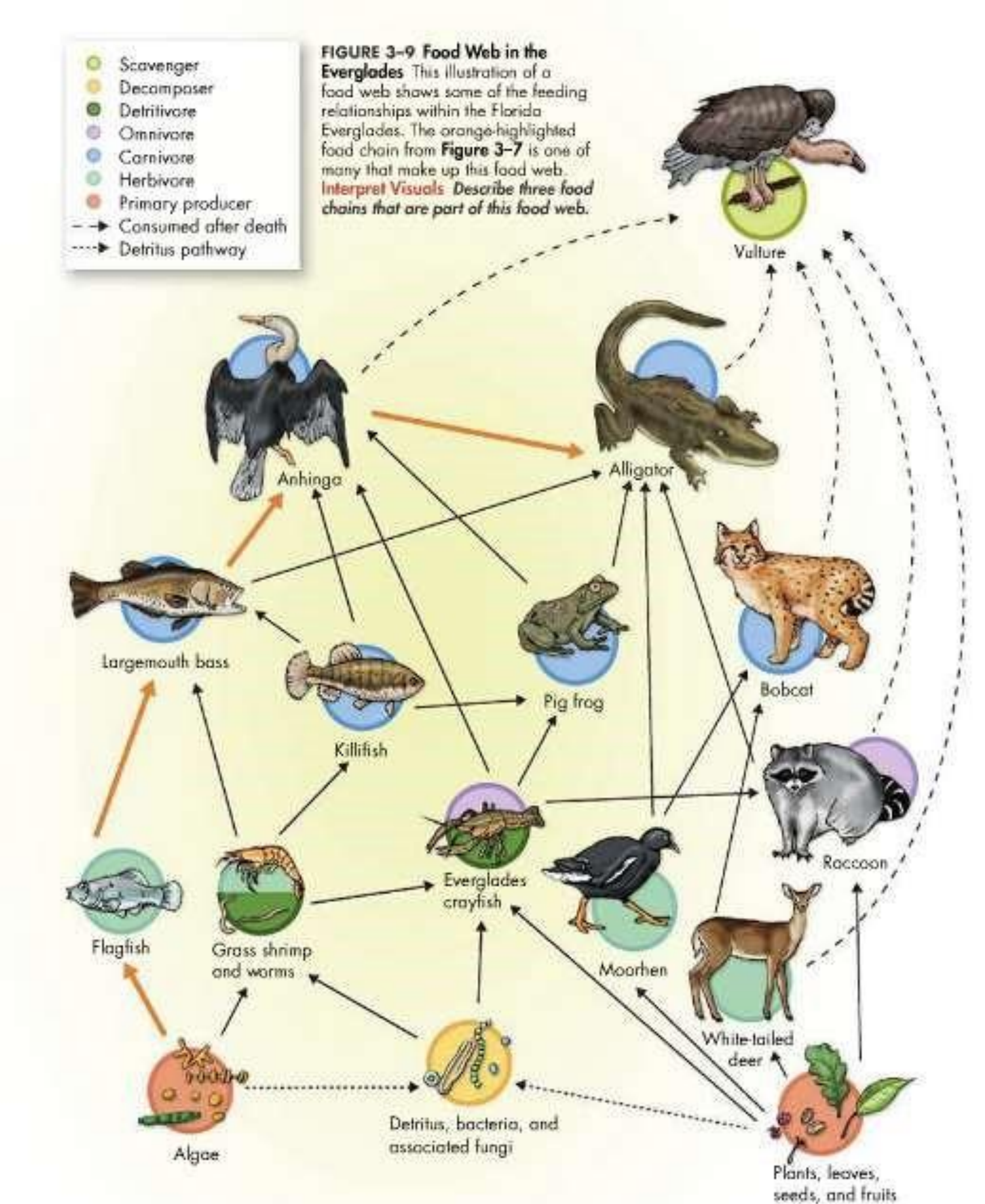
- Remember, energy flows through an ecosystem in one directions, from primary producers to consumers!

- **<u>Food Chain</u>** – series of steps where organisms transfer energy by eating, and being eaten.



Energy Flow in Ecosystems

- **<u>Food web</u> –** network of feeding interactions involving multiple producers, and consumers such as herbivores, carnivores, scavengers, omnivores, and detrivores (decomposers).



- Complete Ecology Review worksheet #1

Chapter 7

- Ecosystems, Populations and Sustainability

7.1- Components of Sustainable Ecosystems

Sustainable ecosystems are ecosystems capable of withstanding **pressure** and giving support to a variety of organisms

Organisms require a sustainable ecosystem to meet their needs, both **biotic** and **abiotic** components, and they need an ecosystem that is resistant to **disturbances**.

What are the Biotic and an Abiotic components of a sustainable ecosystem?

Biotic Factors and Sustainability

Biotic factors include both:

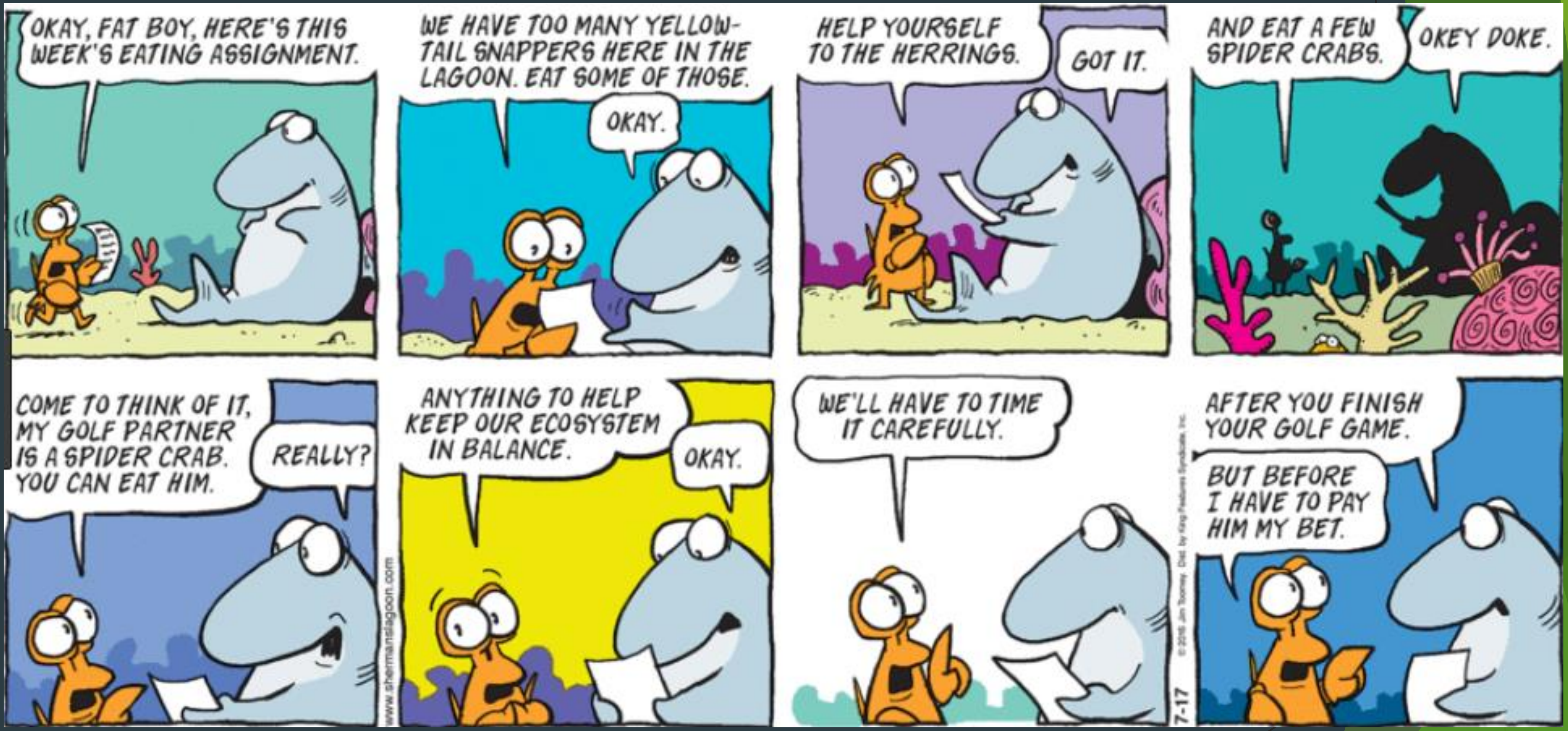
the ORGANISMS *AND*

the interactive RELATIONSHIPS BETWEEN organisms

Examples include:

1) **Predator/prey relationships**
2) **Symbiosis**
3) **Competition**

1) Predator Prey Interactions



- **Predator/prey interaction** - an important biotic factor which helps to limit the size of populations within an ecosystem. A **predator** is an animal that kills and eats another animal for **food**. The **prey** is the hunted animal. There is a **cyclic** balance between the number of predator and prey in any ecosystem.

- For example, the sea otter is a predator of sea urchins.

The Sea Otter

- The Sea Otter is considered a keystone species because of their critical importance to the health and stability of the nearshore marine ecosystem. They eat sea urchins and other invertebrates that graze on giant kelp. Without sea otters, these grazing animals can destroy kelp forests and consequently the wide diversity of animals that depend upon kelp habitat for survival.

2) Competition

Competition - a struggle for survival that occurs between two organisms either of the same or different species over **food**, **territory**, or other resources. Competition tends to **limit** the size of the population keeping it in balance with the available resources.

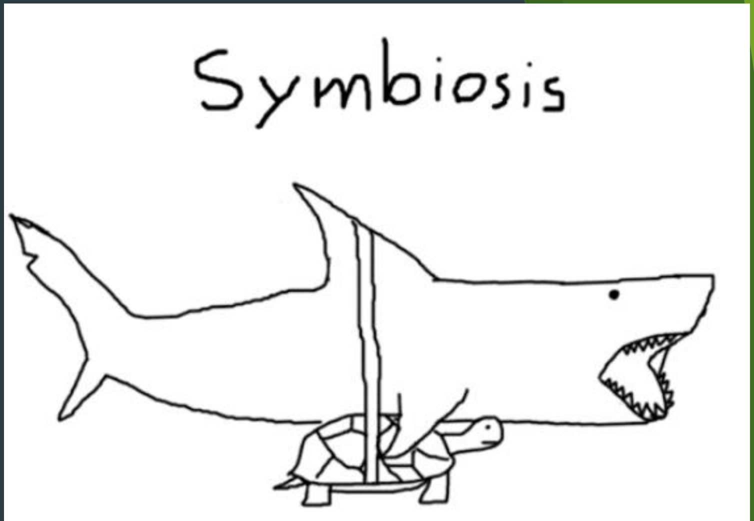
Interspecific Competition – competition between members of **different** species

Blue Jays and Squirrels compete for food…and the Blue Jay usually wins!

Intraspecific Competition – competition between members of the **same** species

Rams compete with each other for mates.

3) Symbiosis

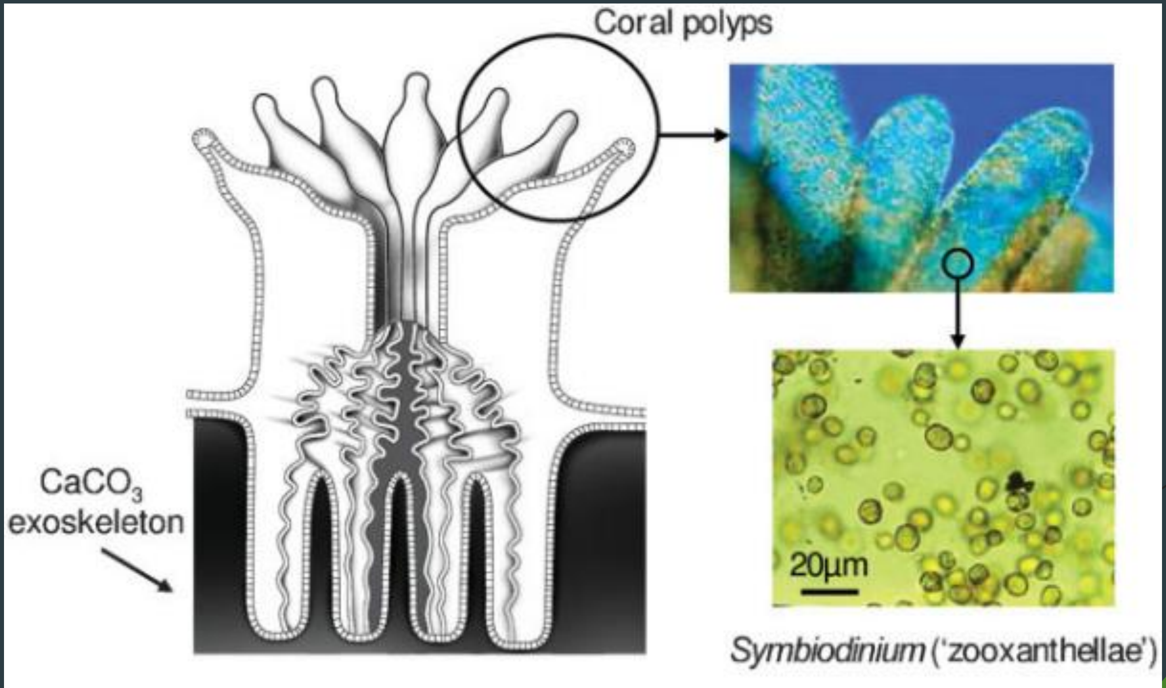


- Symbiotic relationships are **<u>biotic</u>** relationships in which two different organisms live in close association with each other to the benefit of at least one.

- There are three types of symbiotic relationships
  1) **<u>mutualism</u>** – both species benefit
  2) **<u>commensalism</u>** – one species benefit, the other is unaffected
  3) **<u>parasitism</u>** – one species benefits, the other is harmed

Mutualism in Coral Reefs

- Most reef-building corals contain photosynthetic algae that live in their tissues. The corals and algae have a **mutualistic** relationship. The coral provides the algae with a protected **environment** and compounds they need for **photosynthesis**. In return, the algae produce **oxygen**, **nutrients** and help the coral to remove wastes. The relationship between the algae and coral facilitates a tight recycling of nutrients in nutrient-poor tropical waters.



- When corals are **stressed by changes in conditions** such as **temperature**, **light**, or **nutrients**, they expel the symbiotic algae living in their tissues, causing them to turn **completely white** causing damage to the **reef** ecosystem.

Abiotic Factors and Sustainability

The **NON-LIVING FACTORS** which affect life in an ecosystem.

Examples include:

1) **water** - All organisms need water to **survive**. Plants take up water through their roots. Some animals need water to help regulate their **body temperature**. Animals also use water to get rid of **wastes**. Many organisms live in freshwater and saltwater ecosystems.

2) **oxygen** - O_2 is necessary for **cellular respiration** (body process that releases energy from food).

3) **light** - ultimate source of energy for **photosynthesis**.

Abiotic Factors and Sustainability

The **NON-LIVING FACTORS** which affect life in an ecosystem.

Examples include:

4) **nutrients** - inorganic nutrients such as **nitrogen** and **phosphorous** are necessary for **plant growth**.

5) **soil** - The **physical** structure of soil (**sandy** or nutrient rich) determines the type of plant-life that an area can sustain, and hence the **animal-life** that inhabits a region.

Complete the following Case Study

- “Newfoundland bees drawing international scientific attention”
- https://www.youtube.com/watch?v=DRIBz1MuFaE

- Brenda and Paul Dinn of the Goulds look over one of their hives at Adelaide's Newfoundland

Different Geographic Locations Can Sustain Similar Ecosystems

- The type of ecosystem found in an area depends on the abiotic conditions of the area. These include....

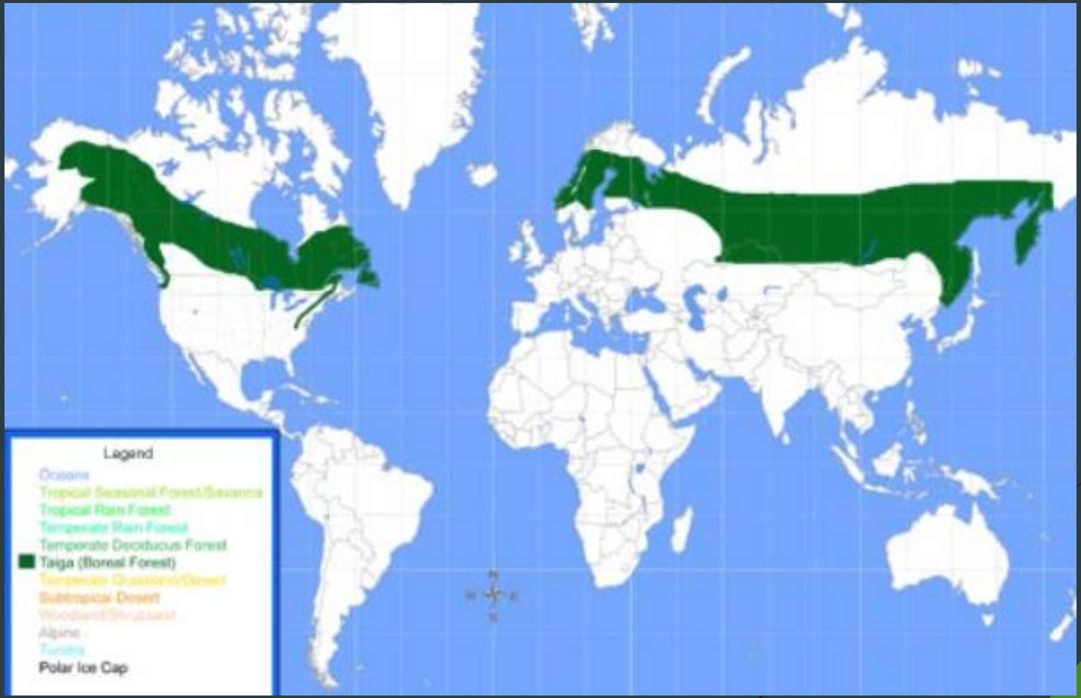
1) **<u>climate</u>** (temperature, precipitation, and availability of sunlight)

2) **<u>soil</u>** (salinity, fertility, moisture, texture, etc.)

3) **<u>geographical features</u>** (latitude, altitude, and proximity to mountain ranges or large bodies of water).

Boreal Forest

- Large geographical regions with similar **climate** and a dominant form of **plant life** are called **biomes**.
- The largest terrestrial biome on Earth, found in every province and territory in Canada, is the **boreal forest.**
- Boreal forest ecosystems are found across **Canada** as well as across large regions in **Russia**, Finland, and Scandinavia.



- This phenomenon occurs because these diverse geographic locations have similar combinations of **abiotic** characteristics (e.g., **latitude**, **elevation**, **climate**, **hours of sunlight**, **soil type**, **nutrient levels**).
- Abiotic characteristics determine the type and abundance of **plants**, and other photosynthetic organisms, that can survive.

- The plants, in turn, determine the **diversity** and abundance of **animals**, fungi, and other species that can inhabit the location.
- As a result, different geographic locations can sustain similar communities of **species** adapted to the particular combination of abiotic factors.

- Brown Bear in Siberia, Russia

- Brown bear in Alberta, Canada

Section Review (p. 291)

Students should answer the following questions to supplement information learned in class

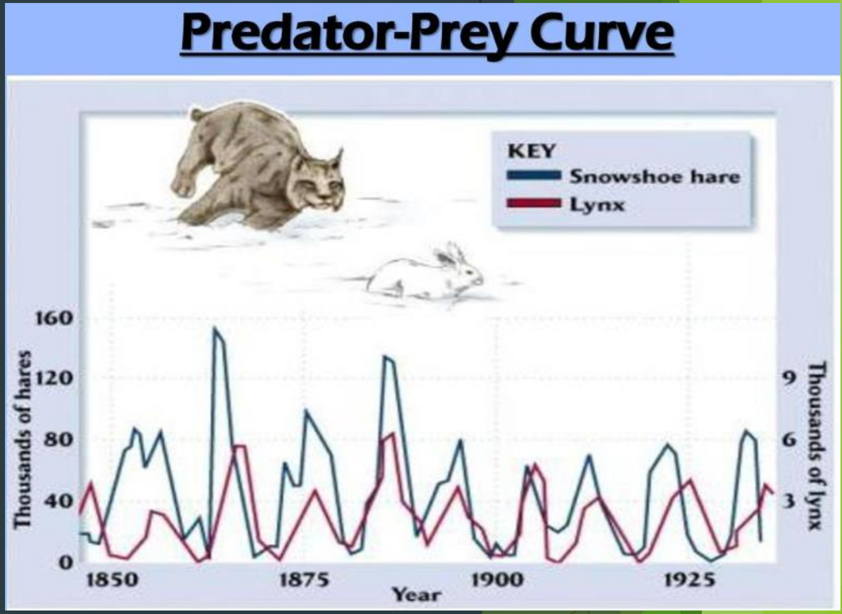
- Checking Concepts: Q 1, 2, 4, 5, 6, 7, 8, 9, 10
- Understanding Key Ideas: 14, 15, 17, 18

Complete the following activity in your booklet

- **Ecosystems and Geography Activity**
- **Map of Hypothetical Island/Continent**

7.2 – Populations and Sustainability

- In science, '**equilibrium**' refers to a balance between opposite forces
- An equilibrium will be **stable** or unstable, steady state or **dynamic**, depending on both the stability of the interactions.
- Ecological communities involve organisms interacting with each other.
  - **Predator–prey**
  - **Competition**
  - **Symbiosis**

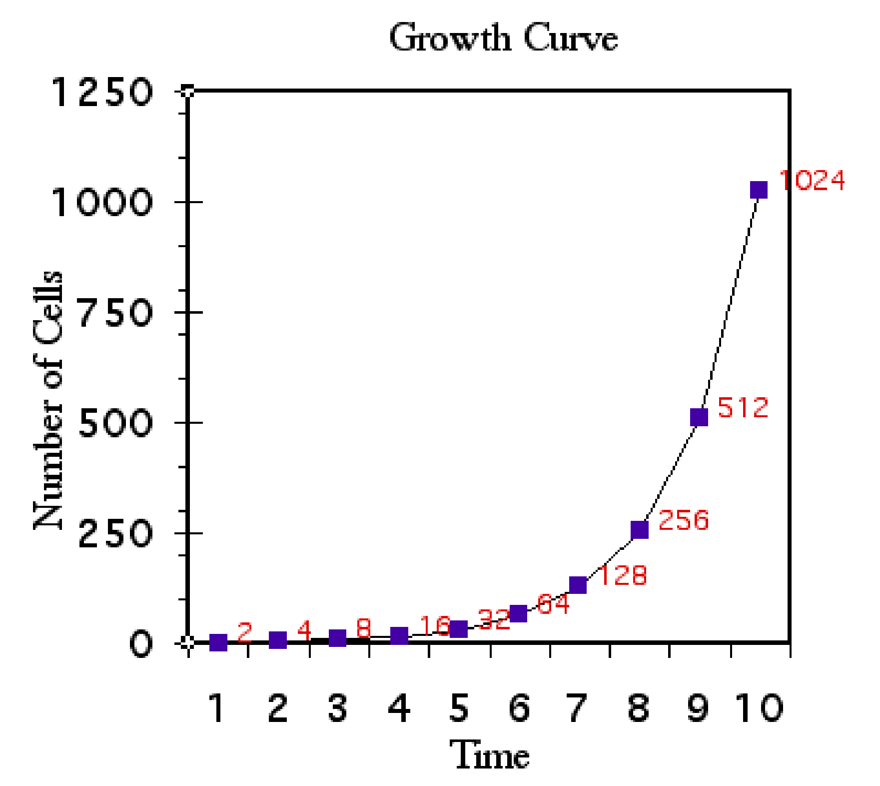


- Ecology has mainly used the term equilibrium to refer to a situation characterized by **little variability** in species **composition** over time.
- A community at equilibrium is **persistent**, **self-sustaining**, and at which further 'change' is limited if at all possible.

How Fast Do Populations Grow

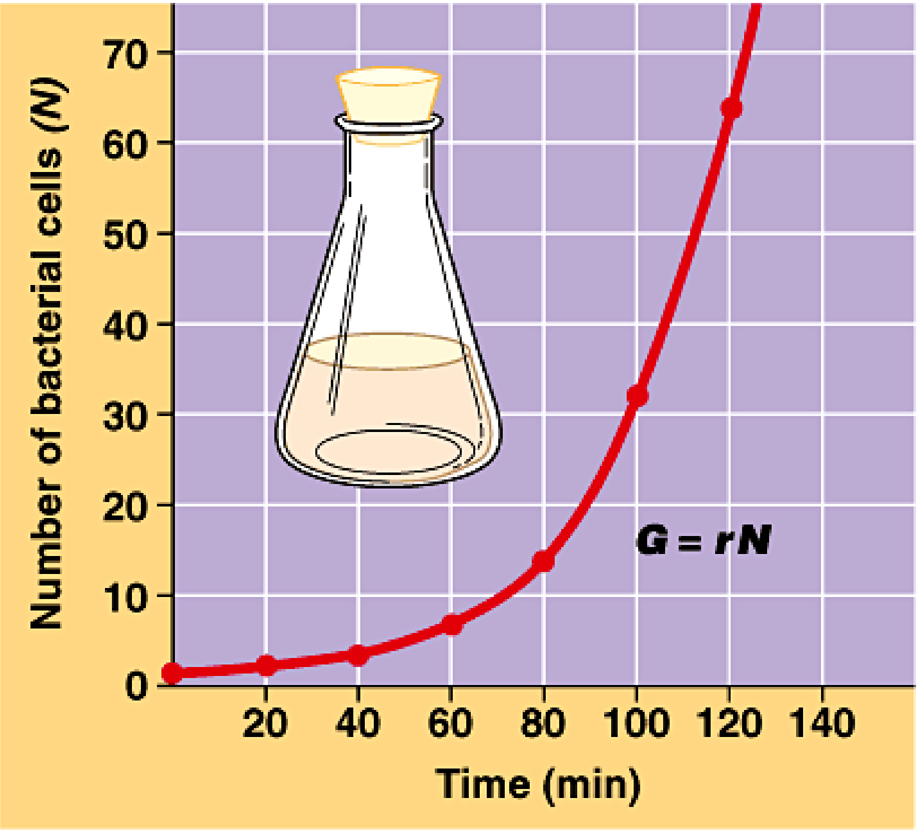
<u>Exponential Growth</u>

- Usually slow at first
- Called a **<u>"J"-shaped curve</u>**
- Slow at first because number of reproducing organisms is small
- Called **<u>exponential growth</u>**, as a population gets larger it grows faster

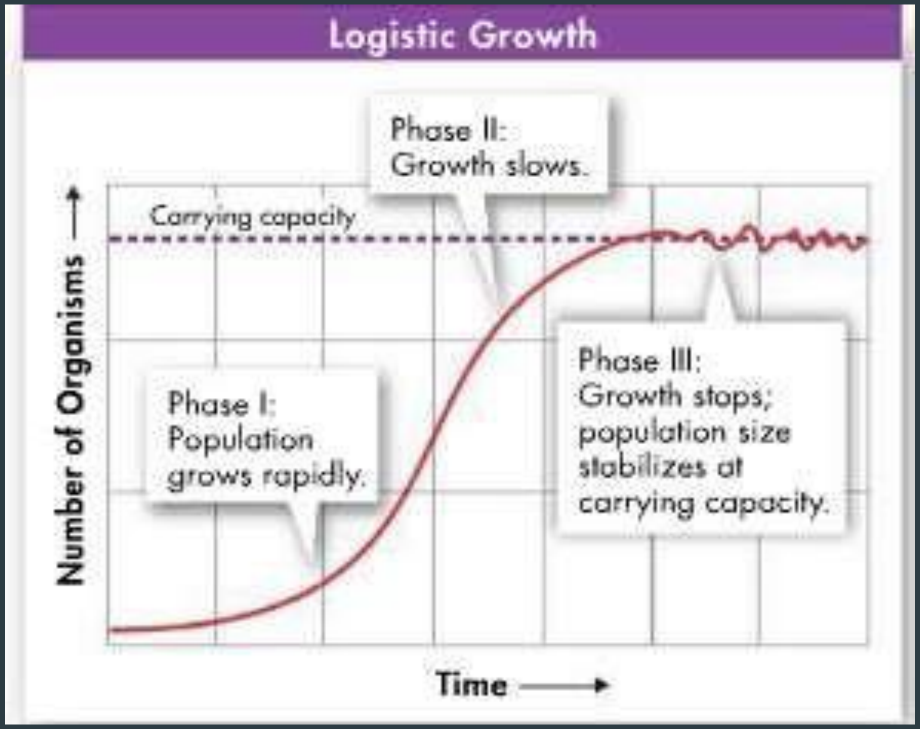


Exponential Growth Curve

Time	Number of Cells	
0 minutes	1	$= 2^0$
20	2	$= 2^1$
40	4	$= 2^2$
60	8	$= 2^3$
80	16	$= 2^4$
100	32	$= 2^5$
120 (= 2 hours)	64	$= 2^6$
3 hours	512	$= 2^9$
4 hours	4,096	$= 2^{12}$
8 hours	16,777,216	$= 2^{24}$
12 hours	68,719,476,736	$= 2^{36}$



Population Growth – Logistic Growth



- **Logistic Growth** – occurs when a populations growth slows, then stops, following a period of exponential growth
- Produces **"S" shaped curve**
- **Carrying Capacity**- the maximum number of organisms of one species that an environment can support

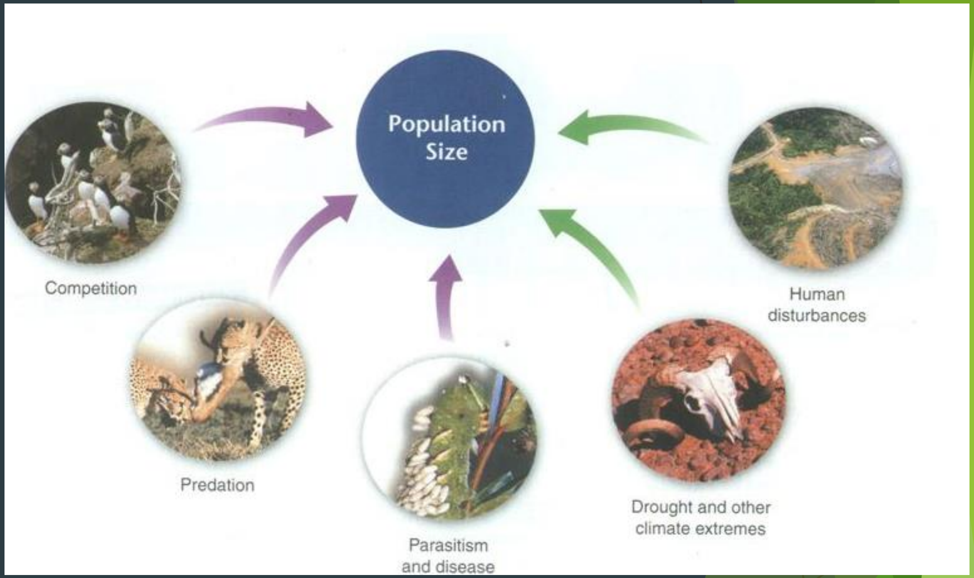
Limiting Factors of the Environment

- Population growth usually stops due to lack of resources
  - **Food**
  - **Water**
  - **Shelter**
  - **Space**

Environmental Limits to Population Growth

- **Limiting Factors**: biotic or abiotic factors that regulate size of a population

- Two types of limiting factors



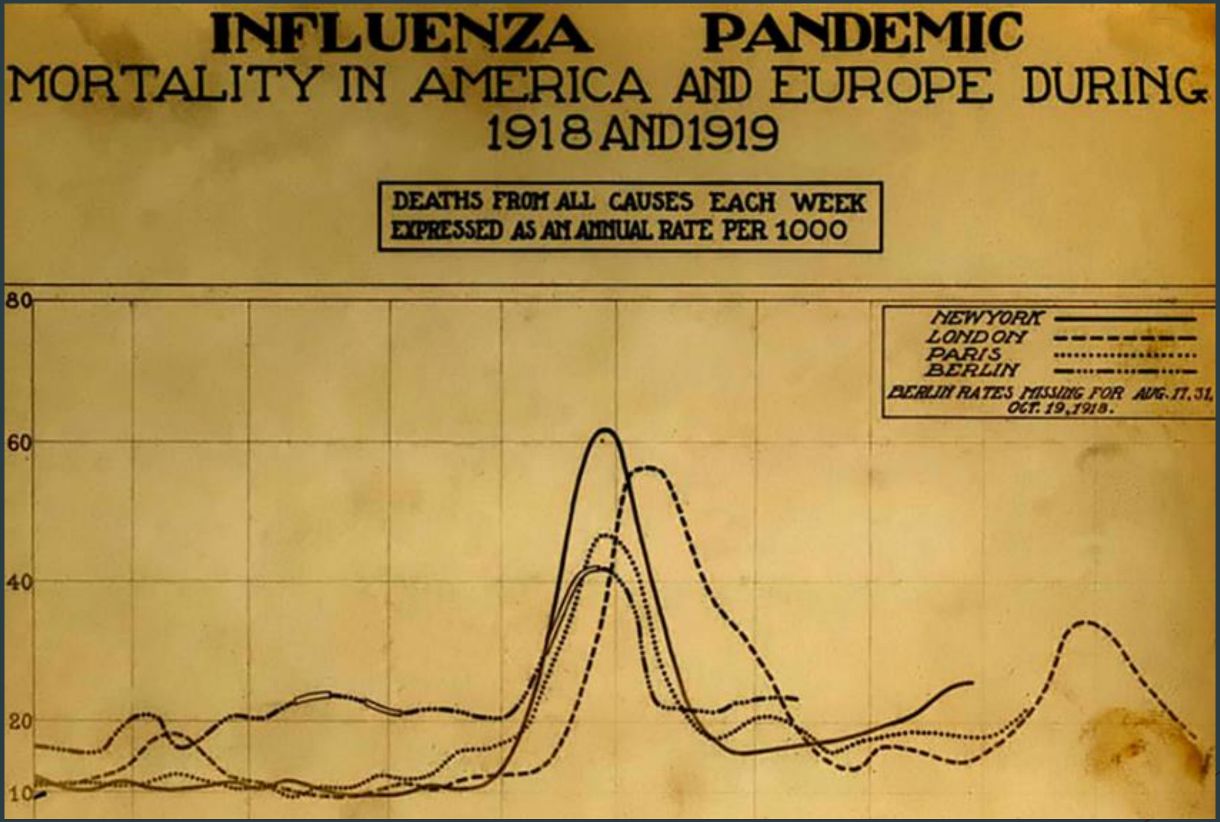
  - **Density dependent factors**
  - **Density independent factors**

Density Dependent Factors

- Increasing effect as population size increases
  1) **Disease and Parasitism**
  2) **Competition**
  3) **Predation**

- The more dense the population the faster disease can spread
  - Big problem in agricultural crops

Disease is a Density Dependant Factor

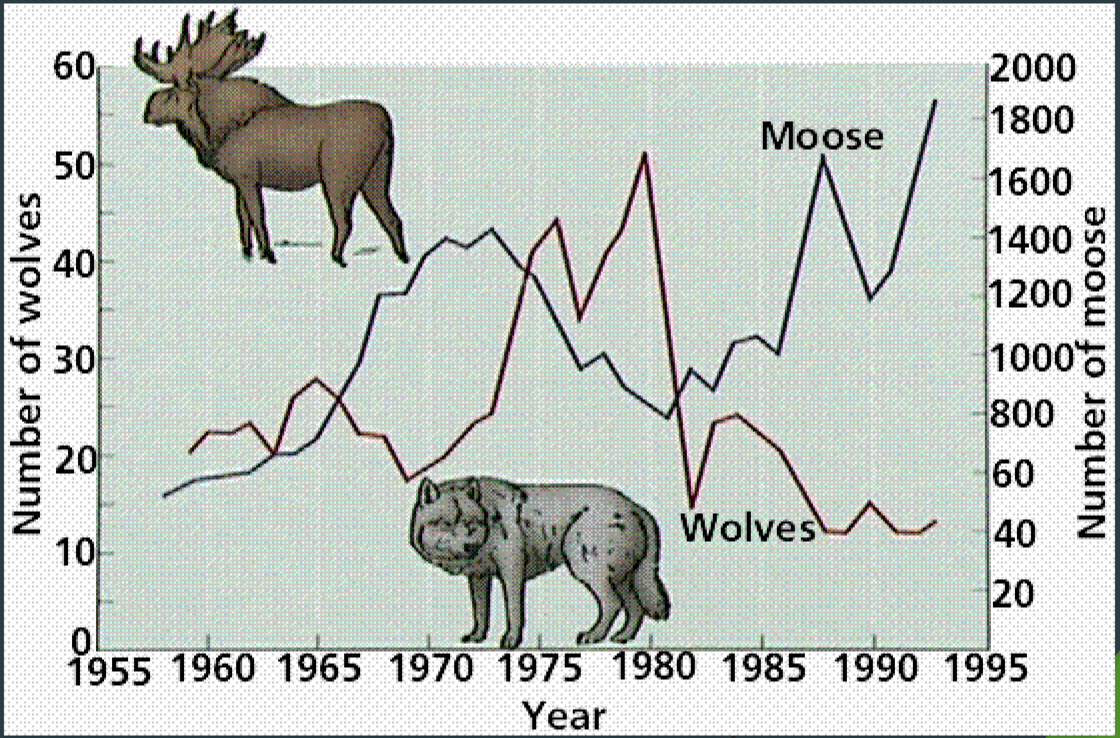


Remembering Okak: A Century Since Inuit Community Devastated By Deadly Flu (VOCM, Nov. 16, 2018)

Commemoration events are underway in Labrador to mark the 100th anniversary of a devastating event that changed the course of history for the Inuit of Labrador.
In October of 1918 the supply ship SS Harmony left St. John's for northern Labrador. What was not known at the time was that it was carrying a deadly virus that was making its way around the world.
The Spanish Flu spread quickly, killing entire families and leaving many children orphaned. Hardest hit was Okak where 204 of the community's 263 residents died.
Nunatsiavut President Johannes Lampe says while they remember that dark time in their history, they are also celebrating the resiliency of those who struggled to survive and the generations who followed.

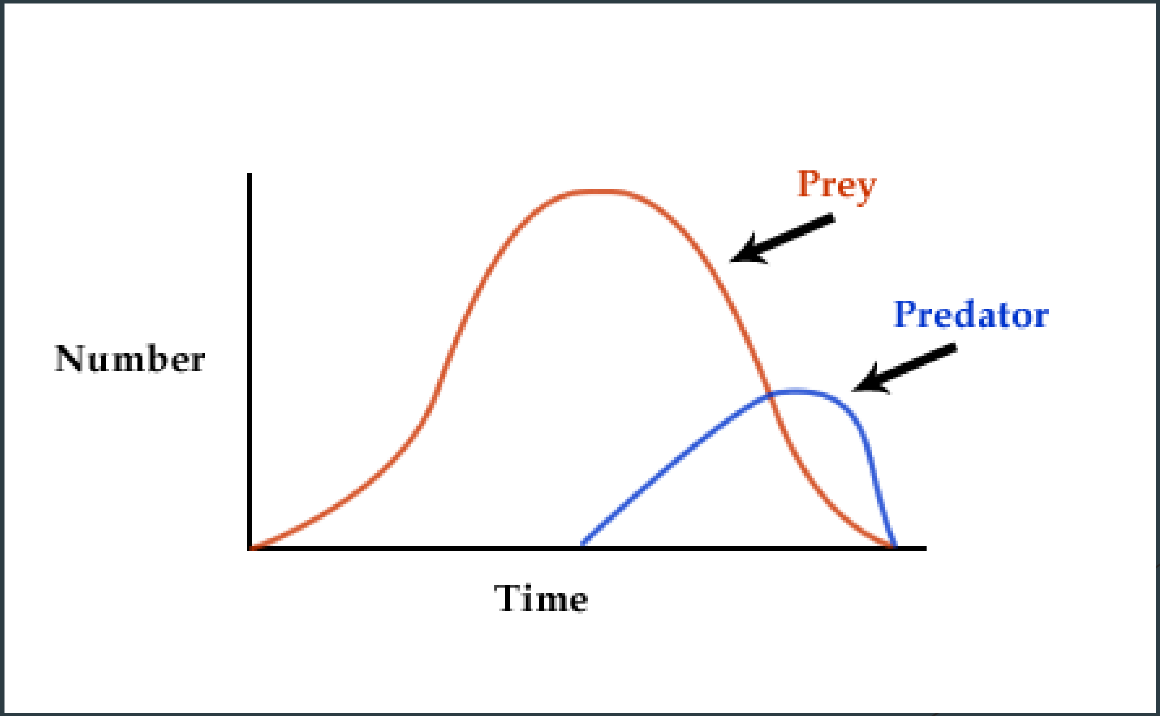
Predation as a Limit to Population Size

- **Predation** affects population size
- Predator prey relationships often show a **cycle** of population increases and decreases over time.



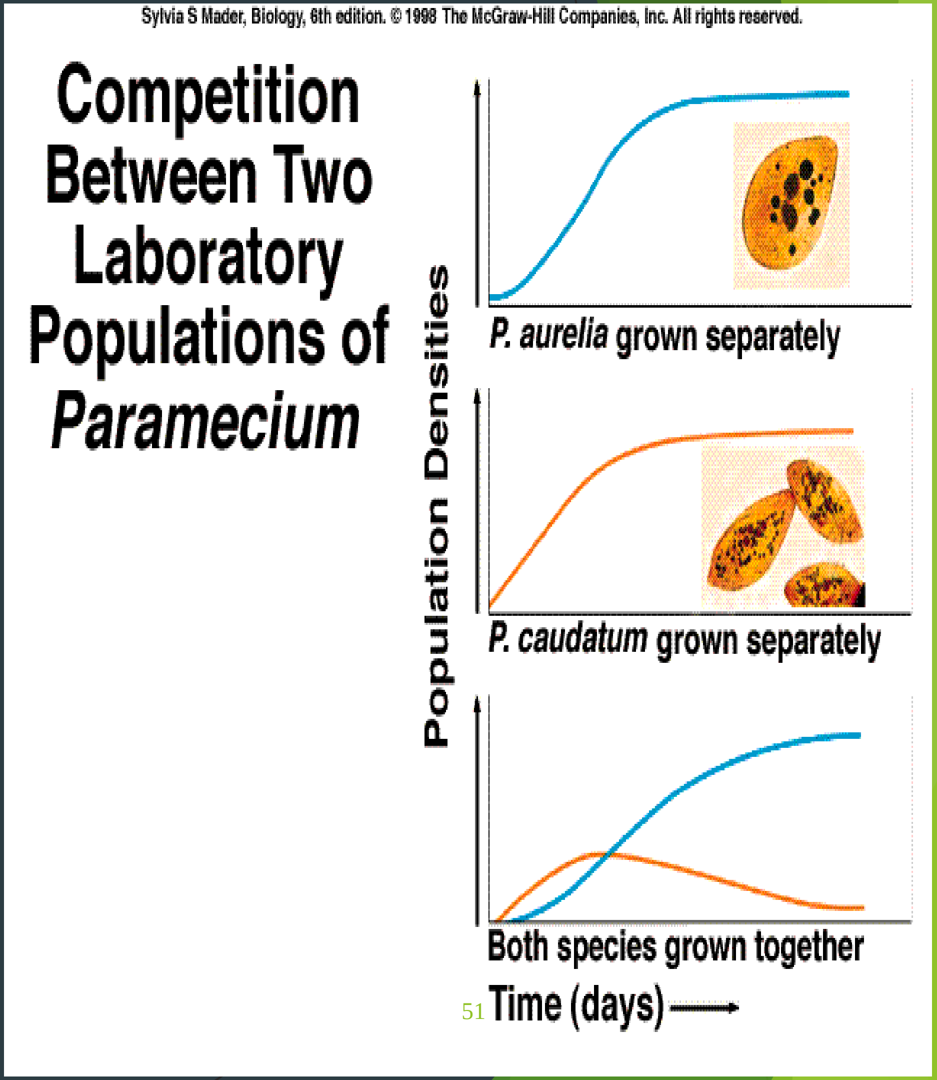
Predator Prey Relationships

- Important for **health** of natural population
- Usually young, old or injured are caught



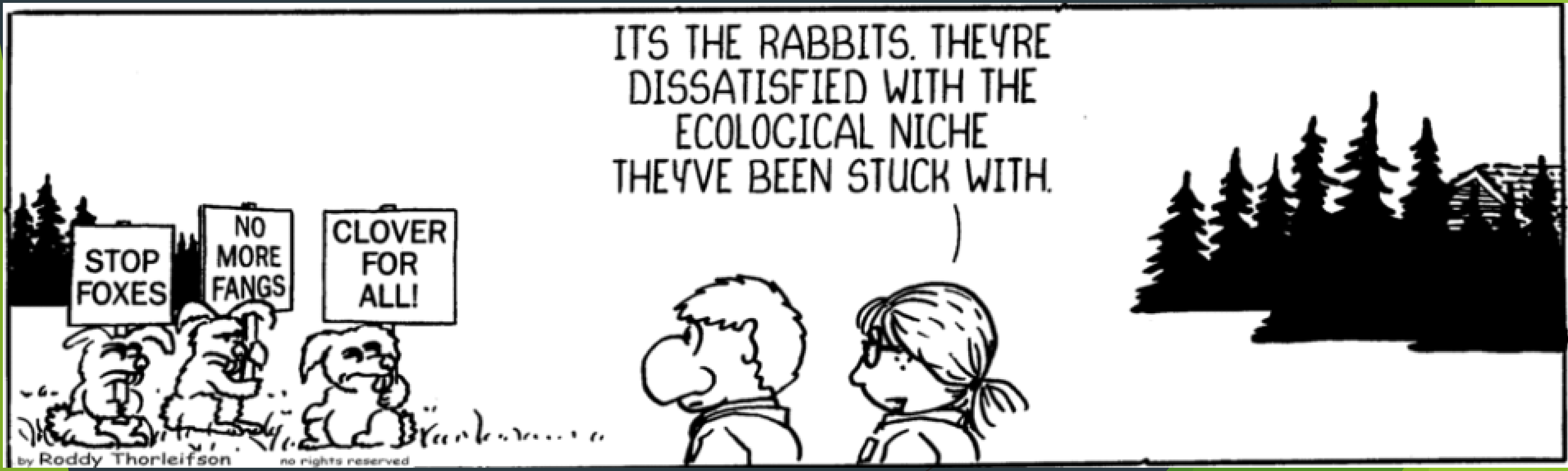
Effects of Competition on Population Size

- **Competition** for food, water, territory are density dependent factors
- Only the **best** suited to the environment survive



Niches and community interactions

- **Niche** – the range of physical and biological conditions in which a species lives and the way the species obtains what it needs to survive and reproduce.
- Sometimes said to be the combination of the organism's habitat and **"role"** in the ecosystem.

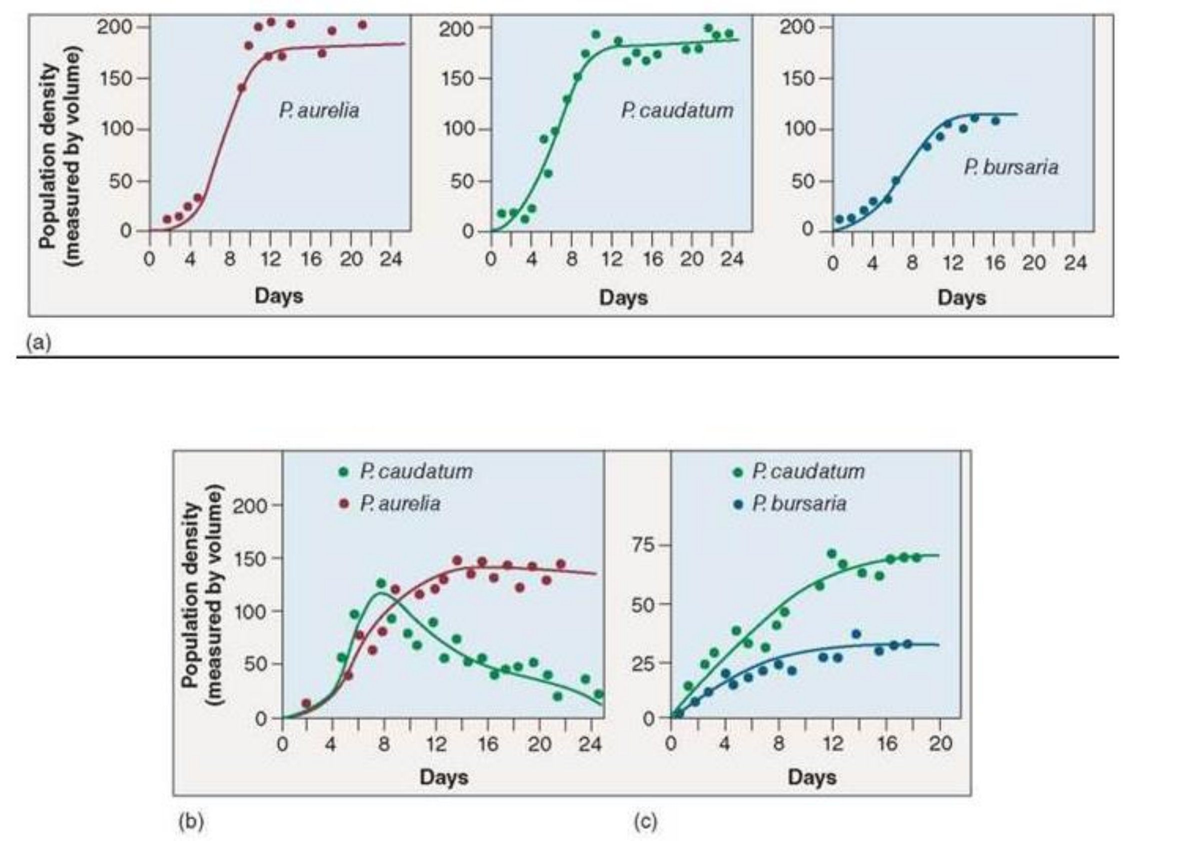


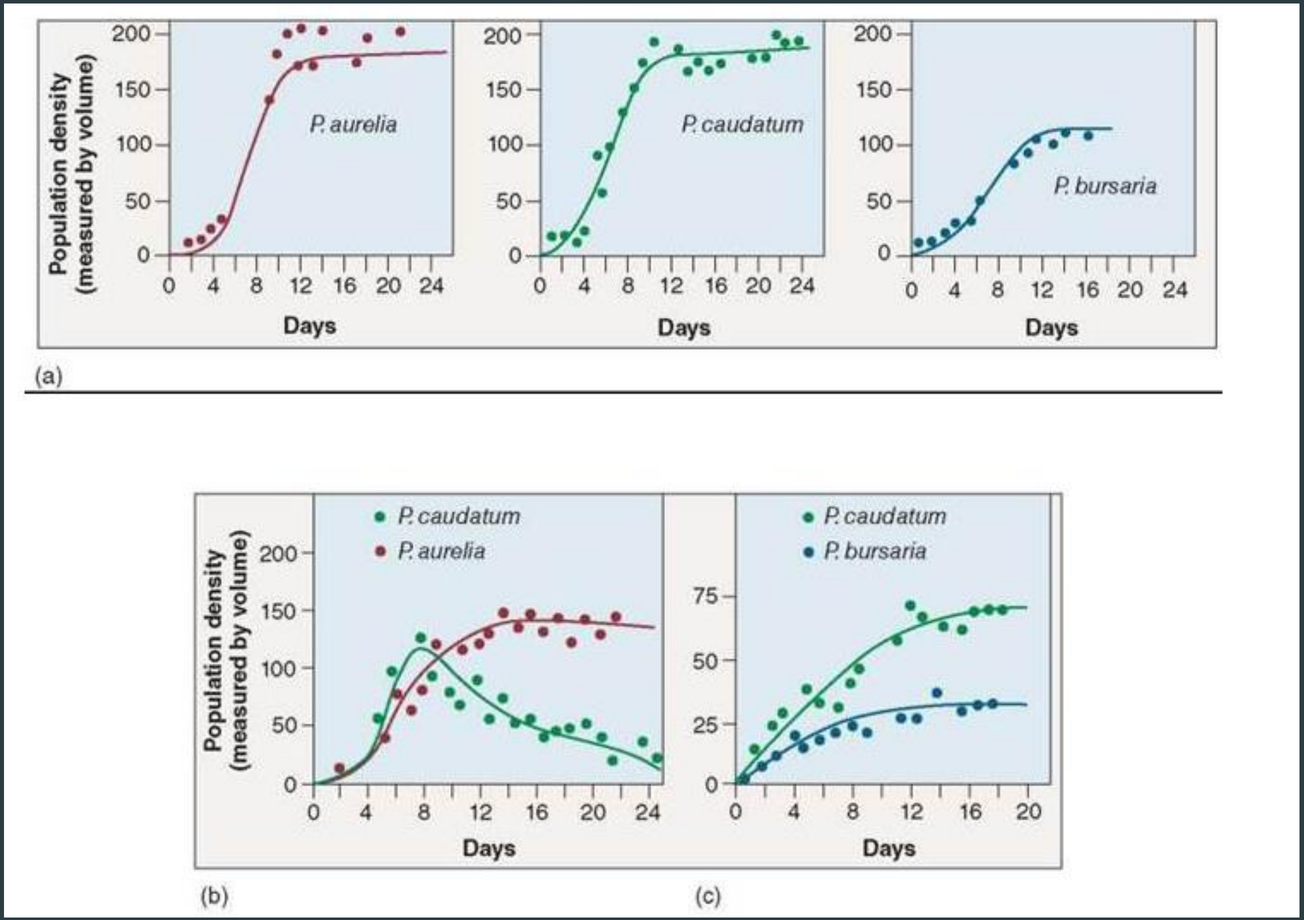
Competition

- **Competitive Exclusion Principle** - states that no two species can occupy the same **niche** in exactly the same **habitat** at exactly the same time.
- If two species attempt to, one will be better at competing for **limiting resources** and will eventually exclude the other species.

- Competitive Exclusion

Principle demonstrated by 3 different species of paramecium





Questions

1) Which bacteria occupy the same niche? How do you know? Which bacteria is the most successful competitor?
2) Which bacteria occupy different niche? How do you know?
3) What do you think would happen to the growth curves if P.bursaria and P. aurelia where grown together?

ANSWERS

- **Questions**

1) Which bacteria occupy the same niche? How do you know? Which bacteria is the most successful competitor?

P. aurelia and P. caudatum occupy the same niche. When they are grown together in the same environmental conditions, both of their population growths are affected because of competition for resources. P. Aurelia is the most successful competitor.

2) Which bacteria occupy different niche? How do you know?

P. caudatum and P. bursaria occupy the different niche. When they are grown together in the same environmental conditions, both of their population growths are unaffected meaning that they are not competing for resources.

ANSWERS

- **Questions**

for resources.

3) What do you think would happen to the growth curves if P.bursaria and P. aurelia where grown together?

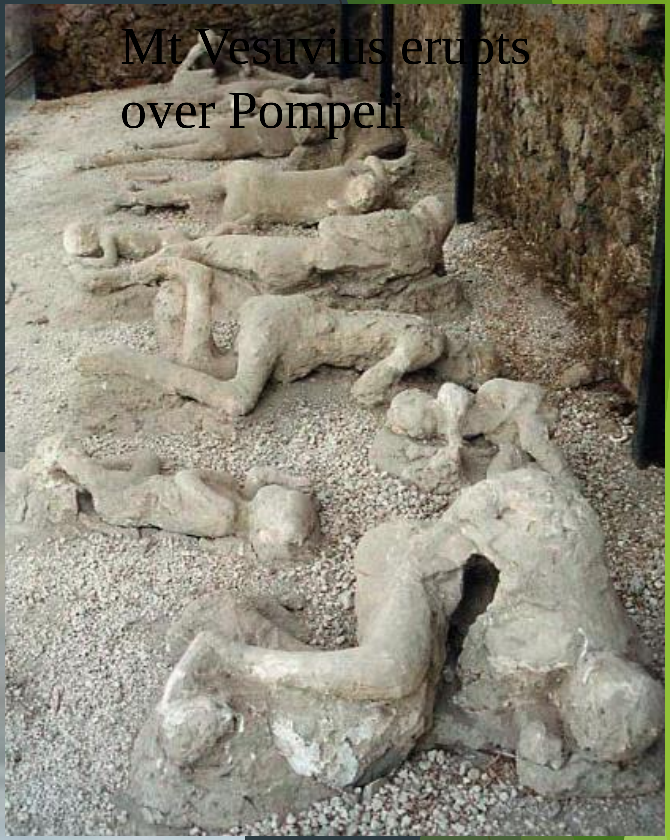
P. bursaria and P. aureilia occupy the different niche. When they are grown together in the same environmental conditions, both of their population growths wold be unaffected since they are not competing for resources.

Density Independent Factors

- Affect all populations regardless of their **density.**
- Most are **abiotic** factors

- Some abiotic factors that could effect the size of a population may be:
  - **Climate/Temperature Change (drought)**
  - **Habitat destruction (floods, storms, earthquakes)**
  - **Pollution/Pesticides**


Nuclear Accident at Chernobyl


Mt Vesuvius erupts
over Pompeii


Meteor hits Yucatan
Peninsula

- Complete Lab Activity 7-2 D

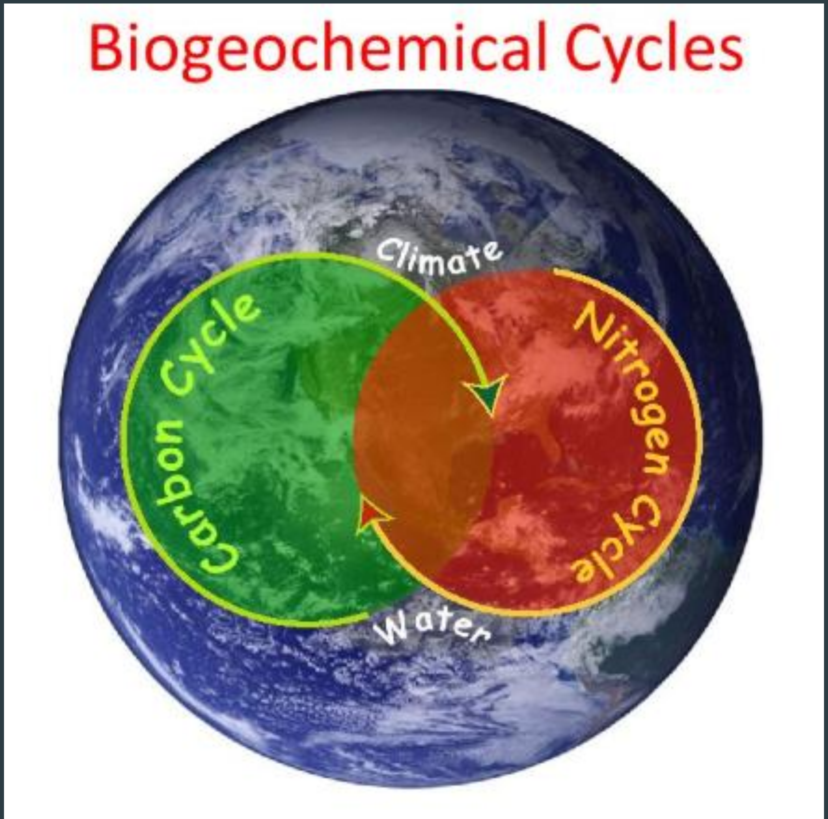
- Complete Activity 7-2 A
- Graphing Population Change

Section Review (p. 303)

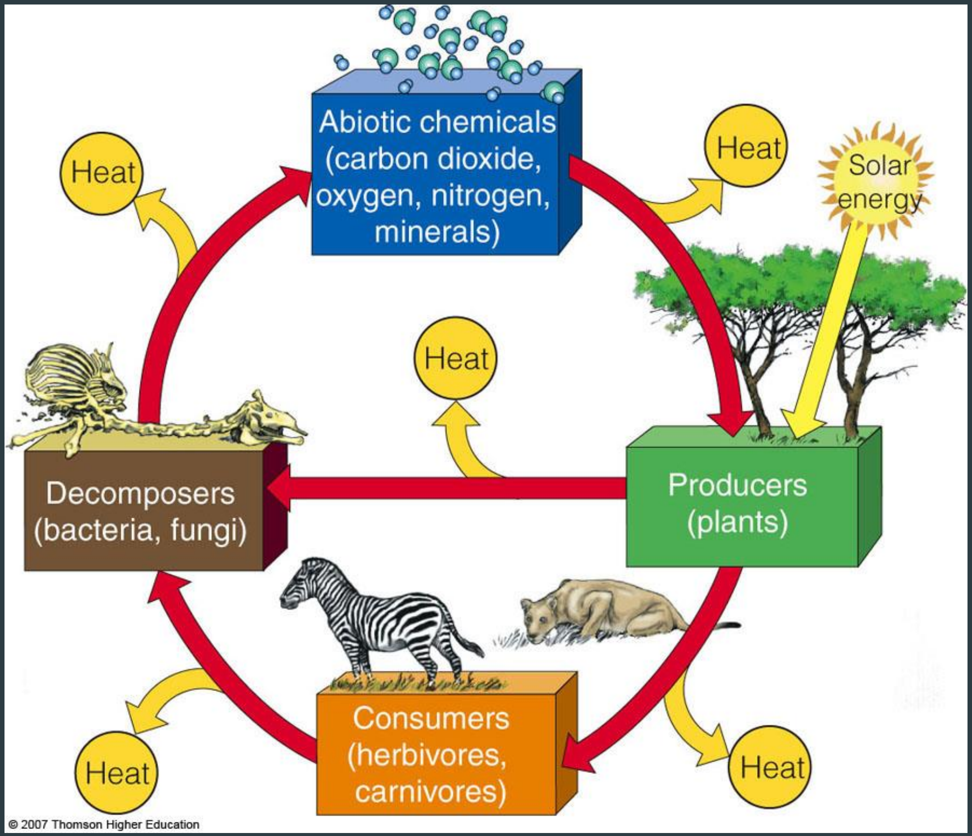
Students should answer the following questions to supplement information learned in class

- Checking Concepts: Q 1, 2, 3, 5, 6, 7, 10, 11
- Understanding Key Ideas: 13, 14, 15

7.3 – Cycles and Sustainability

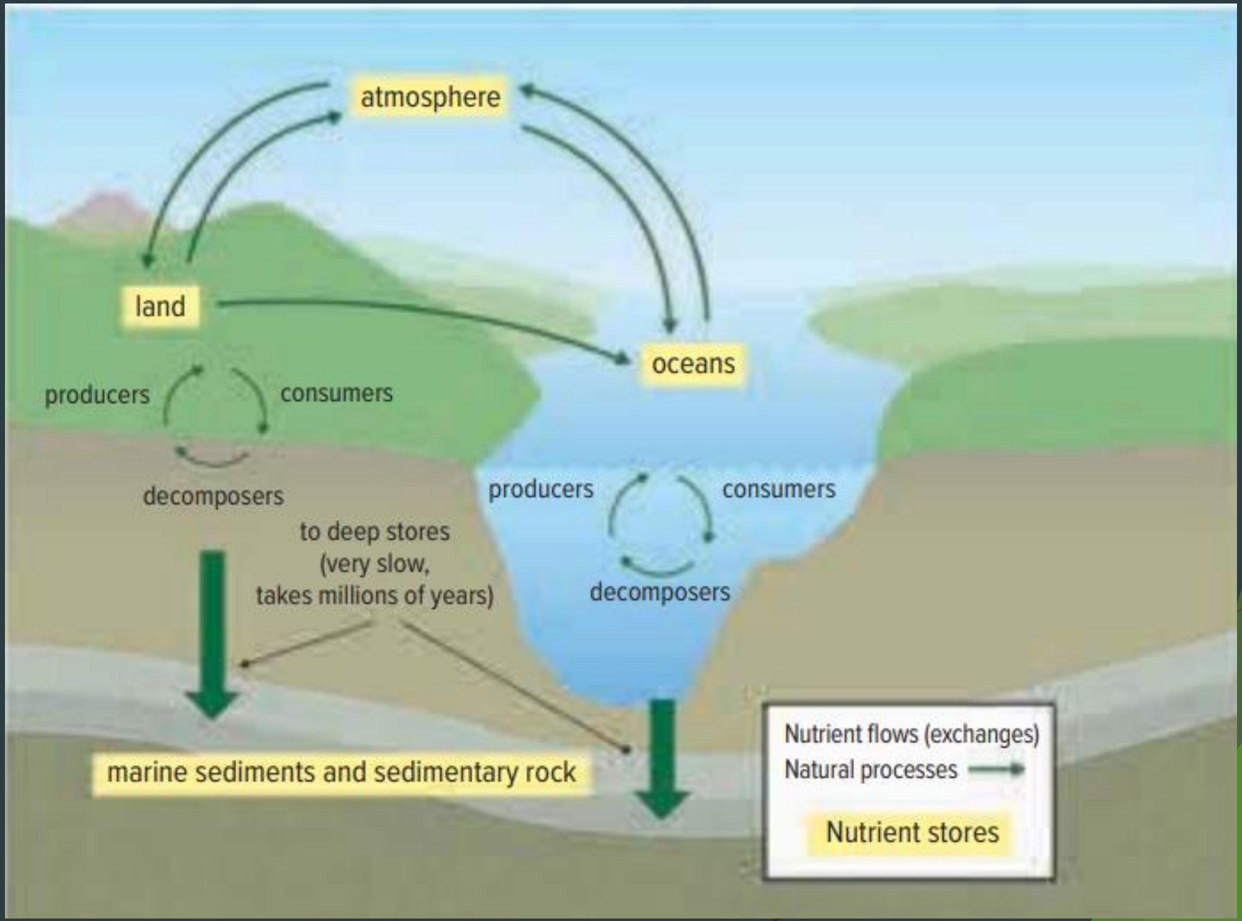


Two Secrets of Survival: Energy Flow and Matter Recycle



- An ecosystem survives by a combination of **energy flow** and **matter** recycling.

- **Nutrients** are chemicals that living things need to carry out all their life processes.
- Nutrients move through the ecosystem by **nutrient cycles** (biogeochemical cycles)



- Nutrients are accumulated for short or long periods of time in the **atmosphere**, **oceans**, and **land masses**.

- These accumulations are called **stores**.

- Stores can be moved by:
  - Biotic processes such as

    decomposition

  - Abiotic processes such as

    river run-off

Nutrient Cycles in Ecosystems

Human activities can upset the natural balance of nutrient cycles.

The following activities can **increase** the levels of nutrients faster than the stores can absorb them:

- **land clearing**
- **agriculture**
- **urban expansion**
- **mining**
- **industry**
- **motorized transportation**

Excess nutrients in the biosphere can have **unexpected** and **significant** consequences.

- Complete Activity 7-3A

The Carbon Cycle

The **Carbon** cycle - involves a series of processes by which carbon compounds are interconverted in the environment, chiefly involving the incorporation of **carbon dioxide** into living tissue by **photosynthesis** and its return to the atmosphere through **respiration**, the **decomposition** of dead organisms, and the burning of **fossil fuels**.

1. **Reservoir** – atmosphere (as CO_2), fossil fuels (oil, coal), durable organic materials (for example: cellulose in trees), and limestone and sea shells as $CaCO_3$.
2. **Assimilation** – plants use CO_2 in photosynthesis; animals consume plants.
3. **Release** – plants and animals release CO_2 through respiration and decomposition; CO_2 is released when wood and fossil fuels are burned.

Carbon Cycle

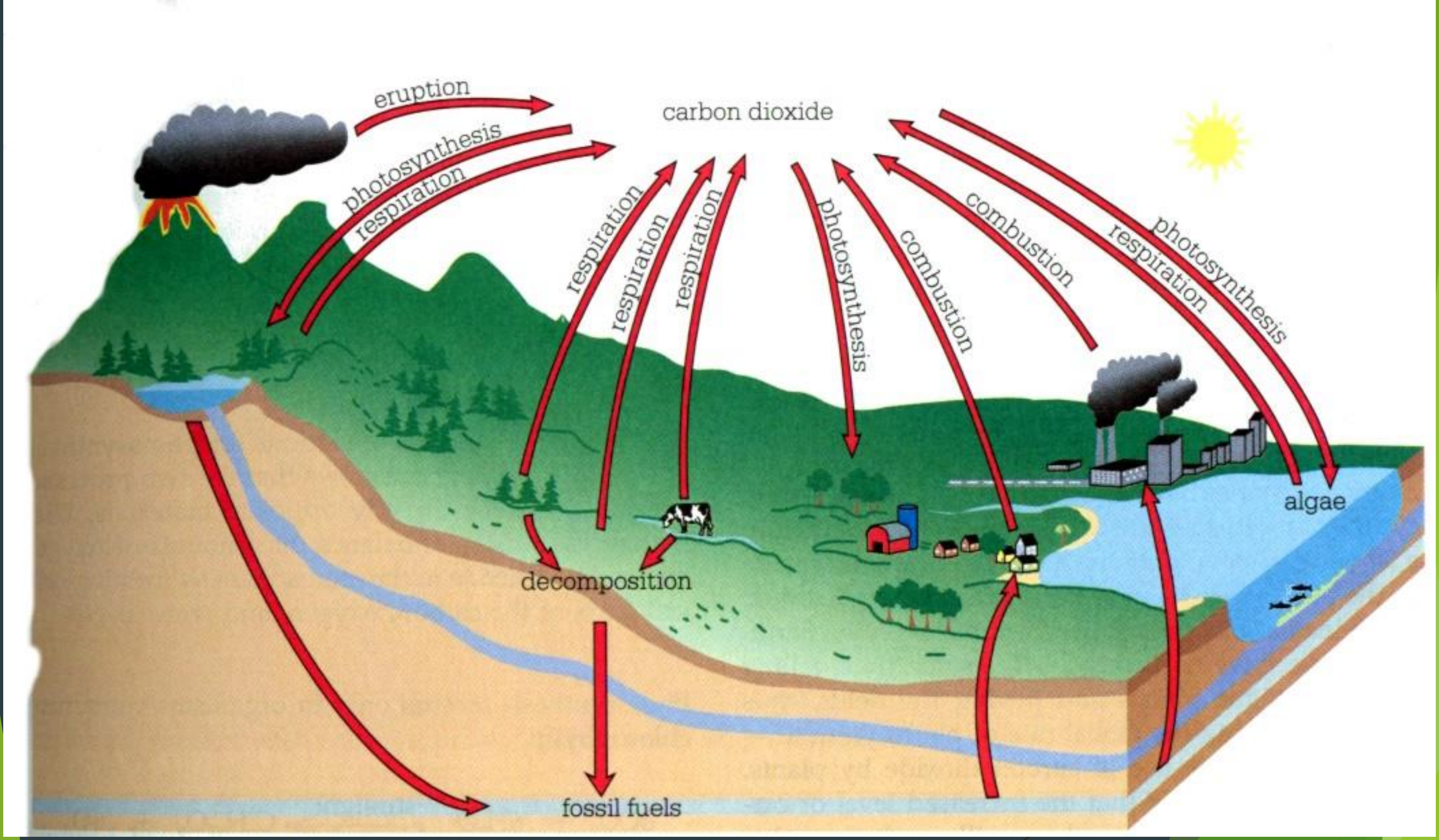
- Carbon (C) enters the biosphere during **photosynthesis**:

$$6H_2O_{(l)} + 6CO_{2(g)} \xrightarrow{light} C_6H_{12}O_{6(s)} + 6O_{2(g)}$$

- Carbon is returned to the atmosphere during **cellular respiration**:

$$6O_{2(g)} + C_6H_{12}O_{6(s)} \rightarrow 6H_2O_{(l)} + 6CO_{2(g)}$$

The Carbon Cycle



Carbon Cycle…

Processes that Remove Carbon from Atmosphere	*Processes that Send Carbon to the Atmosphere*
A. Photosynthesis B. Diffusion of CO_2 into water supplies, such as oceans and lakes	A. Fossil Fuel Combustion B. Respiration C. Decomposition D. Geological Activity (volcanoes)
$6H_2O_{(l)} + 6CO_{2(g)} \xrightarrow{light} C_6H_{12}O_{6(s)} + 6O_{2(g)}$	$6O_{2(g)} + C_6H_{12}O_{6(s)} \rightarrow 6H_2O_{(l)} + 6CO_{2(g)}$

Effects of Human Activities on Carbon Cycle

- Since the industrial revolution, humans have releasing huge amounts of carbon into the atmosphere, which may have far-reaching impacts on climate and ecosystems.
- We alter the carbon cycle by adding excess CO_2 to the atmosphere through:
  1) Burning fossil fuels.
  2) Clearing vegetation faster than it is replaced, thus less CO_2 can be removed by photosynthesis
  3) Mining activities disrupt carbon stores in the sediments

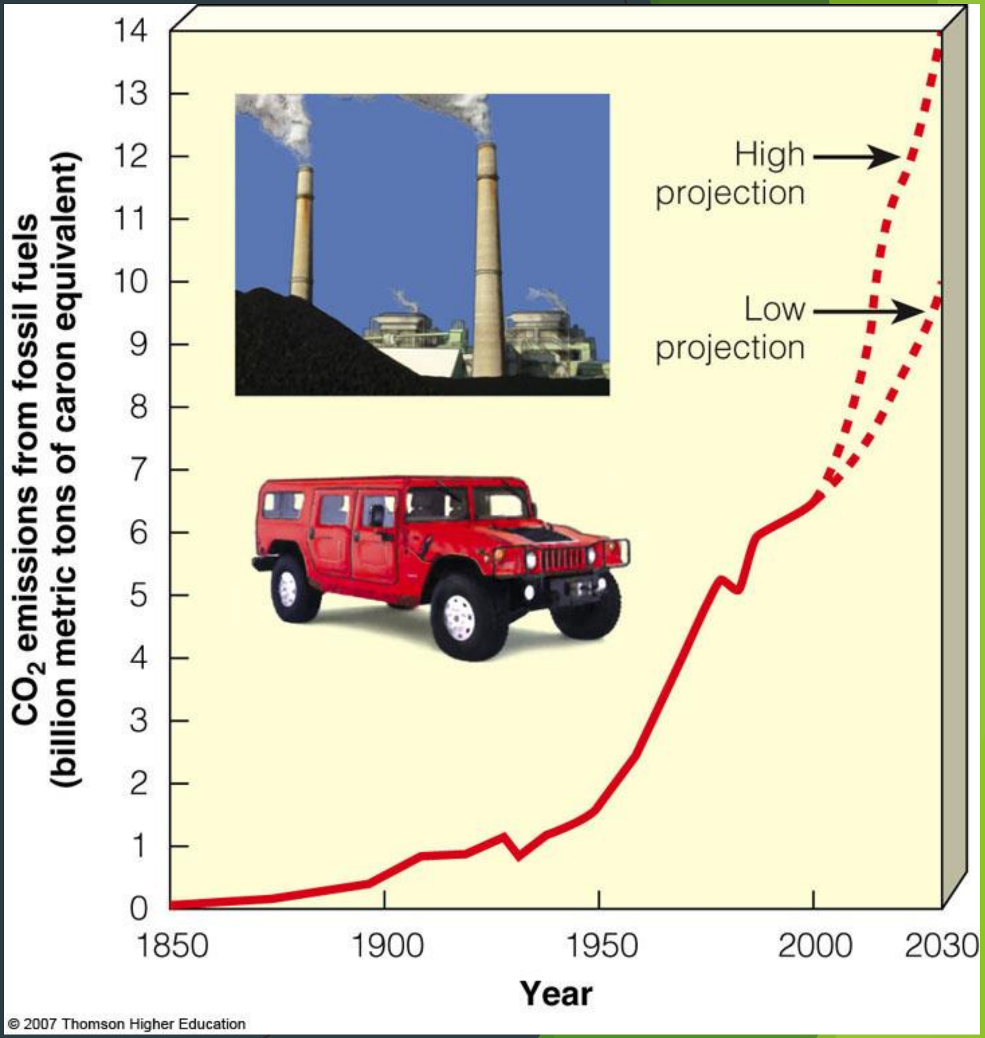


Figure 3-28

The Human Impact on the Carbon Cycle

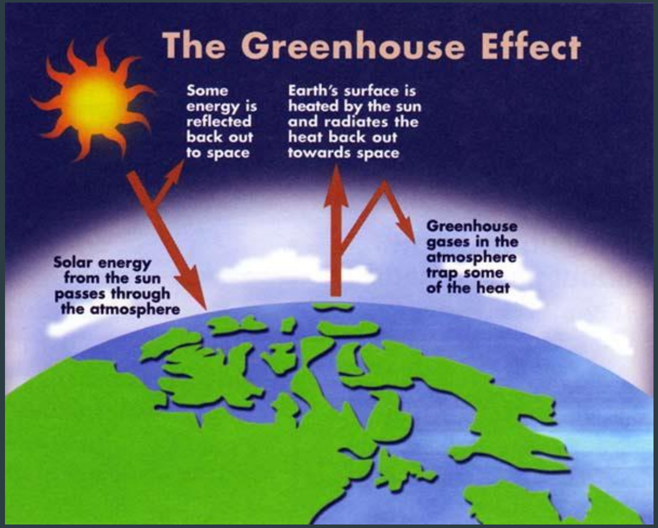
- How are humans impacting the carbon Cycle?

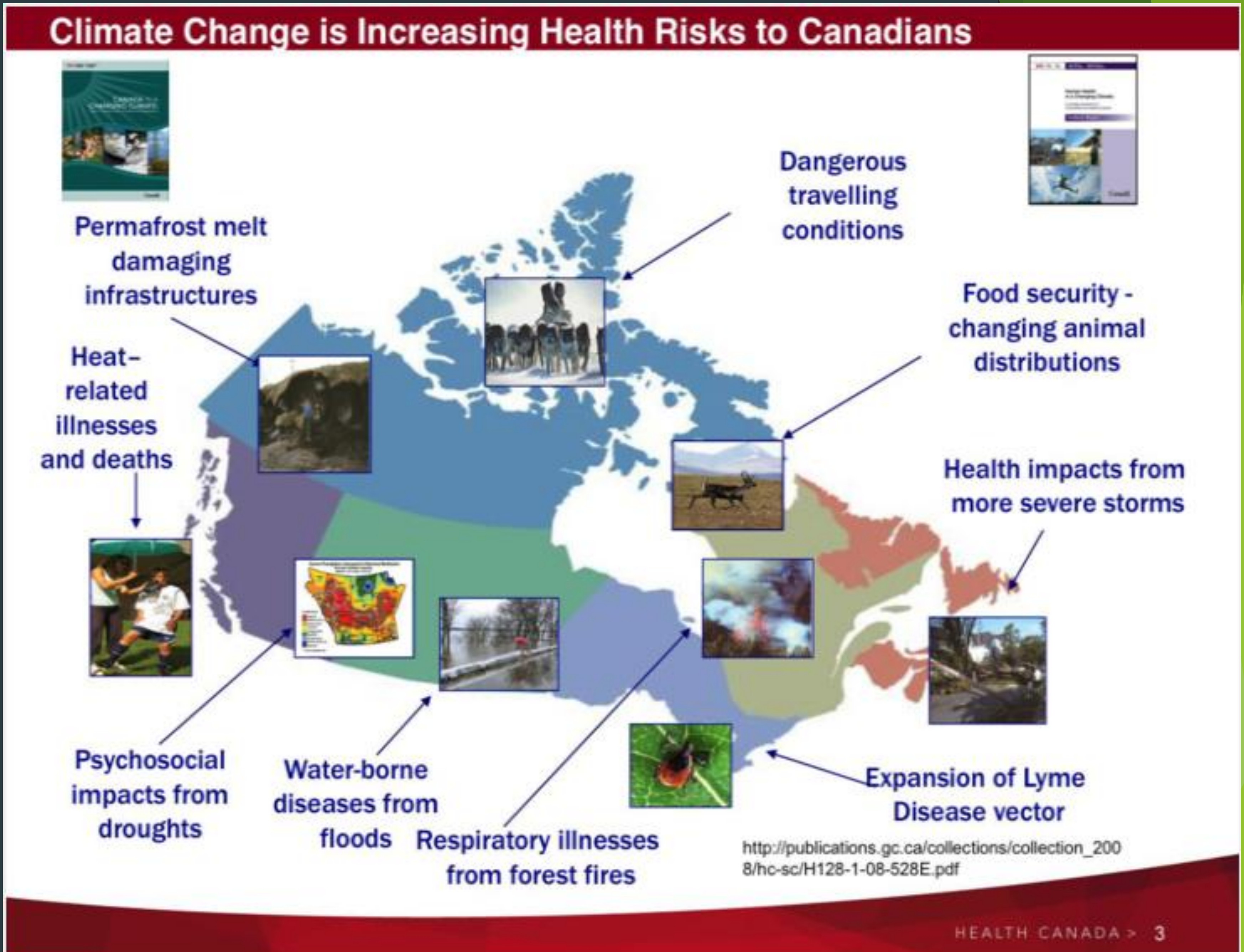
Combustion and Global Warming

- Humans are burning more and more **fossil fuels** which is leading to more CO_2 in the atmosphere. This leads to a phenomenon known as the "**Greenhouse Effect**".
- The greenhouse effect leads to "**Global Warming**" (effects were discussed in Unit 2).

The Greenhouse Effect

- The main concern about increasing carbon dioxide levels comes from the fact that carbon dioxide is a **greenhouse gas**. It traps **infrared radiation** from the Earth's surface which would otherwise escape into space, effectively insulating the planet and increasing its **temperature**.




Climate Change is Increasing Health Risks to Canadians
Permafrost melt damaging infrastructures
Dangerous travelling conditions
Food security - changing animal distributions
Heat-related illnesses and deaths
Health impacts from more severe storms
Psychosocial impacts from droughts
Water-borne diseases from floods
Respiratory illnesses from forest fires
Expansion of Lyme Disease vector
http://publications.gc.ca/collections/collection_2008/hc-sc/H128-1-08-528E.pdf
HEALTH CANADA > 3

The Nitrogen Cycle

- The **nitrogen cycle** is the biogeochemical **cycle** by which **nitrogen** is converted into multiple chemical forms as it circulates among **atmosphere**, **land**, and **marine ecosystems**. The conversion of **nitrogen** can be carried out through both **biotic** and **abiotic** processes.
- Provides **Nitrates (NO_3^-)** that are important for the creation of ***Proteins*** and ***DNA*** .
- Occurs in Three Stages:
  - 1. **Nitrogen Fixation**
  - 2. **Nitrification**
  - 3. **Denitrification**

1. Nitrogen Fixation

- The conversion of Atmospheric Nitrogen, **$\underline{N_2}$** into Ammonia, **$\underline{NH_3}$**.

$$N_2 \quad \rightarrow \quad NH_3$$

- Occurs in two ways.
  - 1. *Lightning*
  - 2. Nitrogen Fixing Bacteria in root nodules (lumps) of some plants.

2. Nitrification

- The conversion of Ammonia, NH_3 into **Nitrates**, NO_3^-.

$$NH_3 \rightarrow NO_3^-$$

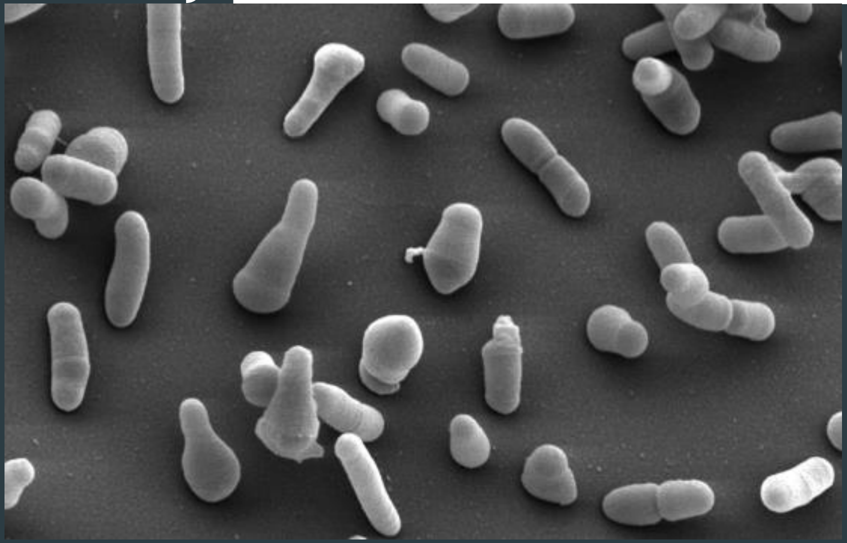
- Done by **Nitrifying bacteria**.
- Plants can absorb and **assimilate** nitrates, NO_3^-, by turning them into **proteins** and **DNA** which is then ingested by **consumers**

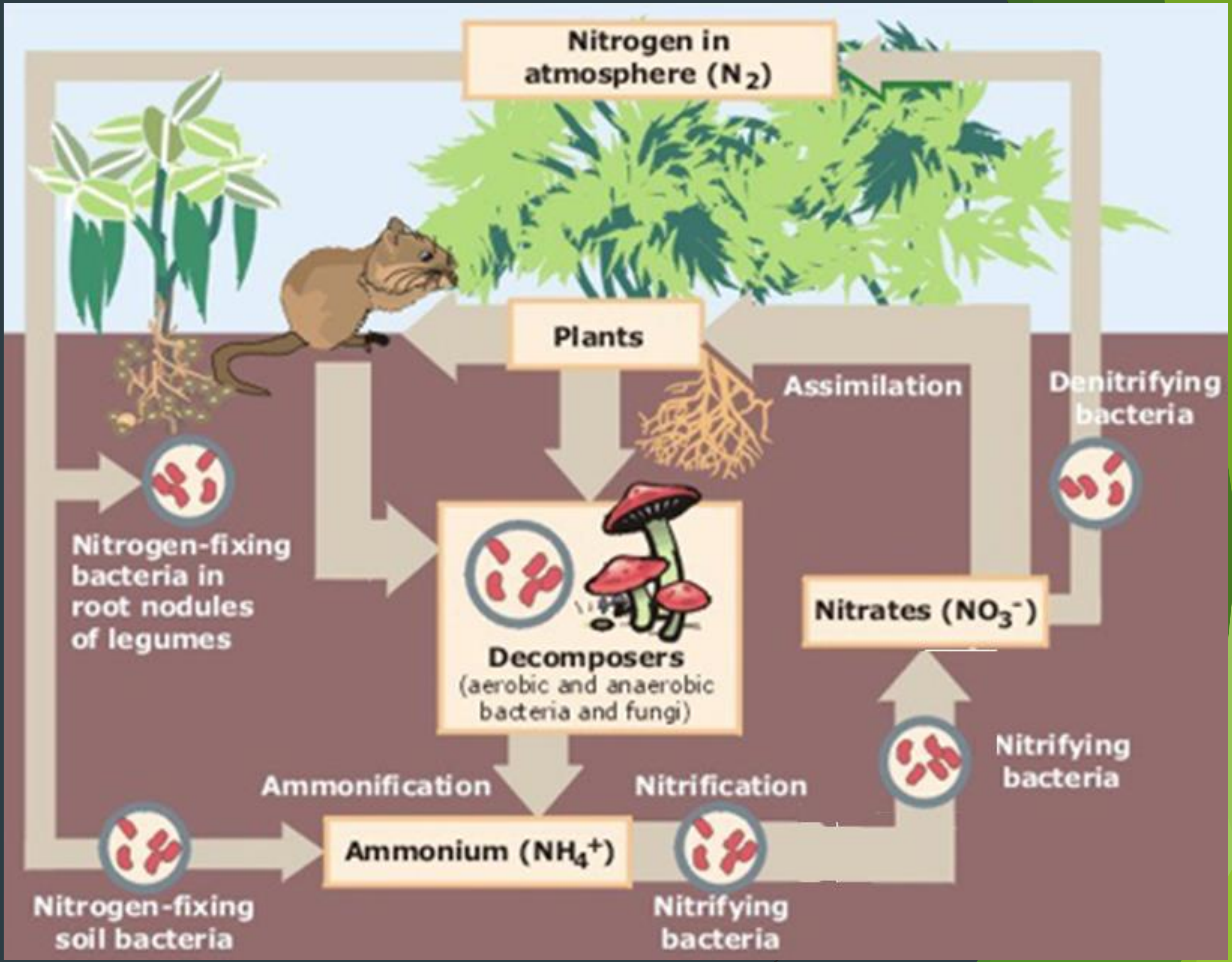
3. Denitrification

- Excess Nitrates, NO_3^- in the soil is converted into Atmospheric Nitrogen, N_2.

$$NO_3^- \rightarrow N_2$$

- Done by **Denitrifying Bacteria**.

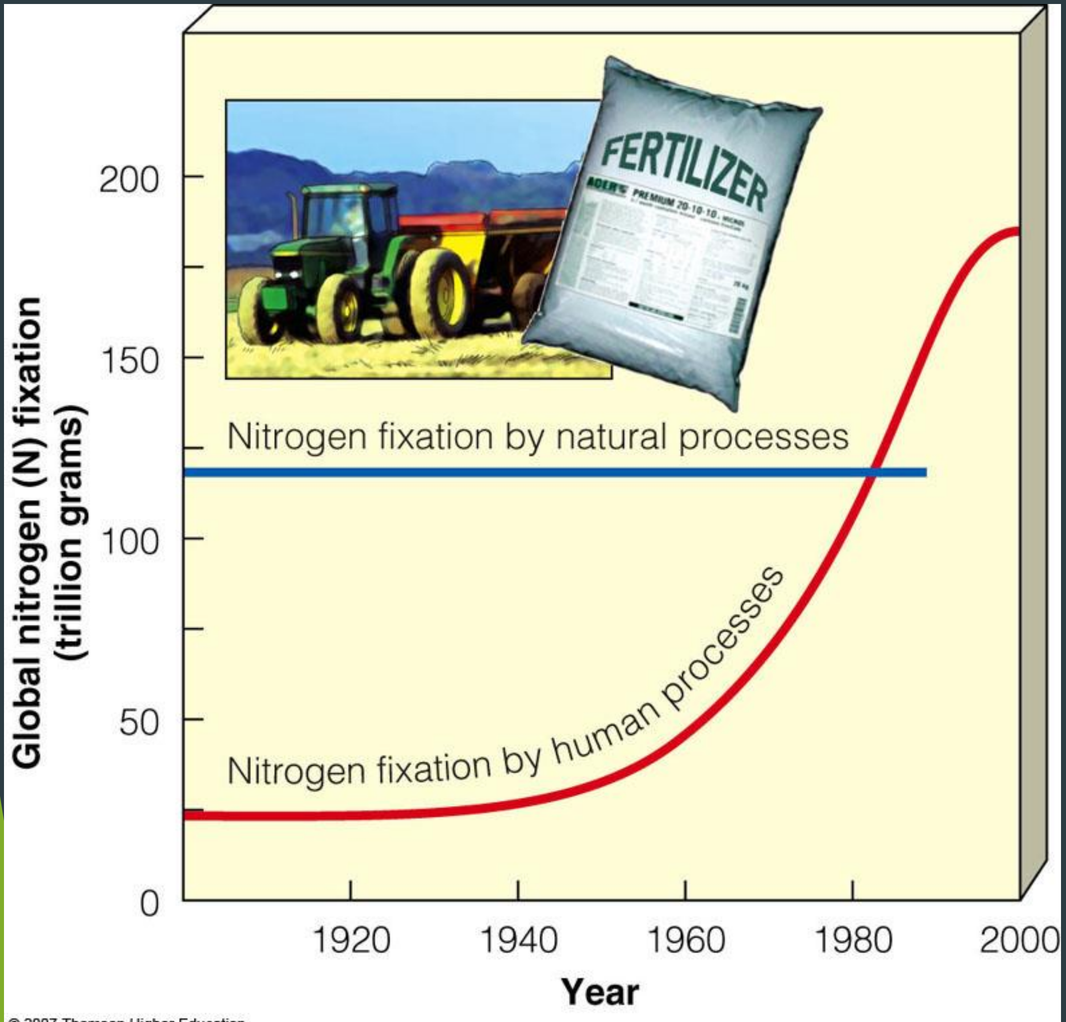



Nitrogen in atmosphere (N_2)
Plants
Assimilation
Denitrifying bacteria
Nitrogen-fixing bacteria in root nodules of legumes
Decomposers (aerobic and anaerobic bacteria and fungi)
Nitrates (NO_3^-)
Nitrifying bacteria
Ammonification
Nitrification
Ammonium (NH_4^+)
Nitrogen-fixing soil bacteria
Nitrifying bacteria

Nitrogen Cycle

- Nitrogen cycle video
- CurioCity Nitrogen Cycle Lesson

Effects of Human Activities on the Nitrogen Cycle



- Human activities such as production of **fertilizers** now fix more nitrogen than all natural sources combined.
- The burning of **fossil fuels** also releases **nitrogen oxides** which also affect the N cycle

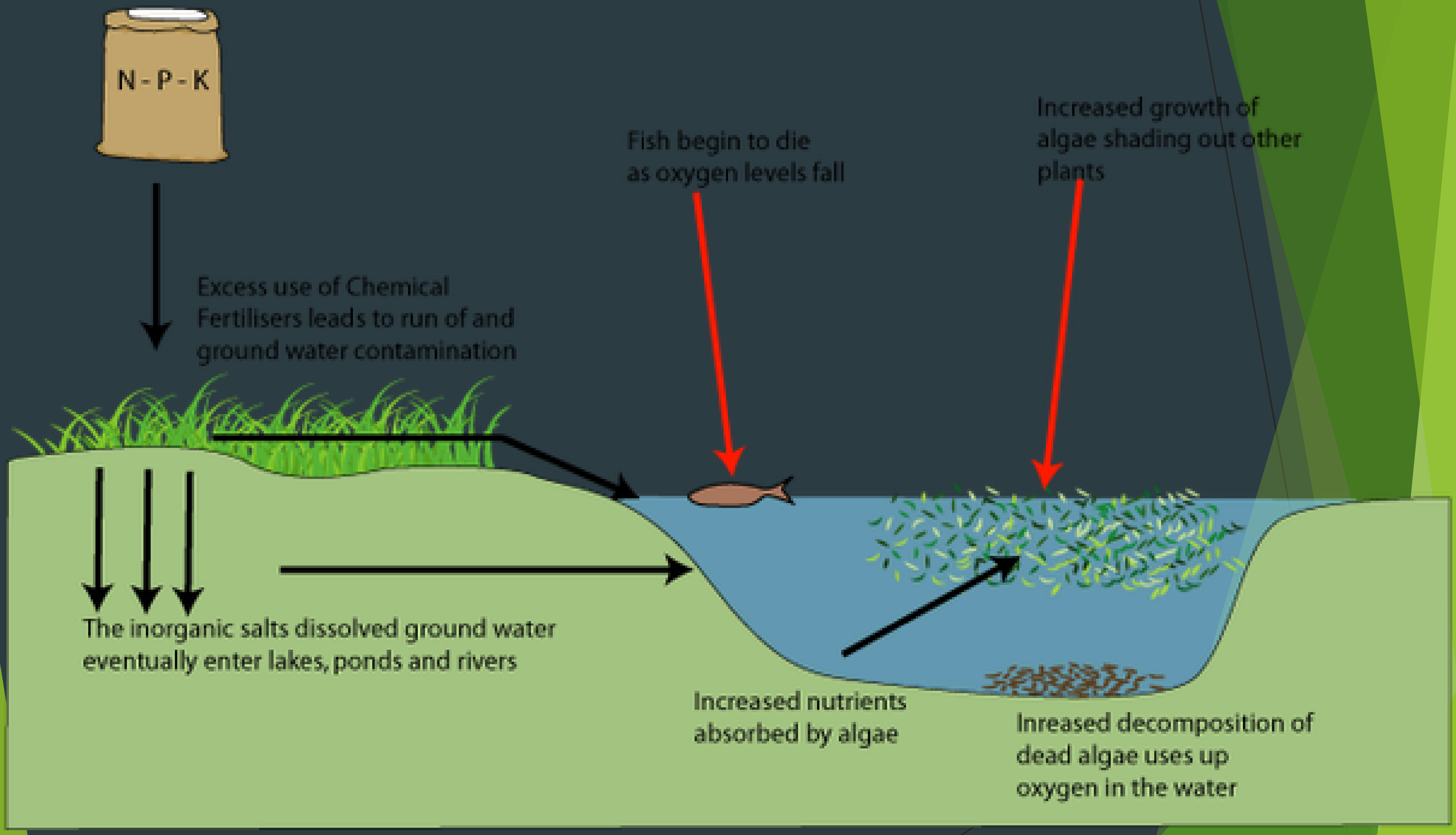
Figure 3-30

Eutrophication - Human activities effects on the Nitrogen cycle…

- Agricultural practices often use large amounts of nitrogen-containing **fertilizers** that fix atmospheric nitrogen into **NO_3^-** that crops can use.
  - excess nitrogen ***leaches*** into waterways, promoting huge growth in aquatic algae (algal blooms) = ***eutrophication***
  - ***algal blooms*** deprive other aquatic plants of sunlight & **O_2**
  - **O_2** is also used up in the **decomposition** of dead algae
  - aquatic animals such as **fish**, **die** due to lack of **oxygen**

Algal Bloom

Eutrophication



Eutrophication

- Eutrophication Video

Match each term on the left with the correct definition on the right.

Nitrogen fixation	The process of making nitrates
Denitrification	Provide nitrogen for the host plant and in return obtain sugars
Nitrifying bacteria	Certain bacteria that convert nitrate back into nitrogen gas
Nitrate	NO_2^-
Nitrogen uptake	Nitrogen gas is converted into nitrate using electrical energy from lightning.
Nitrification	The process where nitrates are converted into nitrogen gas
Ammonium	N_2
Denitrifying bacteria	The process where nitrates enter plant roots
Nitrite	NH_4^+
Nitrogen-fixing bacteria	Certain bacteria that convert ammonium into nitrite or nitrite into nitrate
Nitrogen	NO_3^-

Match each term on the left with the correct definition on the right.

Nitrogen fixation	The process of making nitrates
Denitrification	Provide nitrogen for the host plant and in return obtain sugars
Nitrifying bacteria	Certain bacteria that convert nitrate back into nitrogen gas
Nitrate	NO_2^-
Nitrogen uptake	Nitrogen gas is converted into nitrate using electrical energy from lightning.
Nitrification	The process where nitrates are converted into nitrogen gas
Ammonium	N_2
Denitrifying bacteria	The process where nitrates enter plant roots
Nitrite	NH_4^+
Nitrogen-fixing bacteria	Certain bacteria that convert ammonium into nitrite or nitrite into nitrate
Nitrogen	NO_3^-

Section Review (p. 315)

Students should answer the following questions to supplement information learned in class

- Checking Concepts: Q 1, 2, 3, 4, 5, 6, 7, 8
- Understanding Key Ideas: 10,11,13, 14, 15

Changing Soil Composition and Fertility, and the effect on the Ecosystem

- **Soil** is a vital resource. Soil helps sustain life on Earth—including your life. Soil supports the **growth of plants**, which in turn **supply food** for animals.
- Changes to soil **composition** and **fertility** can have drastic effects on an ecosystem
- Soils are composed of **minerals** (sand, silt, clay) and **organic matter**.
- Soil fertility is based on the **nutrients** (organic matter) present.

How can soil composition and fertility be altered?

Soils can be altered in many ways that can affect the ecosystem

- Adding **manure** or **compost** adds **nutrients** (think of the N cycle)
- Adding **silt**, **clay** or **peat** affects soils ability to **drain**
- **Irrigating**, **mulching**, aerating or tilling increases **moisture** & **dissolved** nutrients
- **Fertilizers** add nutrients
- Adding substances (lime) alters the **pH**

Human Activity and Impact on Soil

- The way people use land can affect the levels of **nutrients** and **pollution** in soil.
- Any activity that exposes soil to **wind** and **rain** can lead to **soil loss**.
- **Farming**, **construction** and development, and **mining** are among the main activities that impact soil resources.

Human Activities that lead to issues with Soil Sustainability

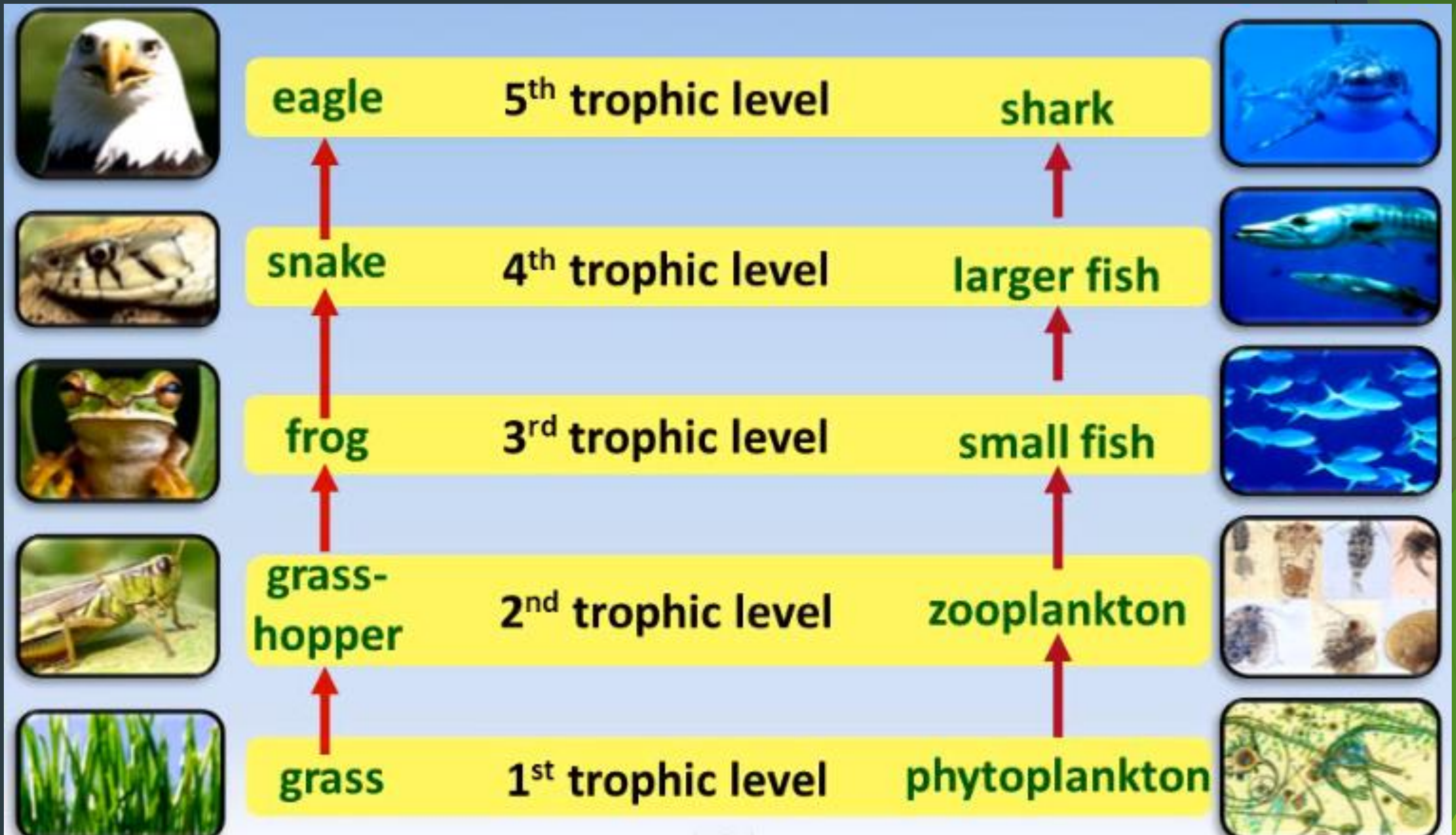
1. Removing vegetation increases soil erosion
2. Use of machinery & vehicles increases soil compaction
3. Adding fertilizers/nutrients can cause eutrophication in aquatic systems and threaten the community

Soil Lab Investigation

Design and conduct an experiment to investigate the effects of altering a selected aspect of soil composition or fertility.

Trophic Levels and Energy

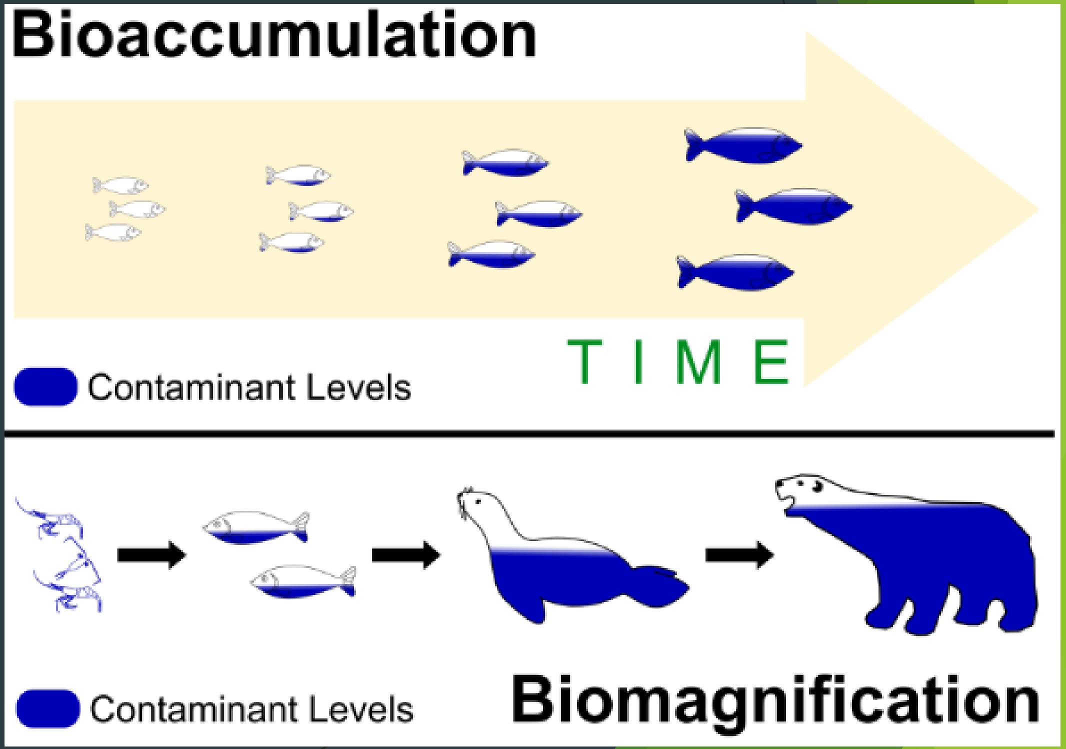
- **Trophic levels** are the feeding positions of all organisms in a specific ecosystem.
- The **first** trophic level, or base, of an ecosystem has the **highest energy** concentration. This energy is dispersed among animals in the subsequent three or four levels.



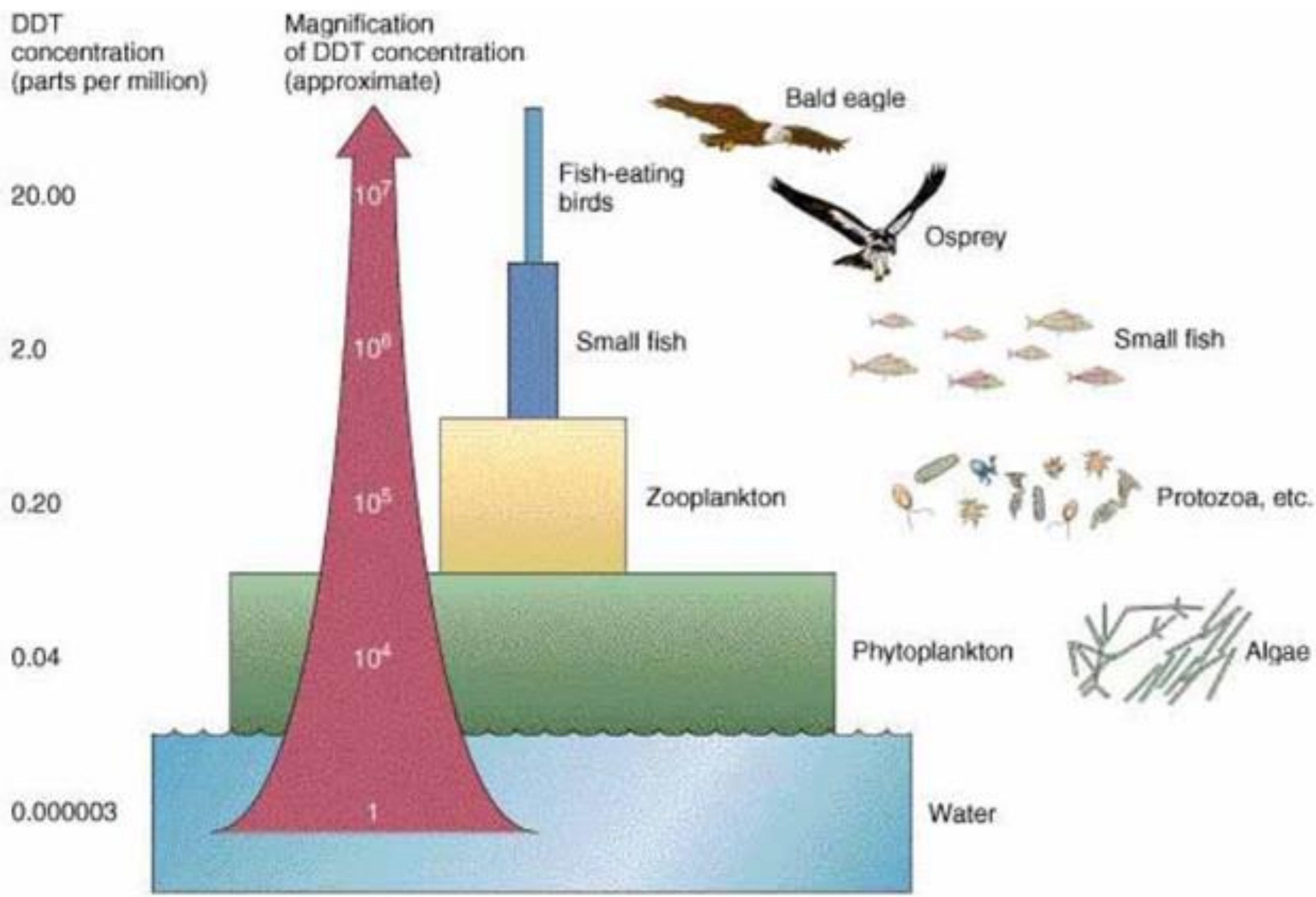
Bioaccumulation vs Biomagnification

- **Bioaccumulation** occurs within a trophic level and is increase in concentration of a substance in our bodies through food and environment.
- **Biomagnification** occurs across different trophic levels in a food chain.

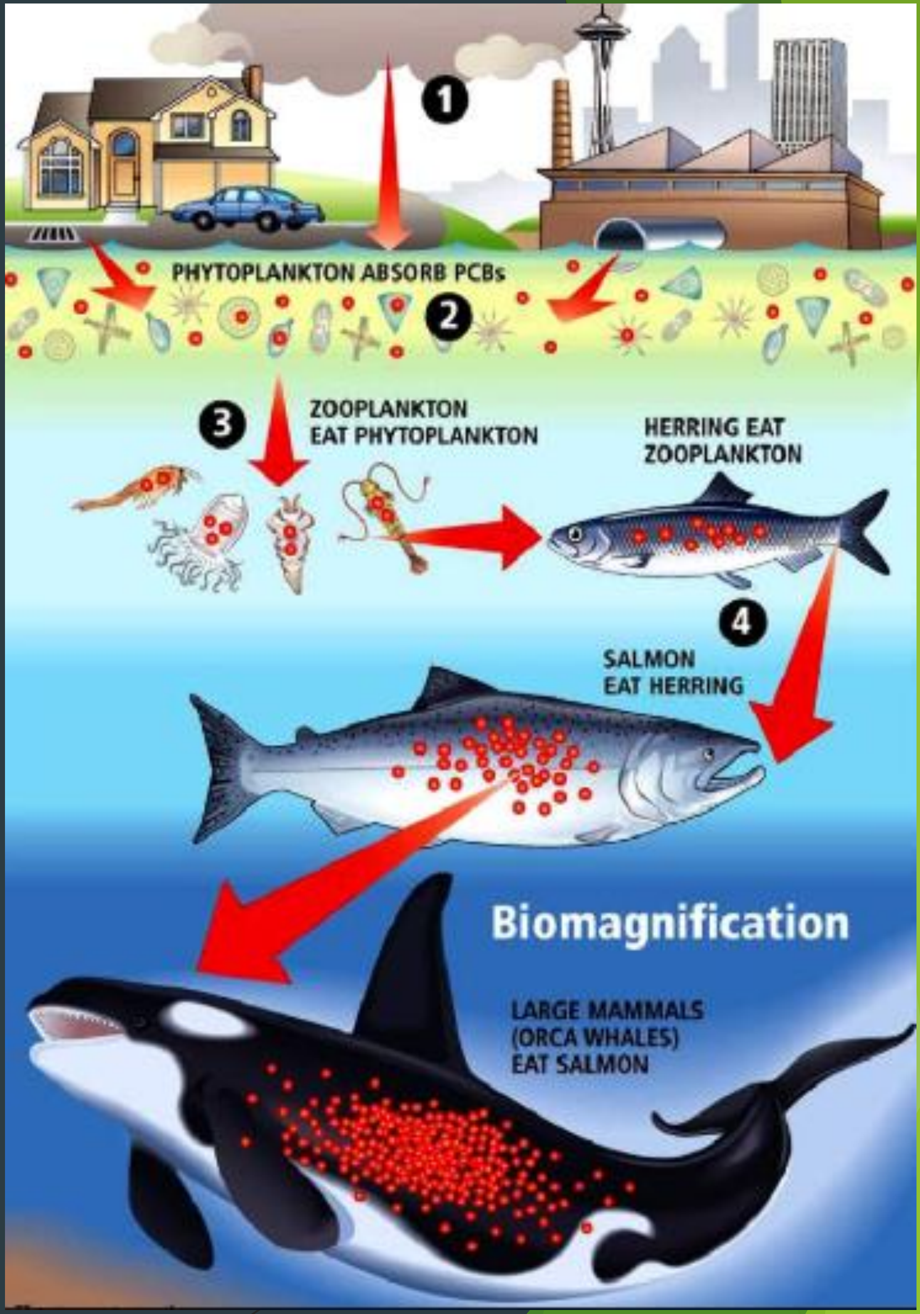
- When an animal consumes food having **toxic** residue, the toxin **accumulates** in the tissue of the animal by a process called **bioaccumulation**. The higher an animal is on the food chain (e.g. **tertiary consumer** such as seals), the greater the **concentration** of toxin in their body as a result of a process called **biomagnification**.



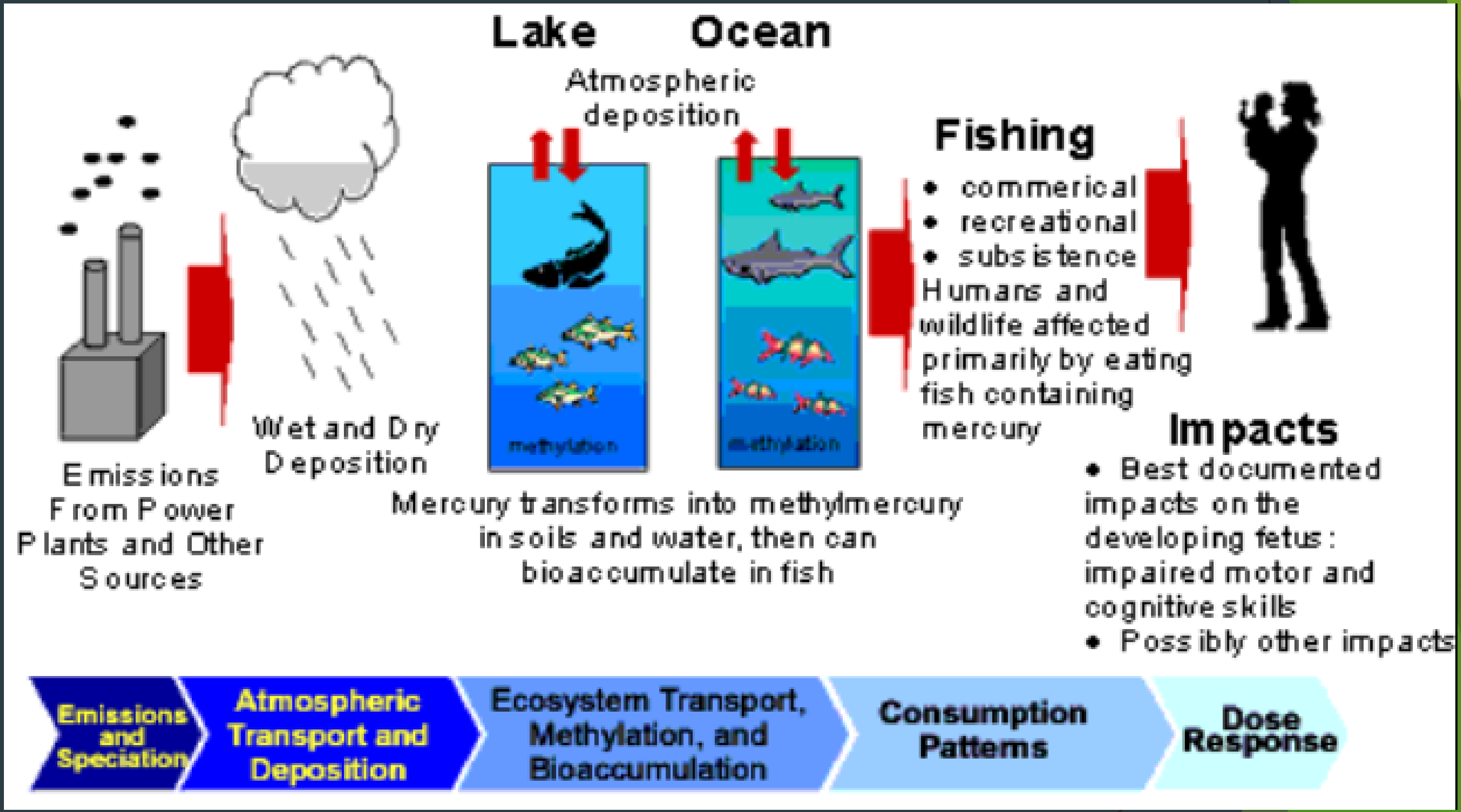
Biomagnification of DDT



- Biomagnification of PCB's



Biomagnification of Methyl Mercury

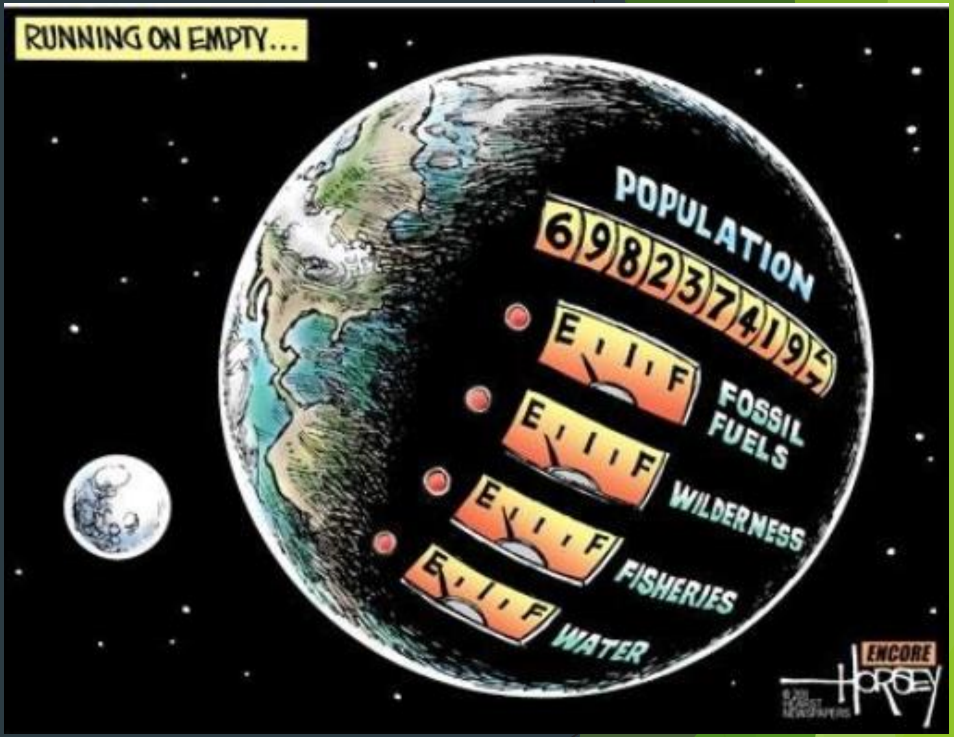


Chapter 8

Shifting Perspectives on Ecosystems

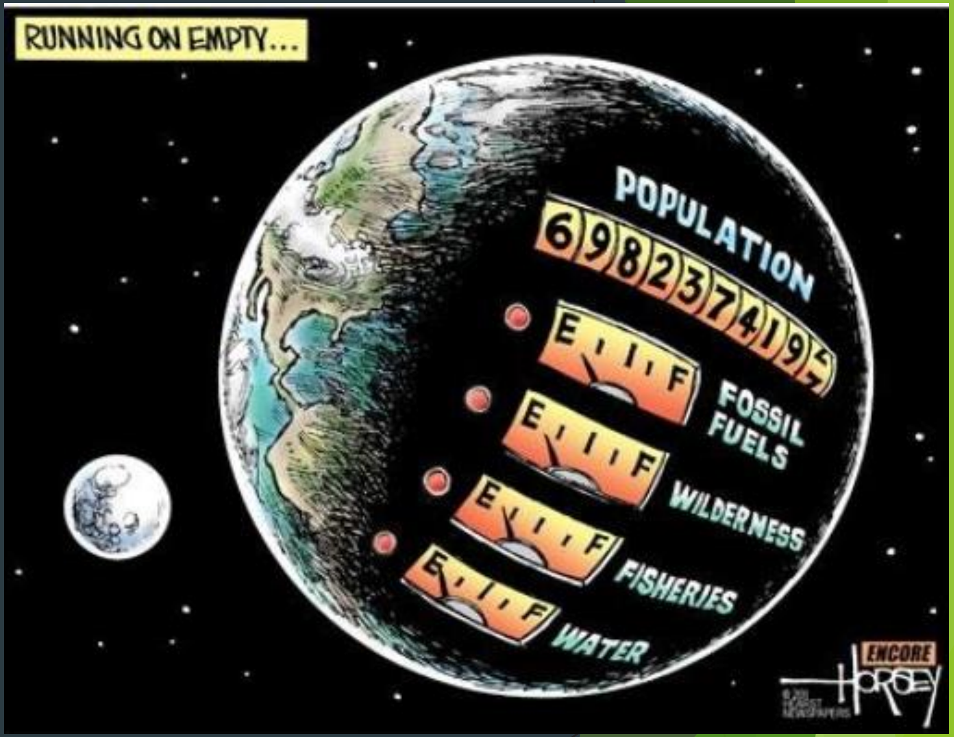
8.1 Factors that Affect the Sustainability of Ecosystems

- Throughout history, humans have depended on Earth's systems, including **ecosystems**, for **resources** such as water, food, and raw materials for energy, shelter, and clothing.
- Between the 1940s and the 1960s, conservationists and environmental scientists began writing more and more about how humans were overusing, **overexploiting**, or **destroying** the very resources on which they depended for survival.



8.1 Factors that Affect the Sustainability of Ecosystems

- Since then, scientists have been conducting studies and collecting data to better understand how ecosystems **function**, how they are **connected** to each other, factors that affect their **sustainability**, and how humans can reduce our impact on them.



Ecosystem Services

- **Ecosystem services** are the benefits sustainable ecosystems provide that are experienced by living organisms, including humans.

Some Examples Are……

1. • Forests take up **carbon dioxide**, release **oxygen**, and maintain soil **fertility**.
2. • Ecosystems maintain **populations** of organisms that are necessary for **pest control**, **pollination**, **waste management**, and other processes beneficial to people.
3. • Ecosystem services include the **cycling of nutrients** and balancing the processes of **growth** and **decomposition**.

Ecosystem Services

.

Some Examples Are……

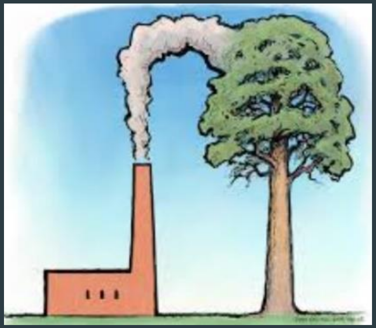
4. Ecosystems provide **habitat** for the diversity of 2 million known species on Earth. They are also a source of **beauty**, inspiration, and **recreation** for many people.

5. Ecosystems provide humans with **resources** such as food, timber, and fossil fuels. Plants from many ecosystems are also used for **medicinal** purposes.

6. Ecosystem services allow ecosystems to function, which is a requirement of **sustainability**.

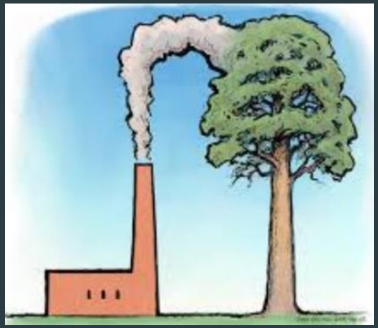
Ecosystem Services Provided by Forests

1. A supply of **trees**, harvested in a sustainable manner, is needed to maintain the **economic activities** of communities that depend on the industry.
2. Forests take in large amounts of **carbon dioxide** from the atmosphere as part of **photosynthesis**, thereby influencing **climate change**.



Ecosystem Services Provided by Forests

3. Forests can also benefit local **watersheds**. Soil **erosion** into rivers and streams is drastically reduced in areas with forested riverbeds.



4. Forests are **home** to many organisms and **deforestation** may lead to extinction of certain species.

Ecosystem Services

Ecosystem services can also be provided by:

- Wetlands (p.323)
- Insects (p.325)

Figure 8.3 Grand Codroy Estuary is a haven for more than 150 species of birds. The area is also home to 19 different species of waterfowl including the endangered piping plover and the thousands of North Atlantic Canada geese that rest and feed here in the autumn before their southerly migration.

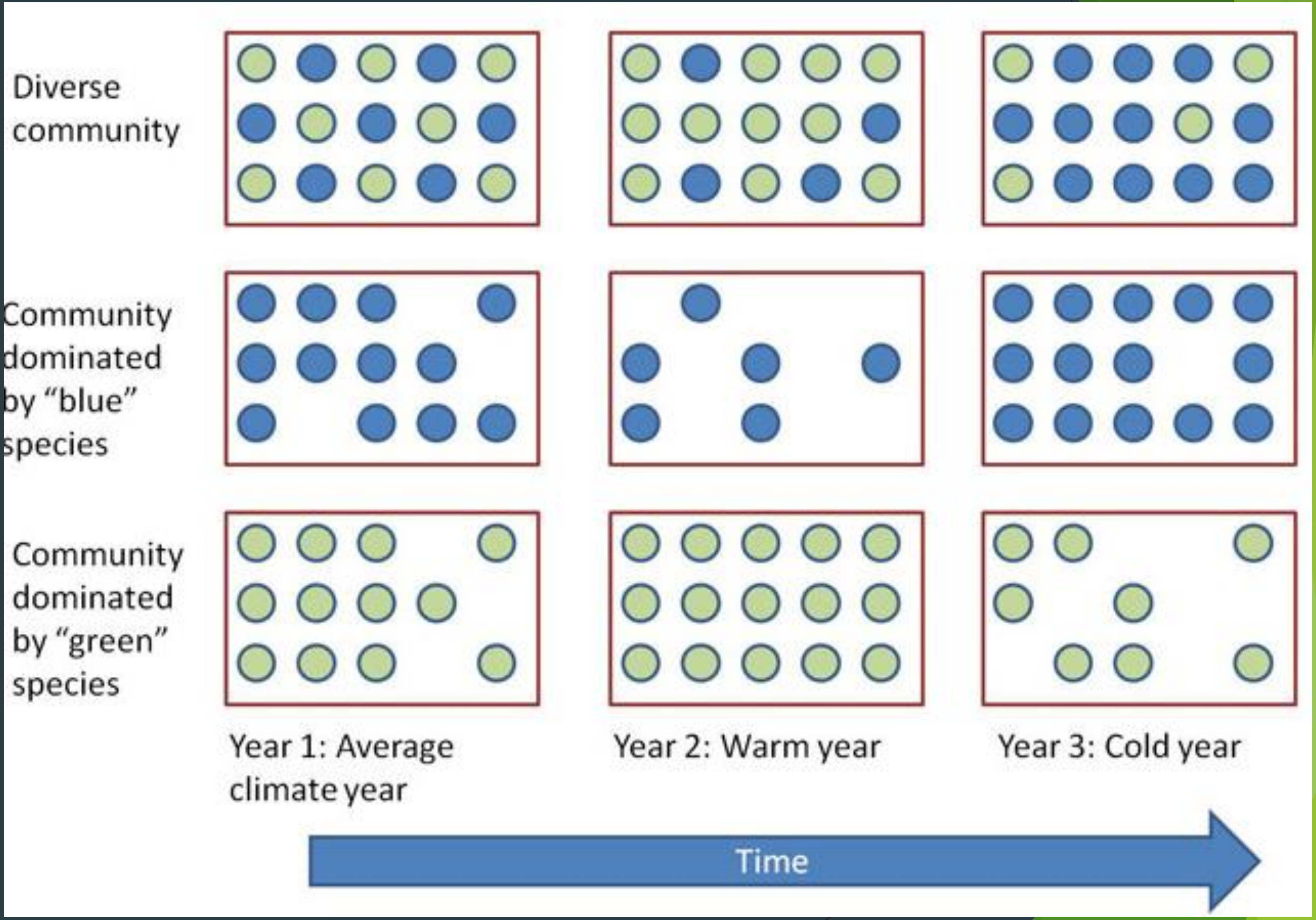
Figure 8.4 When bees or other insects get nectar from flowers, they also pick up pollen grains on their faces, legs, and body. The pollen is transferred as they move from one flower to the next.

Sustainability of Local Ecosystems Investigation

Students should investigate and analyze the impact of external factors (e.g., changing climate, human activities [deforestation, draining wetlands, industry, introduction of non-native species, overexploitation, pollution]) on the sustainability of local ecosystems (e.g., Arctic, freshwater, forests, oceans)

Biodiversity and Sustainability

- Sustainable ecosystems are capable of withstanding pressure and give support to a variety of organisms.
- ecosystems with **greater** biodiversity are more **resilient** to stress
    - **Biodiversity** - the number and variety of organisms found in a specific region
    - **Resilience** - the ability of an ecosystem to maintain a balance, even in the face of significant outside disturbances.


Diverse community
Community dominated by "blue" species
Community dominated by "green" species
Year 1: Average climate year
Year 2: Warm year
Year 3: Cold year
Time

Resilience of Ecosystems

Biodiversity and Ecosystem resilience can be proven by field studies of native plants in plots of land.

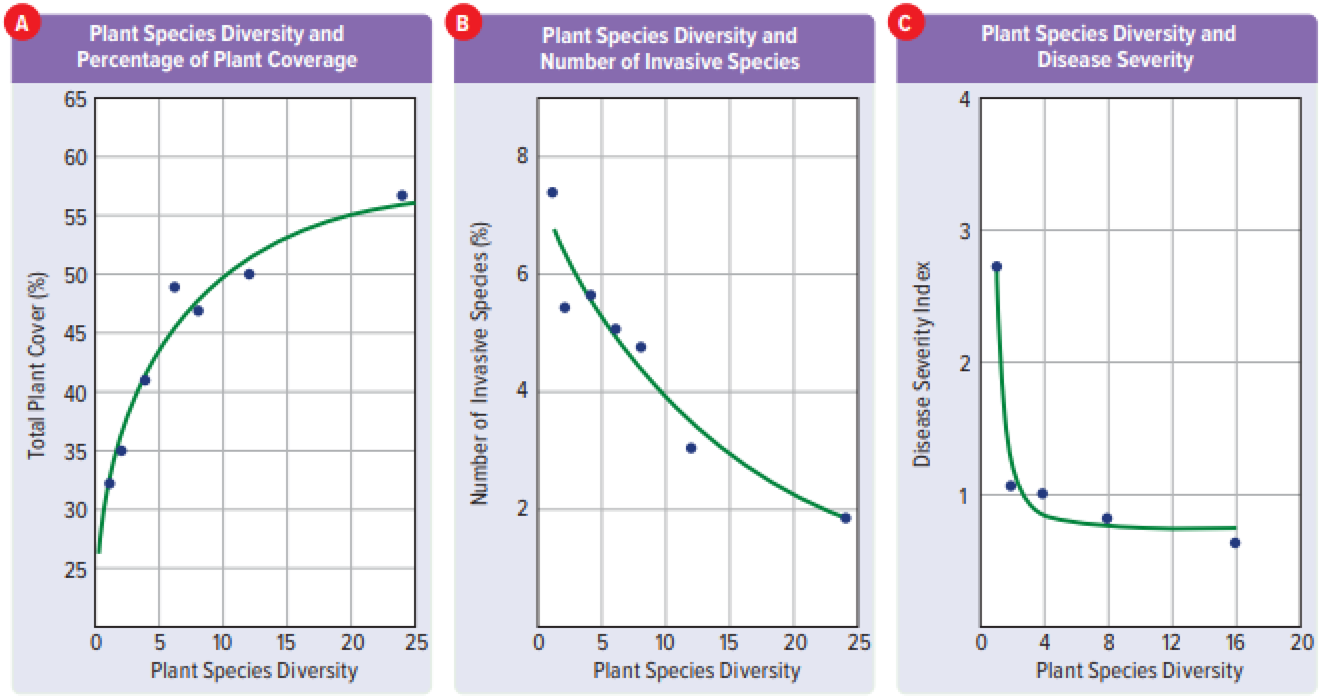


Figure 8.8 In experiments conducted at the University of Minnesota from 1982 to 1993, researchers concluded that greater biodiversity in an ecosystem results in at least three beneficial patterns: increased plant cover, more resistance to invasive species, and more disease resistance.

La produced more **biomass** (consumed more carbon dioxide and nitrates), were resistant to **invasive** species, and resistant to **disease**.

Threats to Biodiversity and Sustainability

Short Term Stresses

1. Wildfire
2. Cutting down trees
3. Natural disasters such as hurricanes or earthquakes
4. Insect infestation

Long Term Stresses

1. Draining wetlands/damming rivers, human land use
2. Invasive species
3. Overexploitation/overharvesting
4. Pollution
5. Climate change

In **healthy** ecosystems, short term stressors are seldom more than a temporary setback, and recovery is generally **rapid**. By contrast, with exposure to long term stressors, ecosystems do not recover, and **degradation** may follow. The stress results in **less** biodiversity, and **lowered** resilience to natural perturbations

Invasive Species

- **Invasive species** - a species that can take over the habitat of native species

European Green Crab

European Green Crab

- European Green Crab was confirmed in Placentia Bay, NL in 2007. It may pose a serious threat to estuarine and marine ecosystems as they are voracious predators feeding on a variety of intertidal animals, including oysters, mussels, clams and juvenile crabs. This species changes the balance between species in the ecosystems and impacts their diversity. Green crab is such an efficient predator that it out-competes native crab species for food. Also, this species is known to disrupt eelgrass beds; productive habitat for many juvenile fish species and can destroy beds of bivalve shellfish. The European Green Crab threatens molluscs, crustaceans and fish, because of its large numbers, its huge appetite and its fierce competition with other species.
- Unless controlled, this new aquatic invasive species will have a significant impact on **biodiversity** and **habitat** in the Canadian ecosystems.

Overexploitation

- Overfishing of yellowfin tuna and **Atlantic cod** during the past few decades has reduced the numbers of these species by **90** percent.

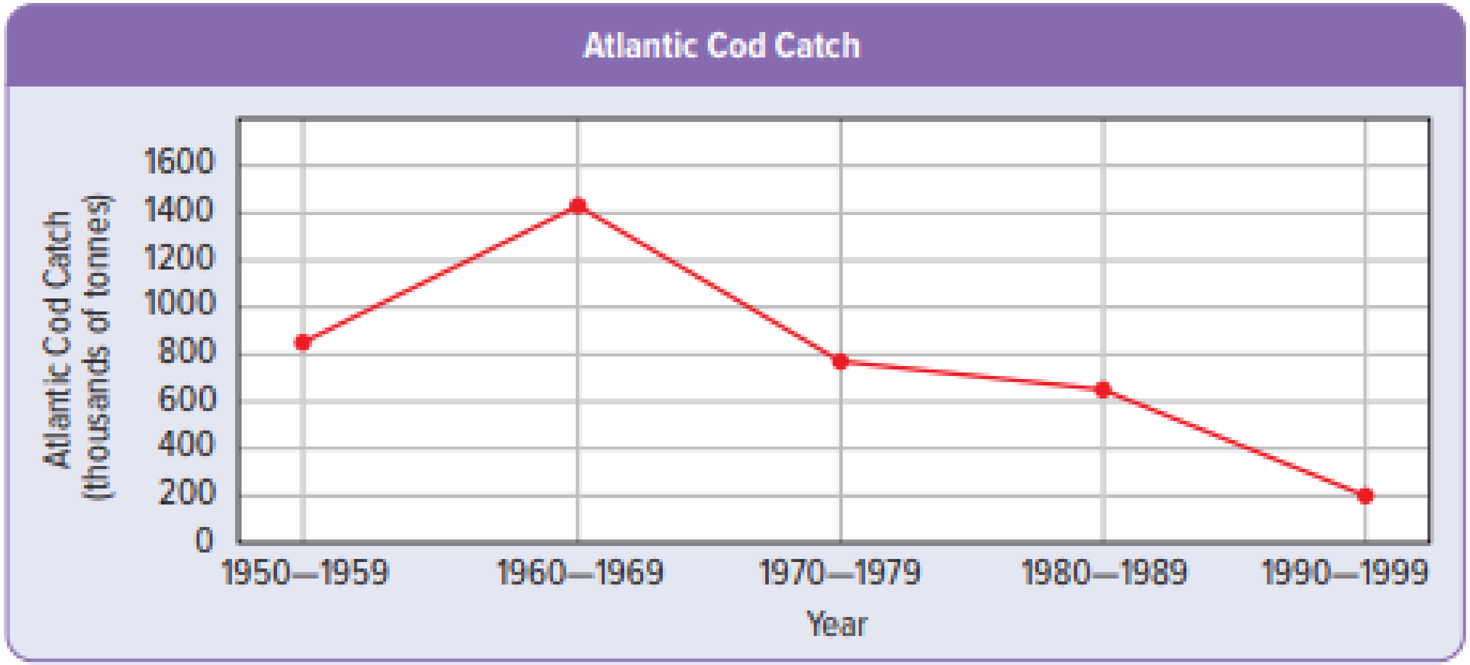


Figure 8.10 The reduced catch of Atlantic cod reflects a decrease in population as a result of overexploitation.

8-1D : Resilience of a Grassland Ecosystem

- Complete the following activity in your booklet

Section Review (p. 333)

Students should answer the following questions to supplement information learned in class

- Checking Concepts: Q 1, 2, 4, 5, 6
- Understanding Key Ideas: 10

8-2: The Shift is On - Attitude, Actions, and Empowerment

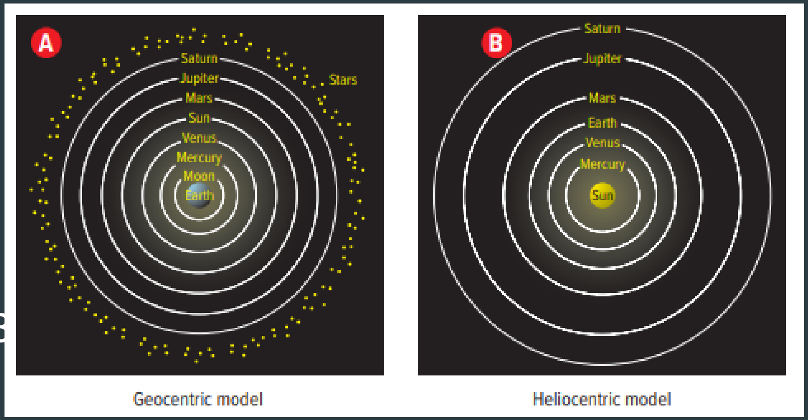
- **Paradigm** - a view of the world or a way of thinking about how the world works
- **Paradigm shift** - a significant change in the way humans view the world

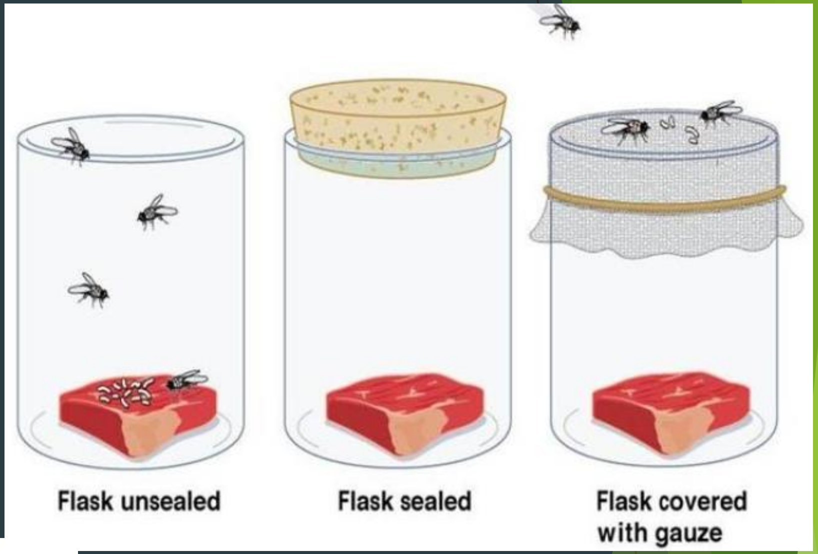
Society is currently in the midst of a paradigm shift related to how we understand **sustainability** and the importance of **ecosystem services**, **biodiversity**, and maintaining sustainable ecosystems

Science-Related Paradigm Shifts

1) geocentrism to heliocentrism

2)spontaneous generation to biogenesis





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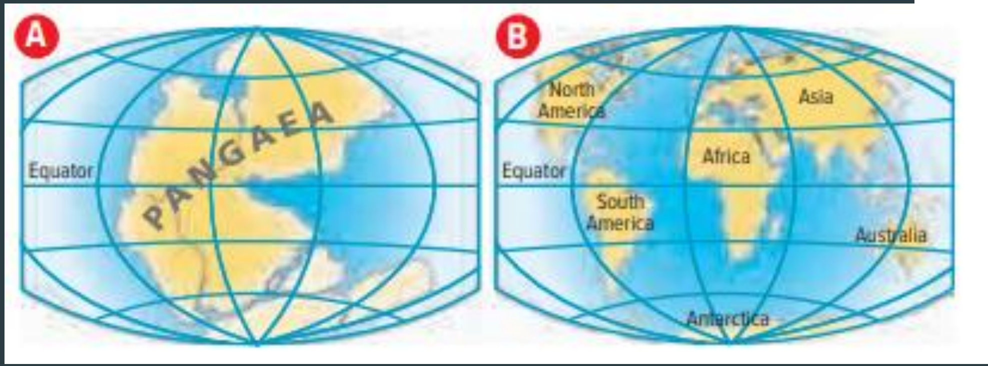

Apollo 17 gave us the first full photo of Earth in 1972, and the world was never the same again:

- Our journeys into space helped us start to see Earth in a way that First Nations and other Aboriginal people have seen it for a long time. We began to see an Earth where everything is connected.

Evidence of Paradigm Shifts

International Level

Millennium Ecosystem Assessment (MA) 	This international effort began in 2001, when more than 1300 scientists worldwide collected data to assess the conditions and trends in ecosystems and ecosystem services, and to report on ways to conserve or increase sustainable use of ecosystems.	• The MA reported significant degradation to ecosystems as a result of human activities, including extraction of resources and interruption of ecosystem services. • The MA concluded that unless the environmental issues were addressed, the sustainability of ecosystems for future generations was in jeopardy. • The MA outlined scenarios to help reduce or reverse the degradation of ecosystems, but noted that significant changes in policies and practices would be necessary.

Evidence of Paradigm Shifts

National Level

Amending Phosphorus Concentration Regulations 	Following Manitoba's Phosphorus Reduction Act, passed in 2008, Environment Canada adopted a national standard to ban phosphorus from household cleaners and household dishwashing and laundry detergents. None of these products would be able to contain more than 0.5 percent of phosphorus by weight.	• The national ban became effective on July 1, 2010. • Scientists estimate that a 10 percent reduction of phosphorus run-off into lakes and other aquatic ecosystems can result by removing phosphorus from dishwasher detergents alone. • With the ban in place, the reduced phosphorus run-off could result in fewer harmful algal blooms in aquatic ecosystems.

Evidence of Paradigm Shifts

Provincial Level

Climate Change Action Plan 	Implemented in 2011, Newfoundland and Labrador's Climate Change Action Plan outlines steps to reduce greenhouse gas emissions, as well as help the province and its communities prepare for environmental changes due to the effects of global climate change.	• Reduce greenhouse gas emissions by at least 10 percent from 1990 levels by 2020 by promoting greater energy efficiency, generating even more electricity from renewable resources, and embracing a green economy, which includes cleaner transportation, increasing recycling, and conducting energy audits, and promoting public transit and bicycling in areas where it is feasible. • Prepare for changes in temperature and precipitation trends, changes in weather events, and sea-level rise due to global climate change.

Evidence of Paradigm Shifts

Local Level

Qalipu Natural Resources Division Qalipu FIRST NATION	Qalipu's Natural Resources Division researches and monitors species such as woodland caribou, eels, Atlantic salmon, and green crabs, runs a Fisheries Enforcement Program, and has Community/Youth Engagement programs in an effort to promote the sustainable use of resources.	• Continue to provide resources for Mi'kmaq to take part in natural resource management. • Continue to support and strengthen Mi'kmaq research and natural resource management without compromising traditions. • Continue to work with government and other First Nations organizations to meet the goals of Qalipu's Natural Resources Division.

8-2A Funding Canadian Research Projects

- Scientific research provides crucial information to society. Research findings are used by citizens, governments, and businesses to make decisions about policy and legislation related to sustainability.
- Research projects are funded by governments, through universities and research councils, corporations, and to a lesser extent by philanthropists, non-profit foundations, professional organizations, and crowdsourcing.
- Complete Activity 8-2A in workbook

8-2A Funding Canadian Research Projects

Think About It

At the start of this chapter, you read about a Memorial University-affiliated program called NLNature, which engages citizens of the province to be part of a data collection network. The end of this unit features an environmental educator who works with an organization called Students on Ice, which helps students learn about the importance of Earth's polar regions. The research conducted by NLNature and Students on Ice would not be possible without financial support. Who provides funding for the many research projects that help to increase our knowledge and understanding of the world around us? You will investigate this question in this activity.

Materials

- access to print or Internet resources

What to Do

1. Work in small groups. Do research to find information about three research organizations or projects in Newfoundland and Labrador. They can involve governments, NGOs (non-governmental organizations), educational institutions, and private groups or individuals. The introduction to this activity already noted two examples—NLNature and Students on Ice. Other examples include (but are not limited to) the following:
   - FISH-BOL (a project involving DNA barcoding of fish)
   - Let's Talk Science
   - Little Green Thumbs
   - Marine Environmental Observation Prediction and Response (MEOPAR)
   - MI Ocean Net
   - Ocean Learning Partnership
   - Project SucSeed
   - Qualipu Natural Resources Division, Terrestrial and Aquatic Programs
   - Renewed Sustainable Aquaculture Program
2. Consult with other groups to make sure a variety of research projects are covered.
3. For each research project:
   (a) Record a brief description. If you are using the Internet, this information is often provided in an "About Us" part of an organization's or project's website.
   (b) Find out who provides funding. For example, does funding come from the provincial and/or federal government? from universities? from private donors? from crowd-sourcing? List the specific donor(s), sponsor(s), and/or partner(s) that support the project.

What Did You Find Out?

1. Which organizations tend to be the most common or significant sources of funding for Canadian research projects? Use your research to support your answer.
2. What factors do you think lead to inspiration and ideas for research projects?
3. Do you think a funding source should have the right to influence the type or the direction of the research that it is supporting? Give reasons to justify your answer.

Sustainable Development - Risks vs Benefits

- **All About Aquaculture: Environmental Risks and Benefits Case Study**

All About Aquaculture: Environmental Risks and Benefits

POSTED ON OCTOBER 16, 2012 BY MADI GAMBLE (CLF)

Finfish aquaculture operations like this one can have detrimental effects on the marine environment - unless prevention measures such as site rotation are used. (Photo Credit: Maine DMR)

For all the positive effects aquaculture can have on food security and conservation of wild fisheries, it can also pose serious environmental risks and create sustainability challenges.

One of the environmental impacts that receives the most attention is the issue of nutrient and effluent buildup on the sea floor below the cages. Because the fish are contained in one place at high densities, their waste – which includes both solids and dissolved nutrients like nitrogen – has the potential to build up below the cages and in the surrounding area. This creates the potential for algal blooms, which deplete the water of oxygen and can create damaging dead zones near aquaculture sites. Regulatory agencies have recognized these problems and implemented measures to prevent them, including siting the cages in places with strong currents to wash away the effluent and moving the cages from year to year to reduce impact on any one area.

Another environmental concern is the effect of the farmed fish on local wild fisheries. Disease and parasite outbreaks in fish farms, though infrequent, can spread rapidly among farmed fish because of the high densities at which they are kept, and disease may spread to wild fish populations. Fish farmers used to combat these outbreaks with antibiotics and other chemicals in fish feed, but this created concern about the effect of the drugs on the ecosystems around the cages, as well as residual antibiotics winding up on consumers' plates. More recently, safe and effective vaccinations for farmed fish have been developed and are widely used, and the use of antibiotics in aquaculture has almost ceased in the United States.

Another major concern is that escapees from fish farms—particularly where farmed species are non-native—may compete with fish from wild populations for food, potentially displacing wild fish. Cages are closely monitored by underwater cameras and regularly inspected by divers for damage, so the frequency of escape is minimal. There are also concerns about farmed fish interbreeding with wild fish and affecting the gene pool of the wild stock, but these concerns have been lessened by the exclusive use of genetically modified, sterile females in finfish aquaculture.

Some aquaculture operations can even have positive effects on environmental and human health. Farmed fish are generally free of environmental contaminants such as mercury and heavy metals, since they eat exclusively human-processed feed for which toxin levels are regulated. In addition, the farming of filter feeders such as shellfish can improve water quality, and in fact shellfish are often integrated into finfish production in integrated multi-trophic aquaculture (IMTA) systems, also known as polyculture. Because shellfish are filter feeders, they use uneaten feed and elements of fish waste as food, and can be cultivated near nets and cages containing finfish to improve water quality and even protect against disease outbreaks. Polyculture systems, which can also involve seaweed cultivation, are prominent in Maine, and there is ongoing polyculture research at schools like the University of Maine, the University of New Hampshire, and many others.

In addition to environmental risks, concerns about the long-term sustainability of aquaculture in meeting our protein needs remain. There are two main issues when it comes to the sustainability of various aquaculture practices: fish food and freshwater and energy use.

In certain forms of aquaculture, such as salmon farming, the fish being produced require large amounts of feed, which often contains fishmeal made from other fish species. This means using many smaller fish to create fewer big fish, wasting energy and protein in the process. Wild caught forage fish like herring and anchovies are the predominant source of fishmeal and oil in feed, and these fish are often from overexploited wild fisheries. Species like salmon that are higher on the food chain require more fishmeal and fish oil in their feed than herbivorous or omnivorous fish like carp and tilapia.

To make feeds more sustainable, the fishmeal and fish oil used in feeds may also come from trimmings produced in processing seafood for humans, and this type of recycling in the feed industry has been on the rise. It is also possible to substitute plant proteins for fishmeal in feed, but this can change the feed's nutritional content and lower beneficial omega-3 fatty acids, which come from forage fish, in the final product, reducing the health benefits of eating fish.

Then there are the issues of energy and freshwater – both limited resources that are in high demand in the aquaculture industry. Land-based aquaculture systems like hatcheries often require huge amounts of water to be pumped into their systems. Pumping the water alone requires electricity, and depending on the design of the aquaculture system, cleaning and filtering the water may also require high energy input. Some fish farmers have found ways to minimize their freshwater and energy consumption by using recirculating water systems, where water from the fish tanks is pumped through a series of filtering tanks that use bacteria and algae to remove solids, nitrogen, and other waste materials. The same water is then allowed to flow back into the fish tanks, conserving vast amounts of fresh water and energy.

Clearly, the sustainability and environmental impacts of farmed seafood products depends on many factors and varies with the methods used by the fish farmers.