Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

a. Cell activities are affected by interactions with biotic and abiotic factors.

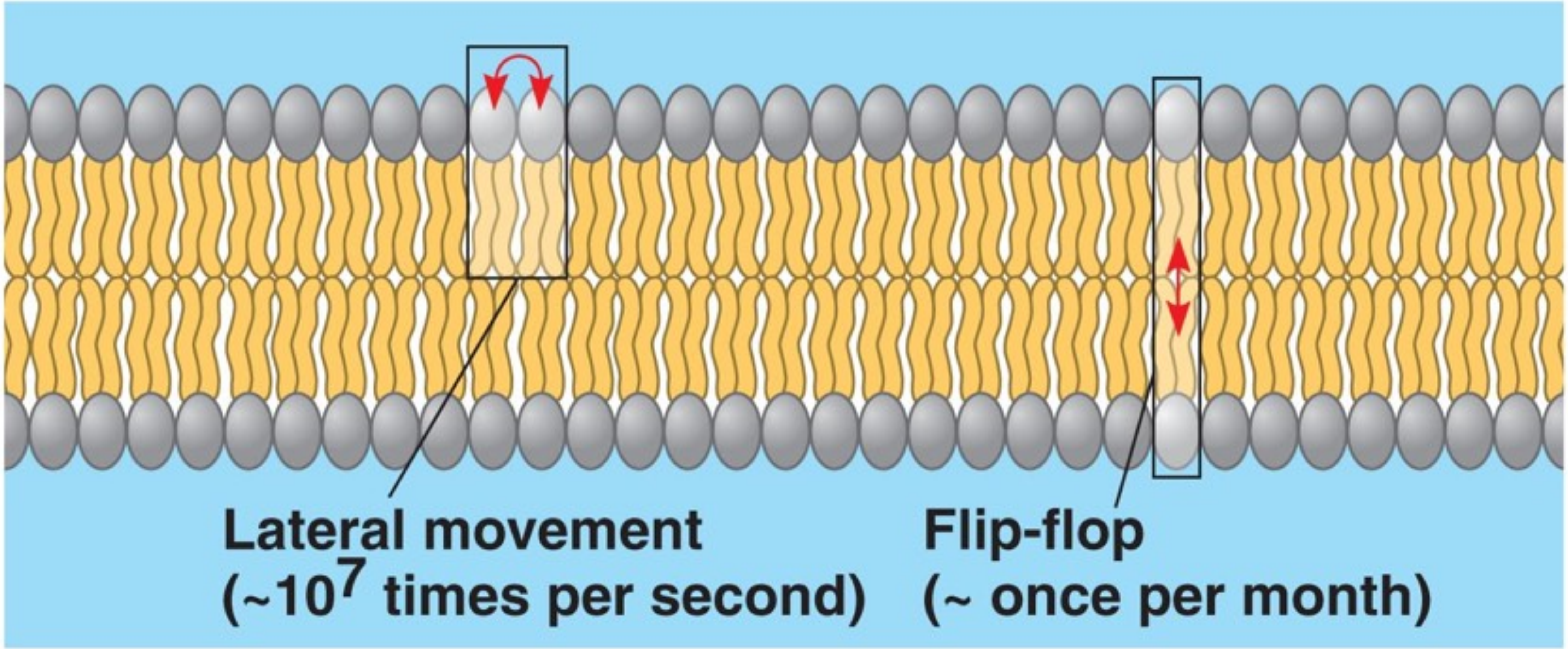
To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Cell density
-Biofilms
-Temperature
-Water Availability
-Sunlight

REVIEW

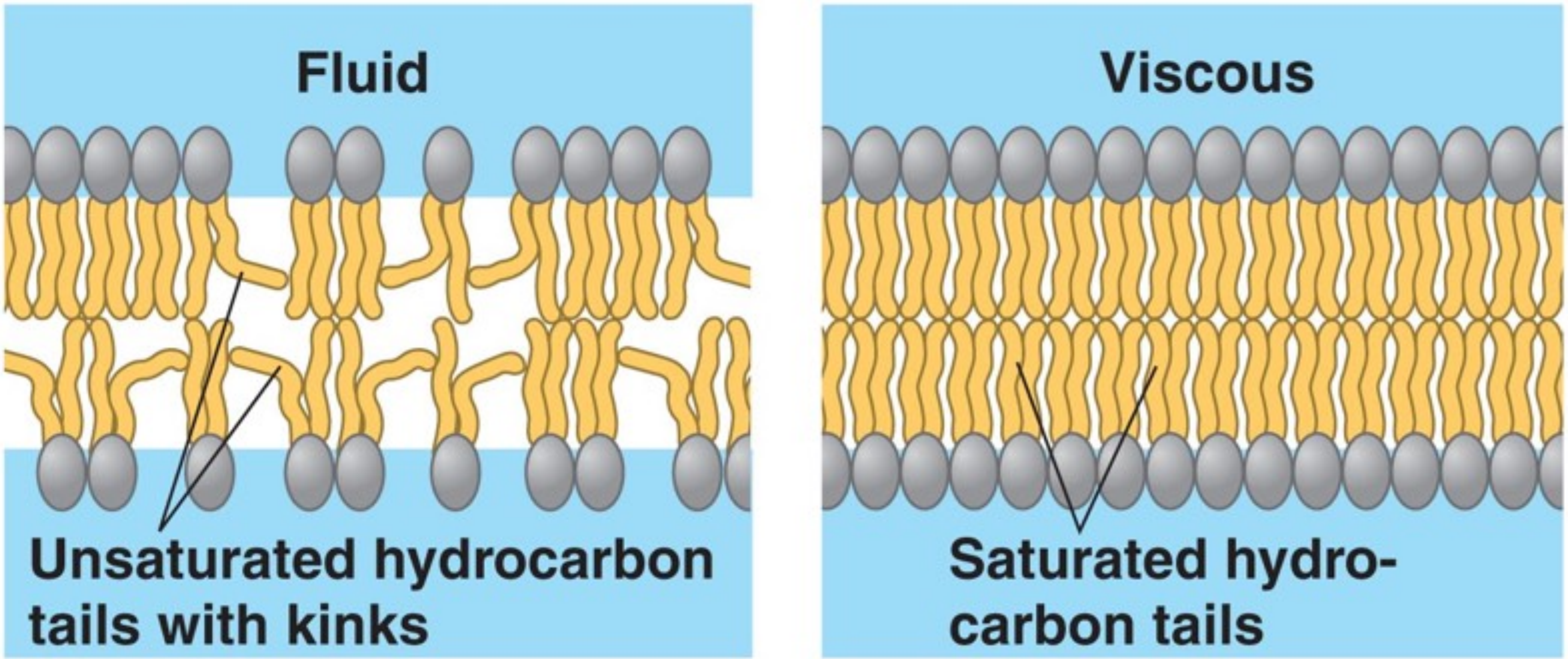
The Fluidity of Membranes

- Membranes are static sheets, they are held together by weak hydrophobic interactions.
- The lipids and proteins both move laterally although the lipids move much more freely.
    - Furthermore some proteins do not move at all because they locked into place by the ECM and cytoskeleton.



The Fluidity of Membranes

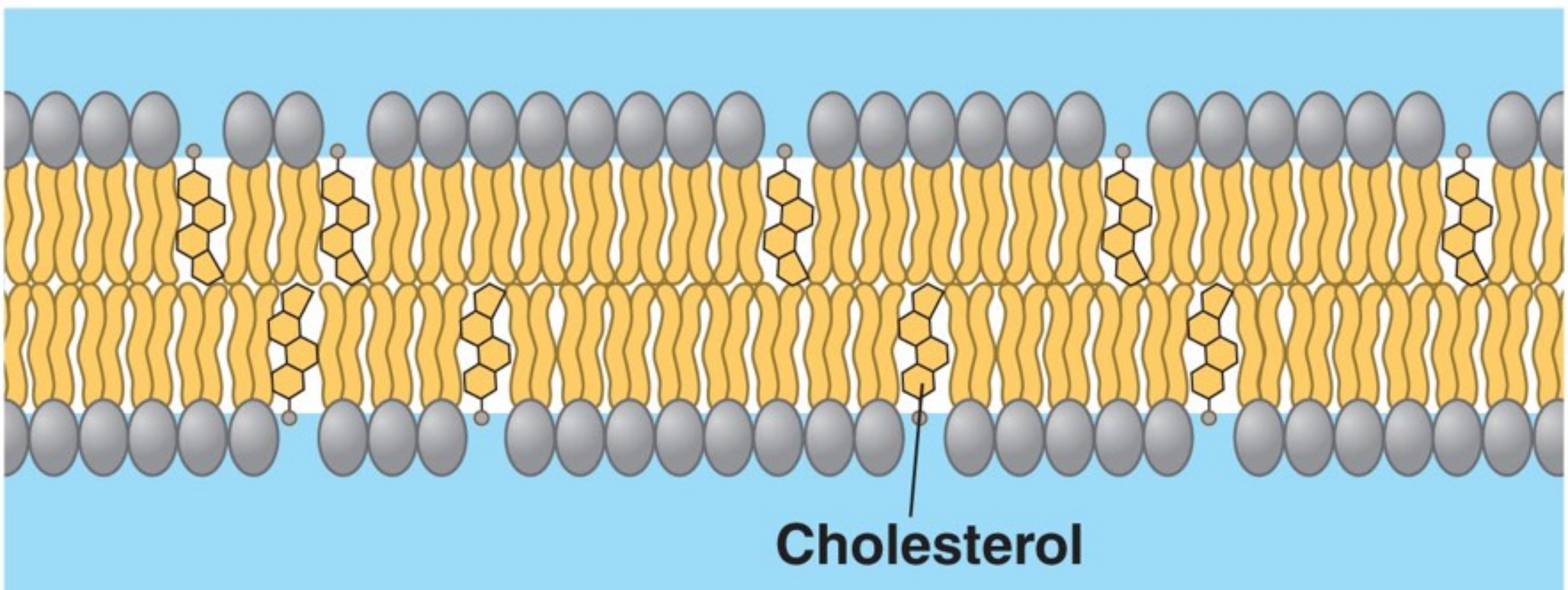
- Membrane fluidity is directly correlated with temperature.
  - The higher the temperature the more fluid the membrane
- The type of fatty acid tails in the phospholipids also effect fluidity
- Membrane fluidity is important because it effects membrane permeability



(b) Membrane fluidity

The Fluidity of Membranes

- Cholesterol acts like a membrane "fluidity buffer".
  - At higher temperatures cholesterol decreases the membrane fluidity, by restraining lipid movement.
  - At lower temperatures cholesterol increases the membrane fluidity, by hindering the close packing.



(c) Cholesterol within the animal cell membrane

Ex. Cells Responding to Abiotic Factor: Temperature

The Evolution of Different Membrane Lipid Composition

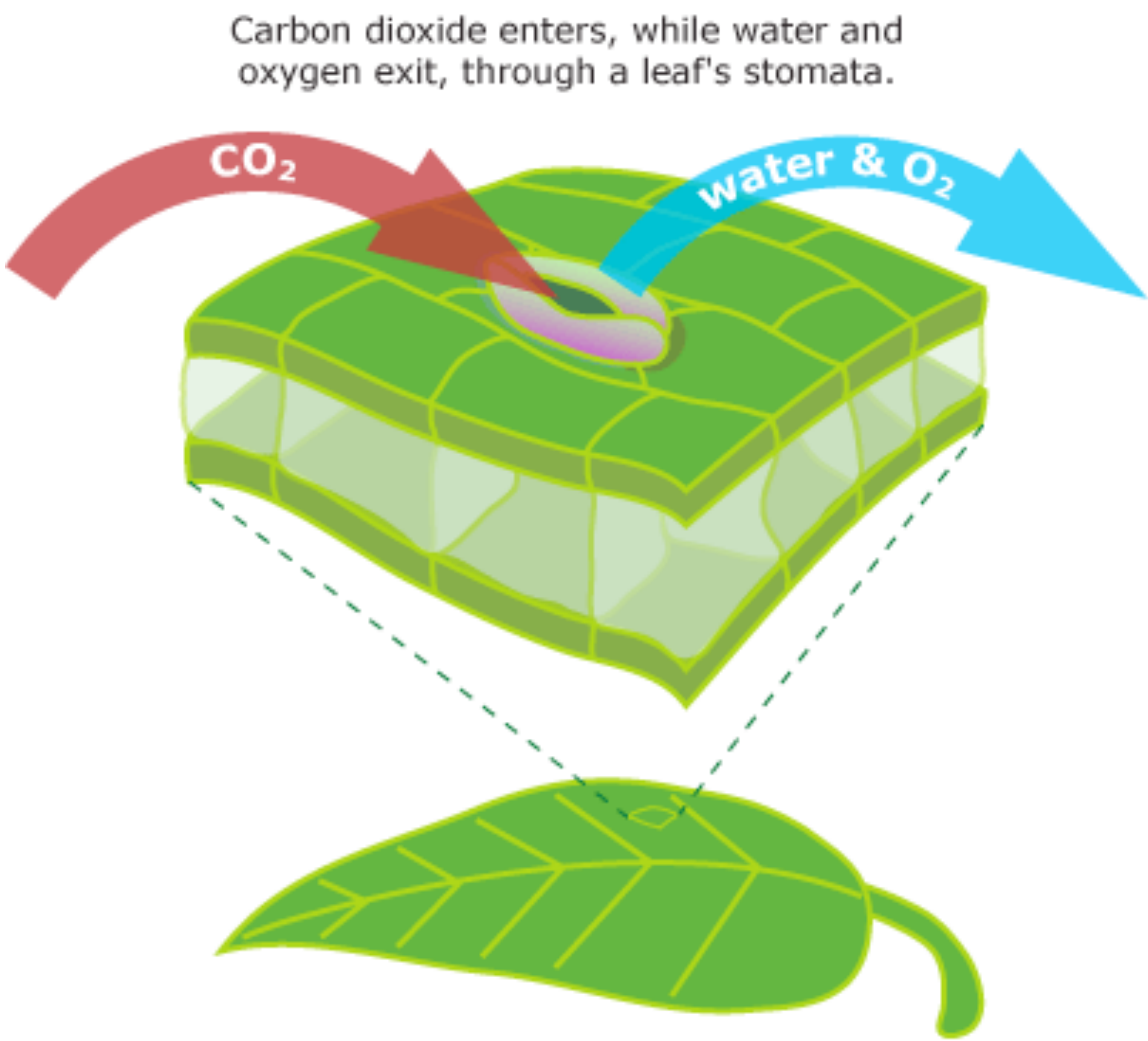
- Variations in lipid composition appears to be an evolutionary adaptation.
  - *Fish that live in cold water have a high proportion of unsaturated fatty acids.*
  - *Bacteria living in thermal hot springs show a high proportion of saturated fatty acids.*

The Evolution of Different Membrane Lipid Composition

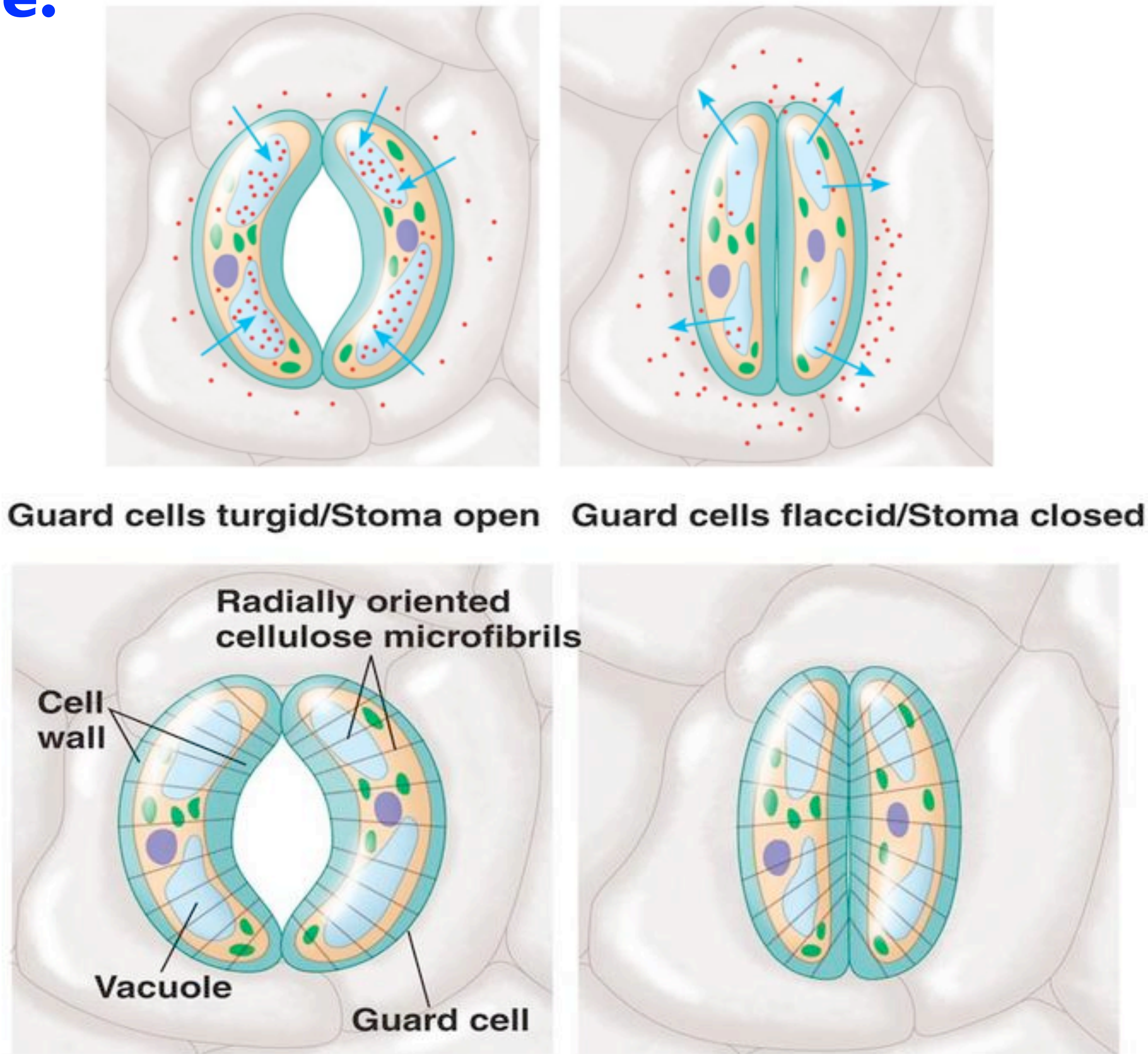
- The ability to adjust lipid composition appears to be an evolutionary adaptation.
    - *Winter wheat* can change its percentage of unsaturated fatty acids that make up its membrane as the seasons change.
- **Natural selection has favored organisms who have a mixture of fatty acid types and or those organisms that can adjust their membrane's permeability as necessary.**

Ex. Cells Responding to Abiotic Factor: Light

Stomates are pores on the leaf surface that allow gas and water exchange

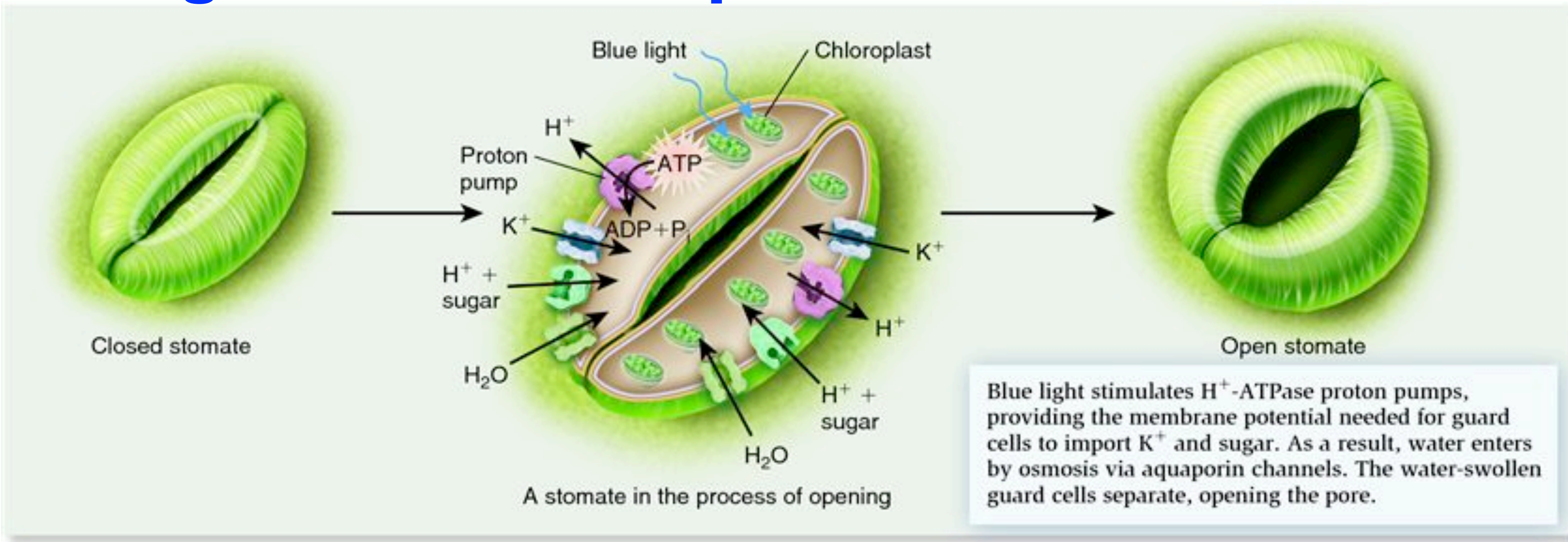


Two guard cells swell or shrink in order to open or close the pore.

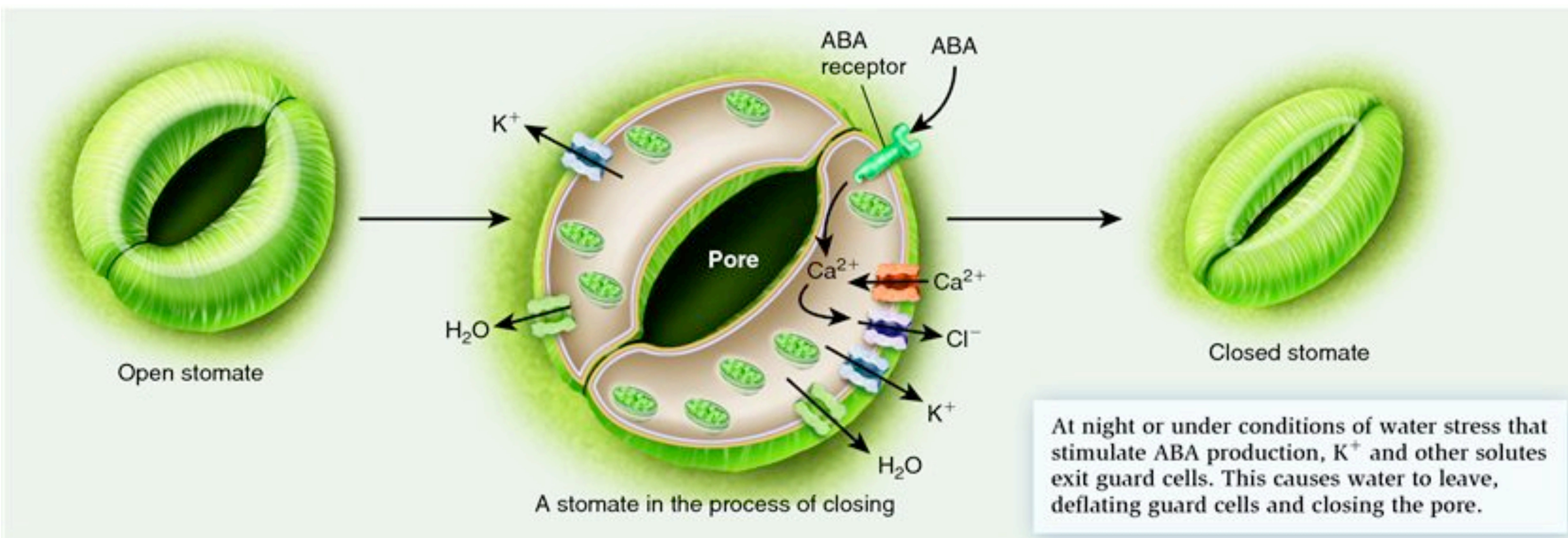


(a) Changes in guard cell shape and stomatal opening and closing (surface view)

Blue Light Controls the process



(a) The process of stomate opening



(b) The process of stomate closing

Ex. Cells Responding to Biotic Factor: Population Density

External Signals

- *Cell Division* can be regulated internally as well as externally.
- Three examples of externally regulated *Cell Cycle Control Systems* include **platelet derived growth factors (PDGF's),** **density-dependent inhibition**, and **anchorage dependence**.
    - PDGF's stimulate cell division
    - While D.D.I and A.D. inhibit cell division

Platelet Derived Growth Factors

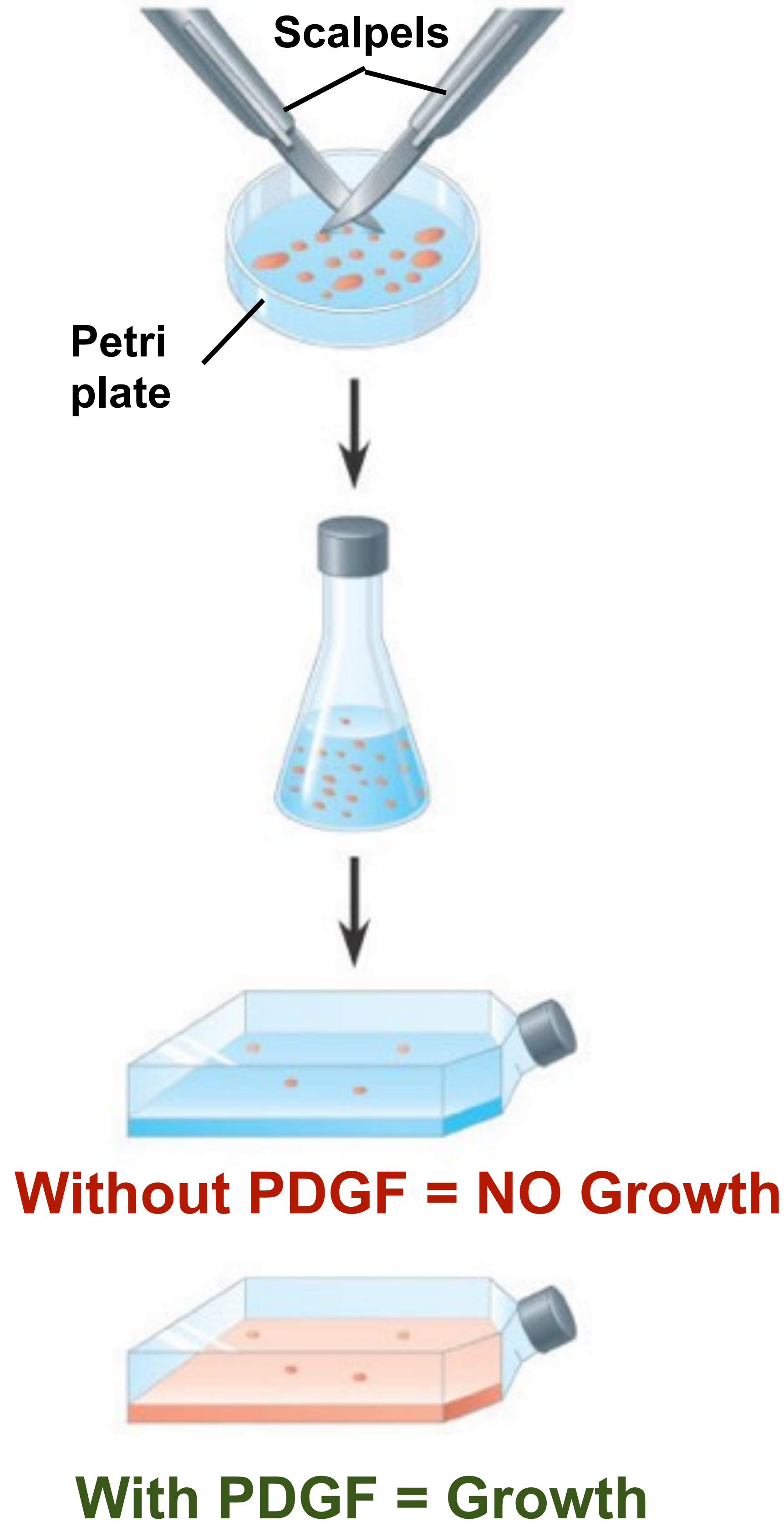
EXPERIMENT

A sample of connective tissue was cut up into small pieces.

Enzymes were used to digest the extracellular matrix, resulting in a suspension of free fibroblast cells.

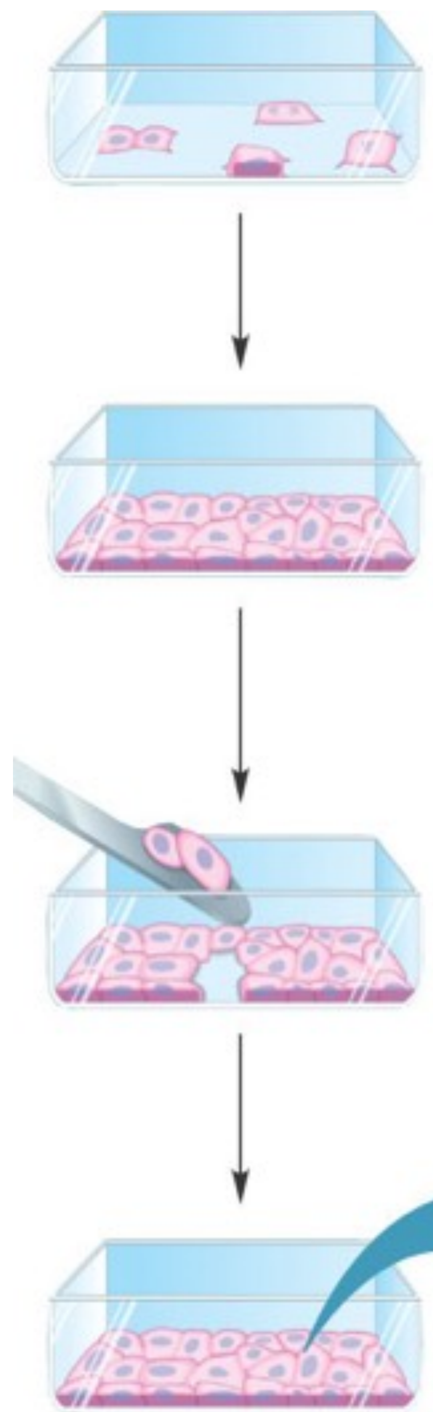
Cells were transferred to sterile culture vessels containing a basic growth medium consisting of glucose, amino acids, salts, and antibiotics (as a precaution against bacterial growth).

PDGF was added to half the vessels. The culture vessels were incubated at 37°C.



Density-Dependent Inhibition & Anchorage Dependence

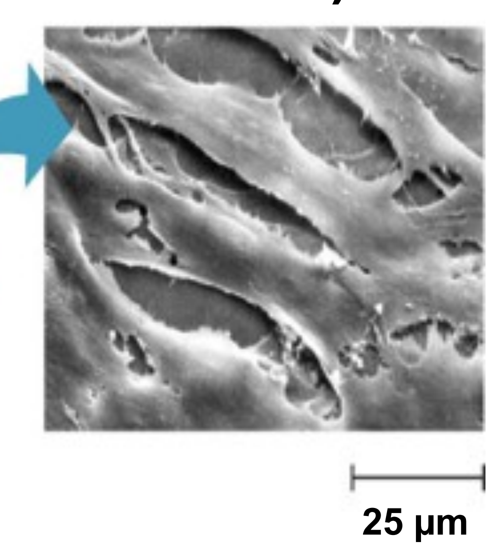
Many cells exhibit A.D., they must be attached to other cells or a surface of some kind in order to reproduce.



Cells anchor to dish surface and divide (anchorage dependence).

When cells have formed a complete single layer, they stop dividing (density-dependent inhibition).

If some cells are scraped away, the remaining cells divide to fill the gap and then stop (density-dependent inhibition).

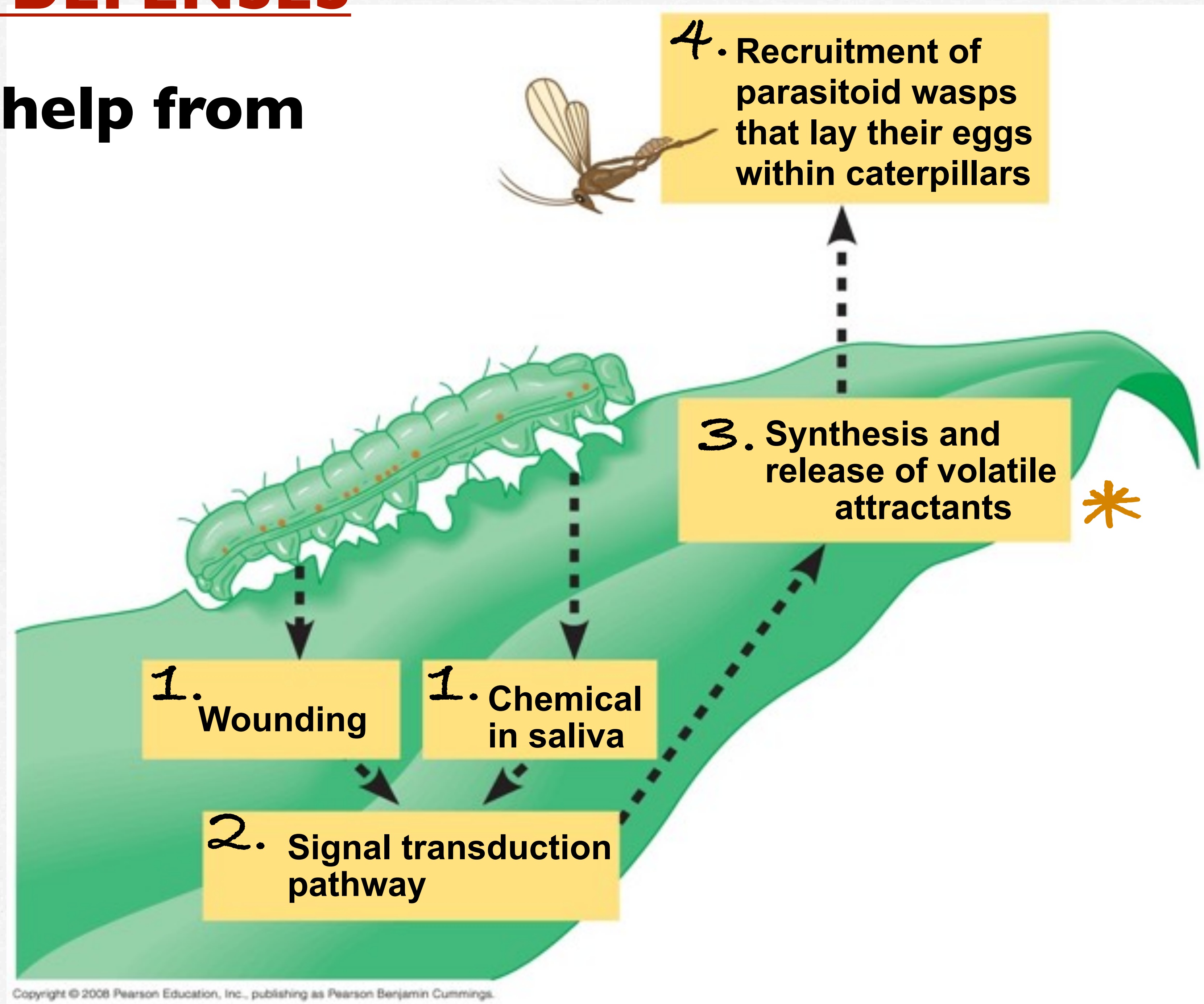


Normal mammalian cells. The availability of nutrients, growth factors, and a substratum for attachment limits cell density to a single layer.

Ex. Cells Responding to Biotic Factor: Predation

Plant Defenses against Herbivores

- **RECRUITMENT DEFENSES**
- **Plants can elicit help from other species.**



* These volatile attractants can also warn nearby plants, so that they might make biochemical changes that make them less susceptible themselves

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

b. Organism activities are affected by interactions with biotic and abiotic factors. [See also 4.A.6]

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Symbiosis (mutualism, commensalism, parasitism)

-Predator–prey relationships

-Water and nutrient availability, temperature, salinity, pH

Biotic Factors

Community Ecology

Main Idea: Species living in close proximity will inevitably interact with each

Main Idea: These interactions can be positive, negative or have little to no effect.

COMMUNITY INTERACTIONS

- A ***community*** is a group of species living close together and interacting
- Some of these interactions affect the survival and reproduction of the two species interacting
- These interspecific interactions include:

Competition (-/-)

- Limited resources cause species to compete for them and this lowers the fitness of both species

Competitive Exclusion

- In 1934, Russian Ecologist G.F. Gause concluded that two competing species could not coexist permanently in the same place
- One species will inevitably have a slight reproductive advantage and eventually eliminate the inferior competitor...***competitive exclusion principle***

Ecological Niches & Evolution

- Sum use a species resources both abiotic and biotic in their environment...***niche***
- *Competitive exclusion principle* rephrased...no two species can occupy the same niche

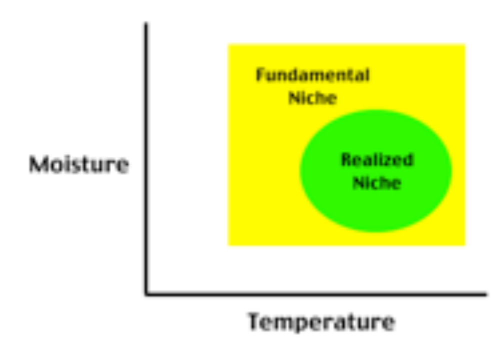
Ecological Niches & Evolution

- Since the two species can not occupy same niche one will use slightly different resources their by differentiating or partitioning the niche
- This resource partitioning allows two species to live in very similar niches
- Evolution by natural selection provides the mechanism for this partitioning.
- Species use their small and unique variations to use these to carve out a specific smaller niche from a larger one

Resource Partitioning

Note: species can partition their niches by *space* seen here or by *time*...think diurnal vs nocturnal

- As a result of competition a species occupies a ***realized niche*** (niche it actually lives in) which is smaller than its ***fundamental niche*** (niche it could occupy)



Predation (+/-)

- Natural selection has fine tuned both predator and prey with remarkable adaptations.
  - **Predators**:
    - acute senses, speed, agility, claws, teeth, fangs, stingers and venoms
  - **Prey**:
    - behavioral defenses; hiding, fleeing, forming herds or schools, alarm calls
    - morphological & physiological defenses; camouflage (cryptic coloration), warning colors (aposematic colorations), spines, poisons, toxins, chemicals, mimicry

Can you think of an example of each?

Herbivory (+/-)

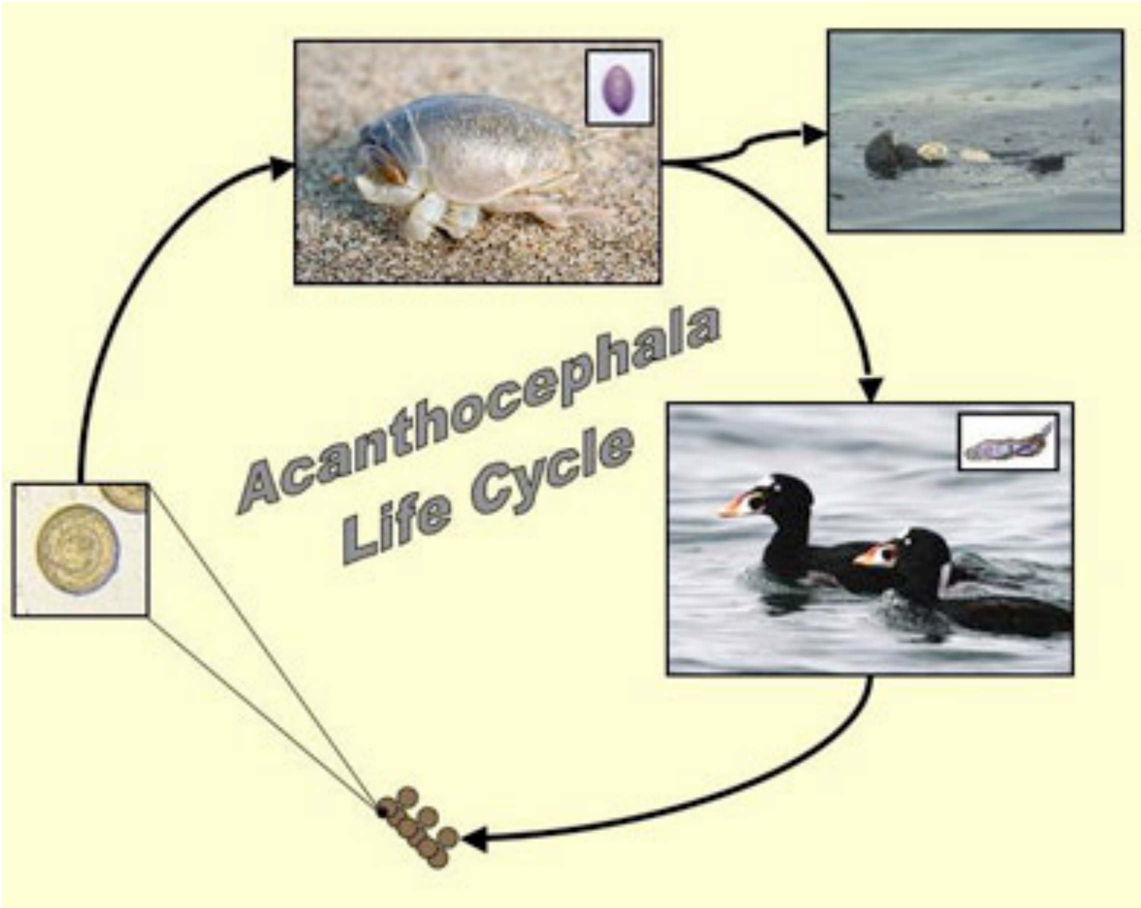
- Natural selection has fine tuned herbivores (and the plants) with remarkable adaptations.
  - **Herbivores**:
    - insects can detect toxic chemicals with their feet
    - mammals
      - use smell to assess plants,
      - mammals also have specialized teeth (molars) for grinding plant matter,
      - mammals have specialized digestive tracts to breakdown cellulose
  - **Plants**:
    - Spines and Thorns
    - Toxins: strychnine, nicotine, selenium, peppermint, cloves,

Symbiosis

Note: Some define symbiosis narrowly as mutualism however the authors of your text use a broader definition to include *all* direct interactions between species, those that we covered already and those to come.

1. Parasitism (+/-)

- *Parasites* are organisms that derive nourishment from a host, the *host* is the organism that is harmed in the process.
  - Endoparasites feed/live within their host (tapeworms)
  - Ectoparasites feed/live on their host (ticks)



Most parasites have complex life cycles. This parasite requires two hosts and the parasite actually alters the behavior of the first (crustacean) to make it more susceptible to predation by its second host (birds).

Mutualism (+/+)

- These interactions benefit both species involved.
- Many important mutualistic relationships exist in nature. *(As a result many of these are relevant on the AP exam...know them well!)*
    - *#1. Nitrogen Fixation (bacteria and plants-legumes)*
    - *#2. Cellulose Digestion in Ruminants (herbivores and bacteria)*
    - *#3. Mycorrhizae (fungi and plants)*
    - *#4. Coral Reefs (algae and animals-corals)*
- Coevolution is often times the mechanism that generating these relationships.
- *Obligate mutualism*: at least one species has lost the ability to live with out its partner
- *Facultative mutualism*: both species can survive with out its partner

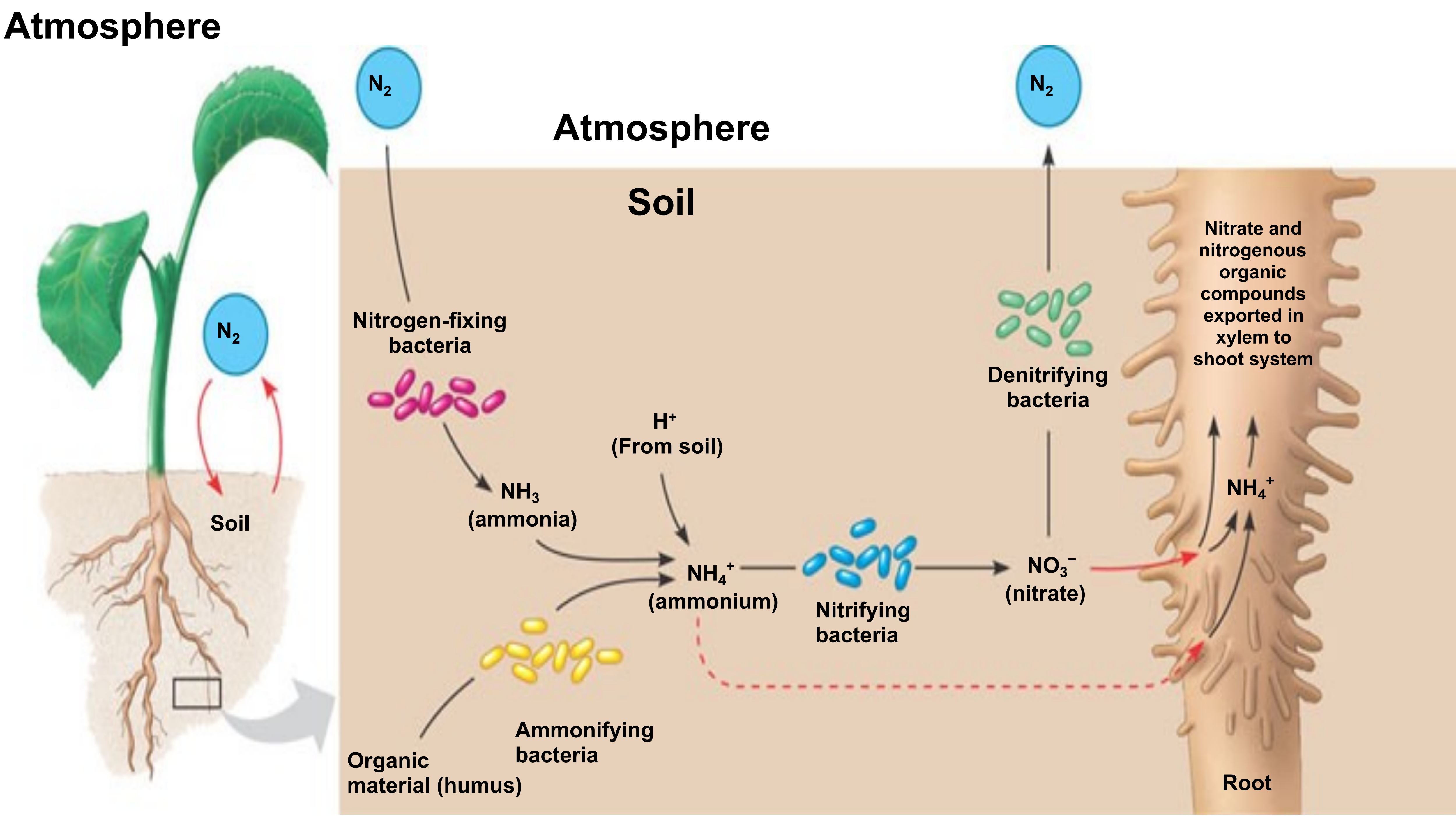
#1. Nitrogen Fixation (bacteria and plants-legumes)

An Introduction

- Atmospheric nitrogen is abundant however it is biologically unavailable. Most organisms are unable to break the triple covalent bonds between nitrogen atoms.
- It is imperative that these bonds are broken because **"life" needs nitrogen atoms** to build amino acids and nucleotides.
- Nitrogen fixation is the conversion of atmospheric nitrogen (N_2) gas to ammonia (NH_3)...$\mathbf{N_2 + 8\ H^+ + 8\ e^- \rightarrow 2\ NH_3 + H_2}$
- This reaction requires ***nitrogenase*** the enzyme cable of fixing nitrogen gas.
- This reaction is **energetically costly**.
- The microorganisms capable of nitrogen fixation are called ***diazotrophs***
  - Cyanobacteria (blue-green algae), Azotobacteraceae, *Rhizobia, *Frankia
    - The latter two form mutualistic relationships with other species

#1. Nitrogen Fixation (bacteria and plants-legumes)

Overview

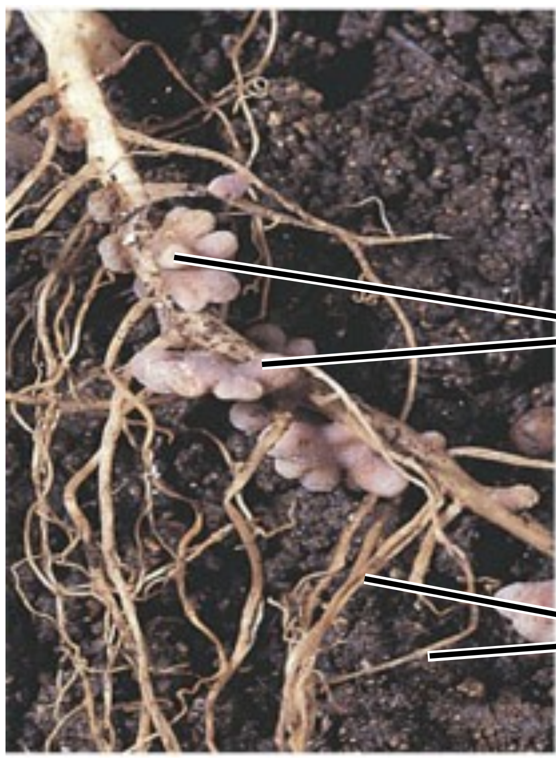


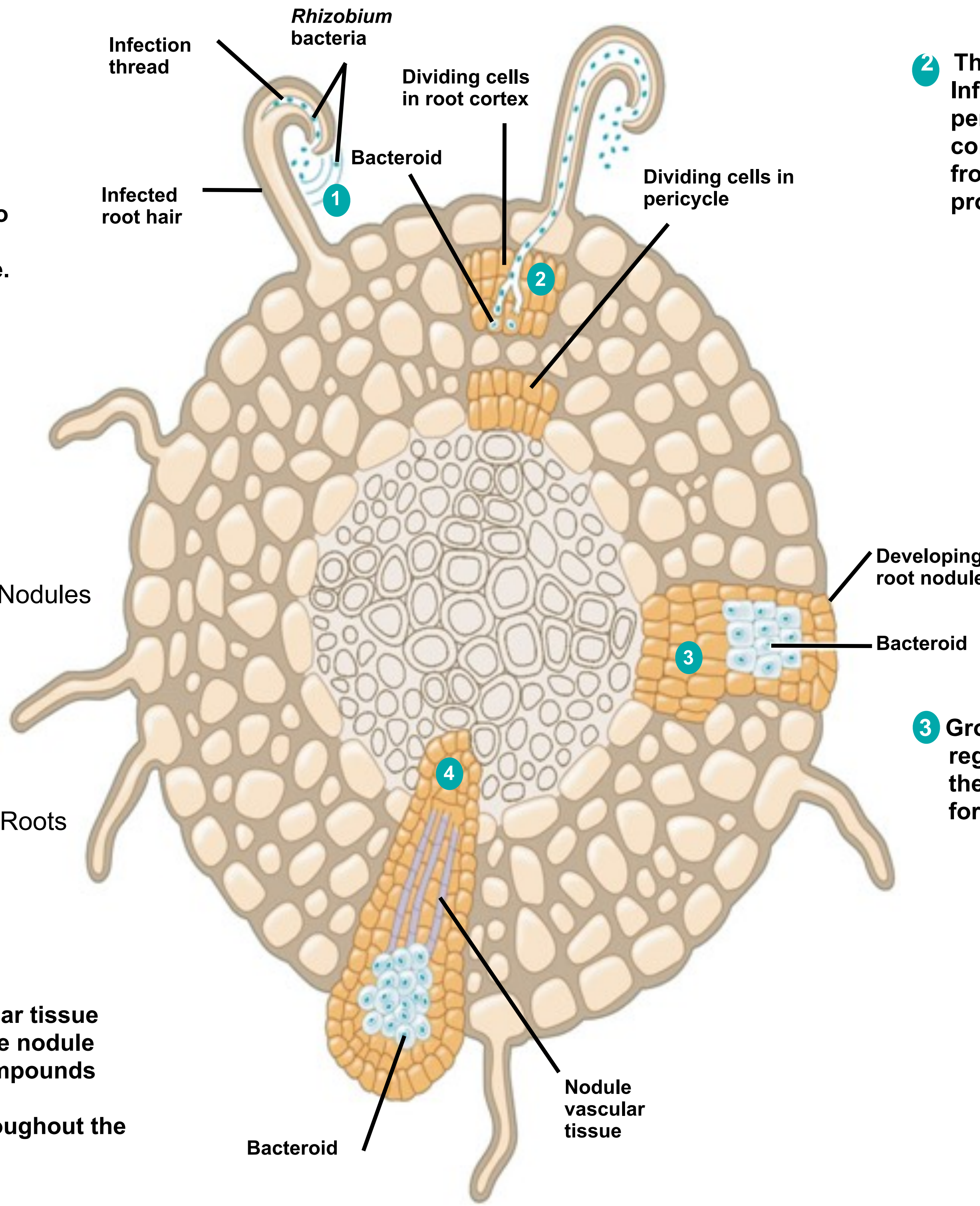
#1. Nitrogen Fixation (bacteria and plants-legumes)

Mutualism: Rhizobium & Legumes

1 Roots emit chemical signals that attract *Rhizobium* bacteria. The bacteria then emit signals that stimulate root hairs to elongate and to form an infection thread by an invagination of the plasma membrane.

2 The bacteria penetrate the cortex within the Infection thread. Cells of the cortex and pericycle begin dividing, and vesicles containing the bacteria bud into cortical cells from the branching infection thread. This process results in the formation of bacteroids.





3 Growth continues in the affected regions of the cortex and pericycle, and these two masses of dividing cells fuse, forming the nodule.

4 The nodule develops vascular tissue that supplies nutrients to the nodule and carries nitrogenous compounds into the vascular
cylinder for distribution throughout the plant.

#2. Cellulose Digestion in Ruminants (herbivores and bacteria)

Overview

- **Herbivores** have an established mutualistic relationship with **anaerobic bacteria** (some yeast and fungi as well) that lives in its digestive tract. These anaerobic bacteria possess the enzyme *celulase* necessary to chemically digest cellulose

- **Termites** have an established mutualistic relationship with a **protist** (some yeast and fungi as well) that lives in its digestive tract. These protists possess the enzyme *cellulase* necessary to chemically digest cellulose.

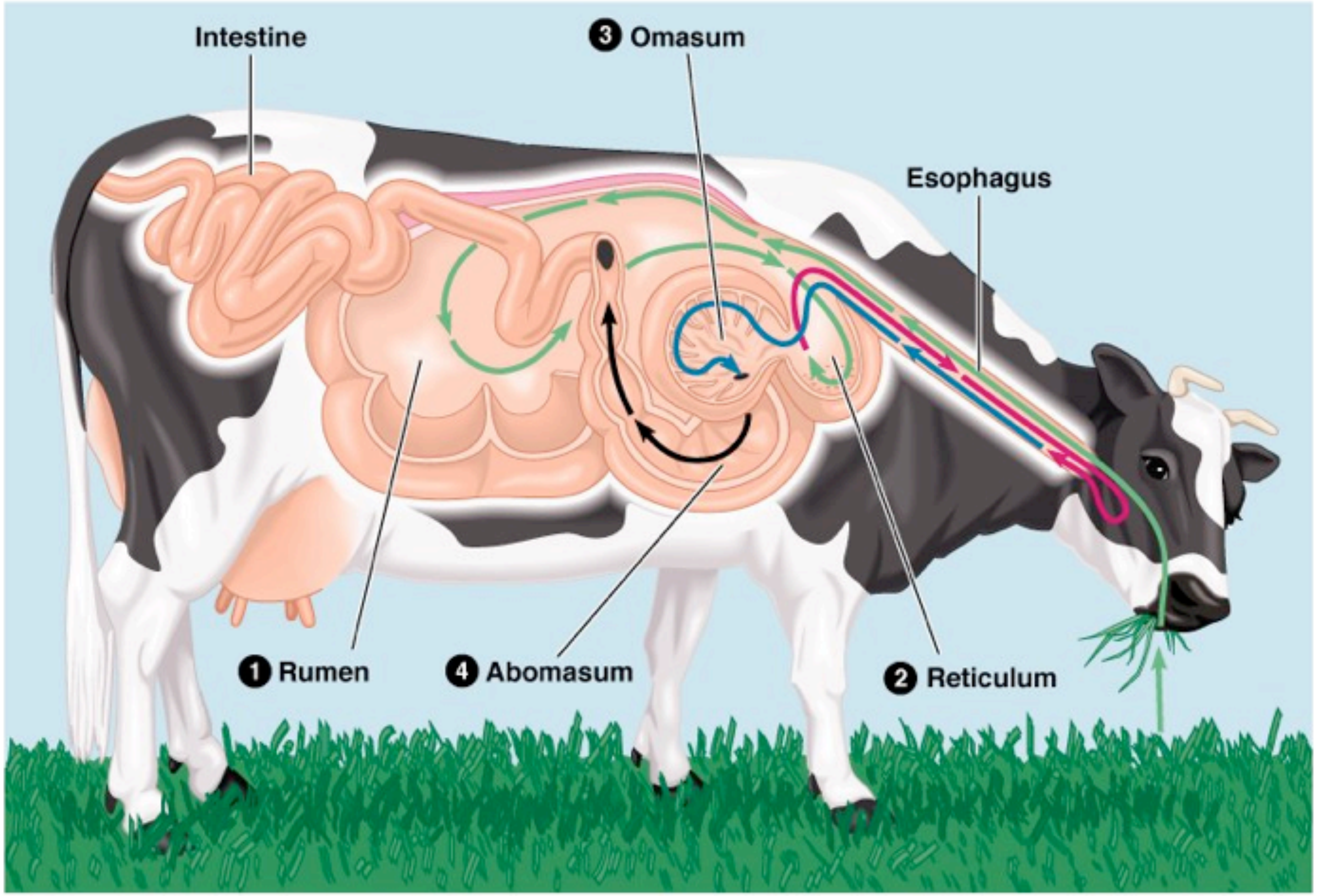
- Many animals, like humans can not digest cellulose which will as a result simply pass through our digestive tracts. This is what we call fiber and diets high in fiber may reduce the risk of colon cancers.

- In Abrahamic religions, a distinction between clean and unclean animals approximately falls according to whether the animal ruminates. The Law of Moses in the Bible allowed only the eating of animals that had cloven hooves and "that chew the cud", a stipulation preserved to this day in the Jewish laws of Kashrut. (source wikipedia)

- **The verb *to ruminate* has been extended metaphorically to mean *to ponder thoughtfully* or *to meditate* on some topic. Similarly, ideas may be *chewed on* or *digested*. *Chew the (one's) cud* is to reflect or meditate. (wikipedia)**

- **Methane has 23 times the warming potential of carbon dioxide and its production by ruminants may contribute to a greenhouse effect or climate change. Methane production by animals, principally ruminants, is estimated 15-20% global production of methane. The rumen is the major site of methane production in ruminants. (wikipedia)**

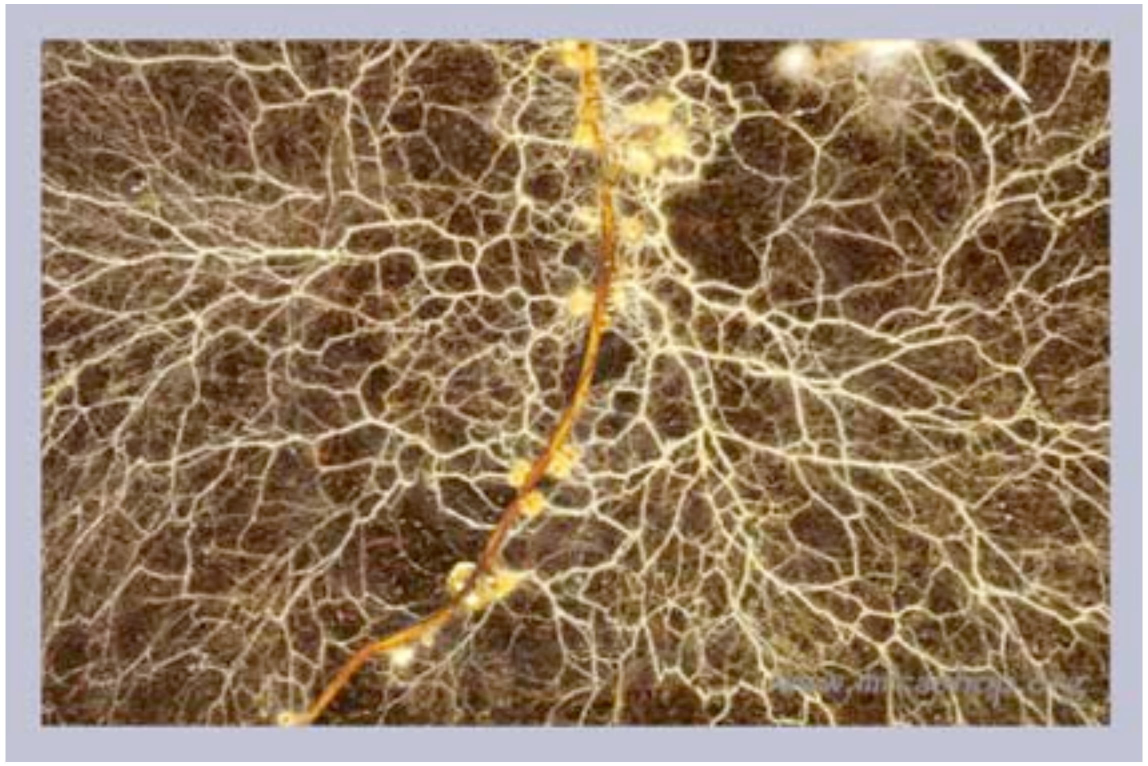
What do the microorganisms get from this relationship?



#3. *Mycorrhizae (fungi and plants)*

Overview

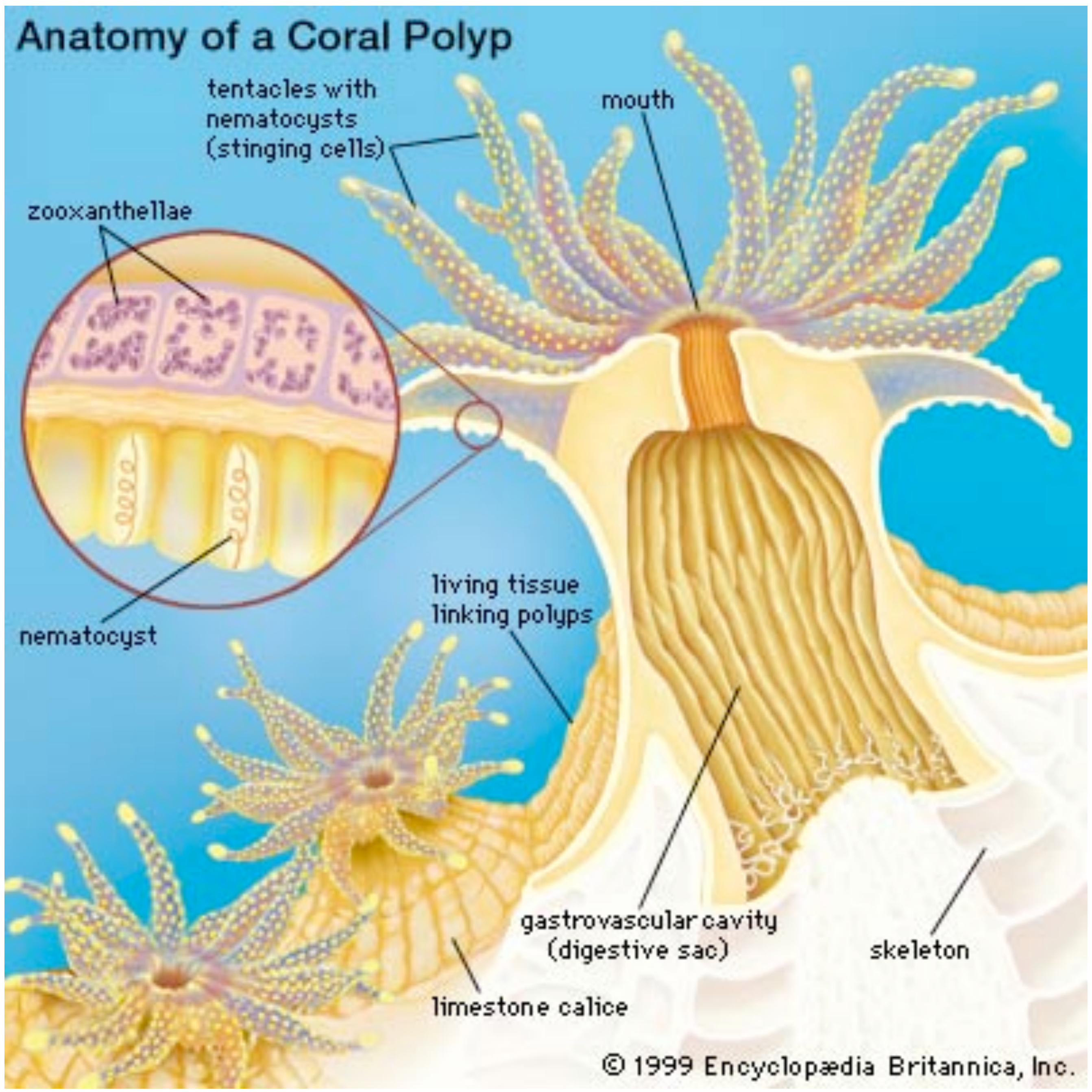
- This relationship is both *ancient* and *extensive*. Fossil evidence suggests that this relationship is over 400 million old and may have contributed to plants colonizing land. Furthermore this relationship is found in roughly 80% of all plant species.
- Plants (through photosynthesis) provide fungi a constant supply of sugar (food) while the fungi provides plants with increased water and mineral absorption (through their vast surface area and unique cell chemistry).
- Mycorrhizal plants are more resistant to disease, toxins and drought.

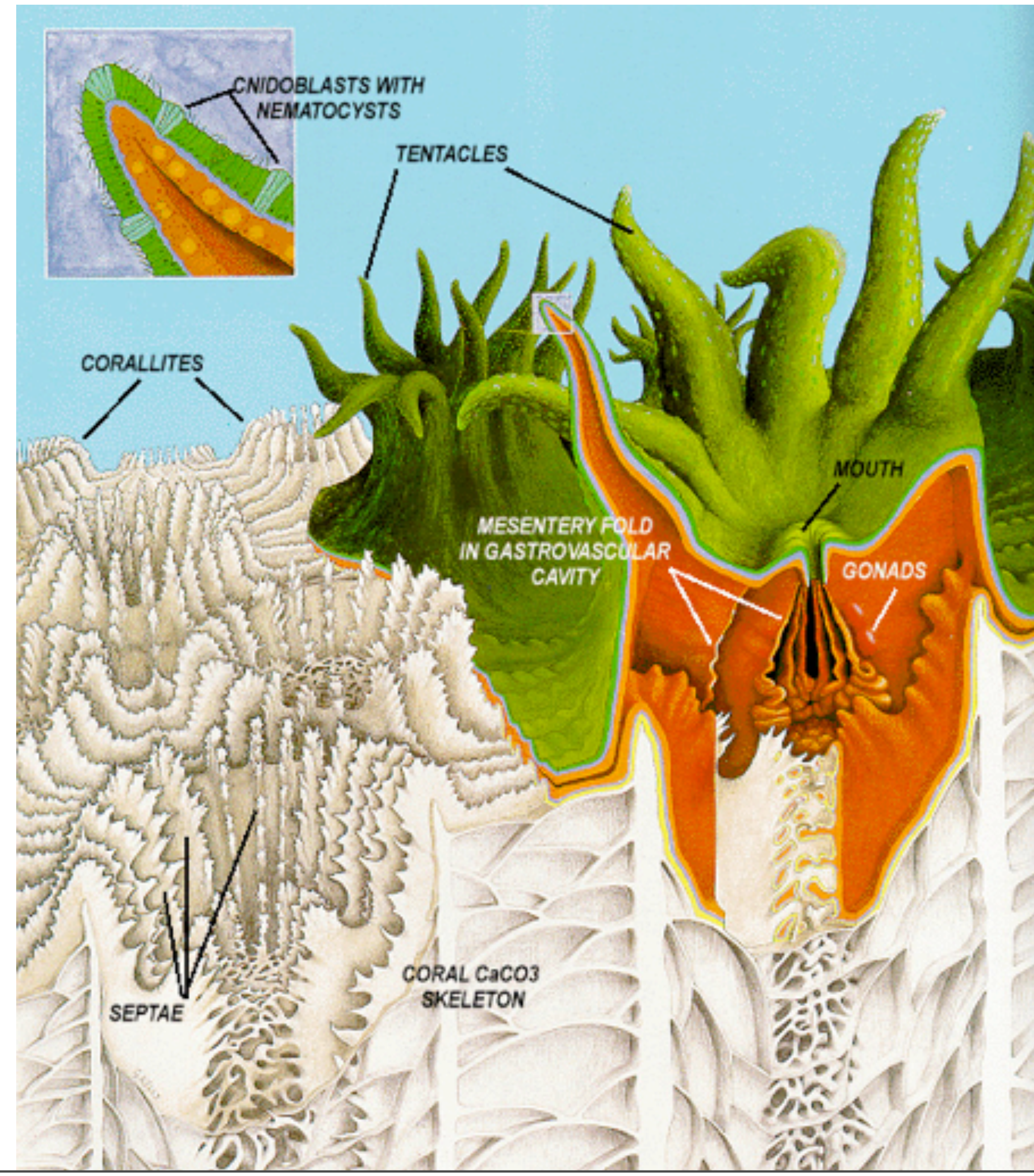


#4. Coral Reefs (algae and animals-corals)

Overview

- **Coral** (a coelenterate = a hollow bodied animal) provides shelter and inorganic nutrients to the **Algae (zooxanthellae)** provides sugars through photosynthesis.





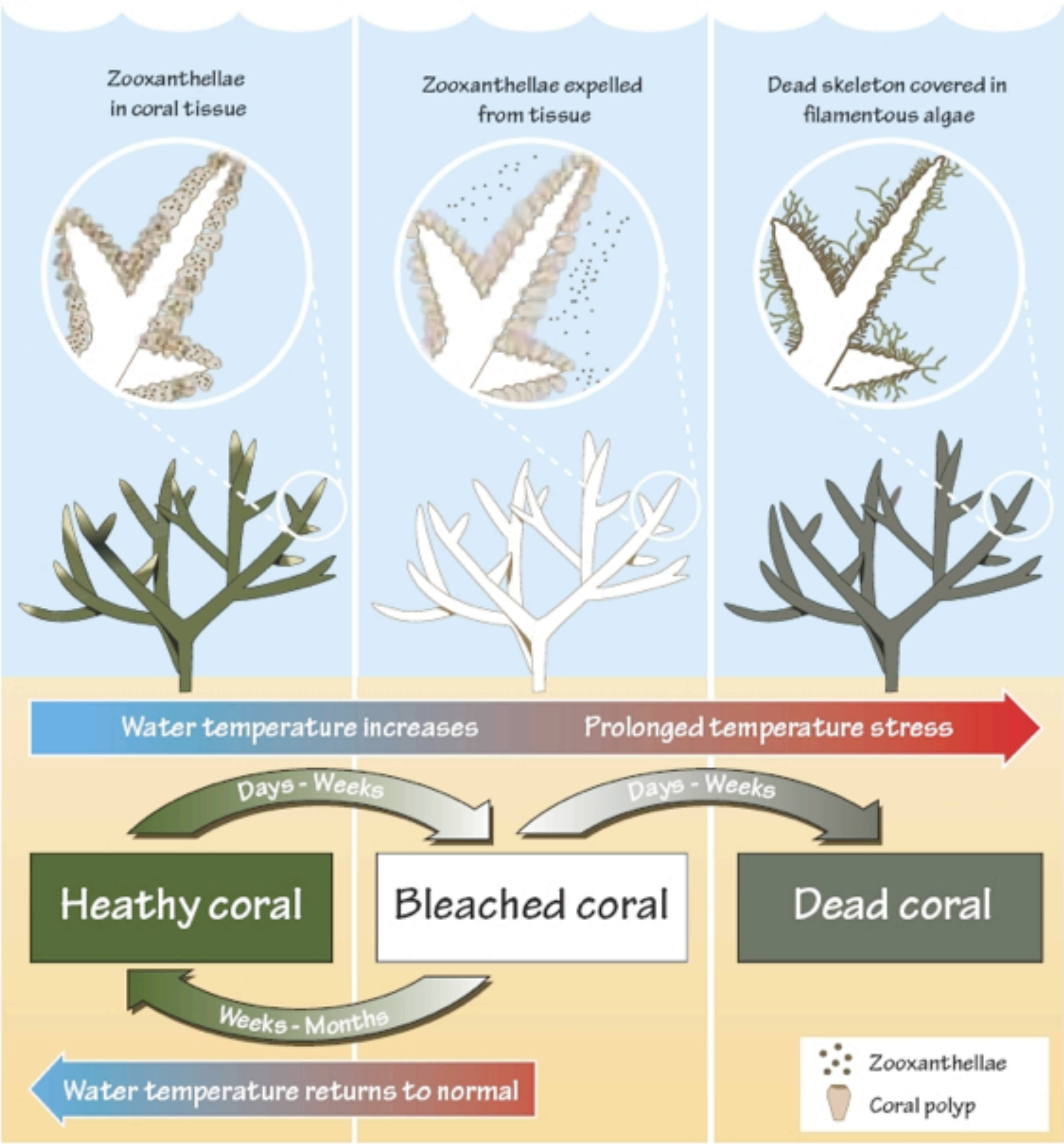
- **Coral bleaching** occurs when the coral expels the algae as a result of environmental stress.

- The algae's photosynthetic pigments (or protozoan) give coral reefs their color when they are expelled all that remains is the light colored inorganic compounds.

Healthy coral

Bleached coral

Dead coral



3. Commensalism (0/+)

- These interactions benefit one species and the other is effected no way positive or negative. Some argue that this can not exist, that all interactions have some effect no matter how small.
  - ex. barnacles on whales, algae on turtle shells

What do you think? Can argue both ways?

On your own checkout the story of the Honey Badgers & Honey Guides. As well as the relationship between the Acacia and Ants

E. Facilitation (+/+) or (0/+)

- Occurs where the survival and reproduction of one species is dependent on another even though they are not in direct contact of a symbiosis.
    - *common in plant ecology, where one species alters the soil composition thereby effecting what other species can or can not live in those conditions.*

Abiotic Factors

Primary Production in Aquatic Ecosystems

Light Limitations

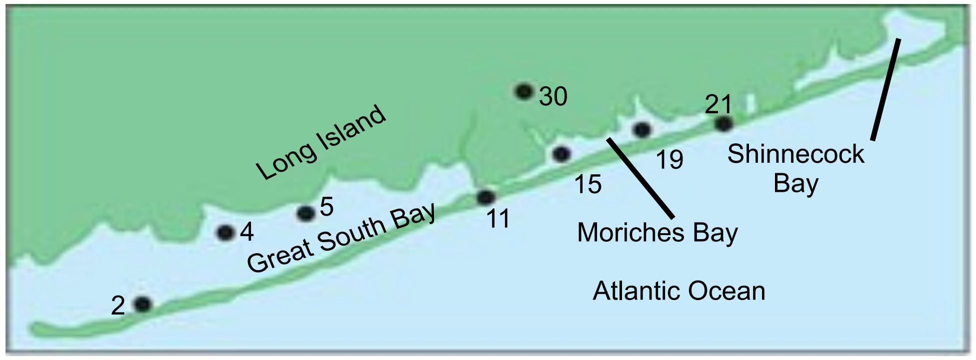
- Light is the obvious choice as limiting factor.
- After all more than half of the solar radiation is absorbed in the first 15 meters of water.
- *Light is very important however it does not appear to be the key limiting factor in aquatic ecosystems!*

Assuming that light was the key limiting factor scientists predicted a gradient in production from the poles to the equator. Would the production gradient increase or decrease as moved away from the poles? Why? Does this gradient exist?

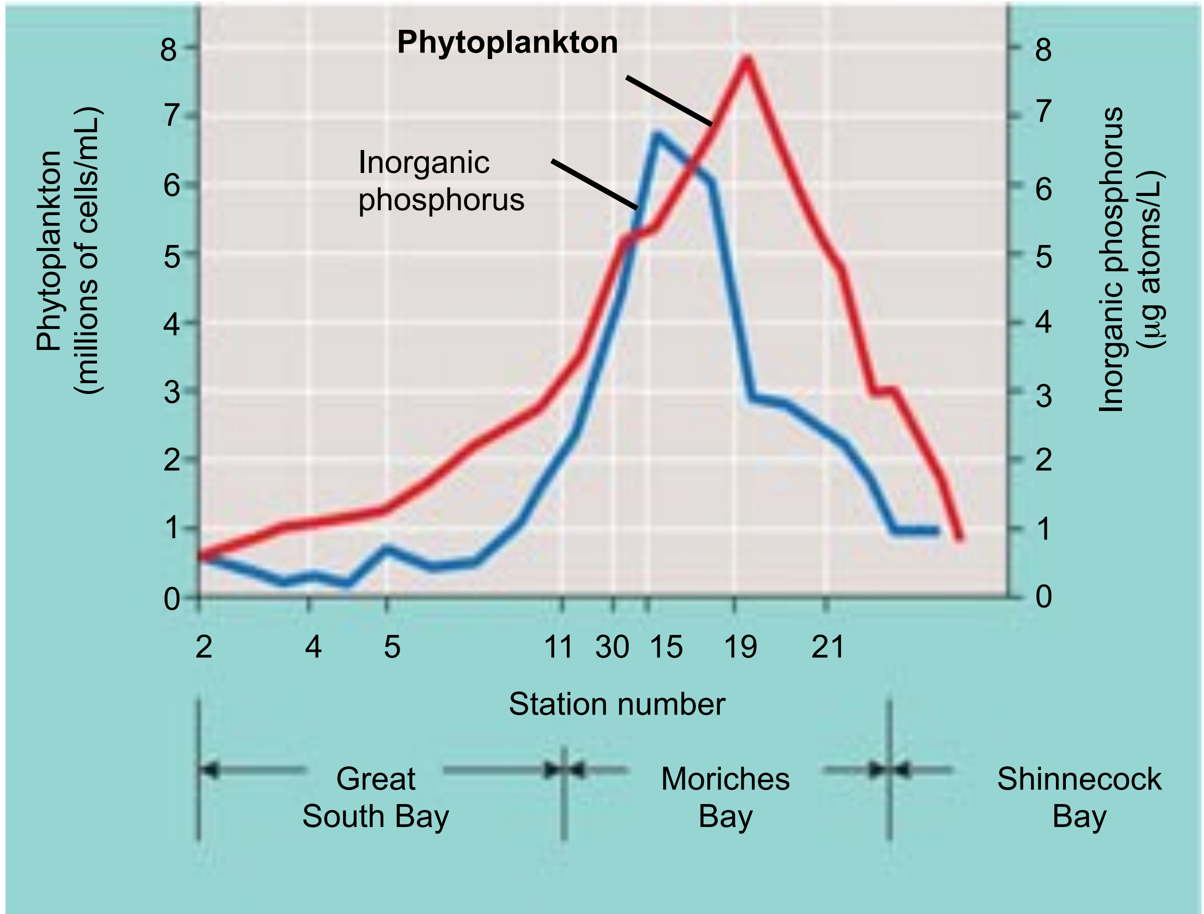
Nutrient Limitations

- *Nutrients appear to be the key limiting factor in aquatic ecosystem production!*
- The most common limited nutrients in aquatic ecosystems are the (macronutrients) nitrogen and phosphorous.
    - Nitrogen happens to be the most limited nutrient in soils as well.
- Micronutrients can be limited in aquatic ecosystems as well.
    - Iron (Fe) happens to be very important and is often limited.
    - *Further support is found in upwellings (deep nutrient rich waters that circulate to the ocean surface).*
        - *Areas of upwellings are diverse and abundant with life...they are often prime fishing locations.*
        - *The abundant nutrients provide a large base for the food webs*

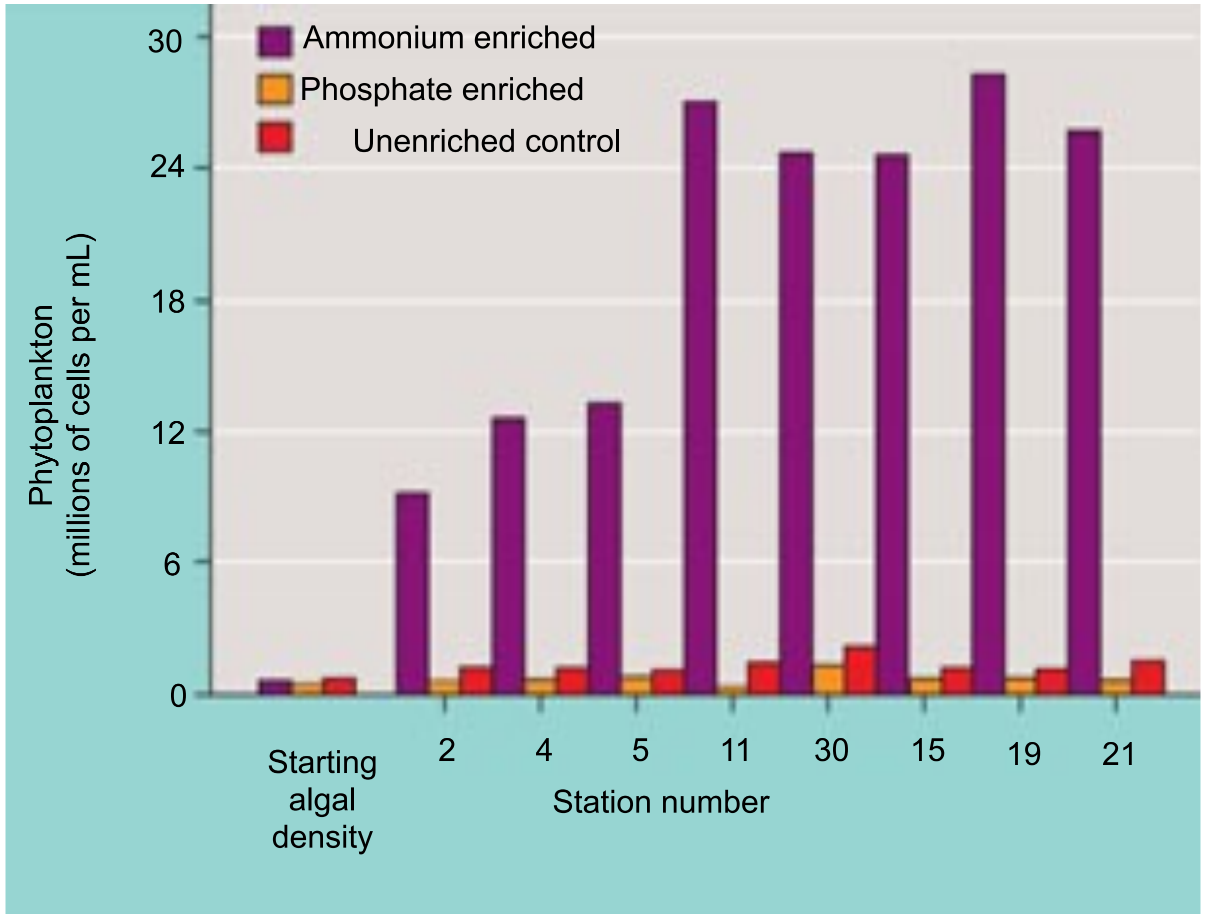
EXPERIMENT Pollution from duck farms concentrated near Moriches Bay adds both nitrogen and phosphorus to the coastal water off Long Island. Researchers cultured the phytoplankton Nannochloris atomus with water collected from several bays.



RESULTS Phytoplankton abundance parallels the abundance of phosphorus in the water (a). Nitrogen, however, is immediately taken up by algae, and no free nitrogen is measured in the coastal waters. The addition of ammonium (NH_4^+) caused heavy phytoplankton growth in bay water, but the addition of phosphate (PO_4^{3+}) did not induce



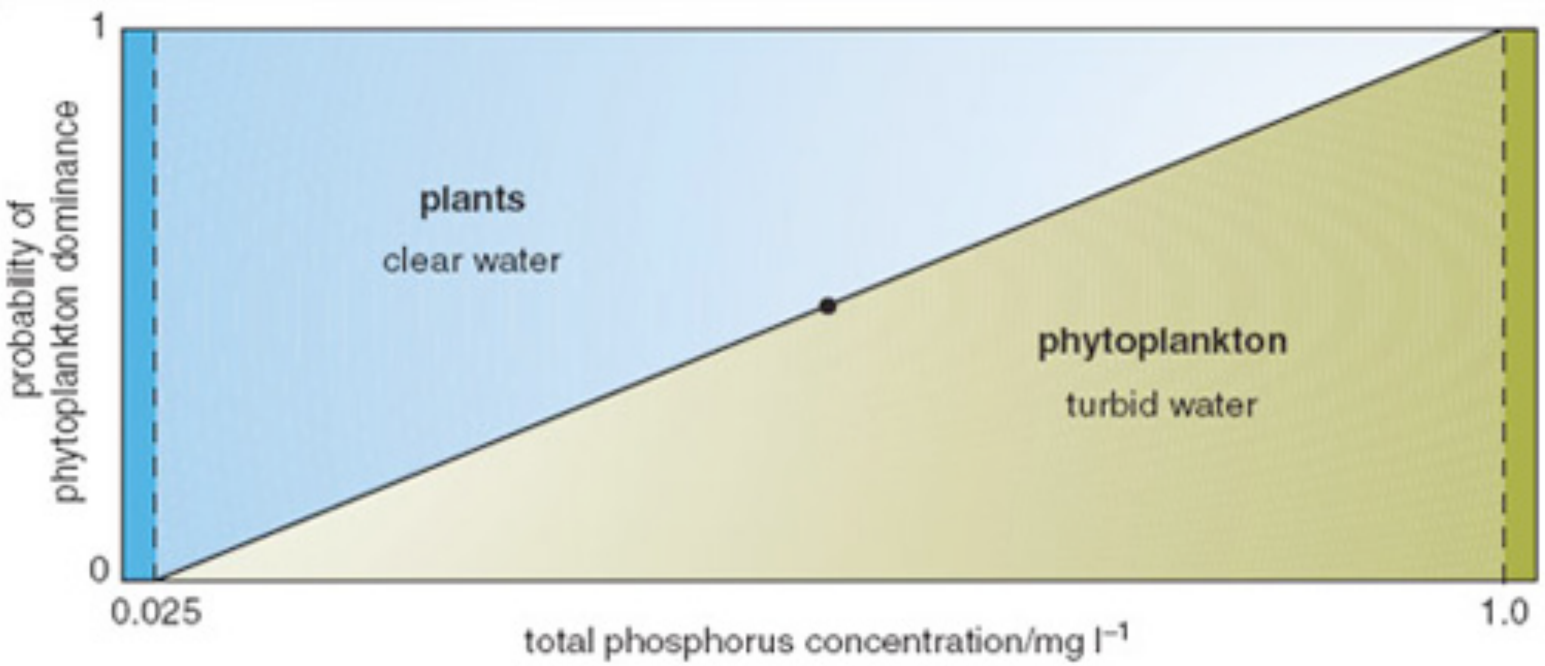
(a) Phytoplankton biomass and phosphorus concentration



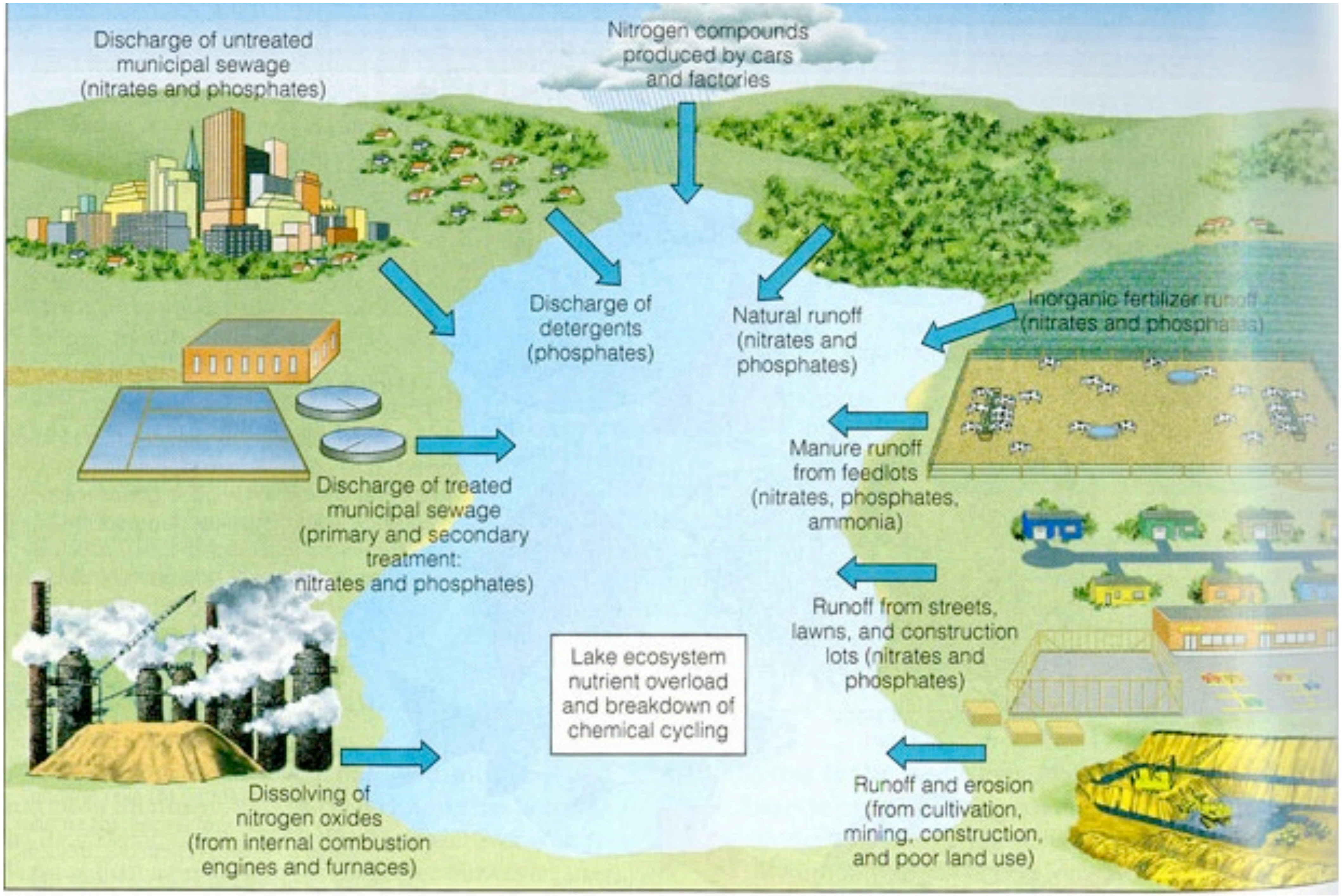
(b) Phytoplankton response to nutrient enrichment

CONCLUSION Since adding phosphorus, which was already in rich supply, had no effect on *Nannochloris* growth, whereas adding nitrogen increased algal density dramatically, researchers concluded that nitrogen was the nutrient limiting phytoplankton growth in this ecosystem.

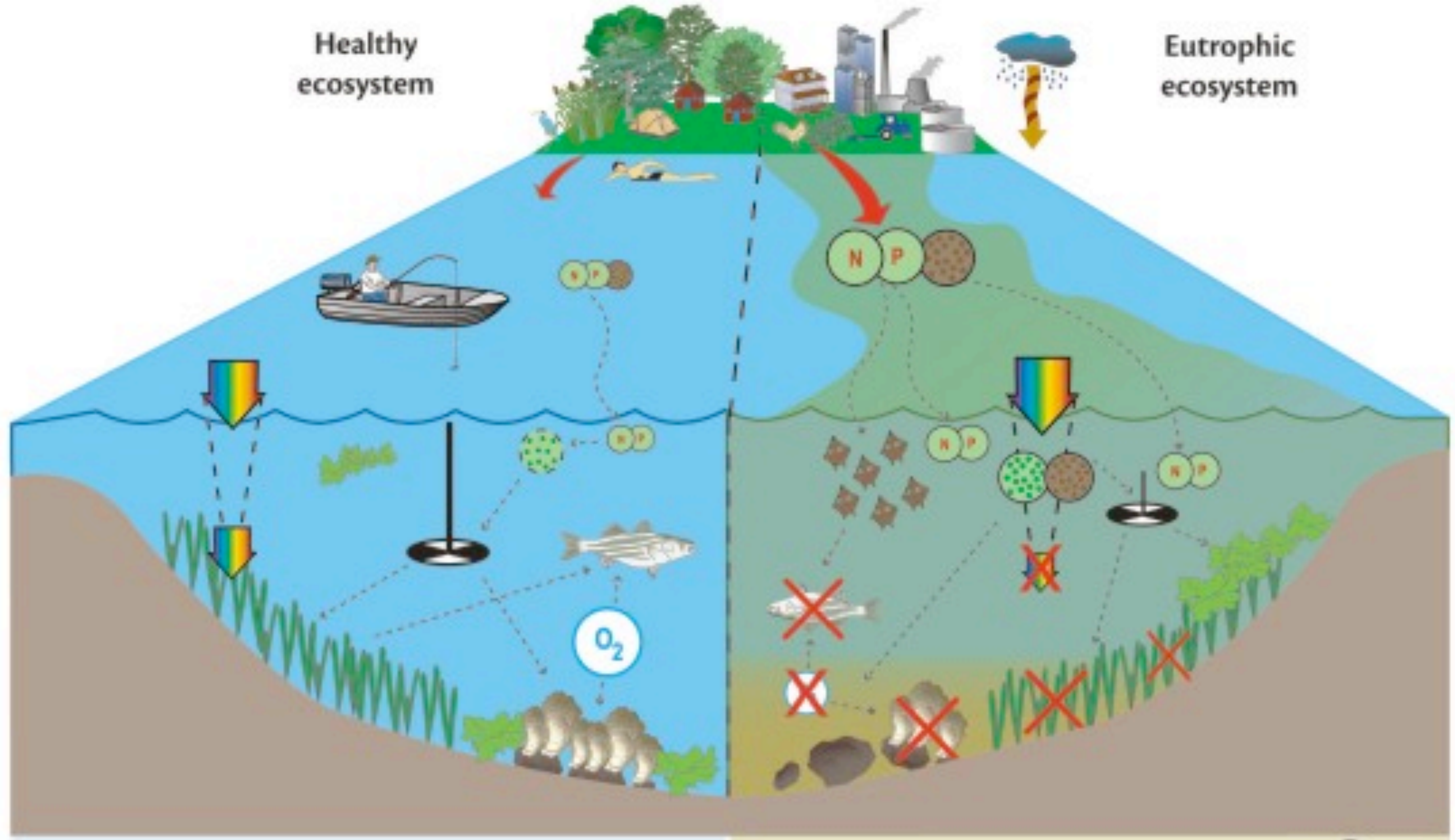
Increase in Phosphorous can cause Eutrophication



Cultural Eutrophication



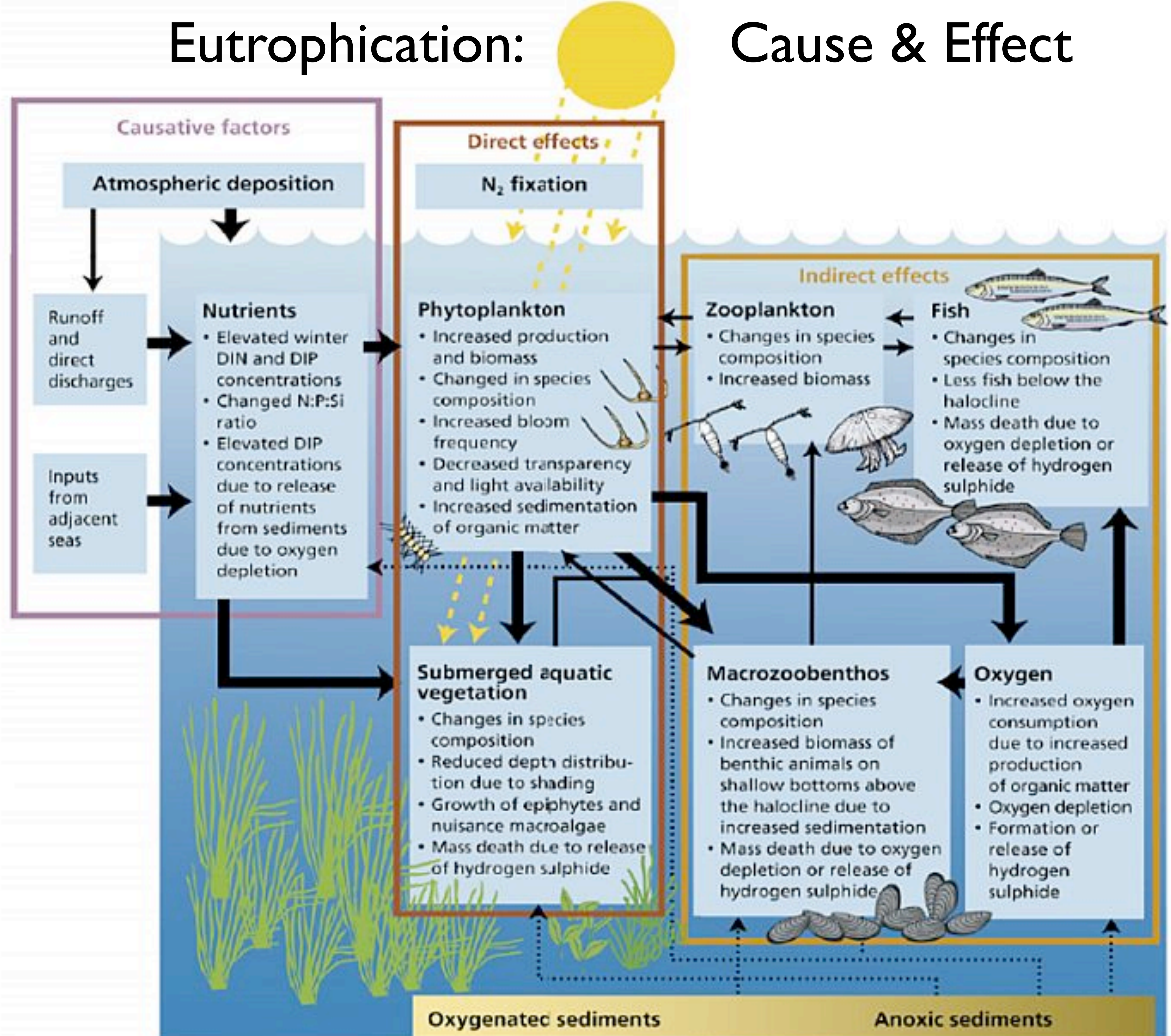
Eutrophication: Before & After



In healthy ecosystems, nutrient inputs, specifically nitrogen and phosphorus, occur at a rate that stimulates a level of macroalgal and phytoplankton (chlorophyll *a*) growth in balance with grazer biota. A low level of chlorophyll *a* in the water column helps keep water clarity high, allowing light to penetrate deep enough to reach submerged aquatic vegetation. Low levels of phytoplankton and macroalgae result in dissolved oxygen levels most suitable for healthy fish and shellfish so that humans can enjoy the benefits that a coastal environment provides.

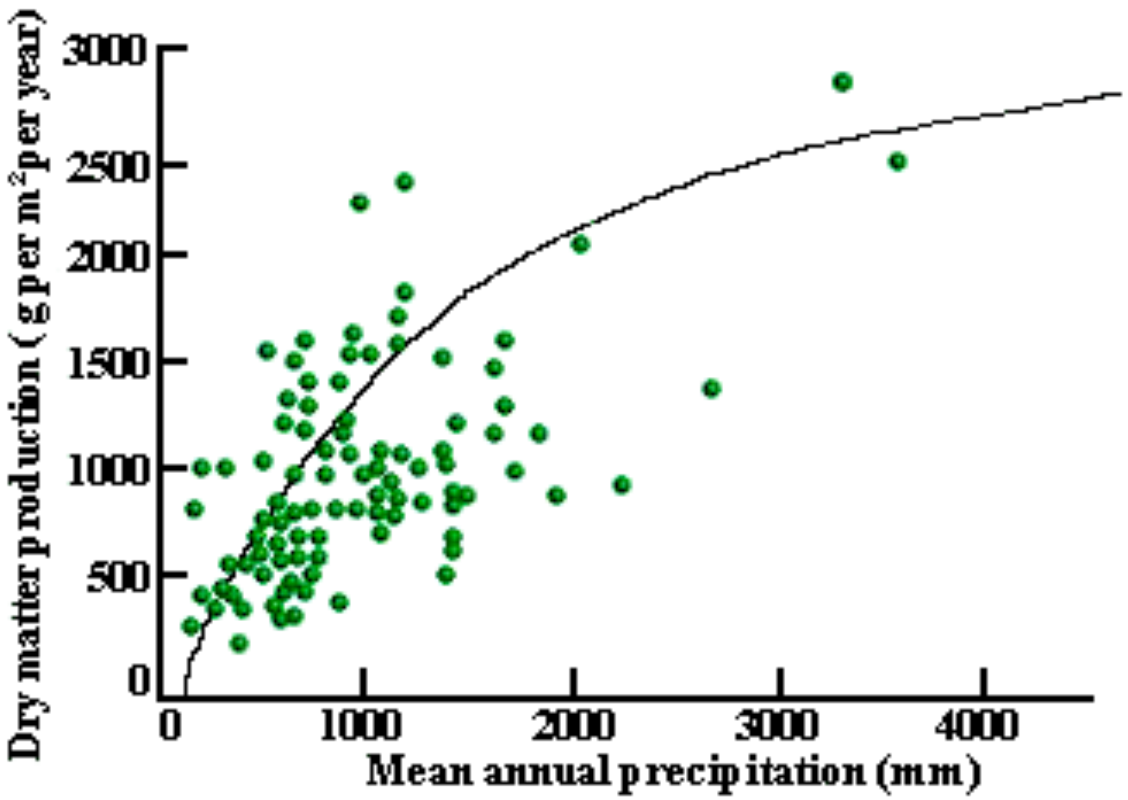
In a eutrophic ecosystem, increased sediment and nutrient loads from farming, urban development, water treatment plants, and industry, in combination with atmospheric nitrogen, help trigger both macroalgae and phytoplankton (chlorophyll *a*) blooms, exceeding the capacity of grazer control. These blooms can result in decreased water clarity, decreased light penetration, decreased dissolved oxygen, loss of submerged aquatic vegetation, nuisance/toxic algal blooms and the contamination or die off of fish and shellfish.

Eutrophication: Cause & Effect



Primary Production in Terrestrial Ecosystems

- **Water** and **Temperature** are the key limiting factors.
- In fact precipitation is a useful tool for predicting productivity because there is such a strong correlation between the two.
  - Actual evapotranspiration is a second useful tool used to predict terrestrial productivity



Where did we see this graph before?

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.

c. The stability of populations, communities and ecosystems is affected by interactions with biotic and abiotic factors. [See also 4.A.5, 4.A.6]

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Availability of nesting materials and sites

-Water and nutrient availability

-Food chains and food webs

-Algal blooms

-Species diversity

-Population density

✘ No specific example is required for teaching the above concepts.

Population Level

REGULATION OF POPULATION GROWTH

- As it turns many factors that regulate population size are in fact *density dependent*.
- Understanding these factors can have practical applications
  - preventing extinctions, managing endangered species, managing pests

Population Change Over Time

- *Once again will simplify matters by ignoring immigration and emigration or assume they cancel each other out!*
- A factor that does not effect birth rates and death rates as the population becomes more dense is said to be *density independent.*
- Should birth rates and death rates change as population size change then those factors are said to be *density dependent.*

Density Dependent Population Regulation

**Negative Feedback regulates population growth. Without this mechanism populations would continually grow, exceed their carrying capacity and crash. (*negative feedback is a common and important theme in biology, you must understand it completely)*

- ***Density Dependent Factors.***
  - Competition
  - Predation
  - Disease
  - Territoriality
  - Toxic Waste
  - Intrinsic Factors

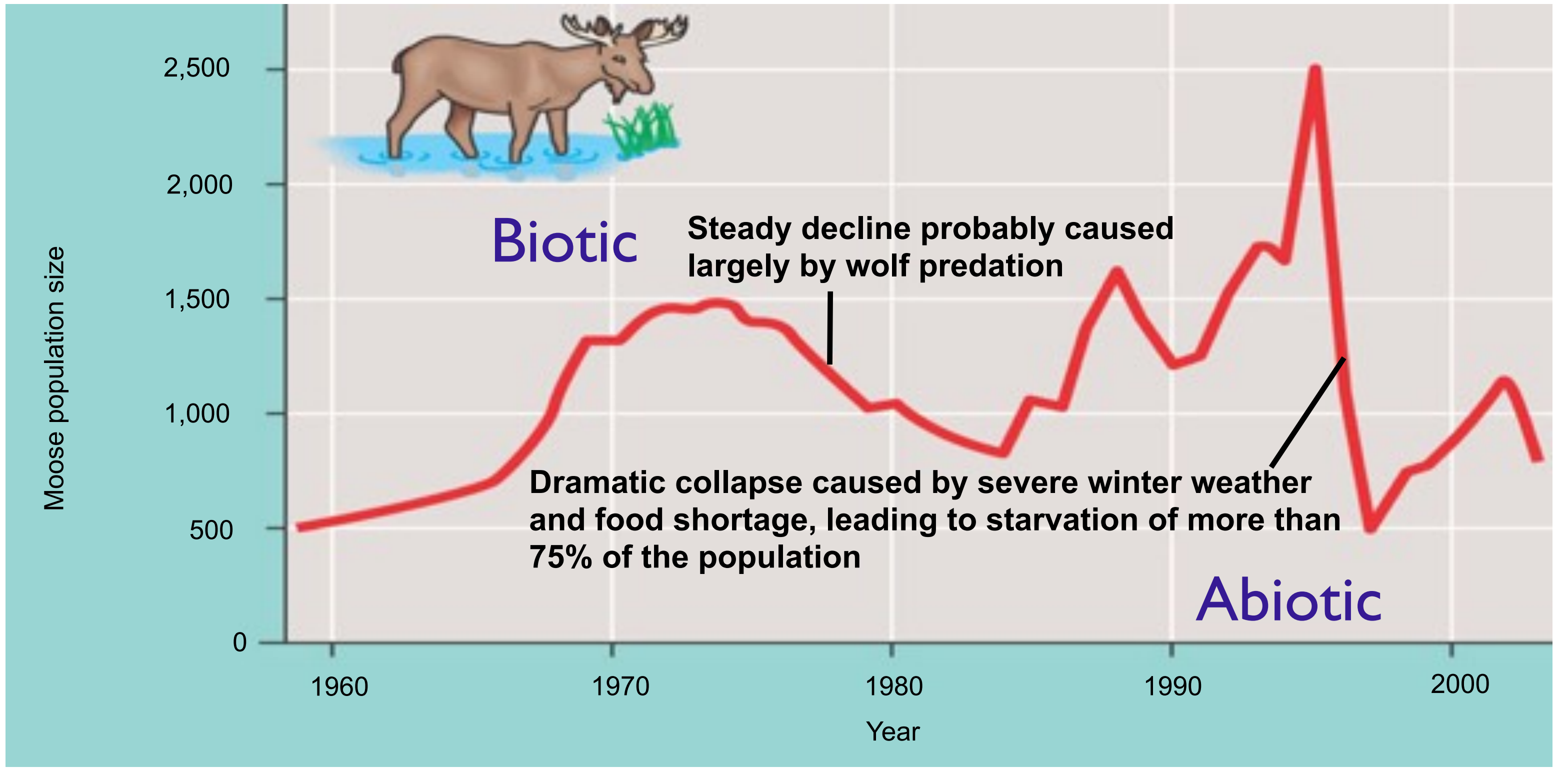
Propose how each of these might regulate population growth as density increases. Can you provide examples?

Population Dynamics

Regardless the mechanism most populations fluctuate to some extent or another. The reasons may be complex and often involve both biotic and abiotic factors.

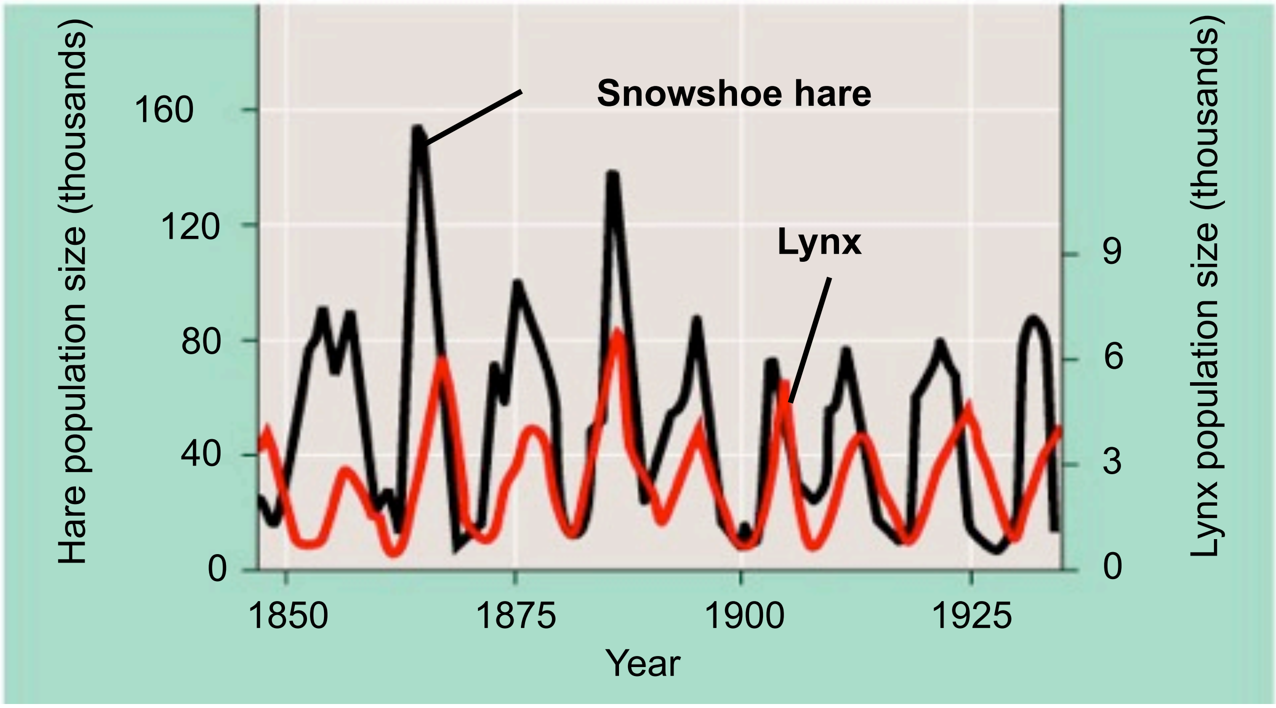
Stability and Fluctuation

- Biotic & Abiotic Factors.
  - ↓harsh weather, ↓parasites, ↓↑ food availability, etc.



Population Cycles

- 10 year cycling pattern in snowshoe hares...Why?
- 3 Hypotheses
  - *if* food shortages...
  - *if* predation...
  - *if* sunspot activity...
  - *and...*_______________
  - *then...*_______________
  - *and or but...*_____________
  - *therefore...*________________



Can you fill in the blanks?

- The sunspot hypothesis is an interesting and remarkable idea.
- Apparently when sunspot activity is low...
- slightly less atmospheric ozone is produced...
- less ozone means more UV radiation reaches the earth (plants)..
- plants respond by making more UV blocking chemicals...
- this results in less secondary compounds being made...
- less secondary compounds to deter herbivores...
- means the quality of food is higher for hares...
- higher quality food can support more hares
- COOL... *this reminds us how sensitive life can be to abiotic factors and further that our actions even if they slightly alter the environment may have larger consequences.*

Community Level

Community Ecology

II.

Main Idea: Diversity is important for healthy communities.

Main Idea: Each community has unique feeding relationships.

Biotic Factors

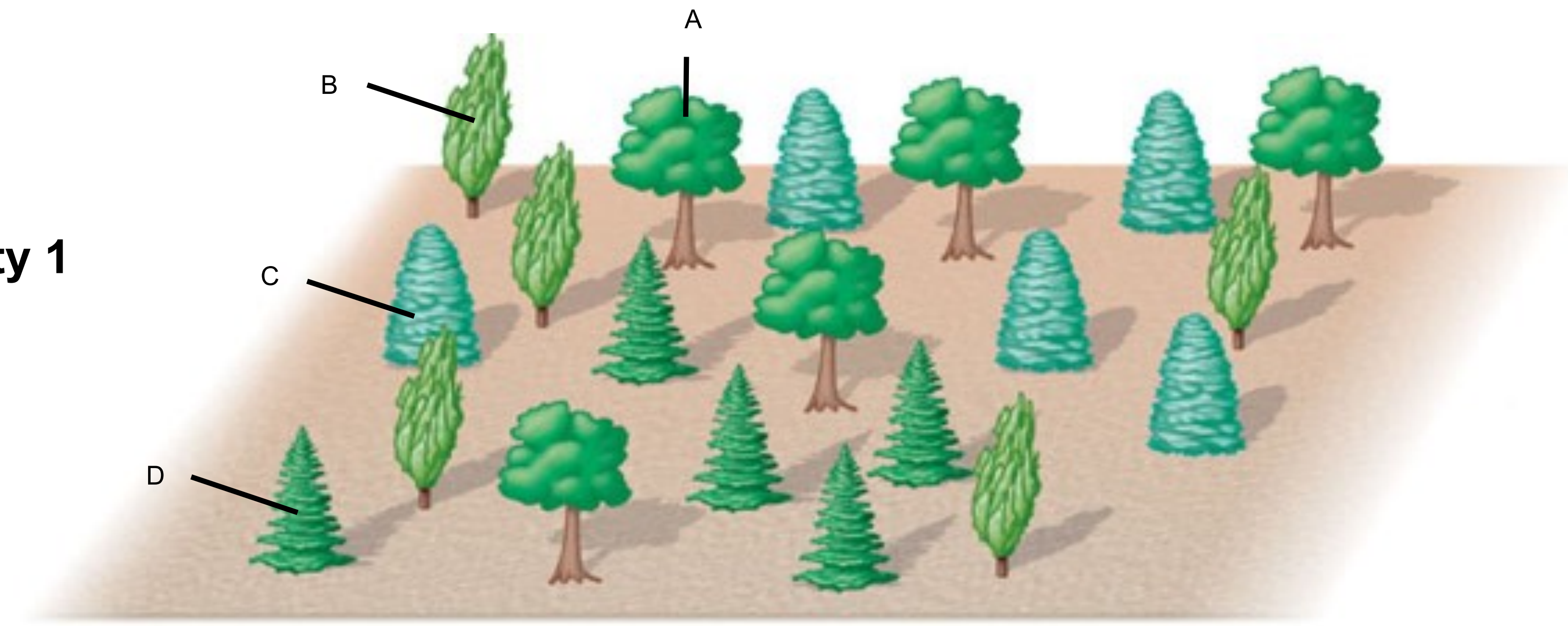
DIVERSITY & TROPHIC STRUCTURE

A. Species Diversity

- Diversity has two components
  - 1. **Richness** = number of different species
  - 2. **Relative Abundance** = the proportion that each species represents of all individuals in the community
- *Shannon Diversity (H)* is a widely used index used to calculate both richness and abundance
  - $H = -(p\text{A}\ln p\text{A} + p\text{B}\ln p\text{B} + p\text{C}\ln p\text{C} + \ldots)$
  - where: A,B,C are species, *p* is abundance, ln is natural logarithm
  - The higher the "H" the more diverse the community
  - Often times finding number and abundance can be difficult.

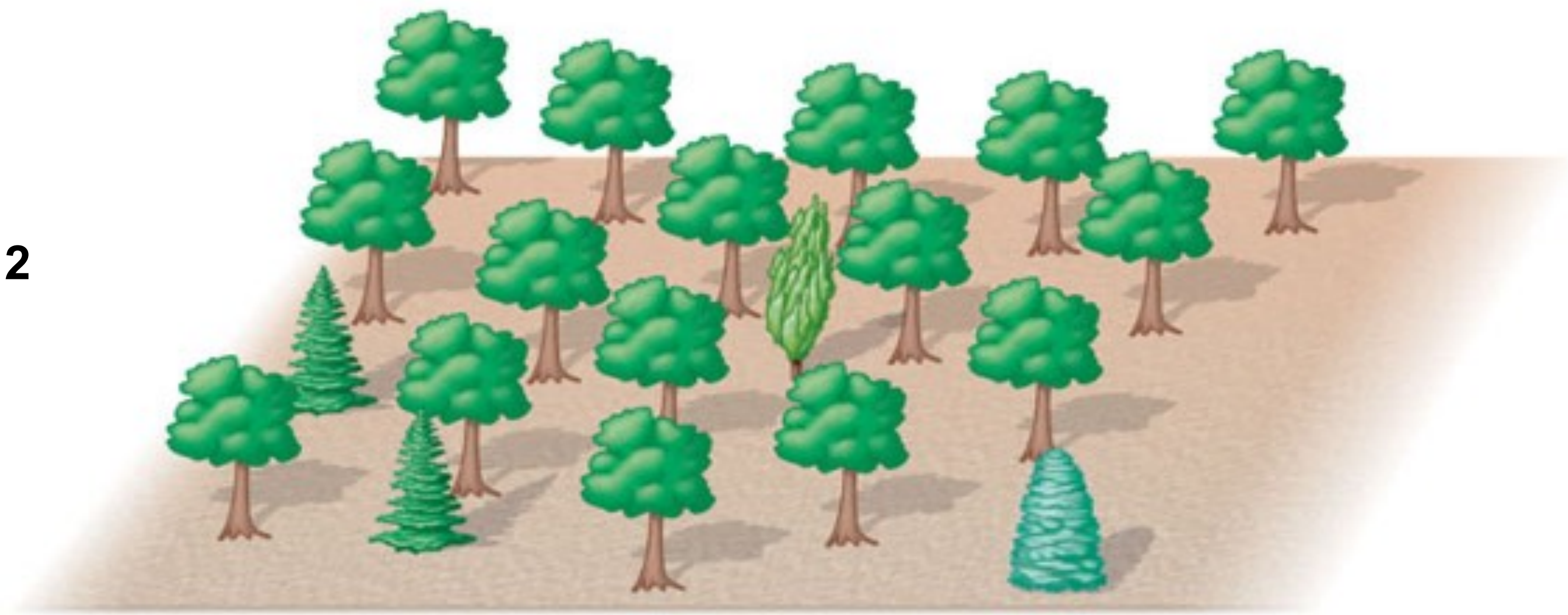
Which community below is more diverse? Use your gut.

Community 1



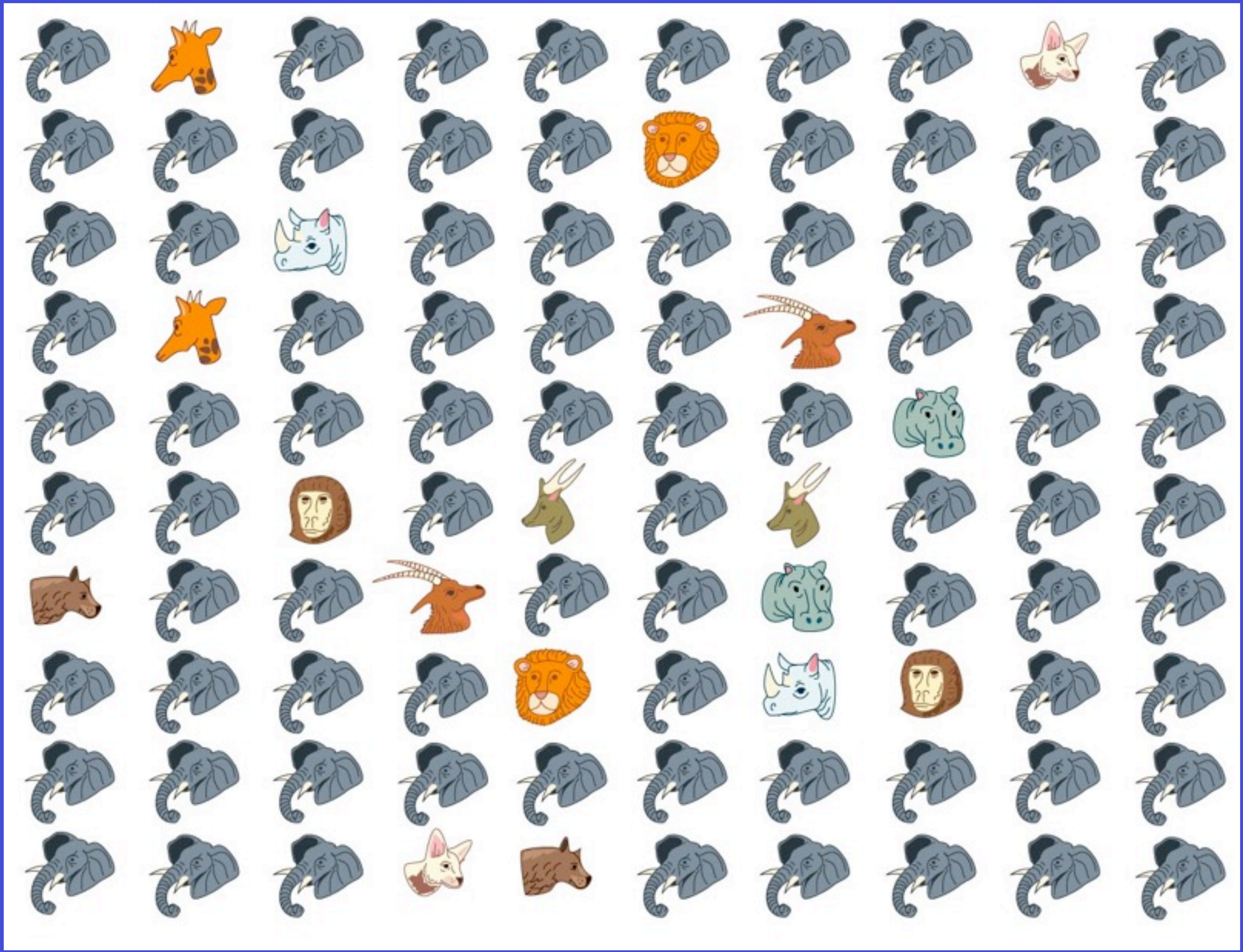
A: 25% B: 25% C: 25% D: 25%

Community 2



A: 80% B: 5% C: 5% D: 10%

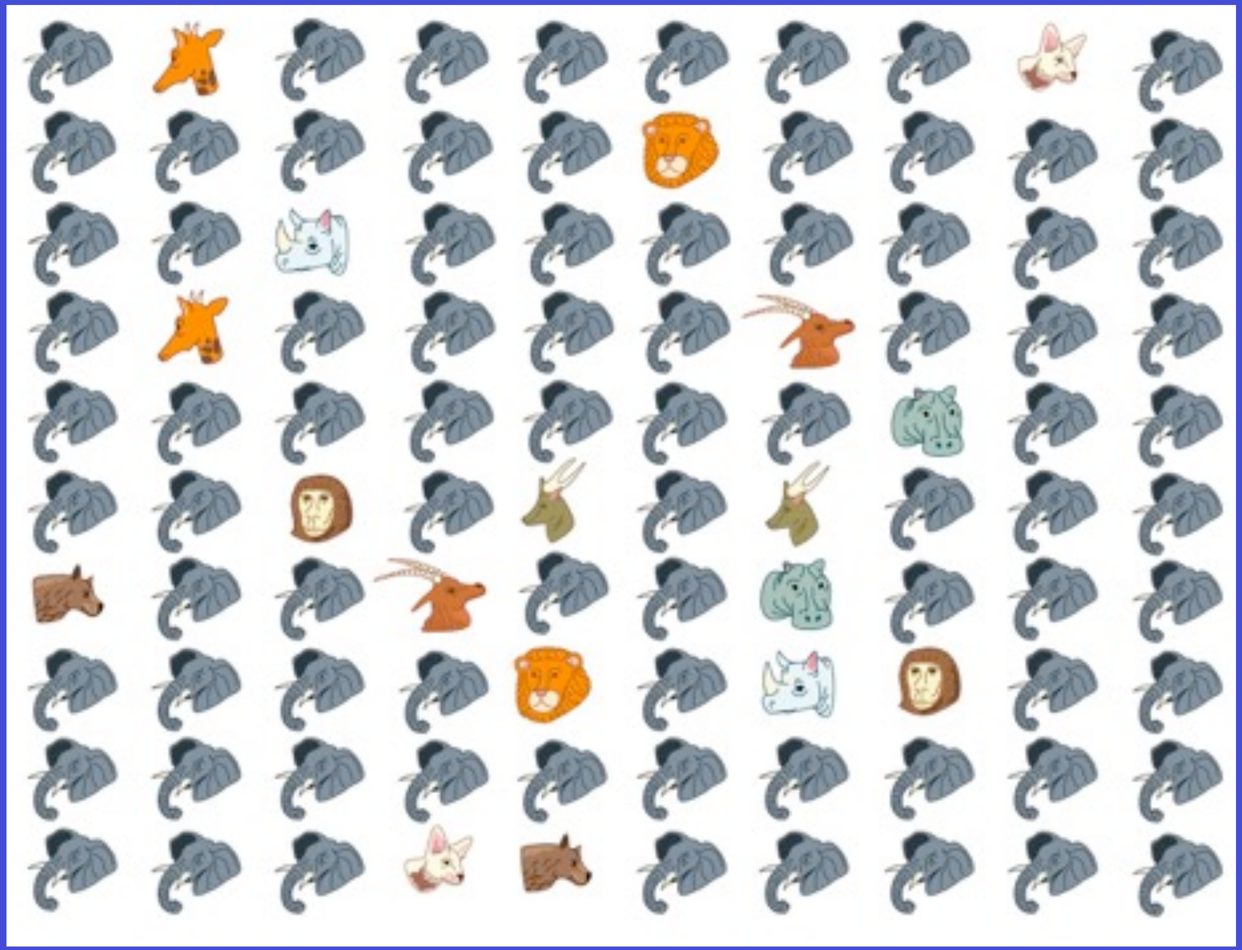
Now check your gut... Calculate the Shannon diversity.



10 species; 100 ind, 87 elephants, 9 sp w/ 2 ind each

10 species; 100 ind, 10 ind each species

Species Diversity



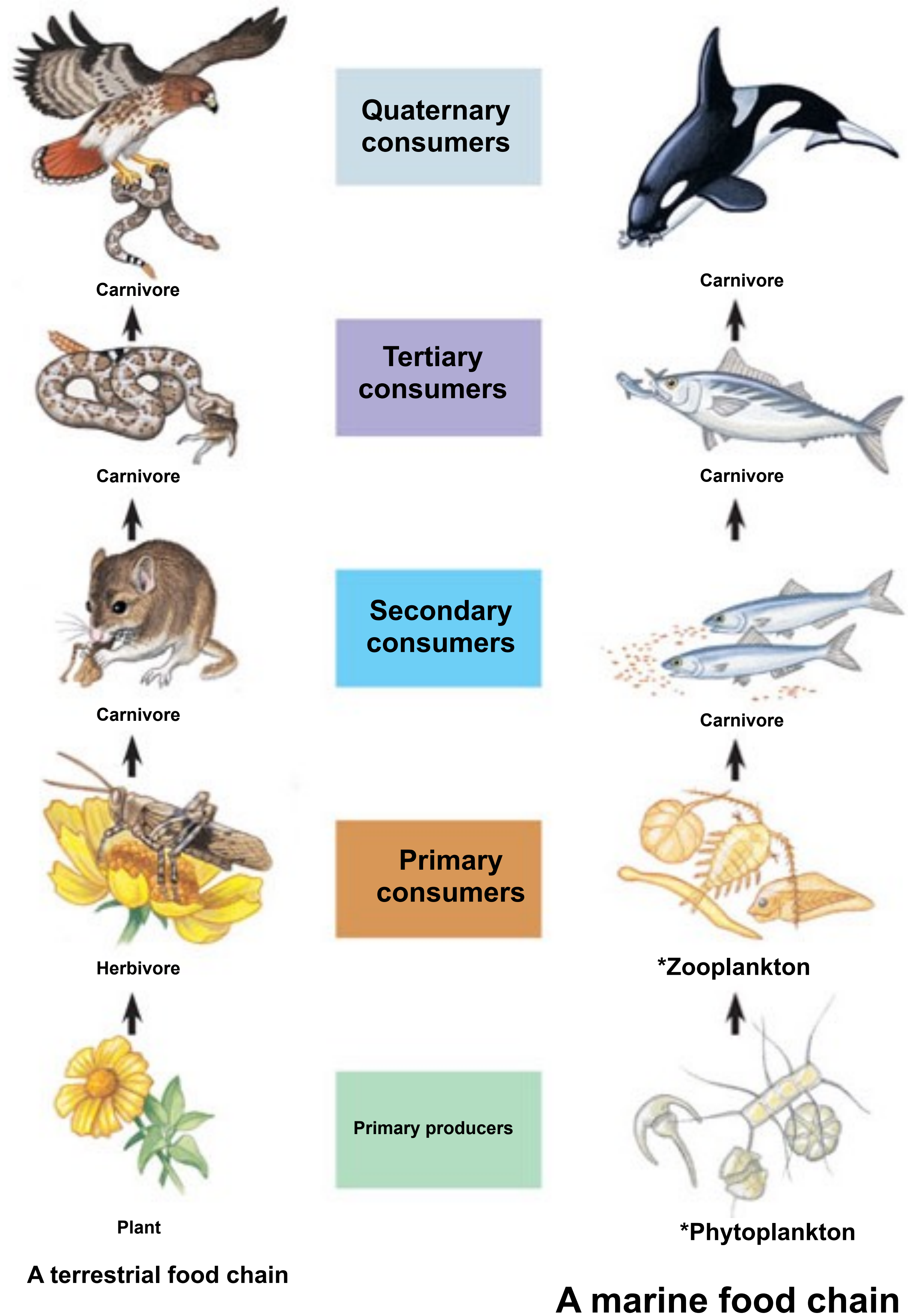
Merely counting the number of species is not enough to describe biological diversity.

Diversity & Stability

- Diversity has its benefits
  - 1. **Productive**, higher diversity communities are more productive
  - 2. **Resilient**, higher diversity communities are more stable during times of environmental stress
  - 3. **Stable**, higher diversity communities are more stable (consistent) year to year in their productivity
  - 4. **Resistant**, higher diversity communities are more resistant against *invasive species*.

Trophic Structure

- **Trophic Structure**...feeding relationships within the community.
- The movement of food energy from autotrophs through and up to the largest consumers...**food chains**.

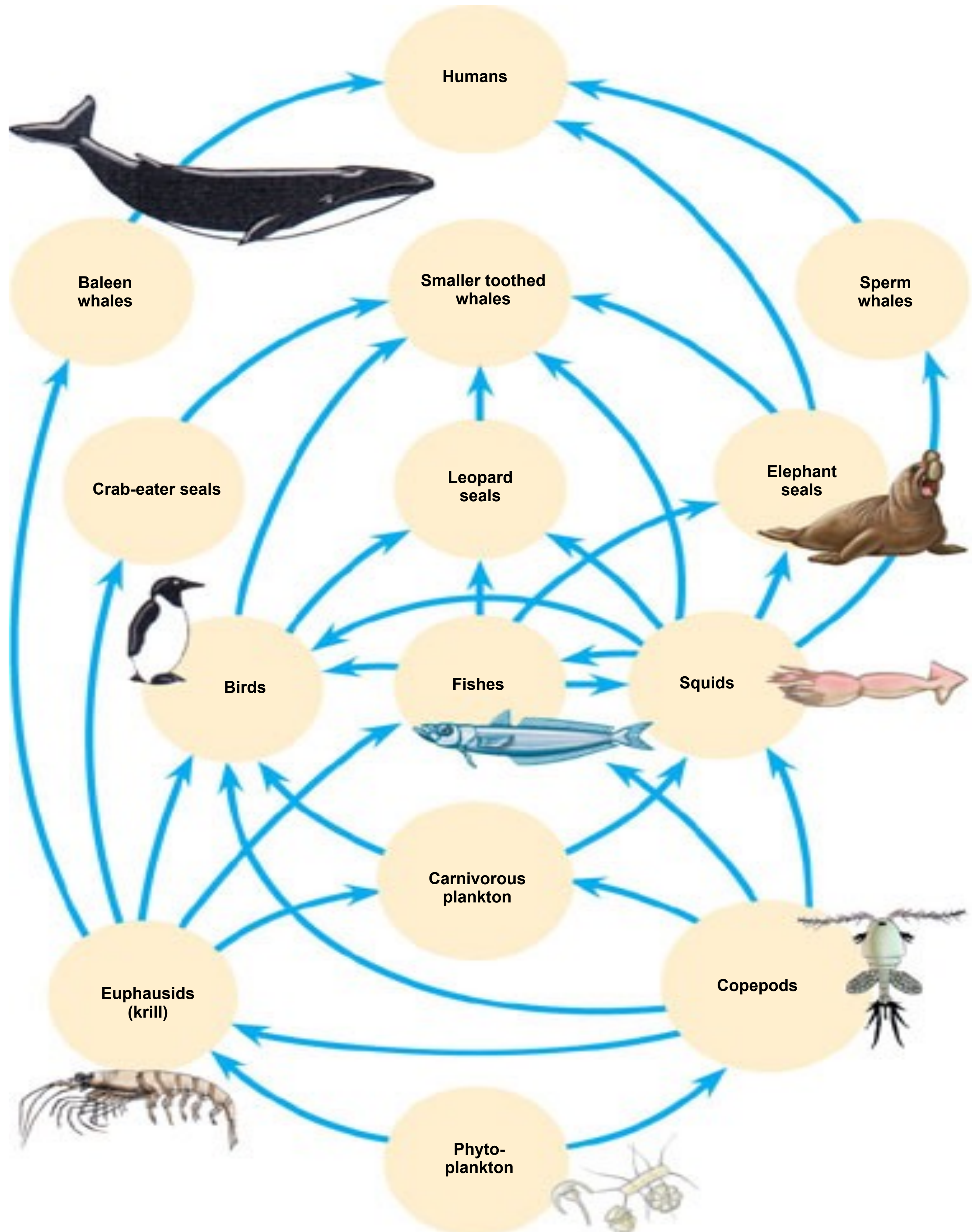


Food Chain Lengths

- Food chains are limited in their lengths.
- The two common hypotheses..
  - The *Energetic Hypothesis* states that the energy transfer one one trophic level to another is inefficient (about 10-20%) and after 3 - 5 transfers there is not enough energy to support another level.
  - The *Stability Hypothesis* states long chains are unstable, that fluctuations in lower trophic levels are magnified in the higher levels.
    - The most current data supports the *energetic hypothesis*.

Food Webs

- Interconnected and linked food chains make up **food webs**.
- The arrow points in the direction of foods movement. In other words A ⟶ B indicates that B is eating A. Many students reverse this so be careful



Could you interpret these feeding relationships IF...
1.the pics were removed?
2. the pics and names were removed?
3.What if I removed all pics, names and turned in upside down?

Dominant & Keystone Species

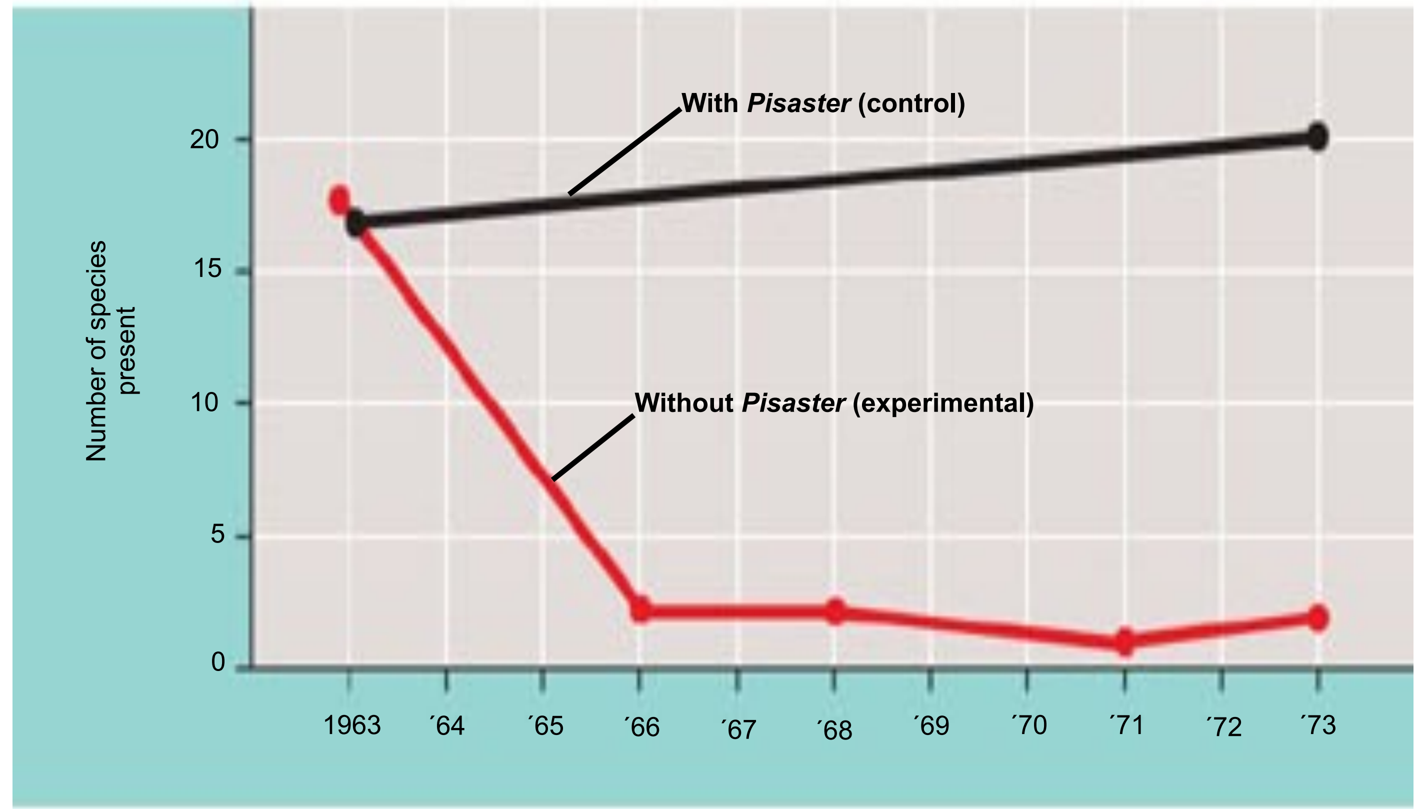
- Certain species have a proportionally larger impact in the community due to their abundance or a key role that they play in community interactions
  - 1. **Dominant Species**; are the most abundant or have the highest biomass.
    - These species often effect the occurrence and distribution of other species.
    - These species are likely dominant for one of two reasons
      - either they are *superior competitors*, that is they capture limited resources better than others OR...
      - they avoid predation and disease better than others

How could you test the effects of dominant species?

Dominant & Keystone Species

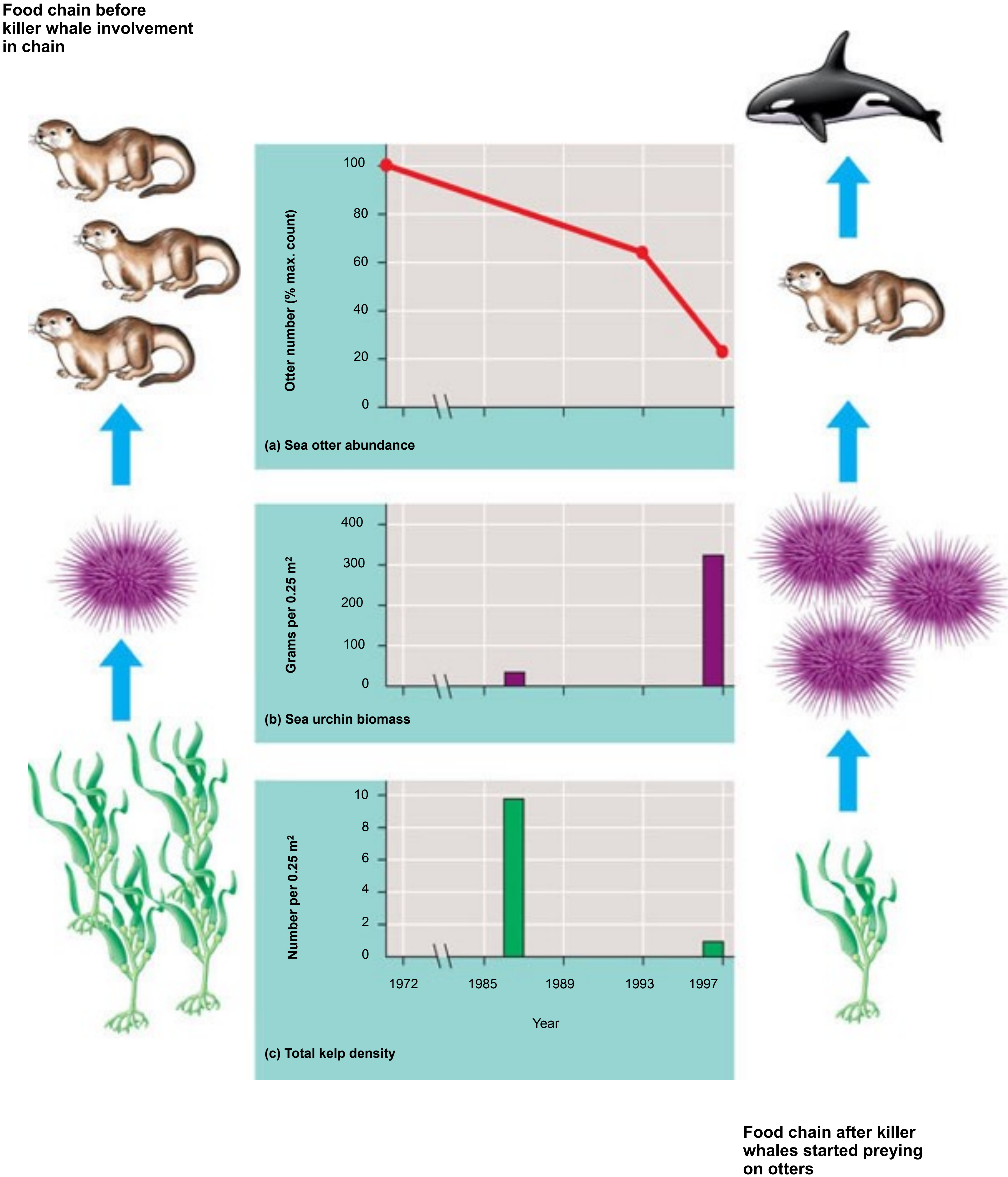
- 2. **Keystone Species**; are not the most abundant but they exert strong control on community dynamics due their unique role or niche.

(a) The sea star *Pisaster ochraceous* feeds preferentially on mussels but will consume other invertebrates.



(b) When *Pisaster* was removed from an intertidal zone, mussels eventually took over the rock face and eliminated most other invertebrates and algae. In a control area from which *Pisaster* was not removed, there was little change in species diversity.

What is a “keystone”?



Note:

- **Engineer Species**; exert strong control on community by changing the physical environment.

Community Ecology

Main Idea: Disturbances play an important role in communities.

Main Idea: Disturbances influence the diversity of species and the composition of species found in a community.

Abiotic Factors

DISTURBANCES INFLUENCE SPECIES DIVERSITY AND COMPOSITION

- **Disturbance-** an event that changes a community by removing organisms from it or altering resource availability.
  - Ex. storms, fire, floods, droughts, freezing, overgrazing, human activities

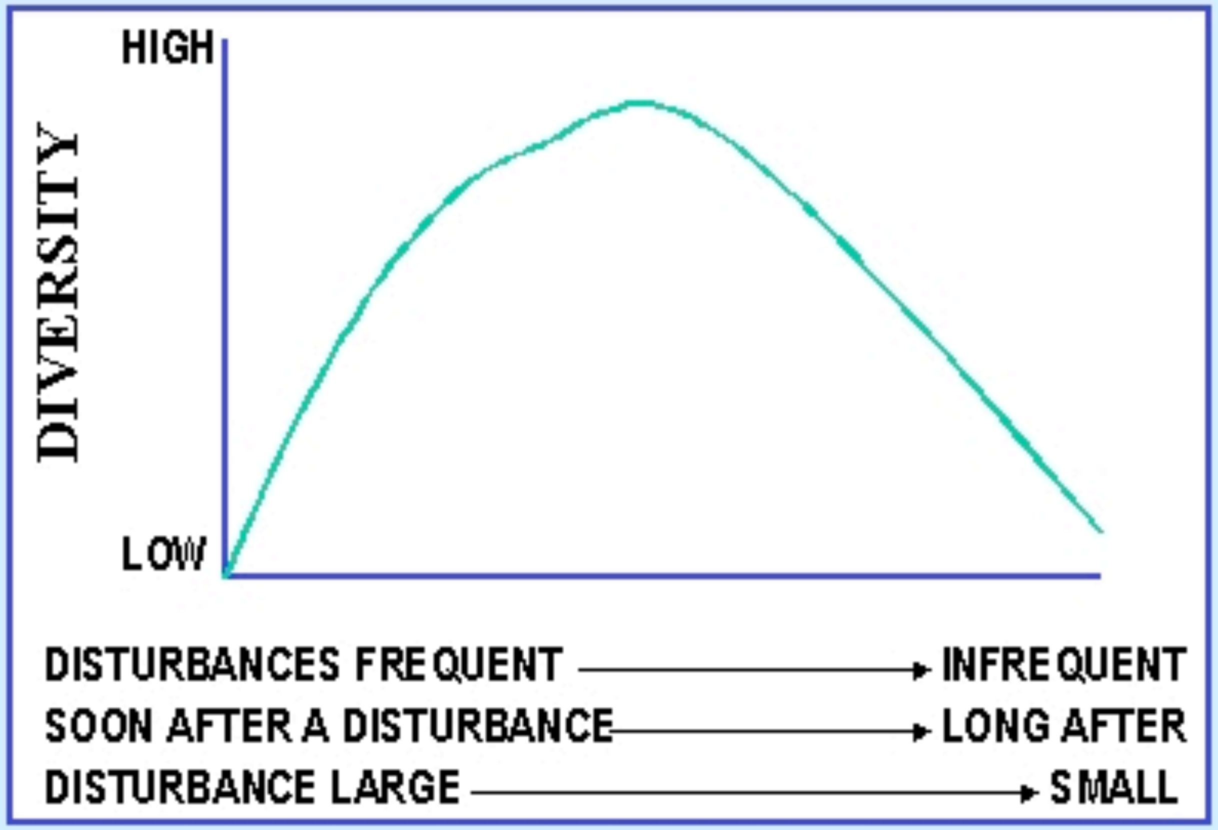
A. Disturbances

- Vary in frequency and severity in each community.
  - *high level disturbance* results from high intensity & frequency
  - *low level disturbance* result from low intensity or frequency

- **Intermediate Disturbance Hypothesis-** moderate levels of disturbance result in greater biodiversity than either high or low level disturbances.
    - high level disturbances exceed the tolerance of organisms
    - low level disturbances allow more competitive species to dominate
    - moderate level disturbances are rarely exceed the tolerance of organisms but may be great enough to create new niches for less competitive species

The Intermediate Disturbance Hypothesis (Connell 1978)

- importance of gap formation
- moderate disturbance counteracts competition



FIRE

(a) Before a controlled burn.
A prairie that has not burned for several years has a high proportion of detritus (dead grass).

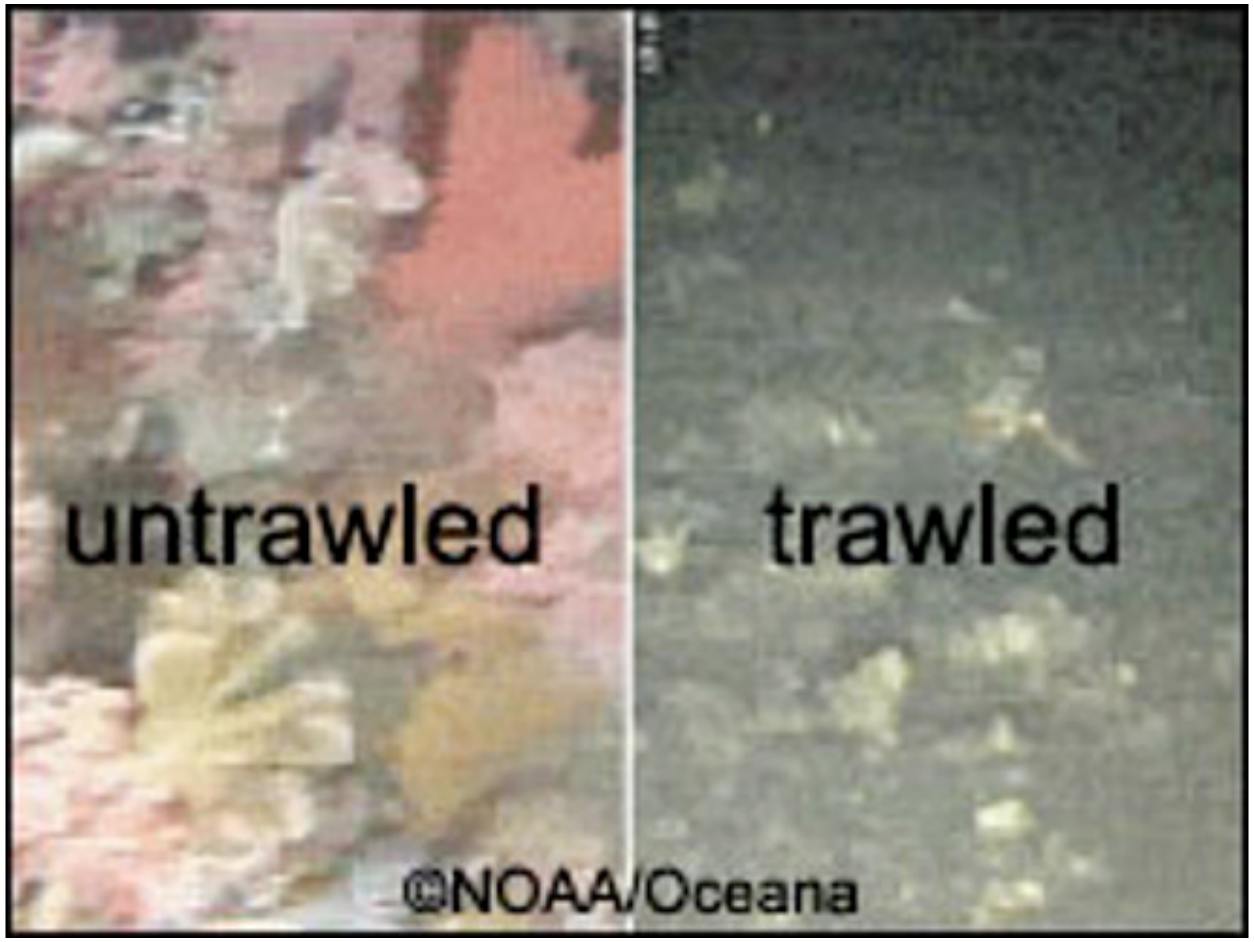
(b) During the burn. The detritus serves as fuel for fires.

(c) After the burn. Approximately one month after the controlled burn, virtually all of the biomass in this prairie is living.

Human Disturbances

- The strongest agent of change today is...US.
  - Reasons include: agricultural development, urban development, logging, mining, trawling, and farming.

Case in Point- Ships can trawl over 15 million km^2 of ocean floor (annually). This is roughly the size of South America and 150x more than clear cut forests per year.



Community Ecology

Main Idea: Latitude and land area effect community diversity.

Abiotic Factors

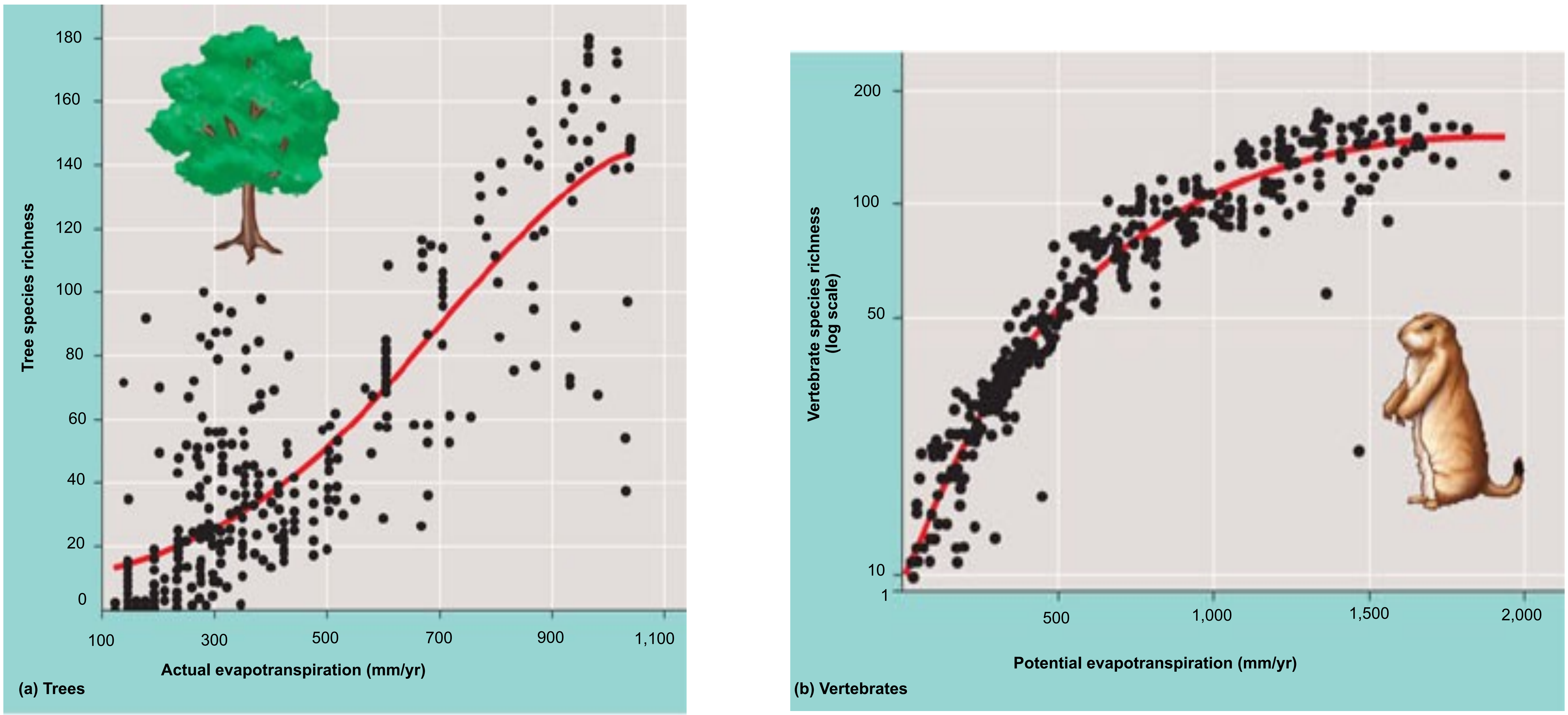
BIOGEOGRAPHIC FACTORS AFFECT COMMUNITY DIVERSITY

- Here we consider larger scale factors that affect biodiversity.

A. Latitude

- *Biodiversity is generally greater at the equator and decreases as you move towards the poles.*
- Two factors contribute to this pattern
  - **Evolutionary History**: Tropical communities are *older* than polar communities this allows more time for speciation to occur AND the *growing season* is 5X as long in tropical communities.
  - **Climate**: Tropical climates receive more *solar energy* and *water* than polar communities

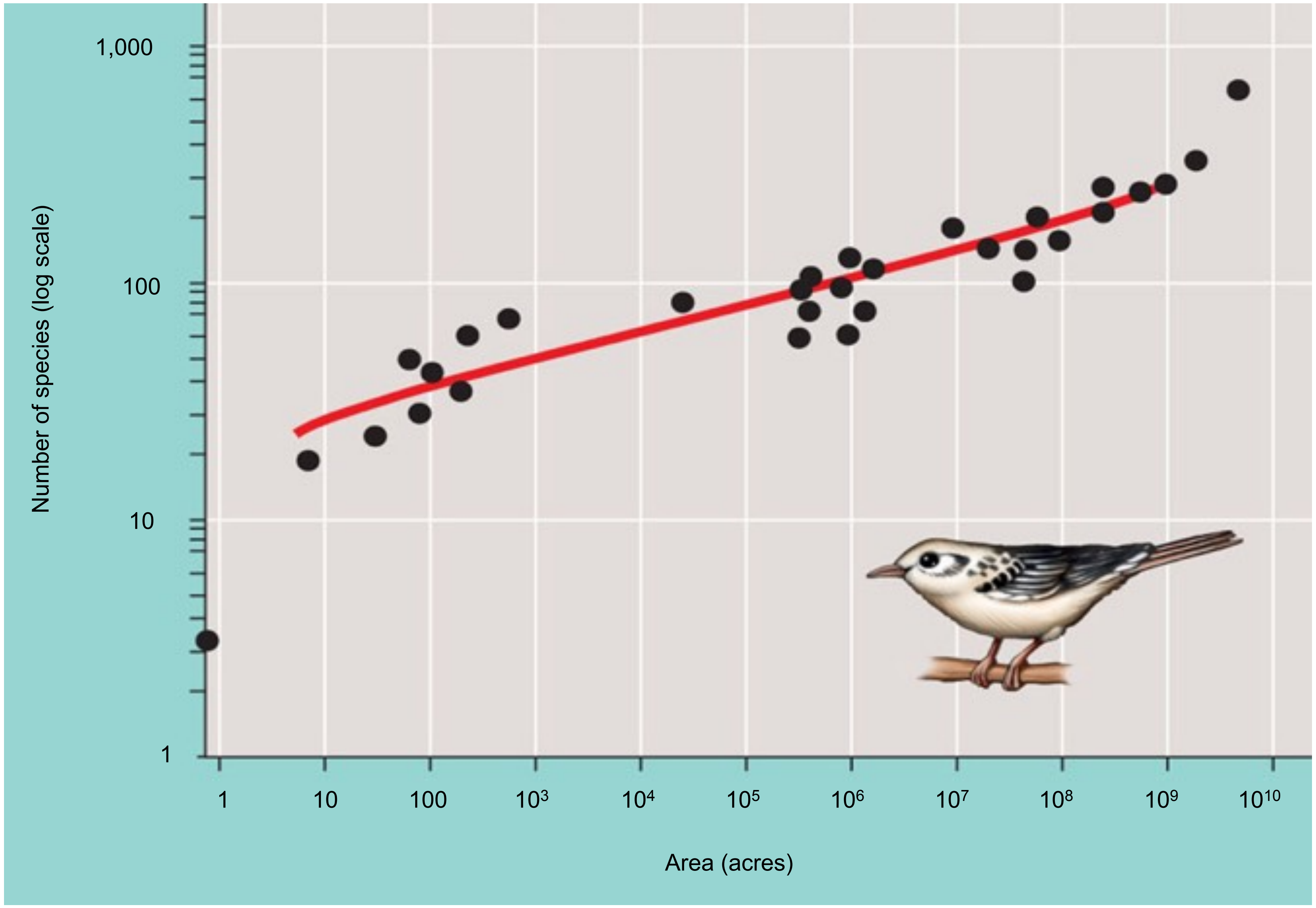
Essentially you can measure evapotranspiration (evaporation form soil & plants) and get a good estimate of biodiversity in an area. This makes sense since evapotranspiration is a function of solar



What happens to the size of mammals as you move towards the poles? Why?

Area

- *All factors equal the greater the geographical area, the greater the biodiversity.*
  - more area = more habitats and niches

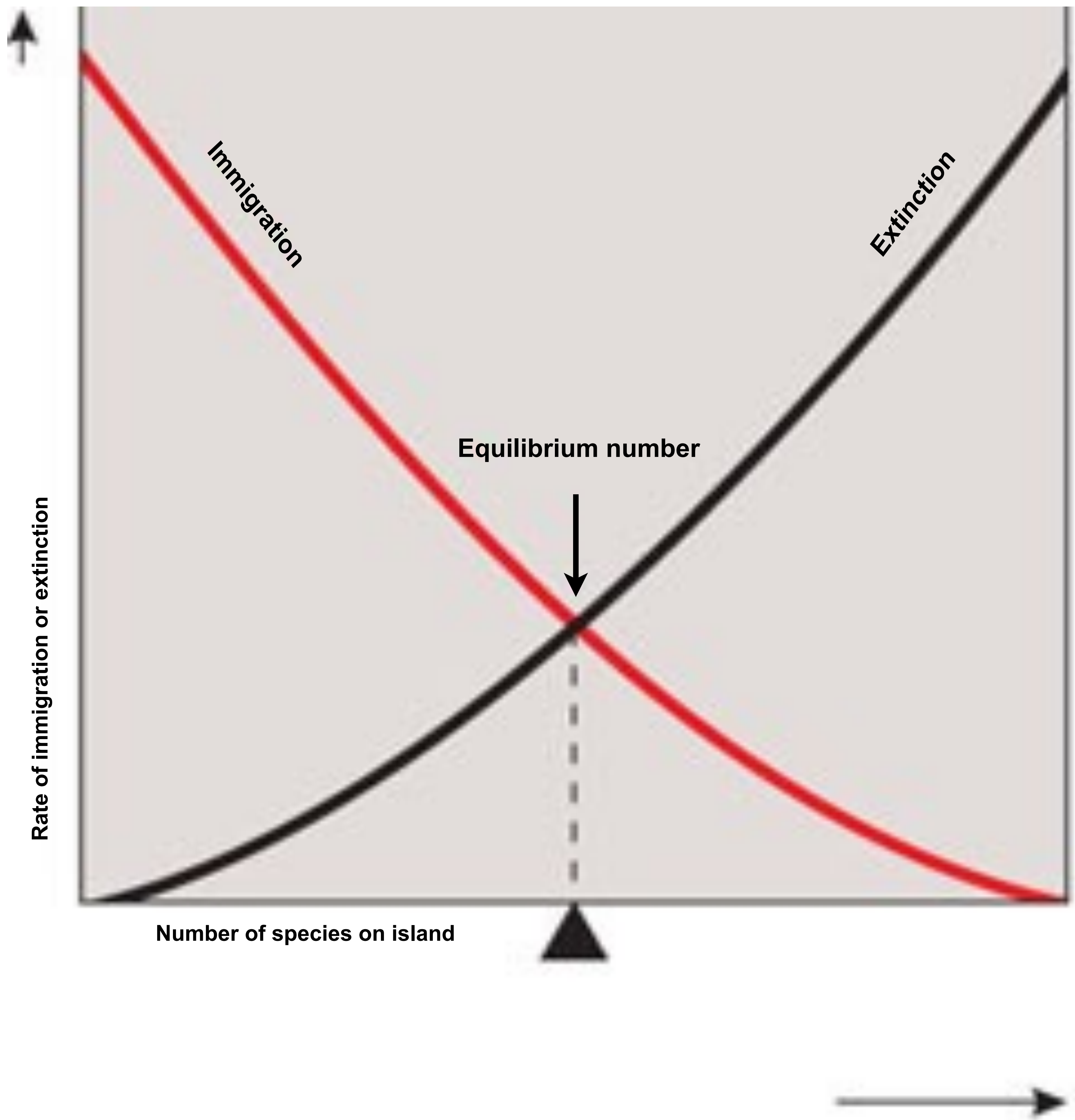


Island Equilibrium Model

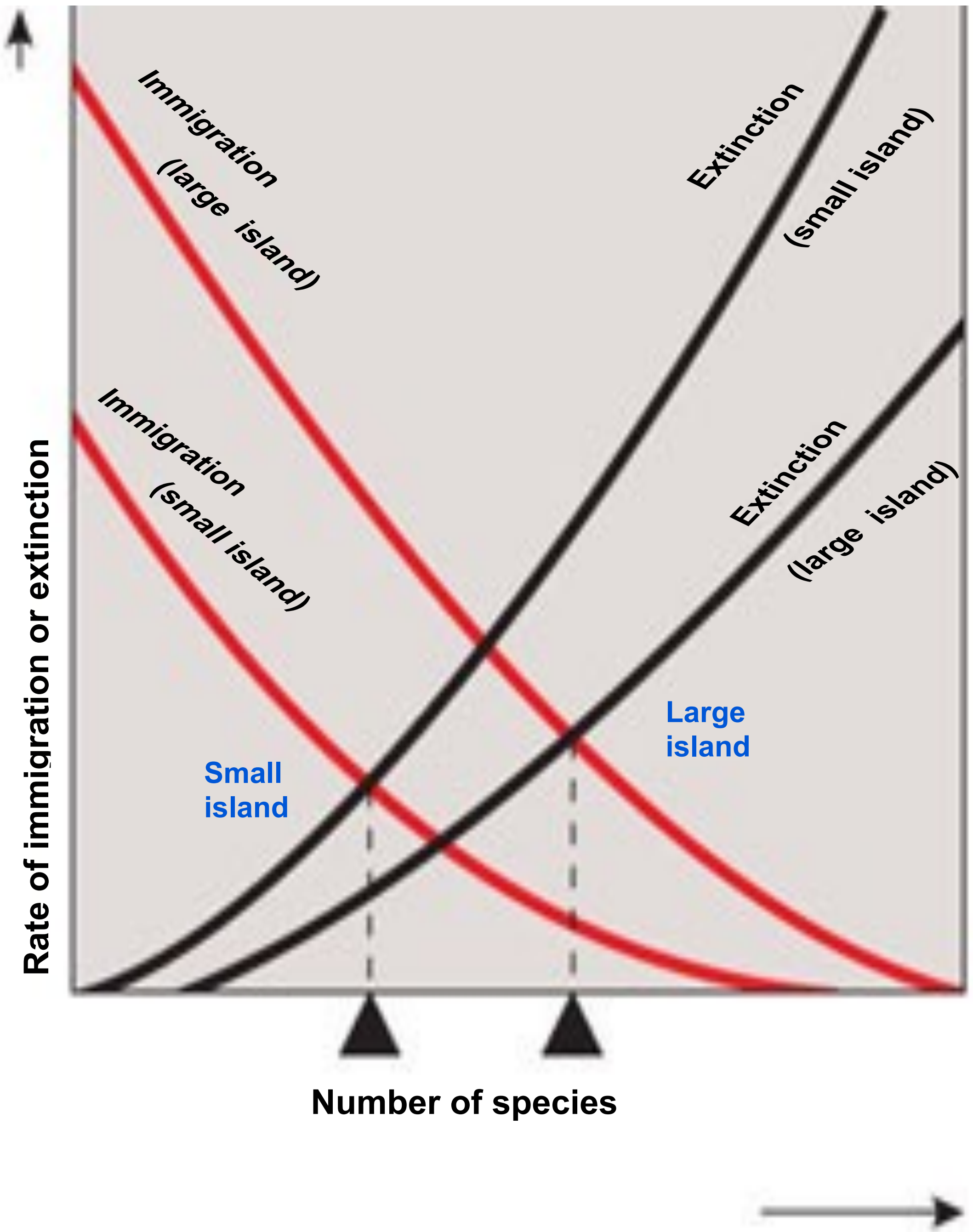
- This includes all "*island habitats*" not just oceanic islands. An "*island*" can be any patch of suitable habitat surrounded by unsuitable habitats.
  - Two factors determine the number of species on an island.
    - Immigration & Extinction
  - Two physical features affect immigration and extinction.
    - Size & Distance (from mainland or suitable habitat)

These factors determine the number of species on an island

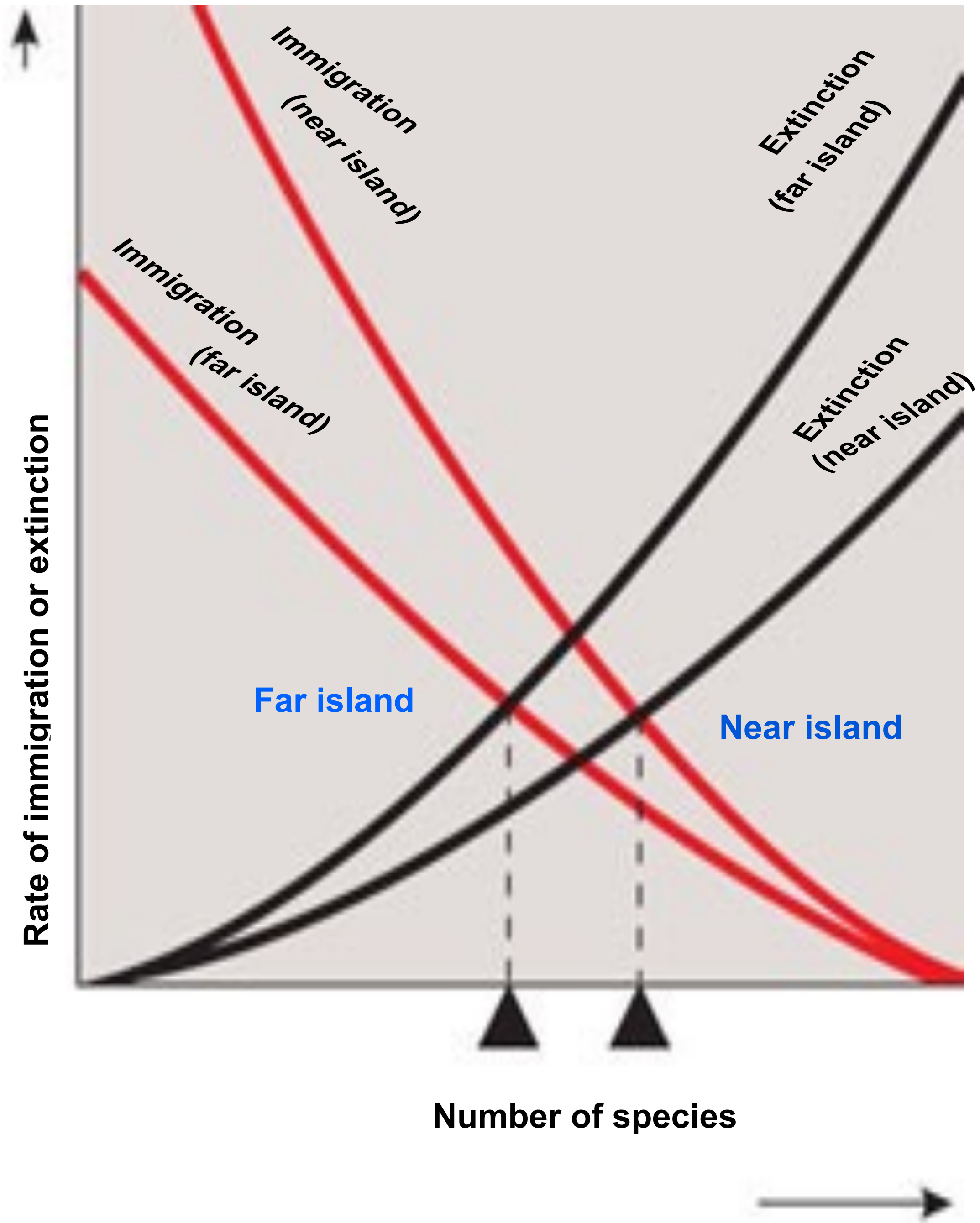
Immigration and extinction rates. The equilibrium number of species on an island represents a balance between the immigration of new species and the extinction of species already there.



These physical features affect immigration and extinction.



Effect of island size. Large islands may ultimately have a larger equilibrium number of species than small islands because immigration rates tend to be higher and extinction rates lower on large islands.



Effect of distance from mainland. Near islands tend to have larger equilibrium numbers of species than far islands because immigration rates to near islands are higher and extinction

Community Ecology

Main Idea: Pathogens effect community structure.

Biotic Factors

PATHOGENS ALTER COMMUNITY STRUCTURE

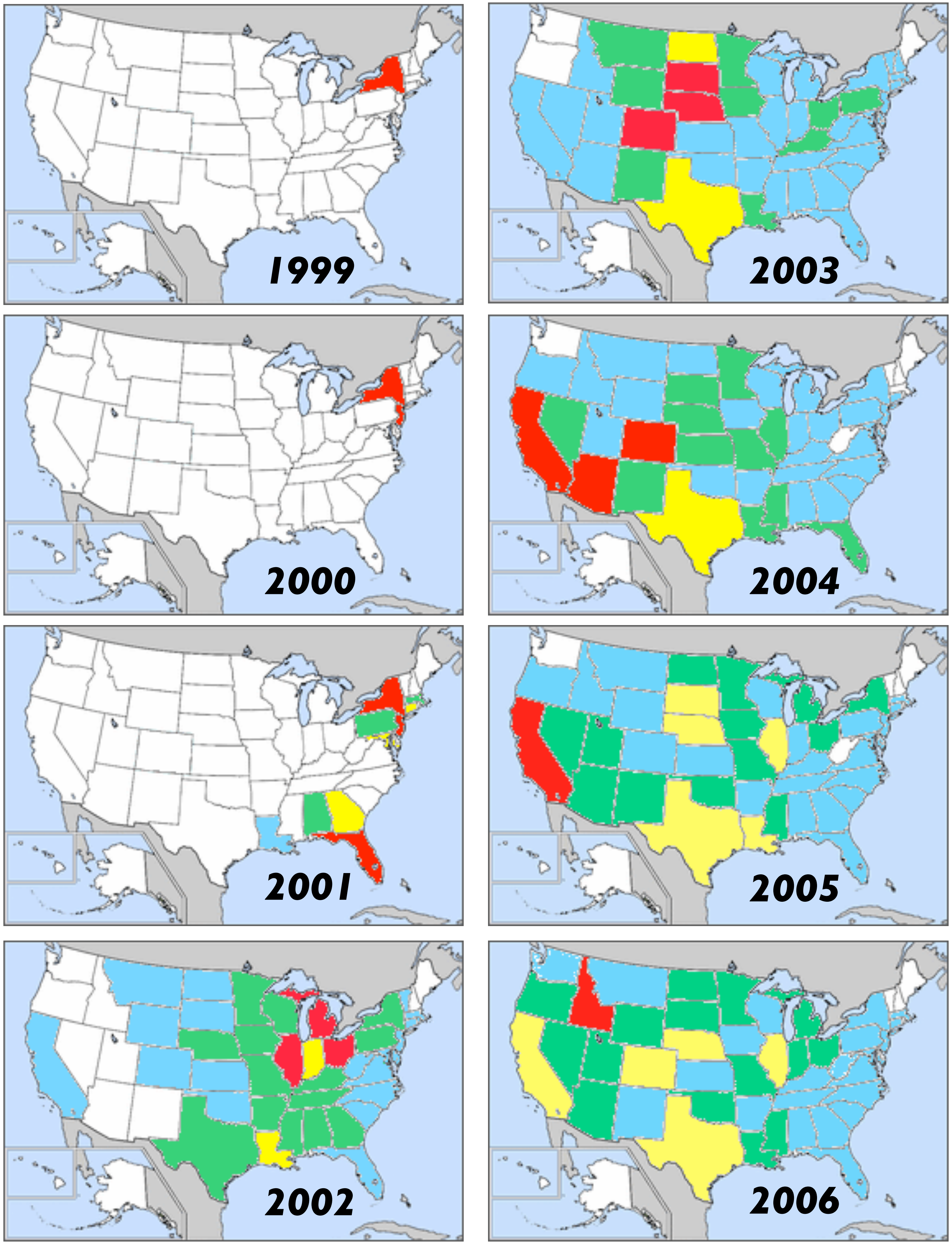
- **Pathogens** are disease causing organisms
  - They include: bacteria, fungi, protists, viruses, viroids, prions
- Their *impact* can be *swift and extensive*
- They have a greater effect when introduced into new habitats
  - new hosts have not had time for natural selection to select for resistant individuals
- Humans are equally vulnerable

A. Pathogens & Community Structure

- Pathogens have effected both aquatic and terrestrial communities
- Human activities are moving pathogens around the world at unprecedented rates
  - Emerging human disease include: Resistant TB, Swine Flu, West Nile virus, SARS

B. Community Ecology & Zoonotic Disease

- *Zoonotic pathogens* are transferred to humans from other animals
- The intermediate species that passes the pathogen on to humans is called a *vector*, they include: mosquitoes, lice, ticks
- Knowledge of these interactions help us to track and maybe reduce the effects of these zoonotic pathogens.



West Nile Virus

- white - no cases
- blue - less than 1%
- green - between 1% and 5%
- yellow - between 5% and 10%
- red - over 10%

	Cases	Deaths	Mortality Rate
1999	62	7	11%
2000	21	2	10%
2001	66	10	15%
2002	4156	284	7%
2003	9862	264	3%
2004	2539	100	4%
2005	3000	119	4%
2006	4269	177	4%
2007	3623	124	3%
2008	1356	44	3%
2009	720	32	4%
2010	981	45	4%

Ecosystems

Main Idea: Energy and other limiting factors control primary production.

Main Idea: Primary production dictates the energy budget for the entire ecosystem.

Recall...

Primary Production in Aquatic Ecosystems

Light Limitations

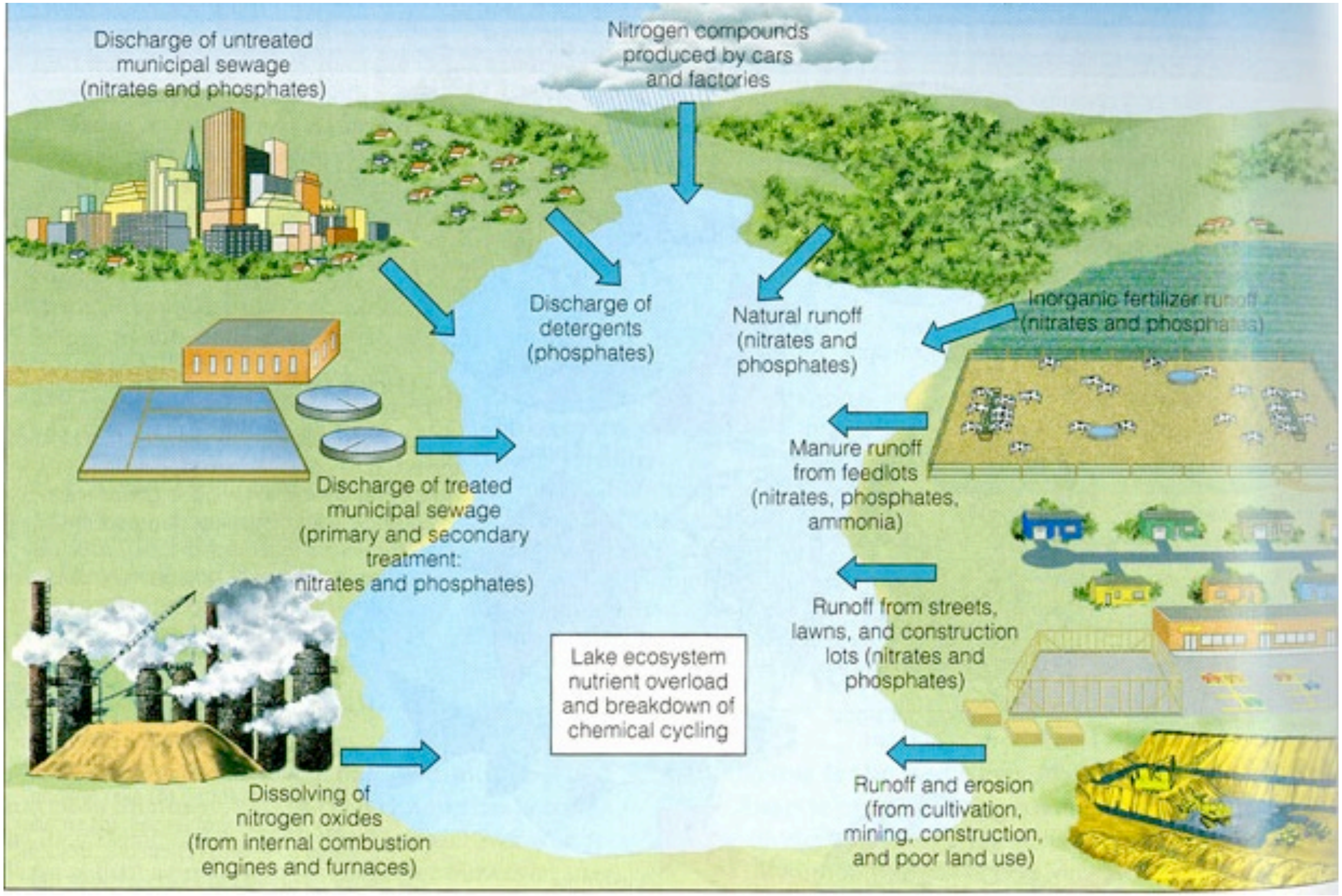
- Light is the obvious choice as limiting factor.
- After all more than half of the solar radiation is absorbed in the first 15 meters of water.
- *Light is very important however it does not appear to be the key limiting factor in aquatic ecosystems!*

Assuming that light was the key limiting factor scientists predicted a gradient in production from the poles to the equator. Would the production gradient increase or decrease as moved away from the poles? Why? Does this gradient exist?

Nutrient Limitations

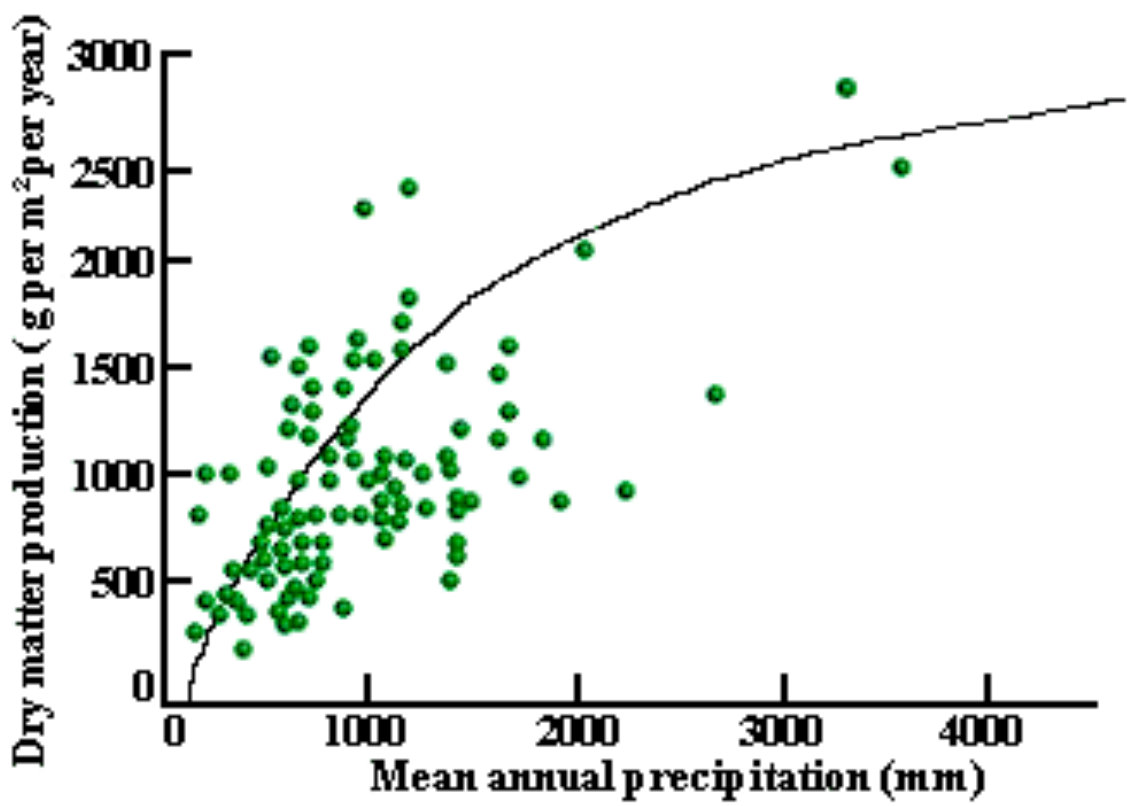
- *Nutrients appear to be the key limiting factor in aquatic ecosystem production!*
- The most common limited nutrients in aquatic ecosystems are the (macronutrients) nitrogen and phosphorous.
    - Nitrogen happens to be the most limited nutrient in soils as well.
- Micronutrients can be limited in aquatic ecosystems as well.
  - Iron (Fe) happens to be very important and is often limited.
  - *Further support is found in upwellings (deep nutrient rich waters that circulate to the ocean surface).*
    - *Areas of upwellings are diverse and abundant with life...they are often prime fishing locations.*
    - *The abundant nutrients provide a large base for the food webs*

Cultural Eutrophication



Primary Production in Terrestrial Ecosystems

- **Water** and **Temperature** are the key limiting factors.
- In fact precipitation is a useful tool for predicting productivity because there is such a strong correlation between the two.
  - Actual evapotranspiration is a second useful tool used to predict terrestrial productivity



Where did we see this graph before?

Learning Objectives:

LO 2.22 The student is able to refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems. [See SP 1.3, 3.2]

LO 2.23 The student is able to design a plan for collecting data to show that all biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions. [See SP 4.2, 7.2]

LO 2.24 The student is able to analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems). [See SP 5.1]