New Jersey Center for Teaching and Learning

Progressive Science Initiative

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AP BIOLOGY

Big Idea 4
Part A

March 2013

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Big Idea 4:

Biological systems interact, and these systems and their interactions possess complex properties.

Big Idea 4

The following is the AP's explanation of the fourth Big Idea:

"All biological systems are composed of parts that interact with each other. These interactions result in characteristics not found in the individual parts alone. In other words, “the whole is greater than the sum of its parts.” All biological systems from the molecular level to the ecosystem level exhibit properties of biocomplexity and diversity. Together, these two properties provide robustness to biological systems, enabling greater resiliency and flexibility to tolerate and respond to changes in the environment. Biological systems with greater complexity and diversity often exhibit an increased capacity to respond to changes in the environment... "

Big Idea 4

"At the molecular level, the subcomponents of a biological polymer determine the properties of that polymer. At the cellular level, organelles interact with each other as part of a coordinated system that keeps the cell alive, growing and reproducing. The repertory of subcellular organelles and biochemical pathways reflects cell structure and differentiation. Additionally, interactions between external stimuli and gene expression result in specialization and divergence of cells, organs and tissues. Interactions and coordination between organ systems determine essential biological activities for the organism. External and internal environmental factors can trigger responses in individual organs that, in turn, affect the entire organism. At the population level, as environmental conditions change, community structure changes both physically and biologically. The study of ecosystems seeks to understand the manner in which species are distributed in nature and how they are influenced by their abiotic and biotic interactions, e.g., species interactions. Interactions between living organisms and their environments result in the movement of matter and energy."

Big Idea 4: Part A

Click on the topic to go to that section

- Biological Interactions
- The Naturally Changing Planet
- The Unnaturally Changing Planet
- Global Population Growth
- Intra-organism Interactions

Biological Interactions

Return to
Table of
Contents

Interactions Drive Life Processes

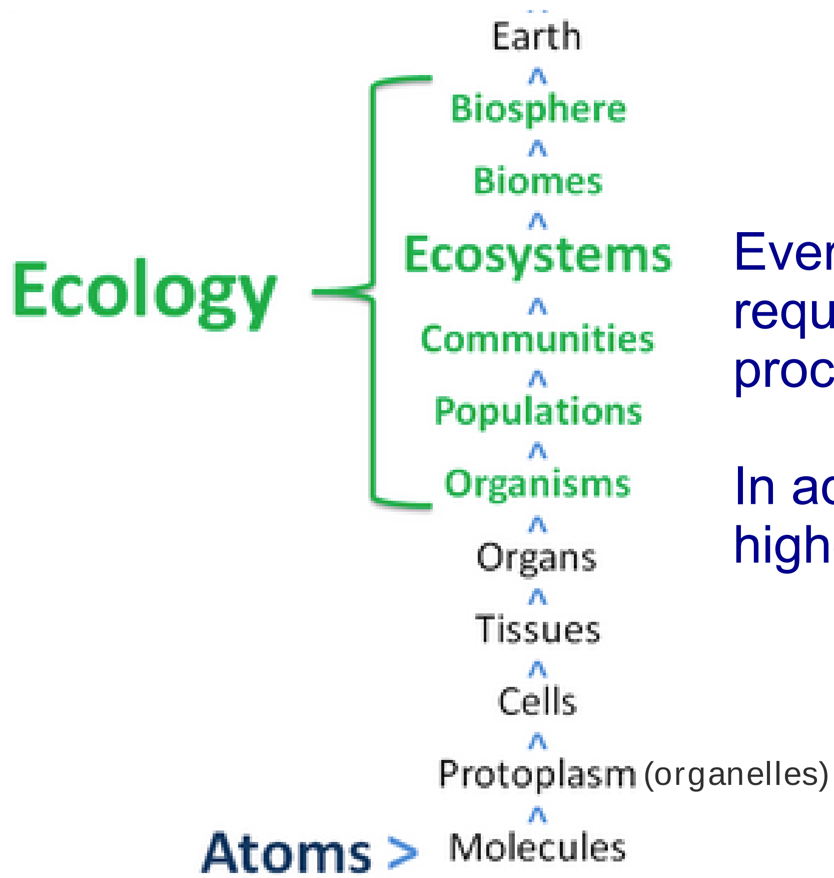
Interactions are either **competition** or **cooperation,** and play important roles in the activities of biological systems. For example:

Interactions between molecules can complete their structure and function, or molecular interactions can inhibit the functions of certain molecules.

Competition between cells may occur under conditions of resource limitation. Cooperation between cells can improve efficiency and convert sharing of resources into a net gain in fitness for the organism.

Cooperation of organs and organ systems provides an organism with the ability to use matter and energy effectively.

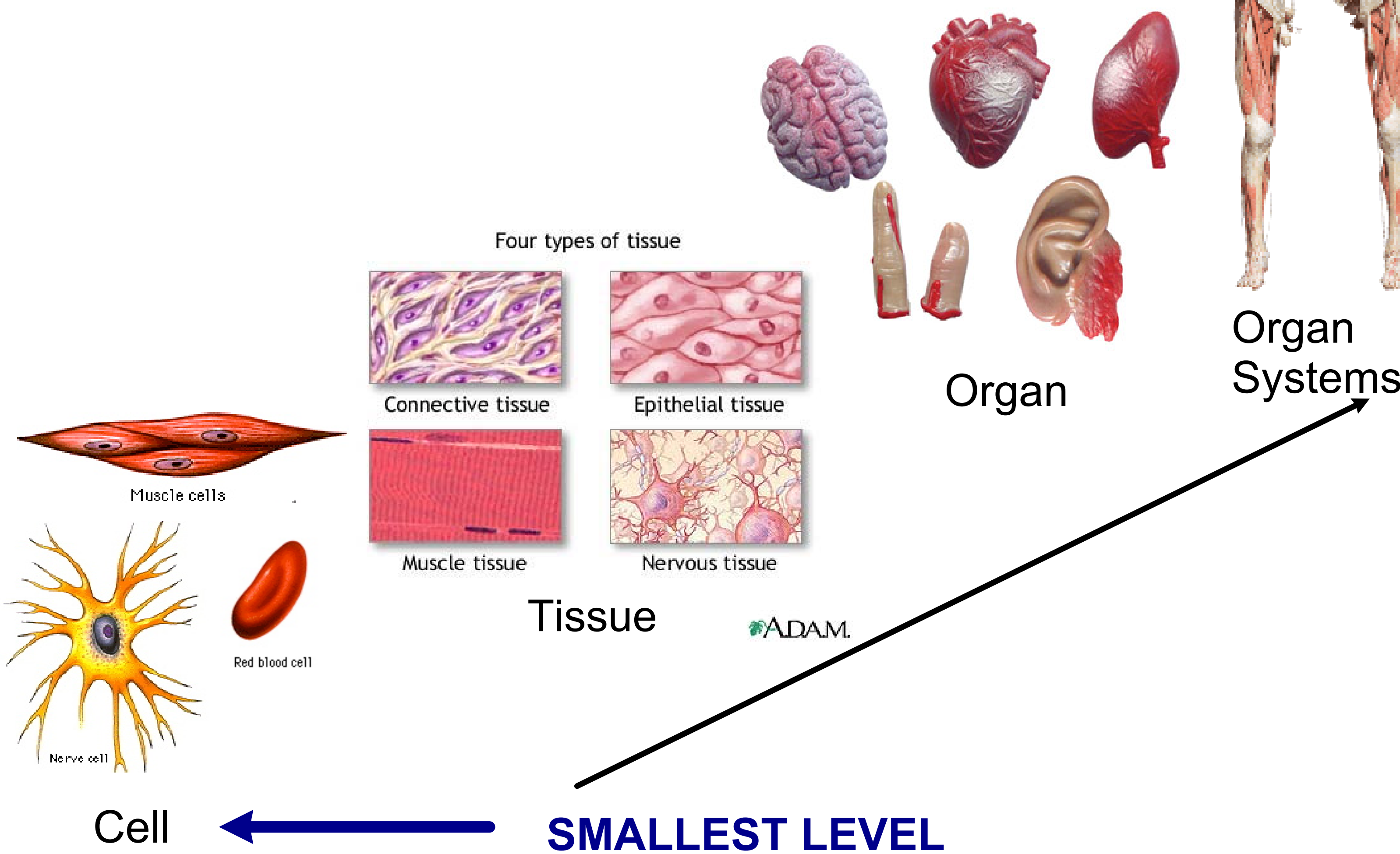
Interactions Happen at Every Level



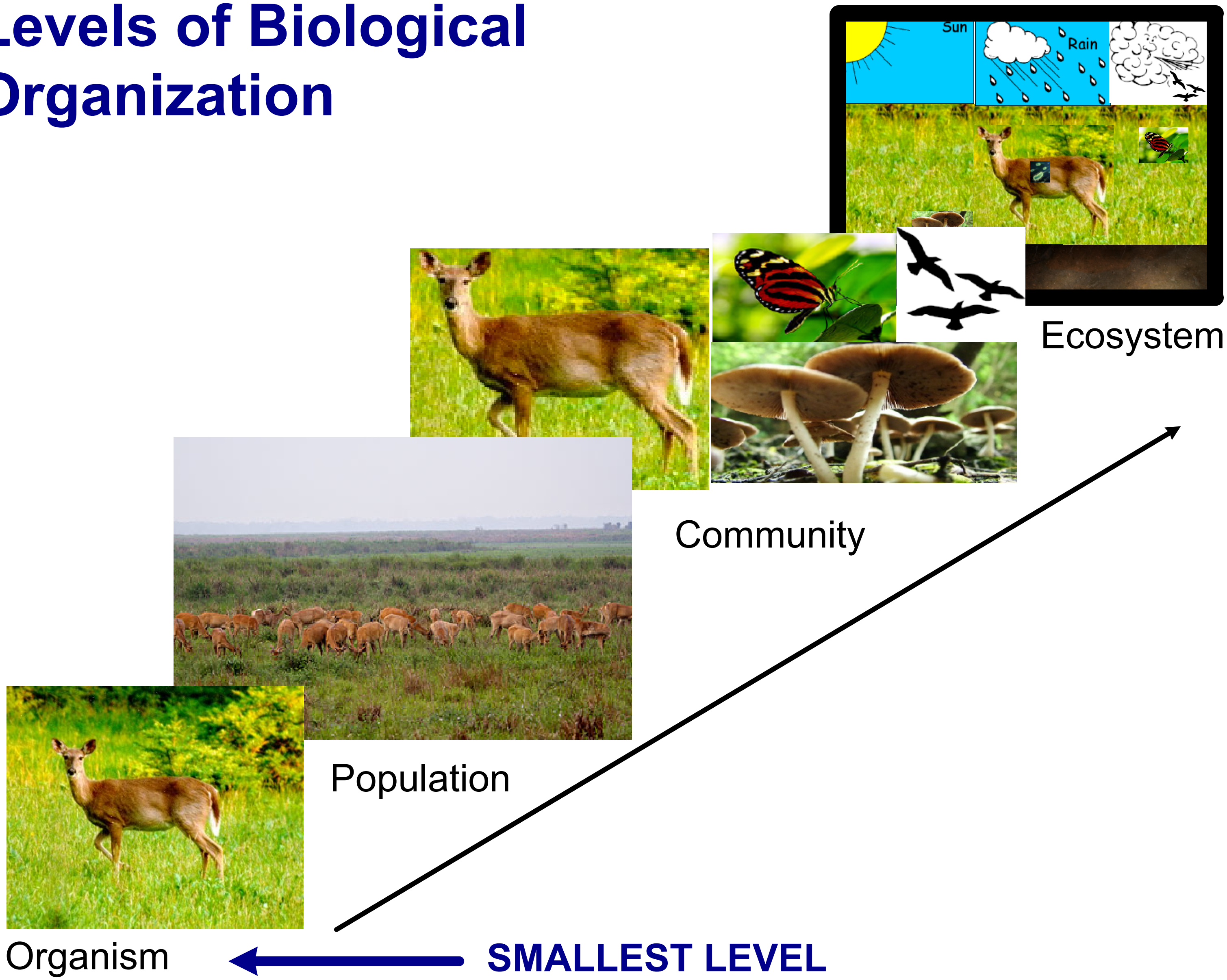
Every level of organization in biology requires interactions to continue the processes within them.

In addition, the interactions allow for higher levels of organization to exist.

Levels of Biological Organization



Levels of Biological Organization



1 Groups of different species living together and interacting in the same environment are referred to as a

- A community
- B population
- C ecosystem
- D biome

answer

2 All of the following are abiotic factors EXCEPT:

- A Algae
- B pH
- C Temperature
- D Nutrients

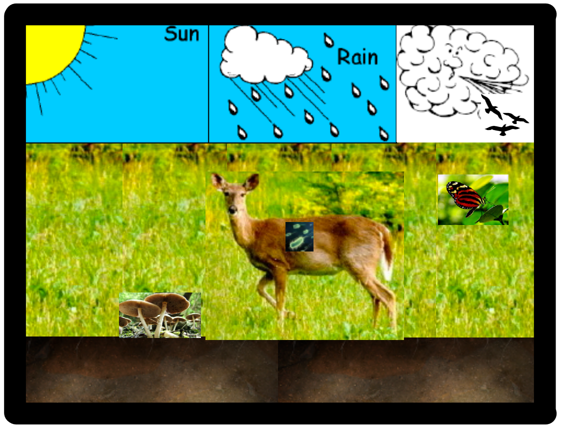
answer

3Which of the following levels of biological organization refers to both abiotic and biotic factors?

- A Species
- B Population
- C Community
- D Biome

answer

Ecosystem Interactions

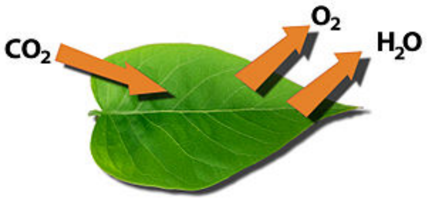


Ecosystem

Living things must interact with their environment to obtain the abiotic substances they need. The availability of these substances limits what type of life can exist within.

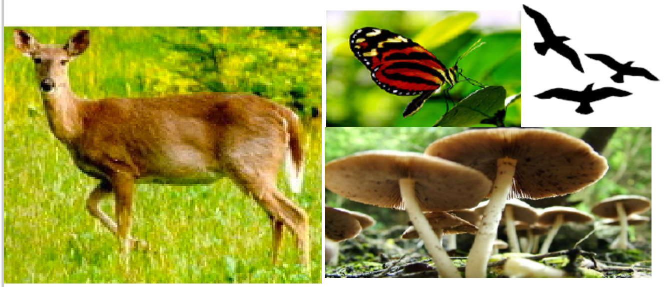
Obtaining energy

Gas exchange



Obtaining water

Community Interactions

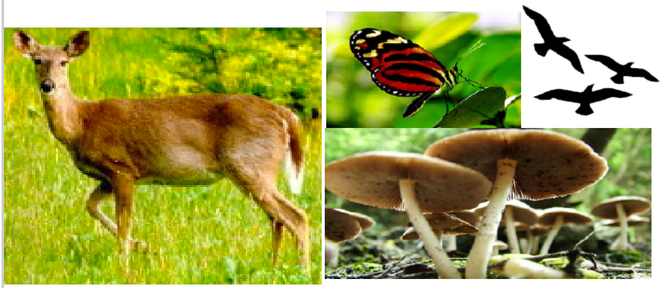


Community

Living things must interact with each other either in cooperation or competition.

In fact every organism in a community can be described by its interaction with other members of the living community

Community Interactions

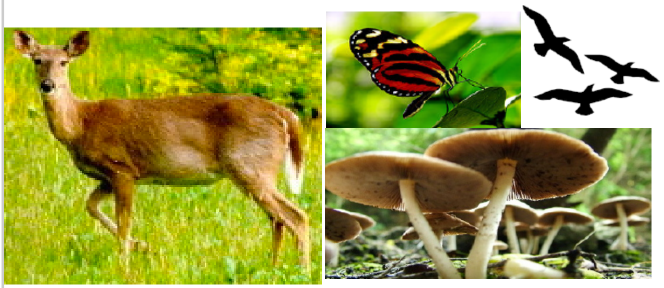


Community

Neutralism describes the relationship between two species which are in the same community but their interactions do not affect each other.

These are interactions where the fitness of one species has no effect on that of the other. When dealing with the complex networks of interactions presented in communities, it is hard to prove that there is absolutely no competition between, or benefit to either species. Since true neutralism is rare, its usage is often extended to situations where interactions are insignificant or negligible.

Community Interactions

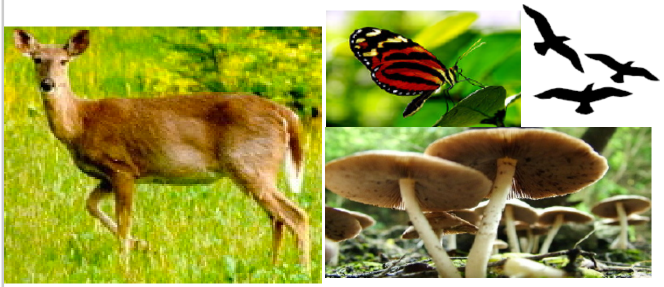


Community

Commensalism is an interaction that benefits one species while the other organism is not benefited or harmed.

A good example is a remora living with a shark. Remoras eat leftover food from the shark. The shark is not affected in the process as remoras eat only leftover food of the shark which doesn't deplete the shark's resources.

Community Interactions

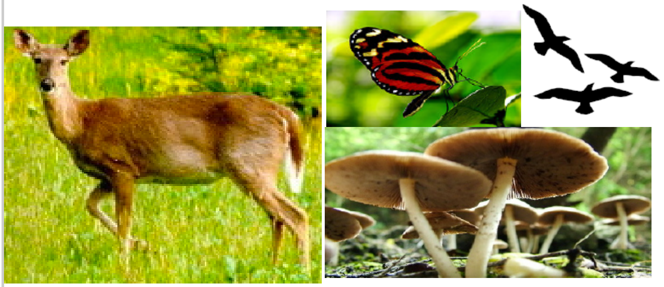


Community

Mutualism is an interaction between two or more species where all species derive a mutual benefit. Mutualism may be classified in terms of the closeness of association, the closest being **symbiosis.** In these cases one or both species involved in the interaction are **obligate**, they cannot survive without the other species.

Pollination illustrates mutualism between flowering plants and their animal pollinators.

Community Interactions



Community

Predation is a biological interaction where a **predator** (an organism that is hunting) feeds on its **prey** (the organism that is attacked). The act of predation often results in the death of the prey and the eventual absorption of the prey's tissue through **consumption**.

Population Interactions

Population

Within a population, members of the same species cooperate and compete, but both types of interaction lead to an improvement of the population.

Competition for food and reproductive success leads to a stronger gene pool.

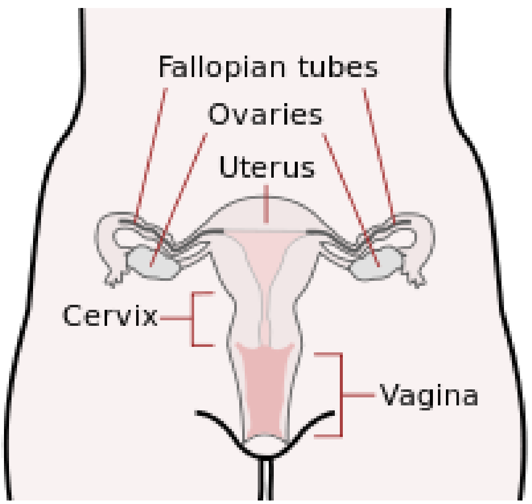
Cooperation like sharing food with young and copulation ensure a healthy next generation.

Inner Organism Interactions

Organ
Systems

Even inside of a singe organism there is cooperation and competition interactions.

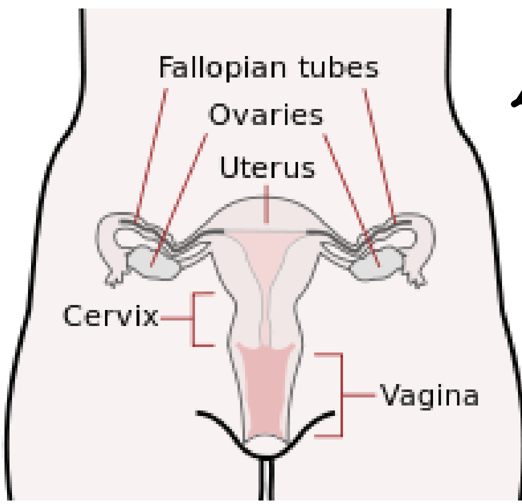
Much like interactions within a population, these interactions are to increase the fitness of the overall organism.

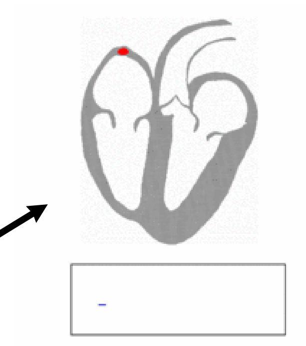


The female reproductive system uses complex inter organ chemical signaling, muscular contraction and multi-organ interfaces for the purpose of producing healthy offspring.

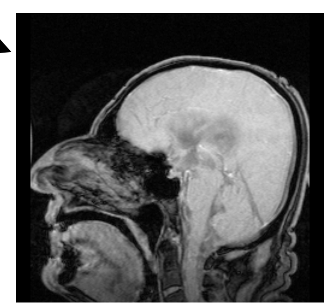
Inner Organism Interactions

Organ Systems

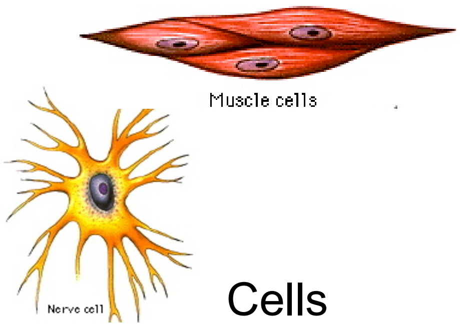




In addition the organs of the reproductive system can send and recieve information to other organs via chemical interaction.



Inner Organism Interactions



Cells

Cells are responsible for producing the signals that will interact and ultimately decide how the whole organism responds to a situation.

The better an organism's cells can communicate the more likely the organism is to survive by adapting to new situations.

In other words, higher complexity in chemical signaling results in an organism's ability to respond to changes in their environment.

4 Oxpeckers are birds that perch on the backs of rhinos. They eat ticks and other parasitic bugs.

- A Neutralism
- B Commensalism
- C Competition
- D Mutualism
- E Predation
- F Parasitism
- G Symbiosis

answer

5 Parrot fish and yellow tang fish both eat the plentiful algae on the same coral reef.

- A Neutralism
- B Commensalism
- C Competition
- D Mutualism
- E Predation
- F Parasitism
- G Symbiosis

answer

6 Many bacteria live in the intestines of humans. They survive because of the internal environment, and they stop outbreaks of bad bacteria in the gut.

- A Neutralism
- B Commensalism
- C Competition
- D Mutualism
- E Predation
- F Parasitism
- G Symbiosis

answer

7 A fungus grows on the back of insects. Its tendrils penetrate the exoskeleton and it feeds on the inner soft tissue of the bug. It will eventually consume the host insect.

- A Neutralism
- B Commensalism
- C Competition
- D Mutualism
- E Predation
- F Parasitism
- G Symbiosis

answer

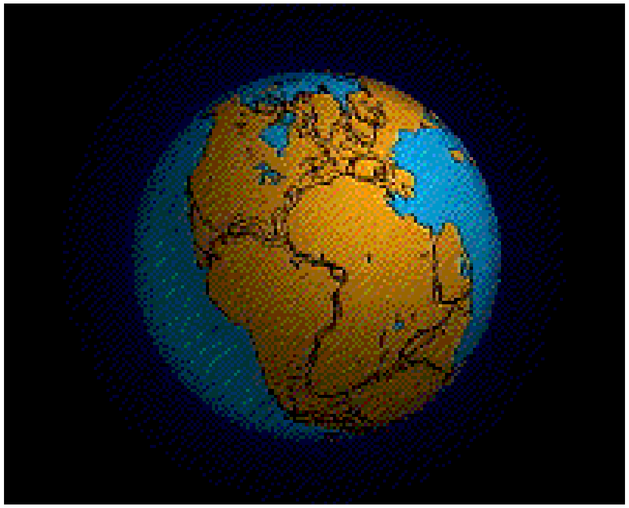
The Naturally Changing Planet

Return to Table of Contents

The Biosphere is Constantly Changing

The Earth is not static. It has been shifting and changing its surface and climate since its beginnings 4.6 billion years ago.

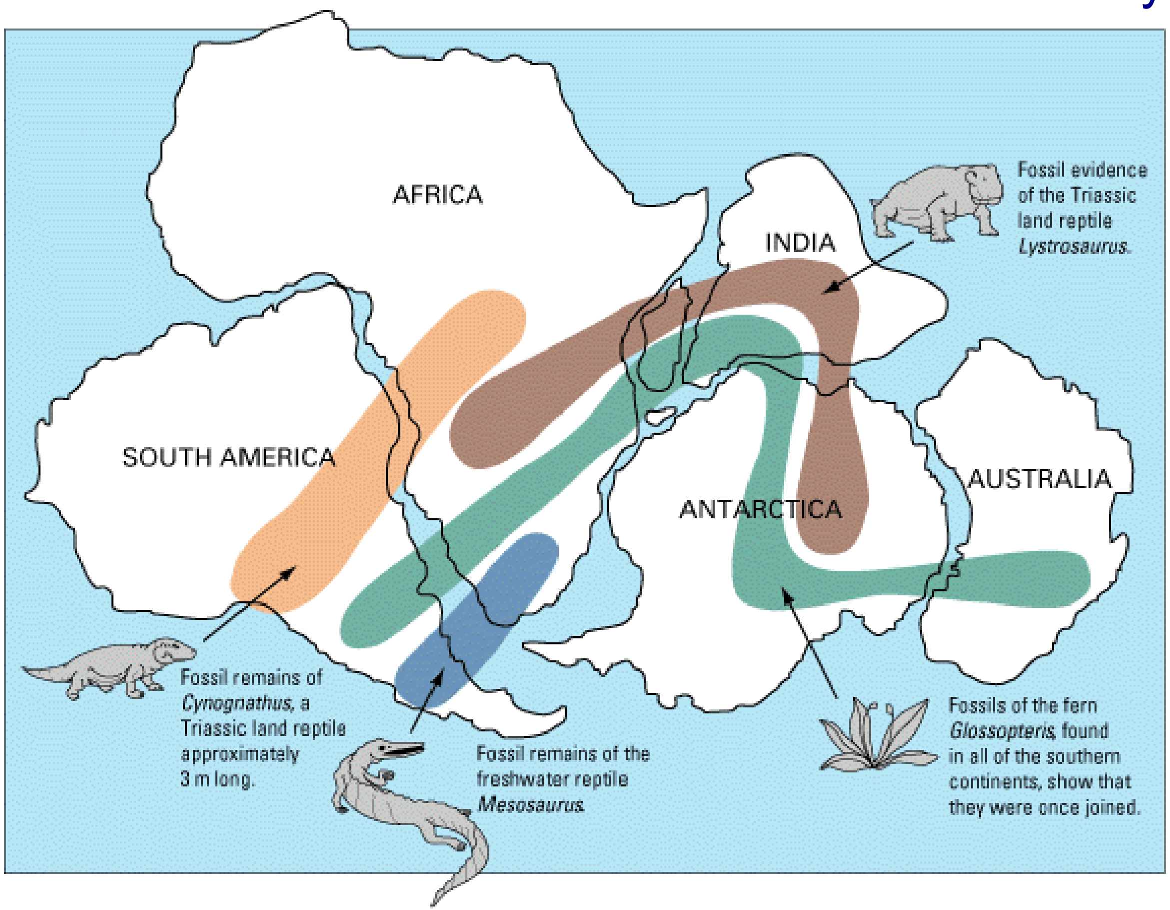
Every small change is a challenge to its living inhabitants.



The rifting of Pangaea, the original continent, is an ongoing process that continues to this day.

The Biosphere is Constantly Changing

As the land mass of the planet broke apart, it broke apart ecosytems as well. Some inhabitants went extinct, others evolved in the new situation to form new ecosystems.



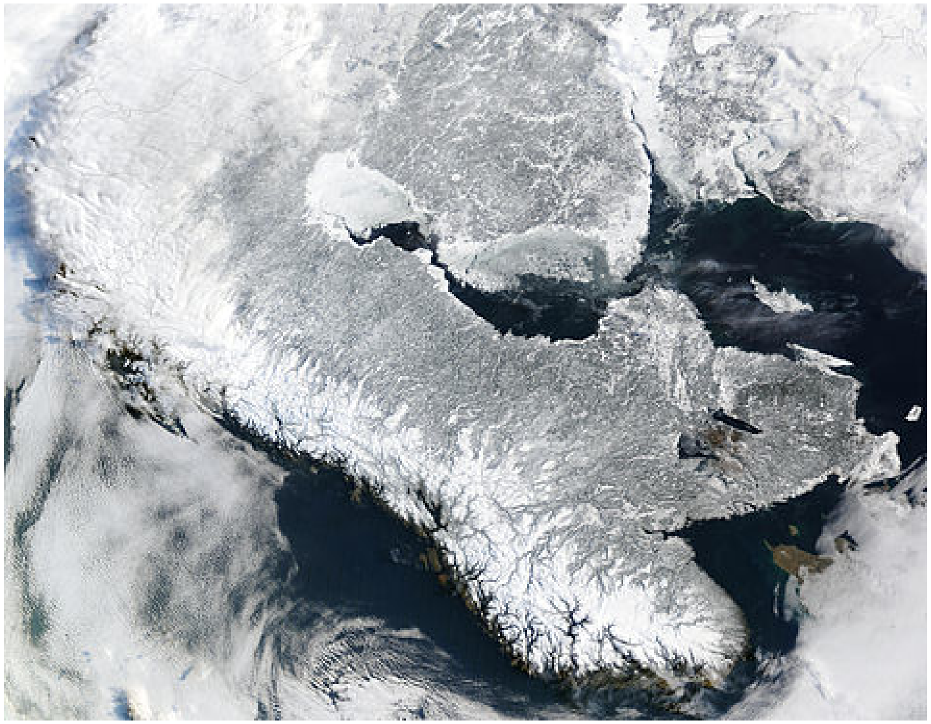
This map shows the presence of similar and identical fossils of species on continents that are now great distances apart.

The Biosphere is Constantly Changing

As the **tectonics plates** shift, these huge pieces of the Earth's surface cause catastrophic events that can forever change the make up of its climate and inhabitants.

The Biosphere is Constantly Changing

Volcanic and **seismic activity**, energy released as plates shift, can release enough ash and debris into the atmosphere to minimize sun rays and cool the earth by many degrees. These large scale shifts in climate cause devastation to established ecosystems.

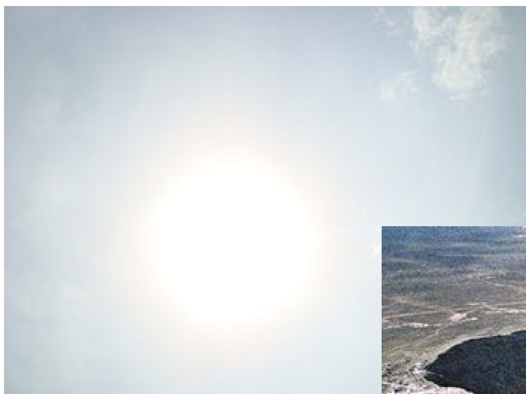


The Biosphere is Constantly Changing

The new climate shifts also cause new ecosystems to spring up in the place of old ones. The abiotic factors dictate what traits are favorable and natural selection trims away the biological traits/genes that are not useful.

External Forces Can Change the World

In addition to the changing factors on the planet, there have been many times in Earth's history when the universe has altered the ecology of our planet.



The two most influential forces have been changes in sun radiation intensity and collisions with meteors.

Looking at an example to show how jarring these events can be to the ecology of the planet can lead to understanding of the importance of interactions.

Dinosaurs vs Mammals

65,000,000 years ago dinosaurs were the top animal. Now they are extinct and mammals rule the planet. What happened?

vs

Take notes of the next pages in preparation for a group discussion about ecological interactions.

Dinosaurs 65,000,000 Years Ago

Dinosaurs represent the pinnacle of a long era of reptilian evolution that lasted nearly 200,000,000 years. These animals were well suited to live in the ecology of the Mesozoic Era of Earth's history.

They typically had large body size because:

This era's ecology was stable and plentiful. Plant life was large and numerous providing plentiful food for primary consumers. Well fed primary consumers fed higher consumers up the food chain. Natural selection favored those that were bigger and stronger for competition and predation.

200,000,000 years of evolution produced finely tuned herbivores and carnivores that could utilize energy efficiently in the current ecology.

Mammals 65,000,000 Years Ago

Mammals were evolving over the same period but they had to take a much different route. Since dinosaurs were dominant hunters, evolution of mammals favored those who could stay out of the bellies of the large reptiles.

Evolution favored mammals that were borrowing creatures, living underground. They were primarily herbivores but they also scavenged carcasses and hunted eggs of larger animals.

Since they had scarce supplies of food and needed to not attract hunters, natural selection favored small body size. The largest mammals at the time weighed less than 20 pounds.

Ecology of the Era

With a partner, try to write down at least five ecological interactions (biotic or abiotic) that were part of the ecology of this time period. Include at least two interactions that involve mammal and dinosaur. Compile a list with the class.

The Tide Turns

The end of the Mesozoic Era is marked by a catastrophic event.

An asteroid the size of Mount Everest strikes Central America.
  The impact created a crater 120 miles wide.
  The molten rock dust cloud spread at 10 miles per second
  In minutes a radius of nearly 1,000 miles was incinerated.

In this initial impact reptiles and mammals, along with every other living thing inside the blast radius, was wiped out.

It is the aftermath that proved more costly for the dinosaurs than the mammals.

The Aftermath

Over the next days the impact caused a dust cloud that shrouded the entire planet. The sun could not penetrate the thick layer of ash and debris. The Earth was in complete darkness for nearly a year.

Nitrogen was burnt out of the atmosphere changing the composition of the air.

The additional minerals vaporized into the atmosphere deflected the sun's rays and created a decrease in temperatures globally.

Rain turned more acidic, dropping the pH of the soil it fell on.

The Aftermath

Life on the planet suffered a tremendous hardship.

90% of all plants were obliterated.

70% of all animal species were wiped out.

In total, less than 10% of the existing bio mass survived the event.

The ecology of the planet and interactions that happen within them were gone forever. The remaining species had to find new ways to survive or join the massive, growing list of extinctions.

What comes next?

With a small group discuss the following:

In terms of ecological interactions, why didn't dinosaurs recover from this event, but mammals went on to dominate the planet?

Group Activity:
A population of small, burrowing, scavenging rodents survives the event. What role will they play in developing a new community? Devise a fictional timeline of events that produces a new ecosystem from these mammals. This should span thousands of years.

The Unnaturally Changing Planet

Return to Table of Contents

Human Impact

The last example explored a natural extinction event. The rapid changing of environments on a global scale almost resulted in the collapse of the tree of life.

Many scientists worry that our fragile planet may suffer another extinction event. However this one may be caused by problems stemming from events other than an asteroid or seismic activity. Instead it will be caused by our species technology.

The following slides will chronicle some of the impacts that humans have had on the environment due to the development of technology.

As you view them, write down any disrupted or new interactions you notice.

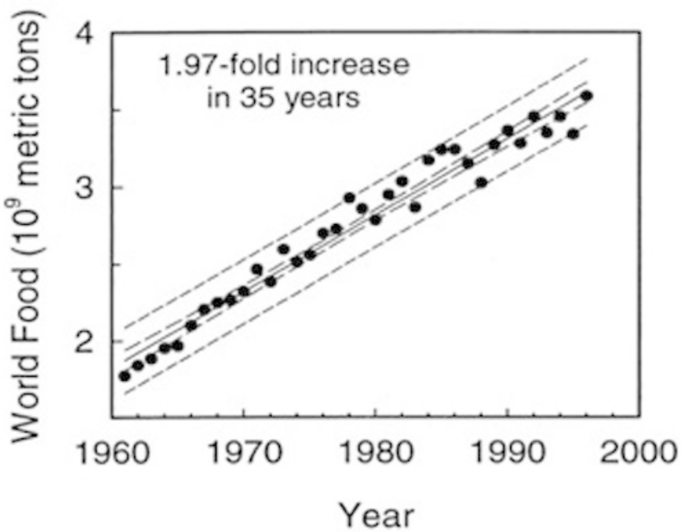
Agriculture

Agriculture is a human technology that transforms natural ecosystems into areas devoted to the production of food and fuel. The current size of the human population was made possible by the advancements in this technology.

Without the huge increase in edible biomass created by agricultural systems, there would simply not be enough to feed the 7,000,000,000 humans on Earth.

Agriculture

The land, water, and energy resources required to support this level of food production are vast. Agriculture represents a major way in which humans impact ecosystems.



Agriculture

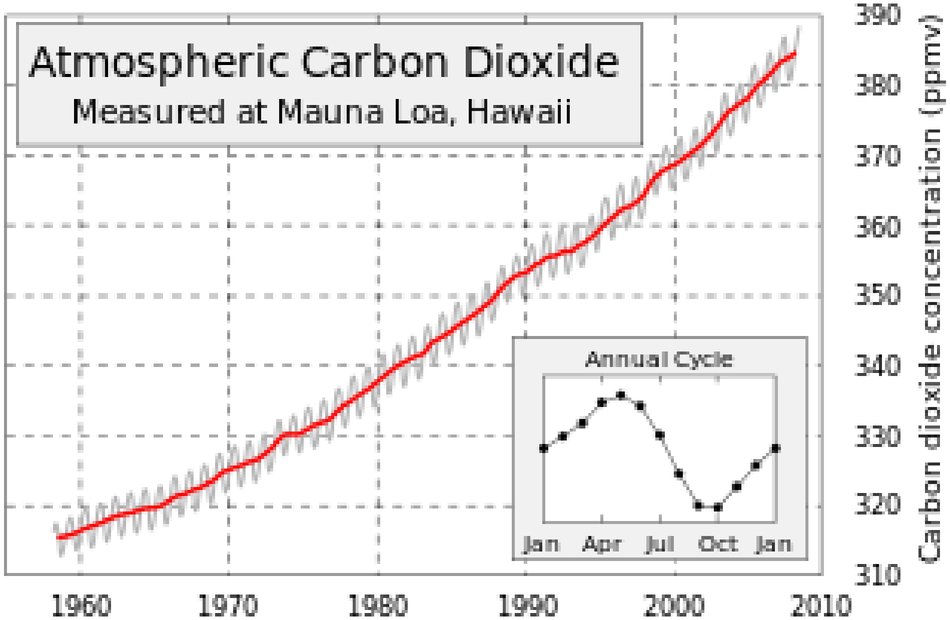
Agriculture can be particularly damaging when chemicals are used to stop pests from eating crops. It may have unintended consequences.

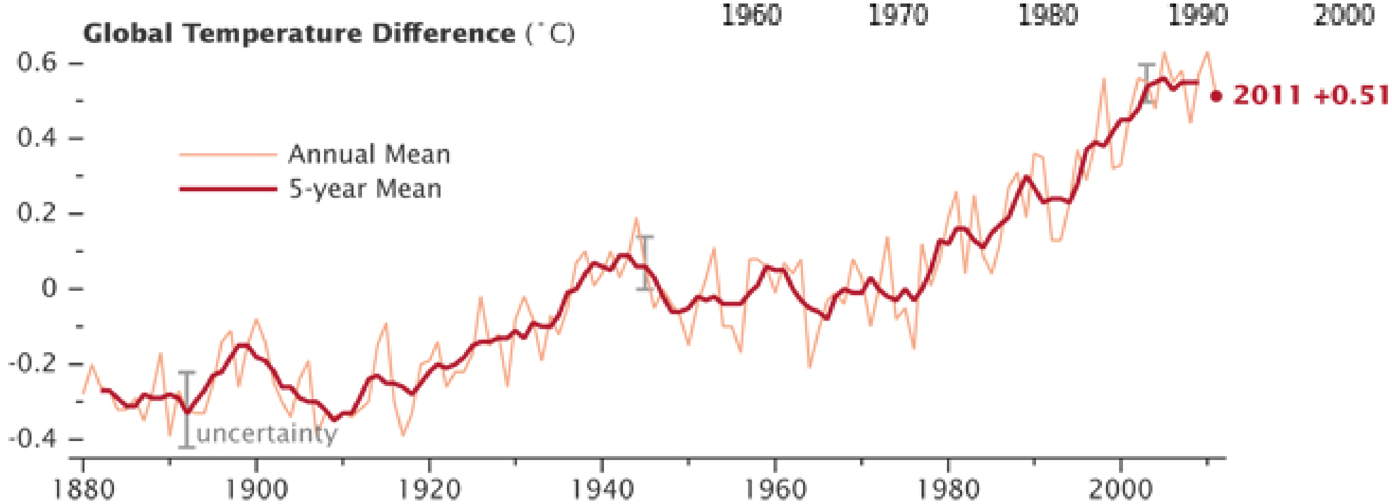
For example, DDT, a chemical used to control insects, nearly caused the extinction of the American Bald Eagle.

Before clicking the box to the left, speculate how this may have happened.

Global Climate Change

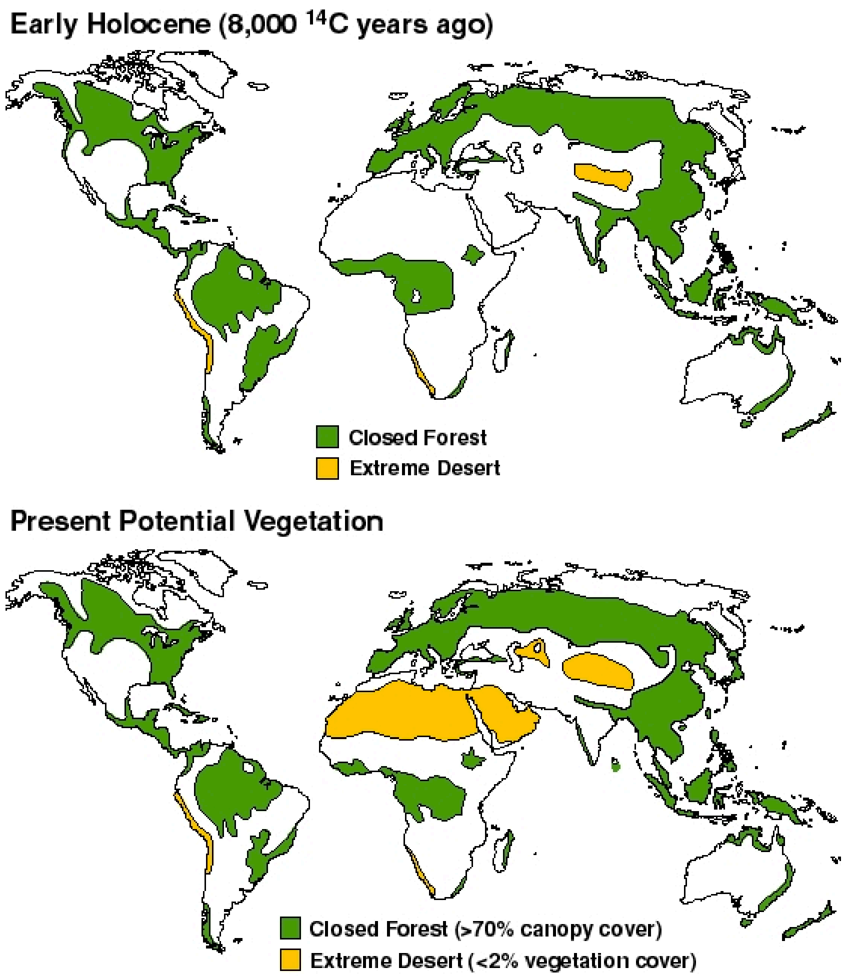
As the population continues to grow and the the demand for energy has increased, a relatively new problem has arose. Increased emissions of gasses and heat into the atmosphere has significantly increased average global temperatures.





Global Climate Change

This change is causing large scale changes in many ecosystems.



Globally there has been an increase in desert biomes and a decrease in forest biomes.

This changeover is expected to increase exponentially as temperatures continue to increase.

Global Climate Change

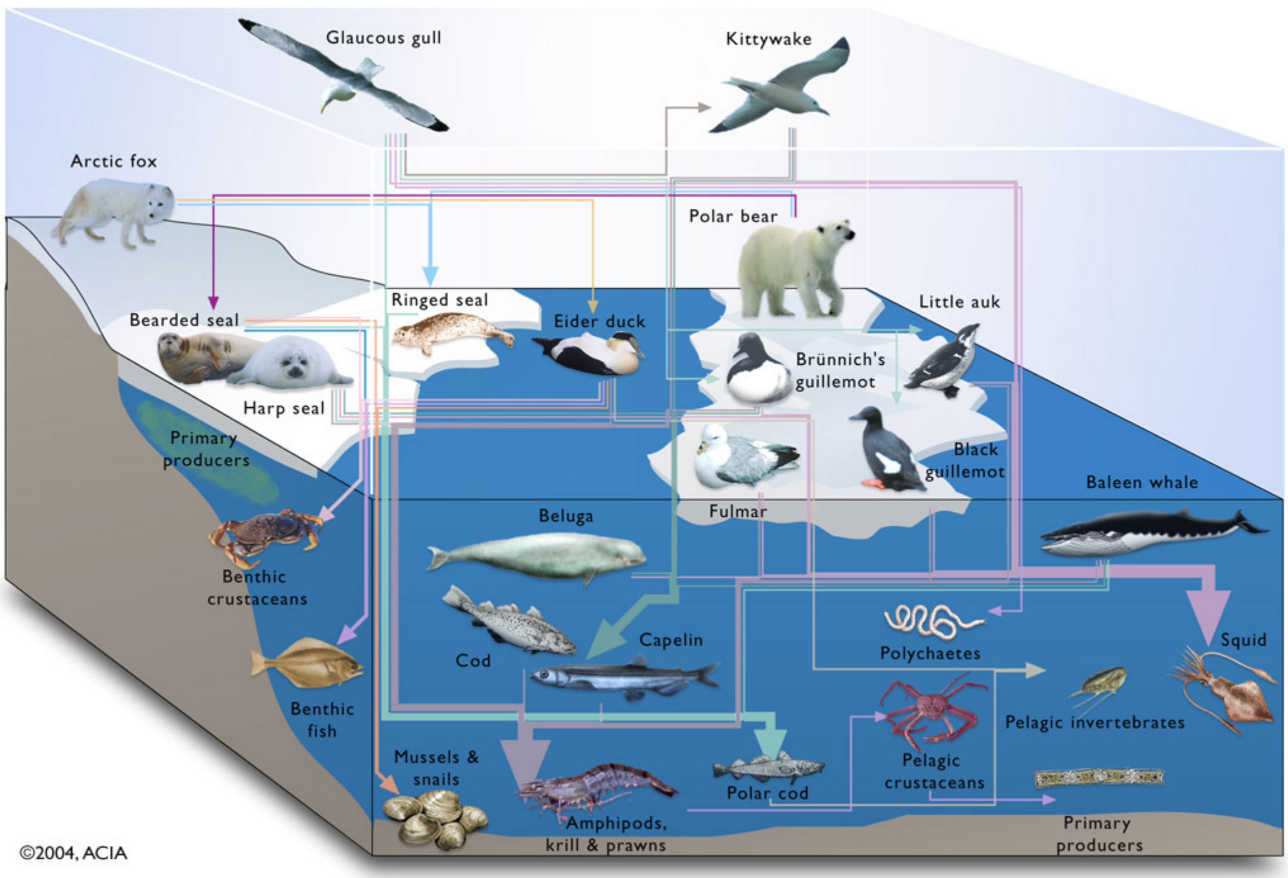
According to the National Oceanic and Atmospheric Administration:

"Climate change impacts have been identified as one of the greatest global threats to coral reef ecosystems. As temperatures rise, mass bleaching, and infectious disease outbreaks are likely to become more frequent.

Additionally, CO_2 absorbed into the ocean from the atmosphere has already begun to reduce rates in reef-building and reef-associated organisms by altering sea water chemistry through decreases in pH (ocean acidification). "

Global Climate Change

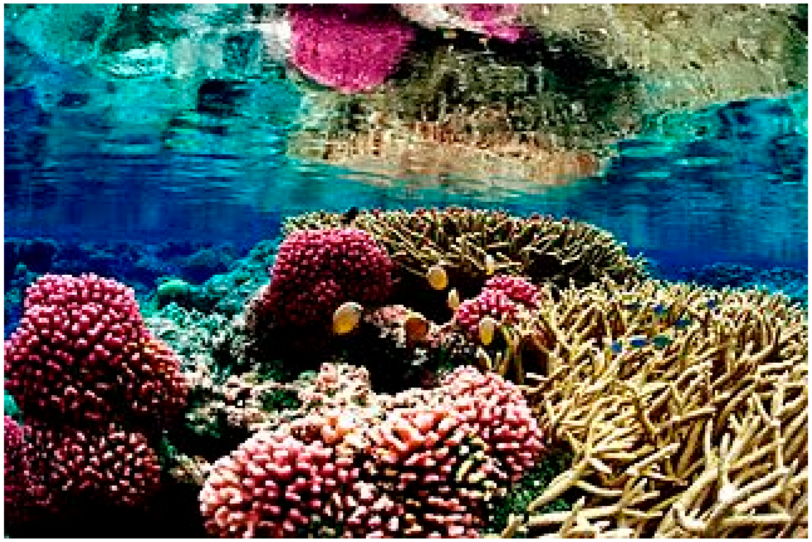
The recent realization that coral reefs are dying is extremely alarming to biologists. They house the primary producers for oceanic biomes. Loss of the reefs could impact thousands of species.

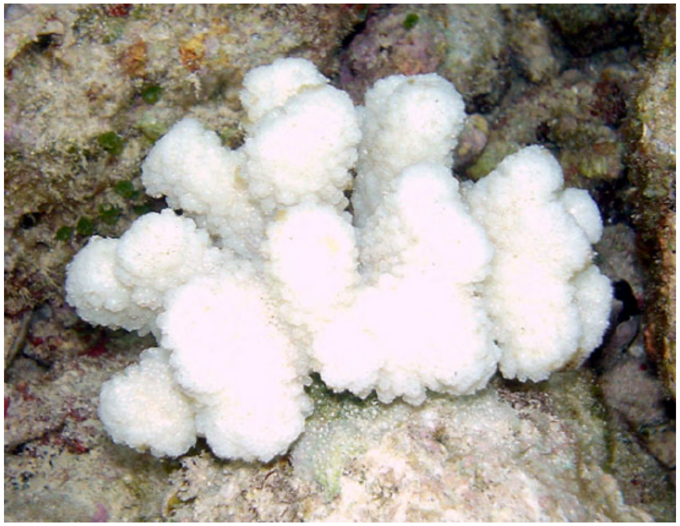


Global Climate Change

A study done by scientists from seven universities and institutions around the globe in late 2012 reported:

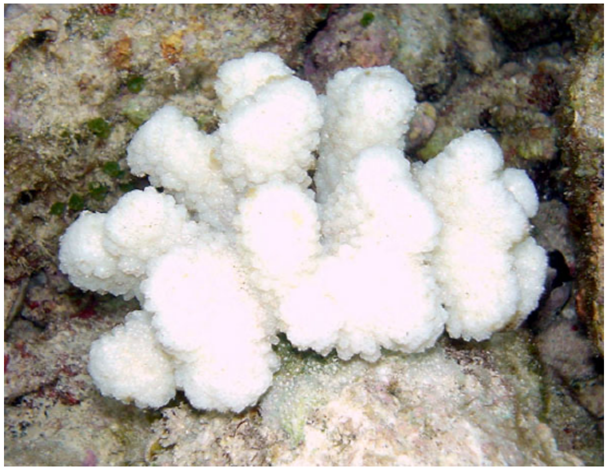
If global climate change continues at the current rate, 70% of all coral reefs on Earth will be lost to degradation by the year 2030.





Global Climate Change

With a partner, draw a chain of events that leads from increased food production for a growing urban area to the colapse of an oceanic ecosystem. Label any steps that involve ecological interaction.



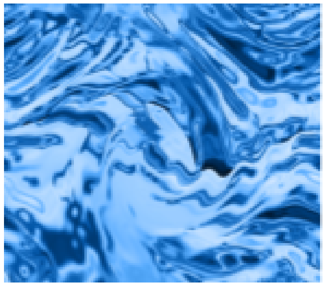
Natural Resources

Natural resources include abiotic and biotic factors that naturally occur in an environment and can be used by organisms for food, shelter, and survival.

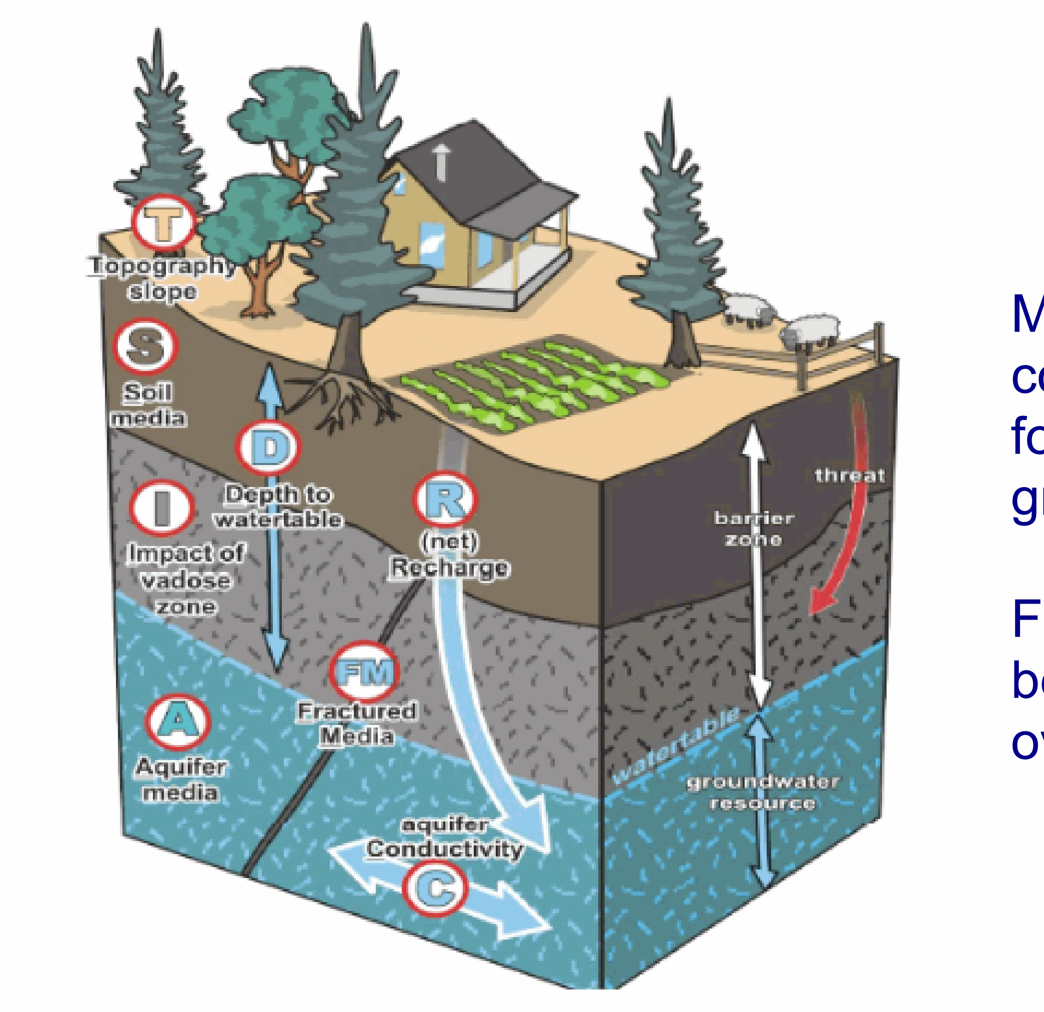
Natural resources fall into two major categories: **renewable** and **nonrenewable resources**.

Renewable Resources

Renewable resources can be regenerated if they are biotic or can be replenished by the cycling of matter if they are abiotic. *Although these types of resources are replaceable, there may be limits to how much is available at a given time.*



Limited Renewable Resources



Most fresh water consumed by humans is found deep below the ground.

Fresh water supplies may be limited by drought, overuse, and pollution.

Nonrenewable Resources

Nonrenewable resources cannot be replenished by natural processes.

Fossil fuels - coal, oil, and natural gas - formed over hundreds of millions of years as organic matter decayed under pressure.

They contain high levels of carbon and release chemical energy when burned.

Once used, they are gone forever.

Coal

Crude Oil

Minerals

Industrial Development

Energy Requirements

The lifestyle of an average citizen in a developed country requires enormous amounts of energy to power the modern technology.

As populations grow the environmental impact will grow exponentially.

Sources of Energy: fossil fuels

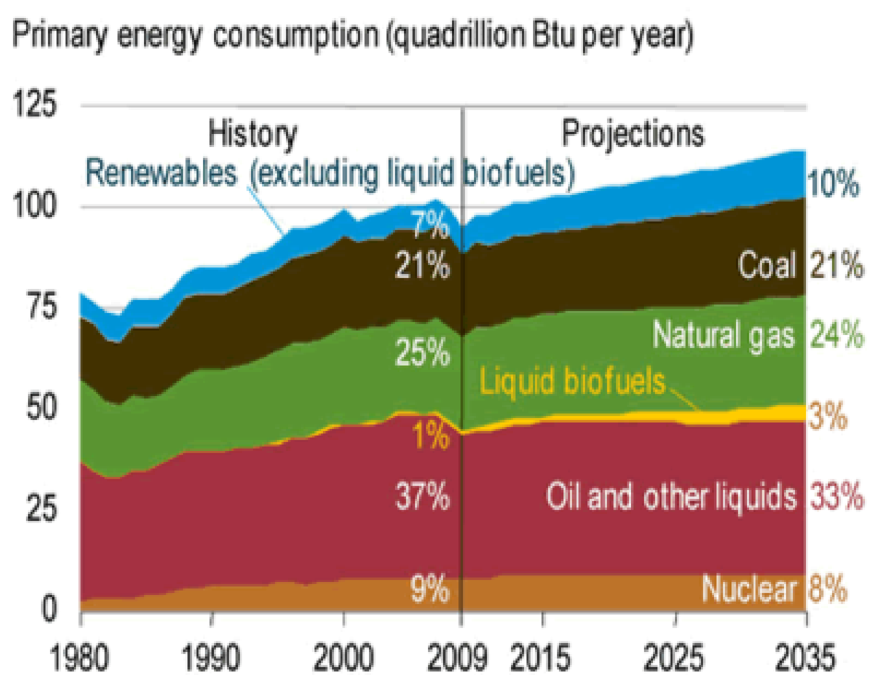


Image and data from the US Energy Information Agency, Annual Energy Outlook, 2011

8 A rock quarry used for producing gravel to make concrete.

- A Renewable
- B Limited renewable
- C Non renewable
- D none of these

answer

9 Air

- A Renewable
- B Limited renewable
- C Non renewable
- D none of these

answer

10 Wool

- A Renewable
- B Limited renewable
- C Non renewable
- D none of these

answer

11 Nuclear Energy

- A Renewable
- B Limited renewable
- C Non renewable
- D none of these

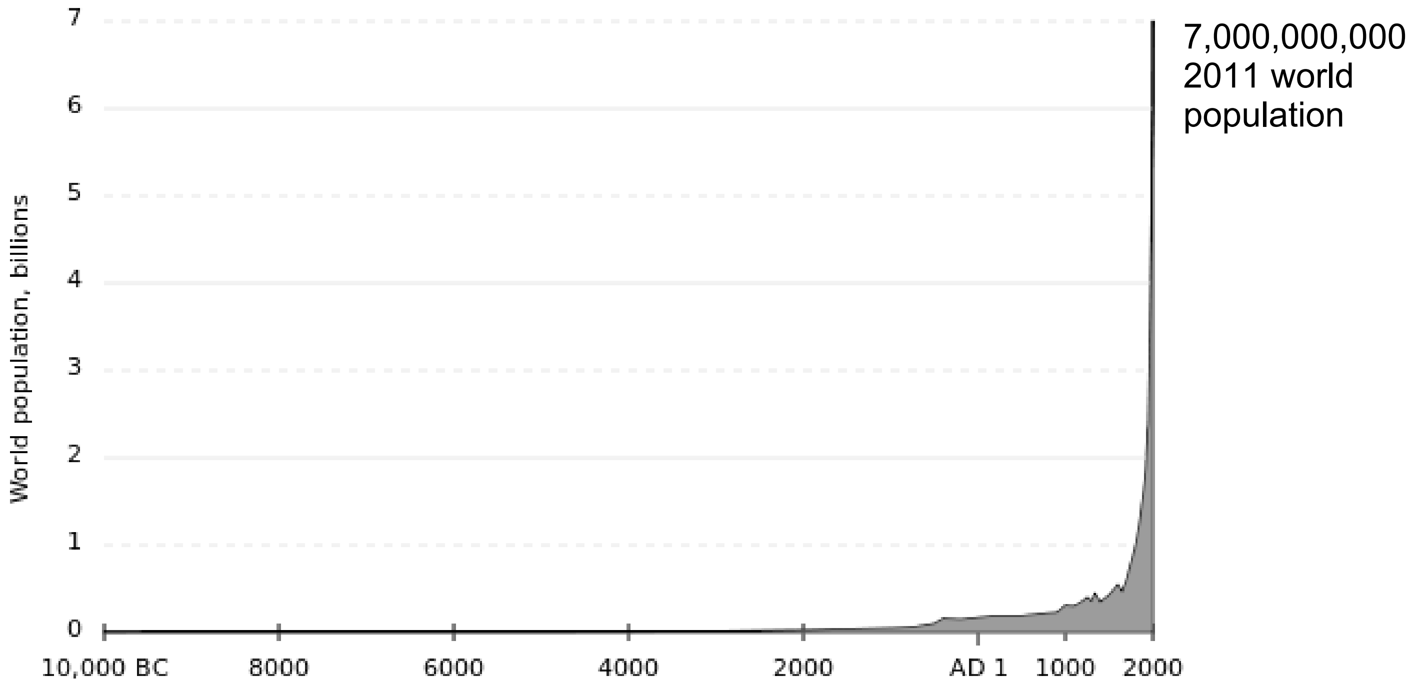
answer

Global Population Growth

Return to Table of Contents

Human Population

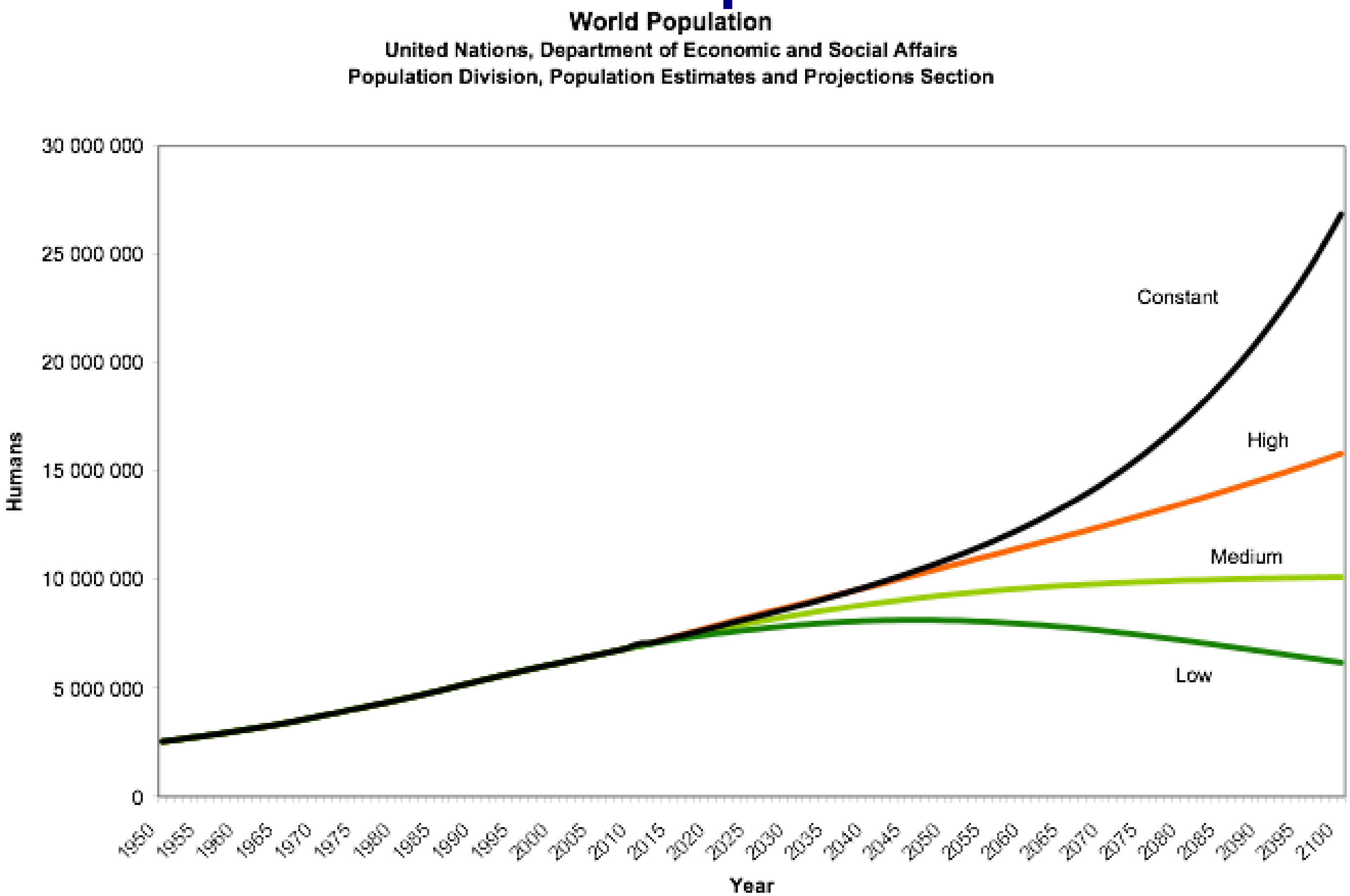
In addition to changing the environment, the advent of new technologies has allowed human populations to grow exponentially. Food and energy have recently been made more and more abundant for the human species, leading to a surge in growth.



Human Population

It has become important to understand how human population will proceed. By many models it is believed that by 2040 human population will exceed 10,000,000,000. This concerns scientists because of the increased impact this will have on our planet.

Human Population



Population Growth

Population experts use mathematics to model aspects of **population growth.** Population growth is the change in a population over time, and can be quantified as the change in the number of individuals of any species in a population using "per unit time" for measurement.

Determinants of Population Growth

Population growth is determined by four factors:
births (B), deaths (D), immigrants (I), and emigrants (E).

Using a formula:

(birth rate+immigrants)-(Death rate+emigrants)

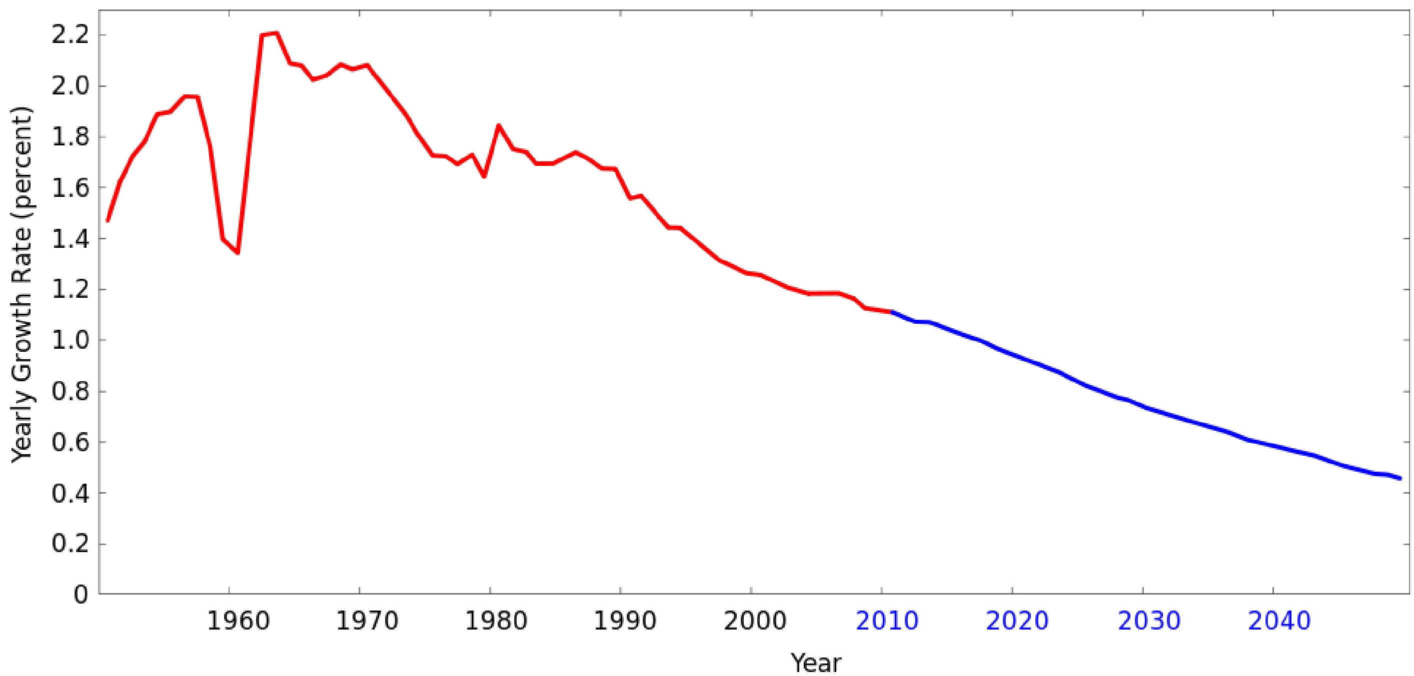
or

(B + I) - (D + E)

The population growth of a period can be calculated in two parts, **natural growth** of population (B-D) and **mechanical growth** of population (I-E). Natural growth is affected by the health of the population and availability of resources. Mechanical growth of population is mainly affected by social factors.

PGR

Population growth rate (PGR) is the rate at which the number of individuals in a population increases in a given time period as a fraction of the initial population. Currently PGR for humans is about 1.1% population increase per year



This rate has been decreasing which means that growth is slowing, but the population is still increasing.

Factors that Influence Population Growth

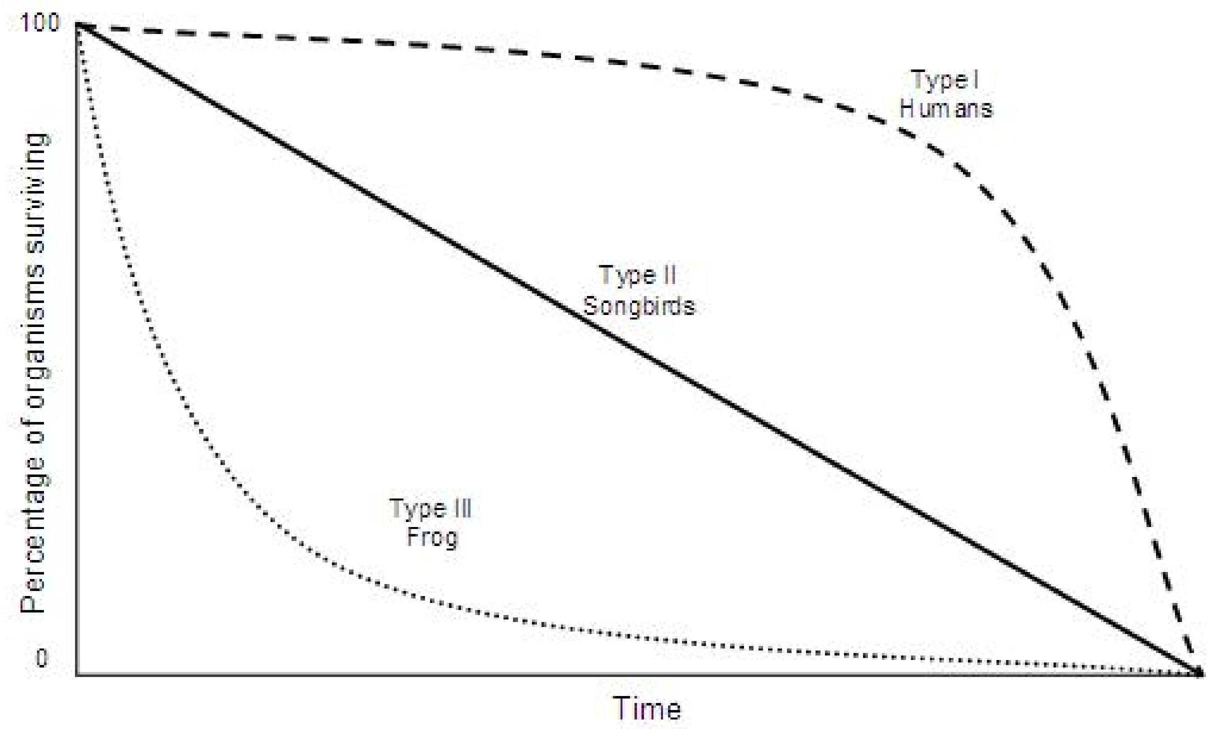
In real populations there are an uncountable amount of known and unknown factors that will play a role in the limitations of population size and the rate at which a population grows.

One important factor is **survivorship.** This is a population's expectation for average death rates at a given yearly age.

Factors that Influence Population Growth

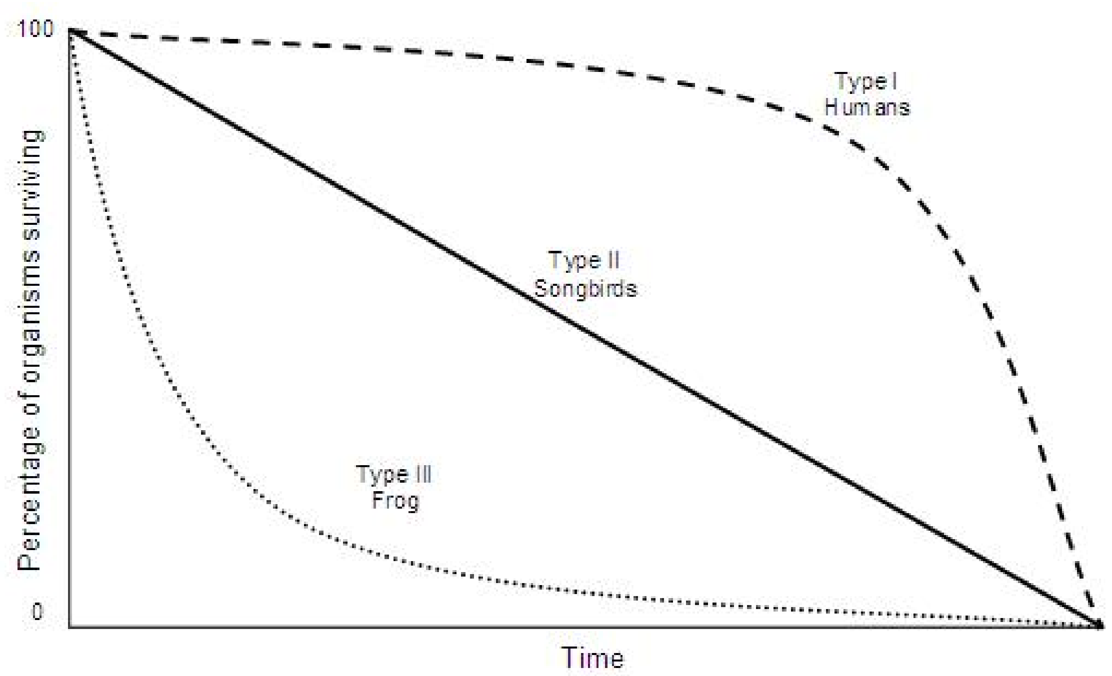
Survivorship curves show the different strategies of survivorship for different species. The curve shows how many individuals are still alive after a certain period of time.

As this curve shows, staring with 100 individuals, when are individuals most likely to die during their life span.



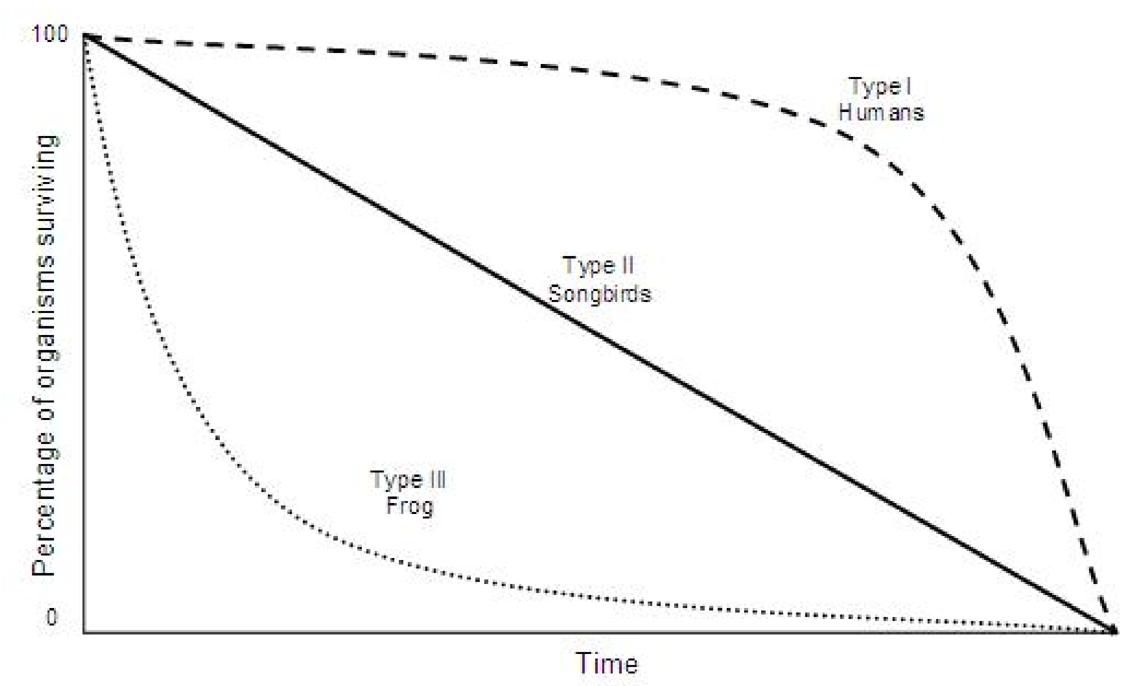
Factors that Influence Population Growth

Humans are an example of type 1. Young humans are likely to survive well, but death rates increase exponentially as the years pass.



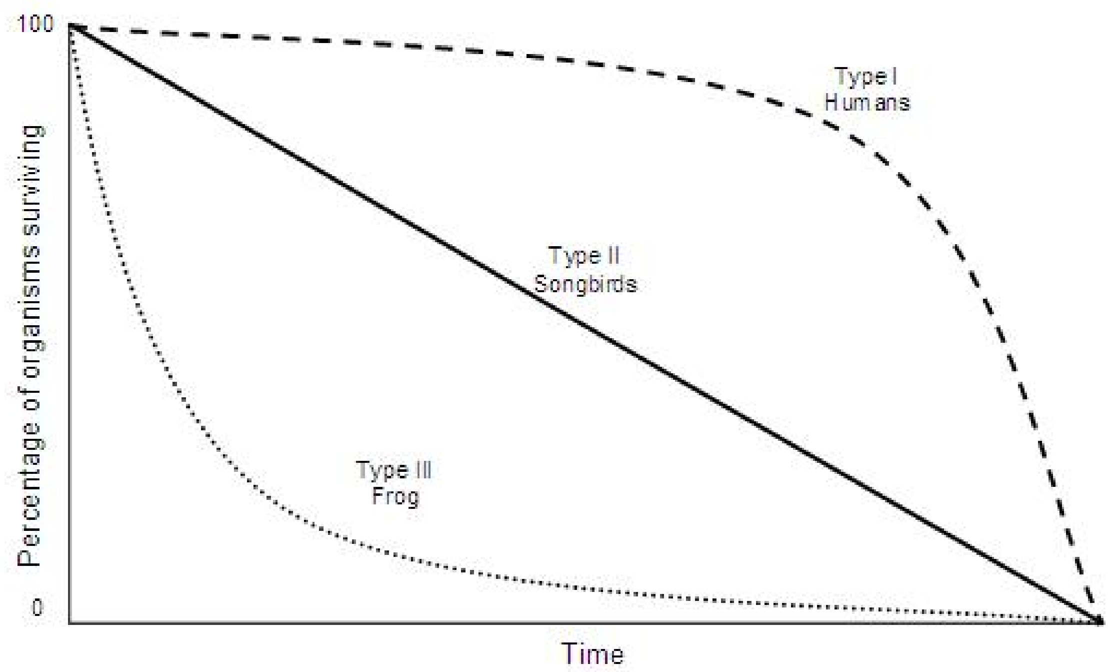
Factors that Influence Population Growth

Birds are an example of type 2. As the linear curve shows, each year a bird is just as likely to die as they were the previous years. Young or old has no bearing on survivability.



Factors that Influence Population Growth

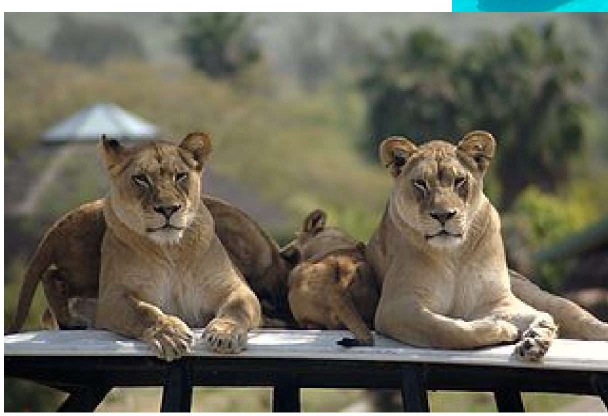
Frogs are an example of type 3. They are very like to die at a young age but if they survive their youth they are likely to live a long time.



Factors that Influence Population Growth

Typical Type 1 Survivability Characteristics:

- Stable environment
- Larger size
- Long life expectancy
- High level of parental care
- Few offspring



Factors that Influence Population Growth

Typical Type 3 Survivability Characteristics:

- Unstable environment
- Early Maturity
- Little parental care
- High number of offspring
- Short lifetime




12 Flies give birth to hundreds of eggs in short periods of time. Most will be born and survive. However, their life span is unpredictable. Flies are:

- A Type I survivability
- B Type II survivability
- C Type III survivability

answer

13 A turtle lays a large clutch of eggs on a beach. However, their is no parental support for the offspring and only a few will make it back to the ocean before being eaten by predators.

- A Type I survivability
- B Type II survivability
- C Type III survivability

answer

r or K Selection

The previous slides on survivability show 3 of many possible variations on life expectancy. Type I and Type III show exact opposite strategies, yet both are very successful in nature.

In ecology, r or K selection relates to the selection of combinations of traits that trade off between quantity and quality of offspring. In addition this selection typically dictates how much parental care is given to offspring.

Environmental conditions dictate which strategy will be favored.

r or K Selection

The theory gets its name from a well know algebraic expression of ecological population dynamics.

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

r is the maximum growth rate of the population (N)
K is the carrying capacity of its local environment
and the notation dN/dt stands for the derivative of N with respect to time (t).

r or K Selection

In unstable or unpredictable environments, **r-selection** predominates as the ability to reproduce quickly is crucial. There is little advantage in adaptations that permit successful competition with other organisms, because the environment is likely to change again.

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

r or K Selection

In stable or predictable environments, **K-selection** predominates as the ability to compete successfully for limited resources is crucial. Populations sizes of K-selected organisms typically are constant and close to the maximum that the environment can accommodate.

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

14 Which of the following is correctly paired?

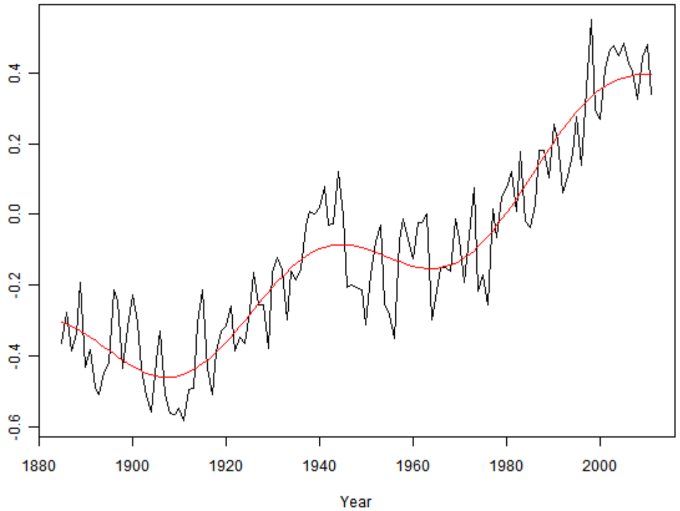
- A r selection, Type I / K selection, Type II

- B K selection, Type I / r selection, Type II

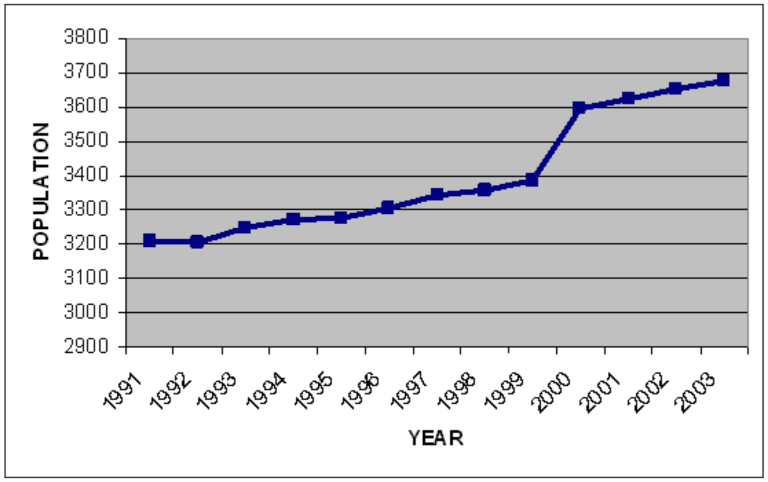
answer

15 Which of the following graphs most likely show a population with r- selection.

A



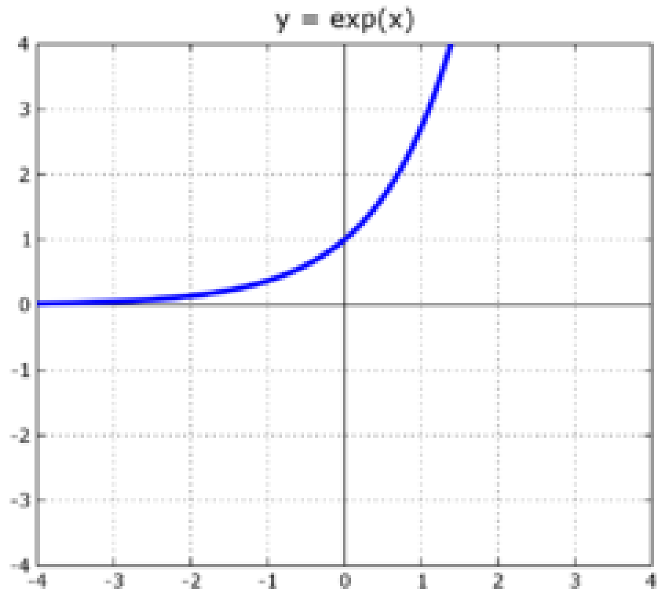
B



answer

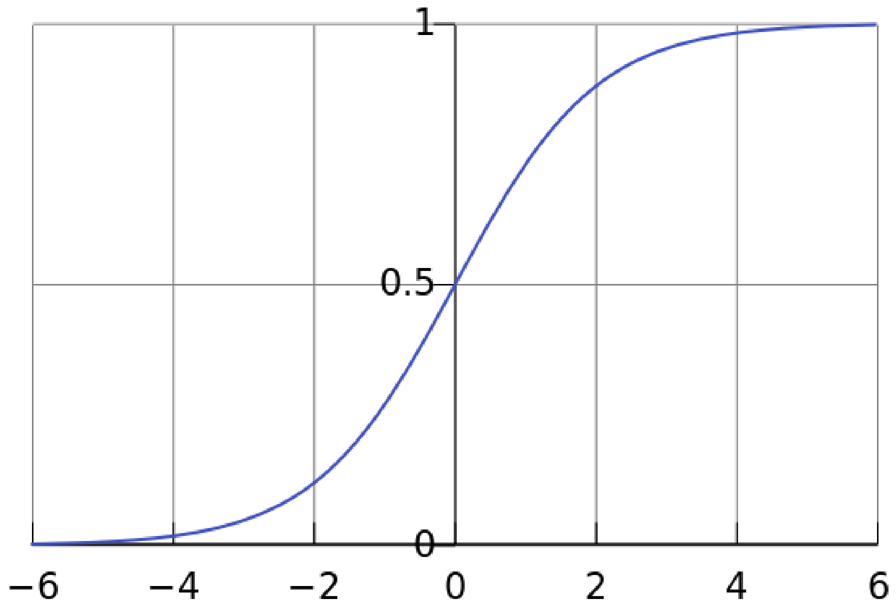
Exponential Population Growth

Under nearly ideal conditions a population can grow exponentially. This is a case were there is no limit to resources or geography and nearly all offspring survive. Growth is near limitless.



Logistic Population Growth

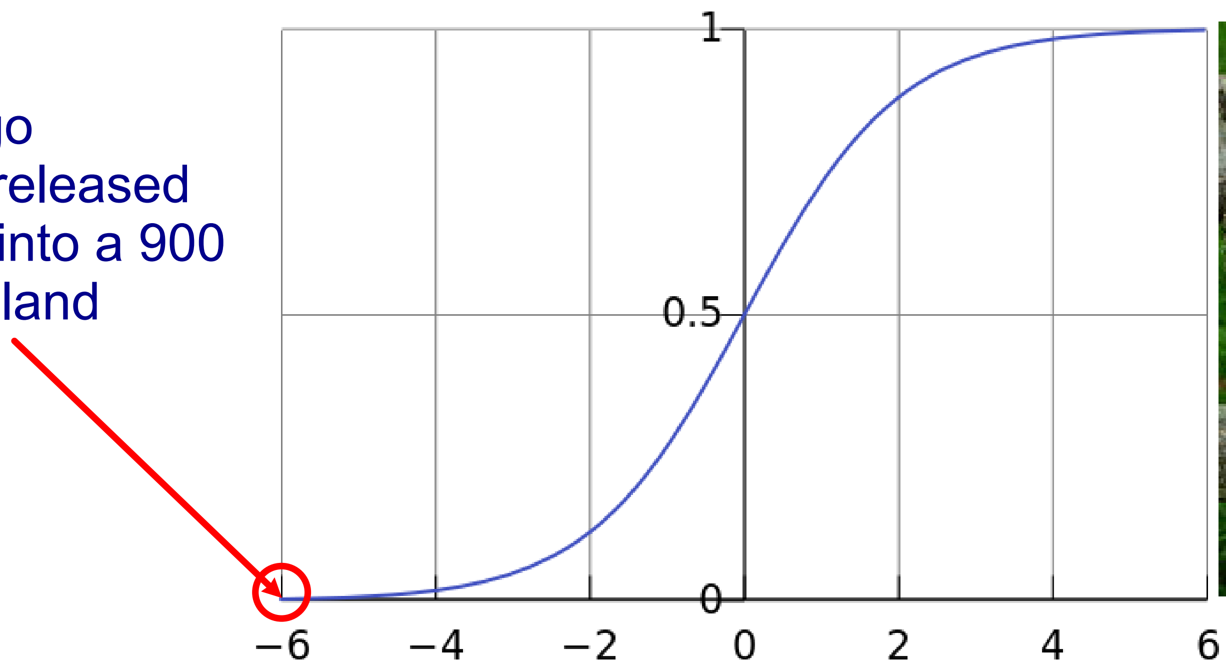
Logistic growth models include a **carrying capacity,** a maximum population size, in the calculations. Notice that this population starts out with exponential growth, but eventually limits defined by the environment slow, then cap the growth of the population.

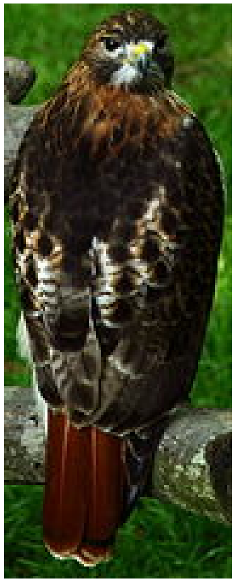


Logistic Population Growth

As an example, we will look at a new population of red tail hawks that have been released by conservationists into a woodland in upstate New York.

6 years ago scientists released 50 hawks into a 900 acre woodland

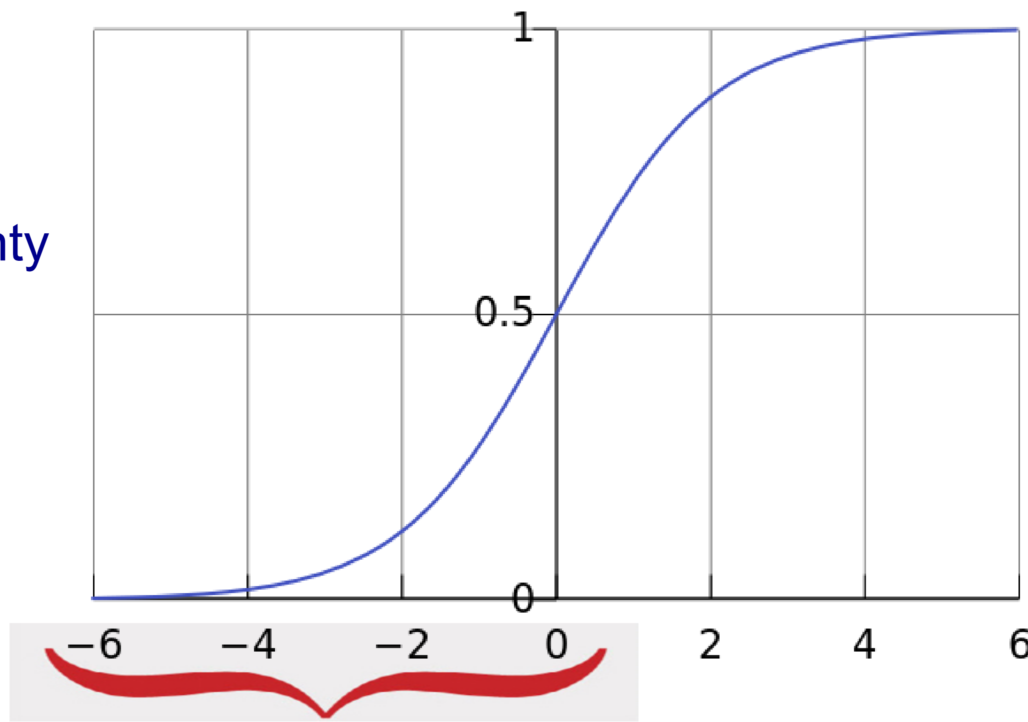


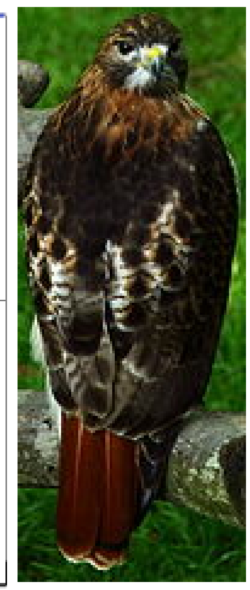


Logistic Population Growth

As an example, we will look at a new population of red tail hawks that have been released by conservationists into a woodland in upstate New York.

Since the hawks had no natural predators and plenty of pray in the environment, they began to show exponential population growth

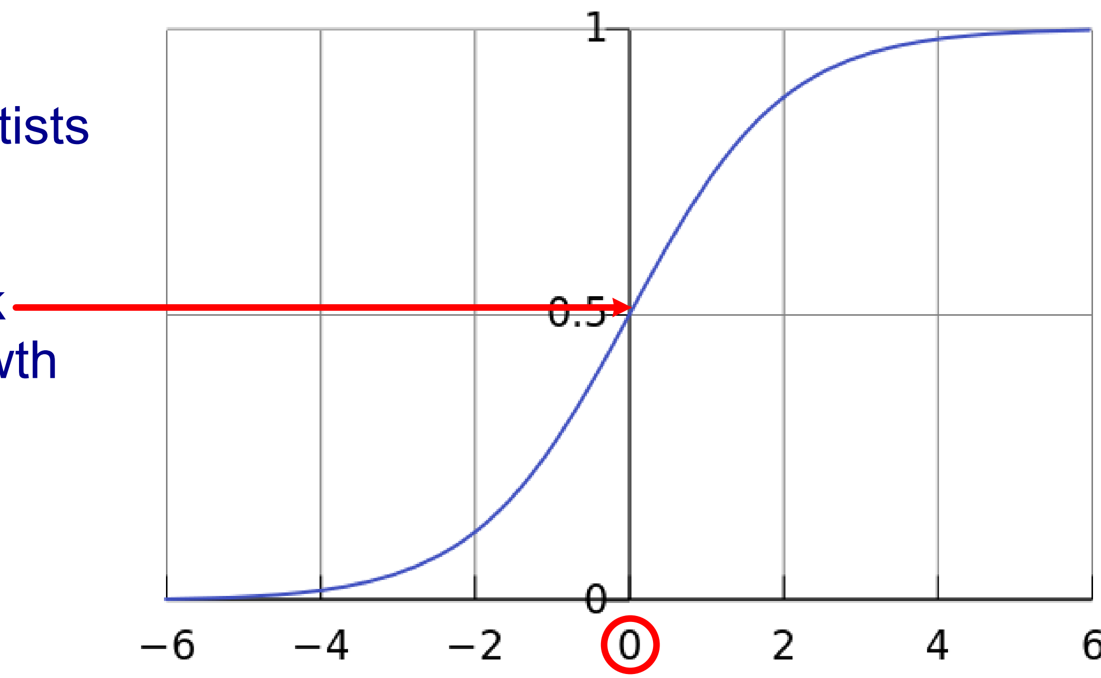


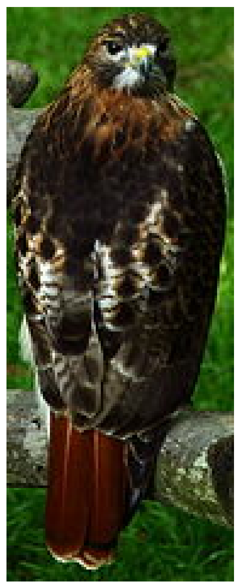


Logistic Population Growth

As an example, we will look at a new population of red tail hawks that have been released by conservationists into a woodland in upstate New York.

This year scientists believe the population has reached a peak population growth rate.

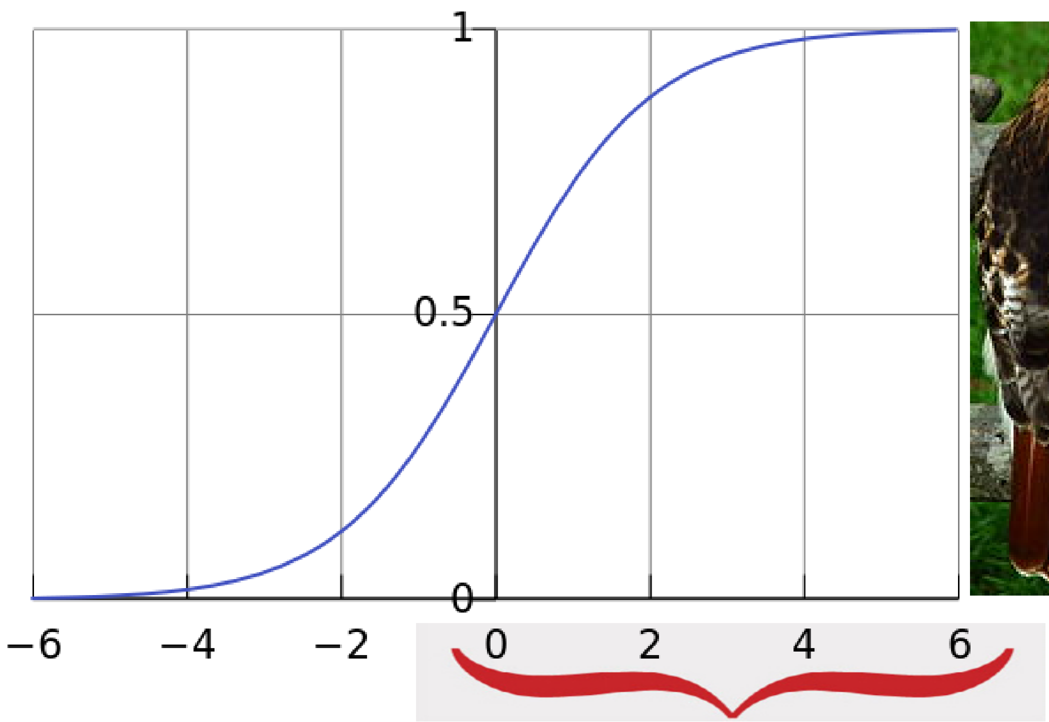


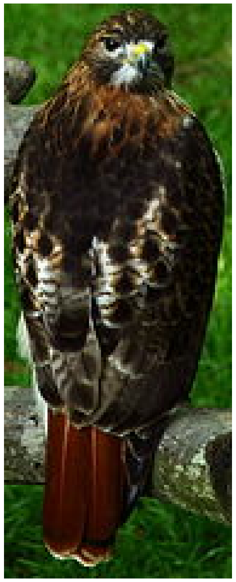


Logistic Population Growth

As an example, we will look at a new population of red tail hawks that have been released by conservationists into a woodland in upstate New York.

Over the coming years growth will slow because the hawks have been consuming much of the prey and their food source is becoming more scarce.



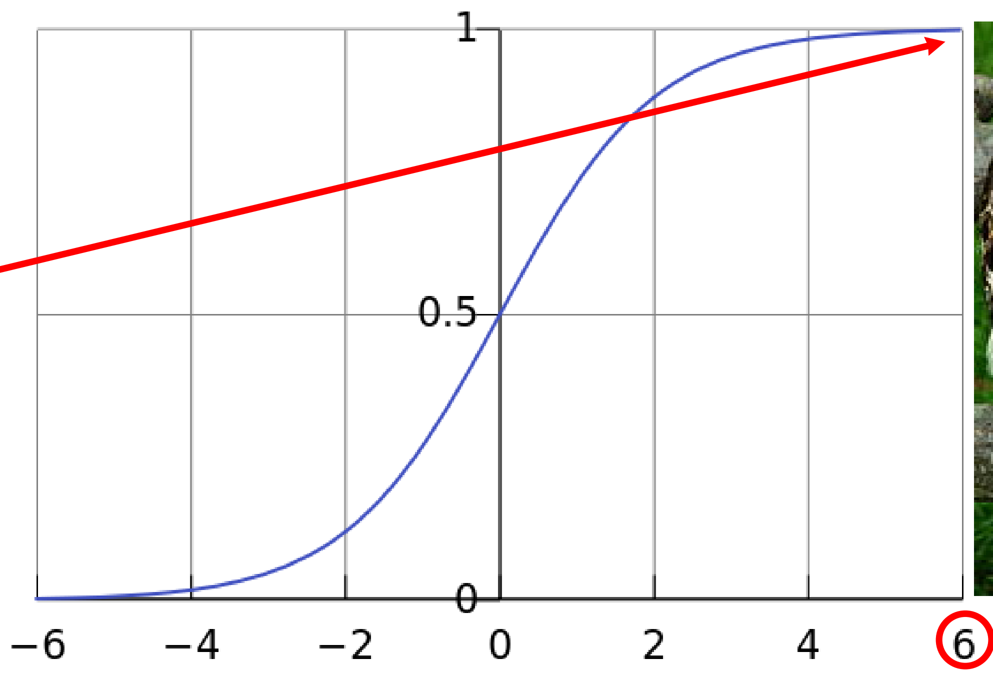


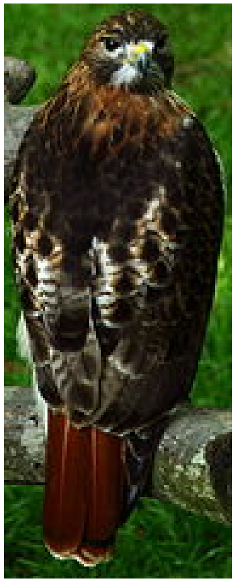
Logistic Population Growth

As an example, we will look at a new population of red tail hawks that have been released by conservationists into a woodland in upstate New York.

They estimate that after six additional years the population will reach the carrying capacity of the woodland.

In other words, death and emigration rate will equal birth rate.





Bacteria Population Growth

Use the following example to produce a growth curve with a partner.

A microbiologist is interested in studying a new strain of Staphlycoccus aureus, which causes a serious type of food poisoning. She has a very small sample and wishes to grow more in a petri dish. She knows that at some point she will have a maximum amount of bacteria but, after a time, the bacteria will begin to die off.

Draw a curve that represents how the bacterial population will grow/die in a petri dish.

Bacteria Population Growth

16 Which of the following represents the exponential phase?

- A Birth = Death
- B Birth > Death
- C Birth < Death

answer

17 Which of the following represents the stationary phase?

- A Birth = Death
- B Birth > Death
- C Birth < Death

answer

18 Which of the following represents the lag phase?

- A Birth = Death
- B Birth > Death
- C Birth < Death

answer

Intra-organism Interactions

Return to Table of Contents

Biosemiotics

Biosemiotics is a growing field that studies the production, action, and interpretation of signals in the biological realm. At the heart of biological signaling is the interactions of molecules that cause cells to change their behavior.

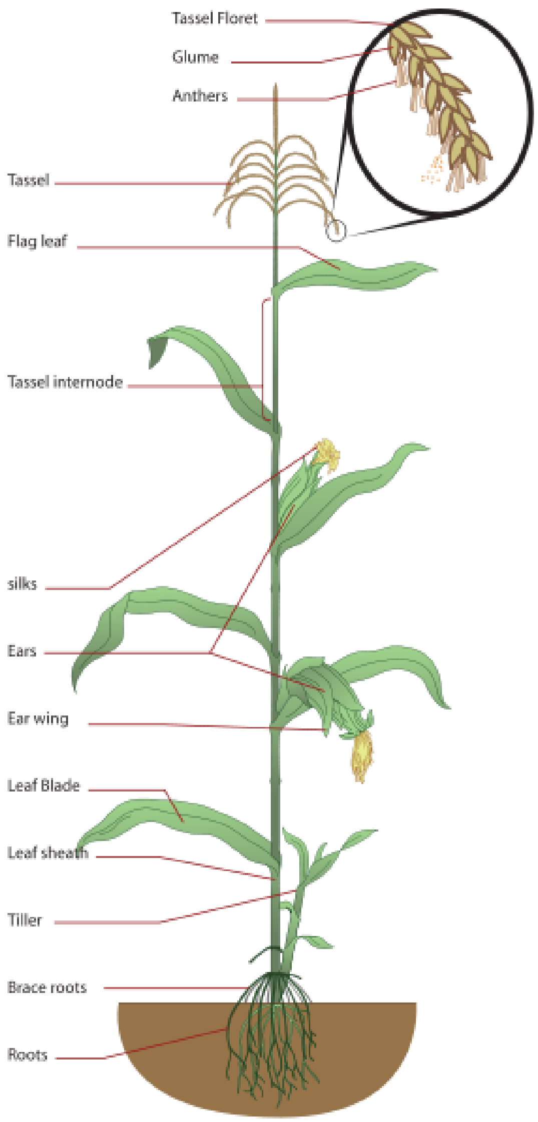
As cells change their behavior they cause new interactions among, tissues, organs, organ systems and the entire organism.

Plant Biosemiotics

As in all organisms, the evolution, development and growth of plants depends on the success of complex communication processes. These communication processes are primarily chemical interactions.

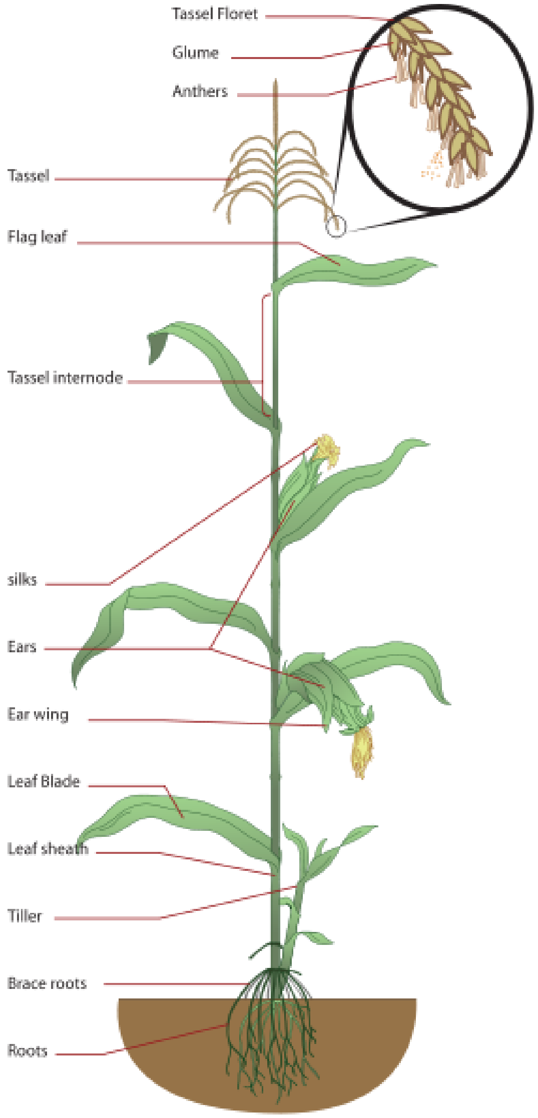
They involve active coordination and active organization conveyed by signals. A wide range of chemical substances and physical influences can serve as these signals.

Plant Biosemiotics



Plants are an ideal example of the complexity of intra organism signaling because they are **sessile (**immobile). They are fixed in one place so they must react to all of outside influences only through growth and development. Correct timing that requires multicellular coordination must be very precise to ensure the plant survives.

Plant Biosemiotics

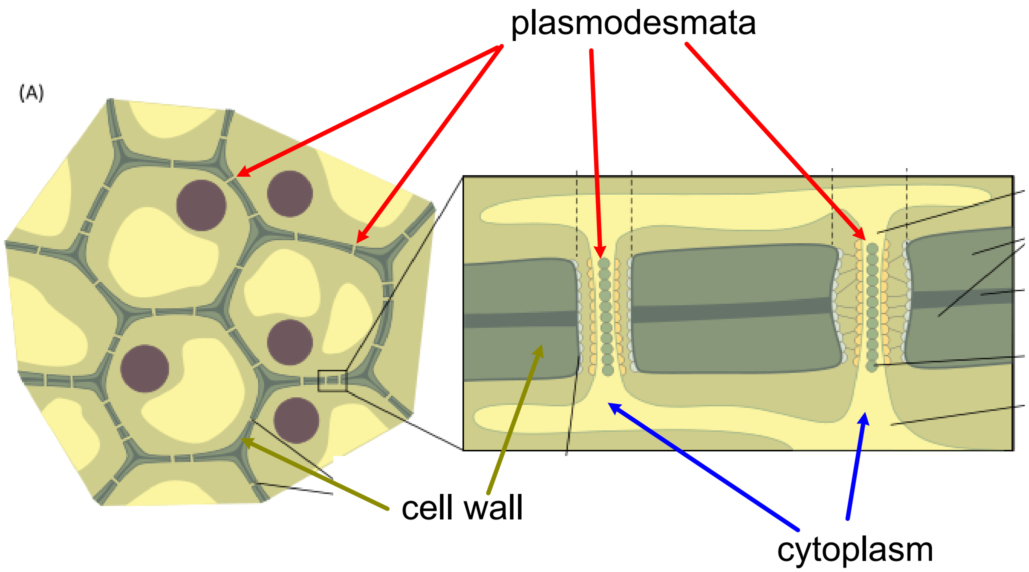


Plants do not have the central nervous system of animals, which controls metabolism and reactions. Local cells must coordinate to control important physiological actions, but using information from other parts of the plant.

For example: how a particular branch should grow, depends on the wind, light angle, overall architecture of the plant, available water, etc.

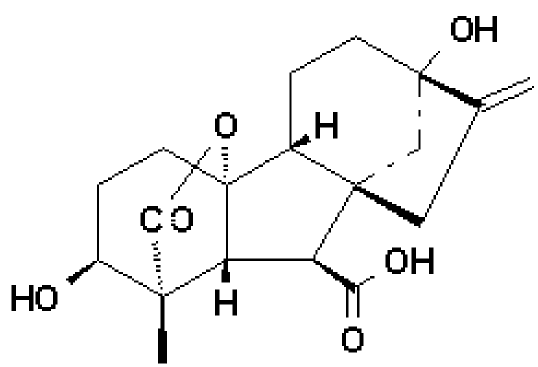
Plant Biosemiotics

Plant cells are connected by plasmodesmata. These connecting channels enable the flow of small molecules as well as ions, metabolites, hormones, macromolecules such as proteins and RNAs. The plasmodesmata provide continuos cytoplasm known as the **symplasm**. Plasmodesmata are more than transport channels; they also regulate and control the exchange of messenger chemicals.



Plant Biosemiotics

Gibberellins are a classification of plant signal that interacts with different types of cells. There are more than 100 known different gibberellins.



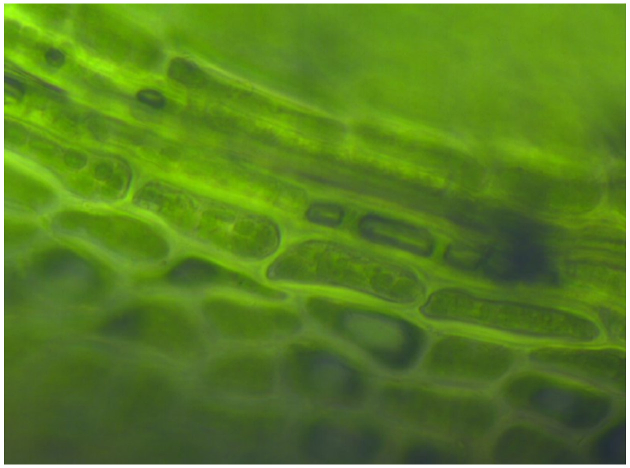
Gibberellin basic structure

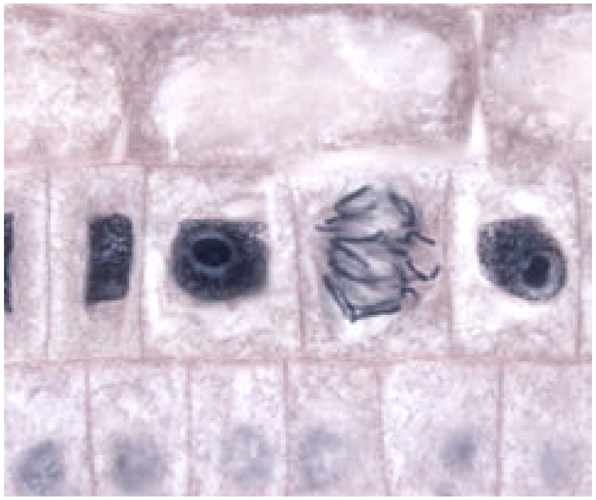
Root cells produce gibberellins in response to increased water and mineral availability.

The signal has different effects on different molecules and cells.

Plant Biosemiotics

The gibberellin interacts with an enzyme that, in turn, interacts with the cell wall to loosen collagen fibers. This allows the cells to elongate causing upward growth of the plant.





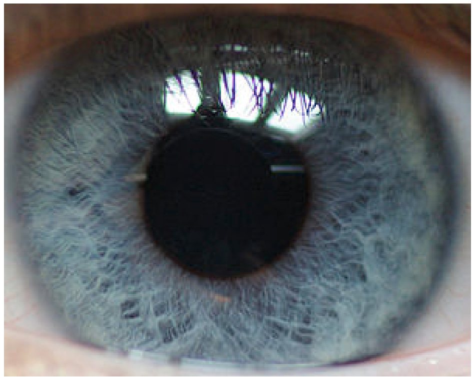
At the same time other molecules of gibberellin interact with receptors in the membranes of fruit cells. Mitosis is stimulated and the fruit becomes bigger.

Intra-Organism Competition

Competition can even occur inside a single organism. Much like the interaction of competition in populations, the contest ensures a stronger overall system. In this case it is the organism that benefits.

Gene Competition

Genes compete for phenotype. In the case of eye color, the gene for brown eyes wins the competition. This does not mean that the gene for blue eyes disappears or stops working. Only that the interaction of the proteins causes the brown phenotype.



Homozygous recessive
(no competition)

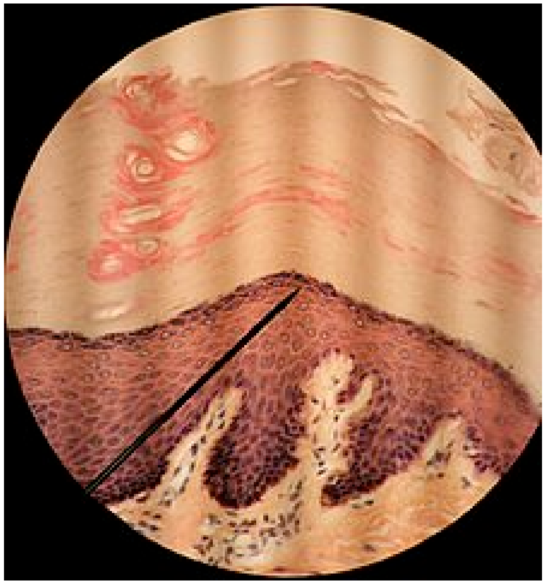
Heterozygous
(competing genes)

Gene Competition

In many cases the competition for phenotype causes an advantage. This is known as the **heterozygote advantage.** It is when the interaction of the 2 alleles creates an organism that is fitter to survive than either of the alleles alone.

Gene Competition

The most common cause of genetic deafness is a recessive gene called GJB2. The large ratio of carriers (heterozygotes) in the general population has caused researchers to search for a heterozygous advantage for the gene.



Skin layers under 100x magnification

Researchers have found that carriers of GJB2 will not be deaf. They have a thickened skin and increased cell repair capacity, giving them a greater barrier to infection, preventing bacterial invasion.

Gene Competition

Sickle Cell Disease is caused by having two genes for Hemoglobin S, which distort the shape of red blood cells into a crescent, or sickle, shape. Heterozygotes for this condition carry a typical Hemoglobin A gene and a Hemoglobin S gene: they have Sickle Cell trait, but not the disease.

Carriers of the Hemoglobin S gene are resistant to Malaria. The carriers don't experience sickle cell disease and are immune to Malaria making them stronger than homozygotes.

Other Examples of Interactions

In the course of this year, this class has covered many biological interactions. With a group, think back to previous sections and produce a list of at least 10 interactions that have been studied.

Give a brief description of the interaction, the primary reactants, the biological level, and the benefit that the interaction provides.