



Themes in the Study of Life



What does it mean when something is “alive”?

■ The Seven Properties of Life:

- ◆ Highly ordered structures
 - Ex: The human eye.
- ◆ Regulation
 - Ex: Human maintaining a constant body temperature despite fluctuations in the environment
- ◆ Energy processing
 - Ex: Using chemical energy to do work
- ◆ Responses to the environment.
 - Ex: On a hot day, humans sweat to cool our bodies off if our temperature starts to rise.



AP Biology

What does it mean when something is “alive”?

- ◆ Evolutionary adaptations that evolved over many generations.
 - Ex: Organisms have traits that are best suited to their environments such as the aerodynamic shape of the wing of birds that aid in flight.
 - ◆ These adaptations can be behavioral, anatomical, biochemical/physiological, and all help an organism survive and reproduce.
- ◆ Growth and development.
 - Ex: Genes control the pattern of development of all organisms.
- ◆ Reproduction



Themes connect key concepts in biology:

- Evolution accounts for the unity and diversity of life.
- New properties emerge at each level in the biological hierarchy.
- Structure and function are correlated at all levels of biological organization.
- Cells are an organism’s basic units of structure and function.
- The continuity of life is based on heritable information in the form of DNA, life’s processes involving the expression and transmission of genetic information.
- Organisms interact with their environments, exchanging matter and energy, life requiring the transfer and transformation of energy and matter.
- From molecules to ecosystems, interactions are important in biological systems.
- Feedback mechanisms regulate biological systems.



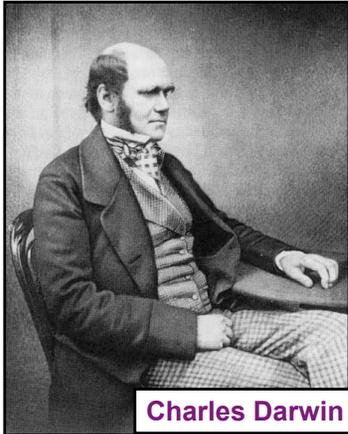
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Evolution:

The idea that organisms living on Earth today are the modified descendants of common ancestors.

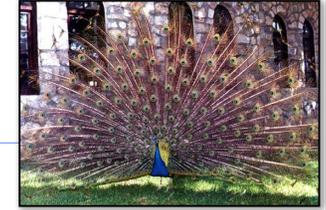
Core theme of biology.



Charles Darwin



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"Nothing in biology makes sense except in the light of evolution."

-- Theodosius Dobzhansky
March 1973
Geneticist, Columbia University
(1900-1975)



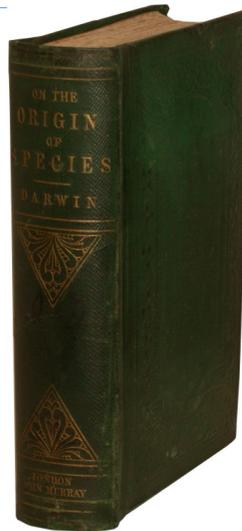
On the Origin of Species by Means of Natural Selection

In his book he articulated (stated) two points:

1. Contemporary (current) species arose from a common ancestor.

This evolutionary history he referred to as "Descent with modification"

2. He called the mechanism for this evolutionary modification (how it works) "Natural Selection"



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Darwin based in theory of **Natural Selection** on certain observations:

1. Heritable traits vary within a population.



2. Since more offspring are produced than the environment can support, competition exists for survival.



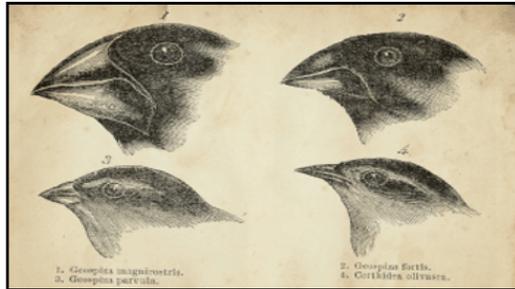
3. Organisms seem to have traits/characteristics that fit their environment.



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Natural Selection

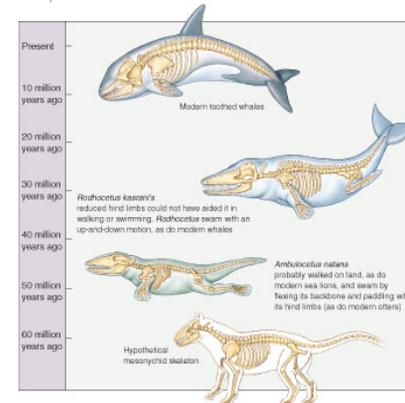
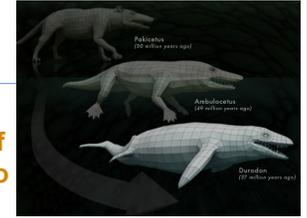
- Evolutionary change is a product of the process of **natural selection**
- Natural Selection leads to **modifications in the FREQUENCY of traits within a population** that enhance reproductive and survival successes
- Over time, species acquire **evolutionary adaptations**



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DARWIN'S RATIONALE BEHIND THE THEORY OF EVOLUTION:

- Individuals who inherit traits that are advantageous have a higher probability of surviving and reproducing than those who do not possess such characteristics.



- Many generations later, the **proportion of traits in a population will have altered**, with many more individuals having the advantageous traits.

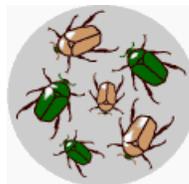
ONLY THOSE TRAITS IN A POPULATION WHICH ARE INHERITED CAN CHANGE IN FREQUENCY DUE TO NATURAL SELECTION!!!

How does Natural Selection happen?

Natural Selection

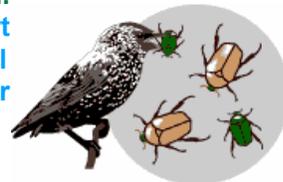
1. There is variation in traits.

For example, some beetles are **green** and some are **brown**.



2. There is differential reproduction.

Since the **environment can't support unlimited population growth**, not all individuals get to reproduce to their **full potential**. In this example, green beetles tend to get eaten by birds and survive to reproduce less often than brown beetles do.



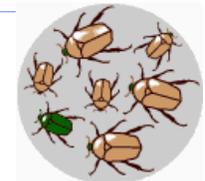
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<http://evolution.berkeley.edu/evosite>

How does Natural Selection happen?

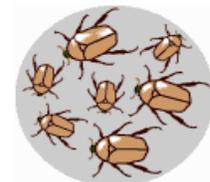
3. There is heredity.

The surviving brown beetles have **brown baby beetles** because this trait has a **genetic basis**.



4. End result:

The **more advantageous trait**, brown coloration, which allows the beetle to have **more offspring**, becomes **more common** in the population. If this process continues, eventually, all individuals in the population will be brown.

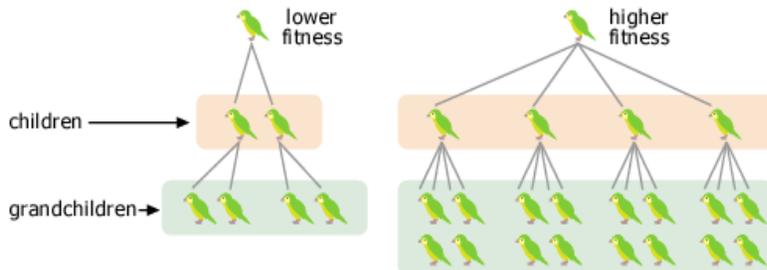


If you have variation differential reproduction, and heredity, you will have evolution by natural selection as an outcome. It is as simple as that.

Differential Reproductive Success occurs because of variation in traits that affect survival time and ability to reproduce

EVOLUTION OCCURS BECAUSE OF THE **UNEQUAL REPRODUCTIVE SUCCESS** OF INDIVIDUALS THAT OVER TIME CAUSES THE POPULATION TO **ADAPT** TO ITS ENVIRONMENT!

Adaptation: Inherited characteristic of an organism that enhances its survival and reproduction in specific environments.



AP Biology (**Fitness** — the number of descendants an organism produces)

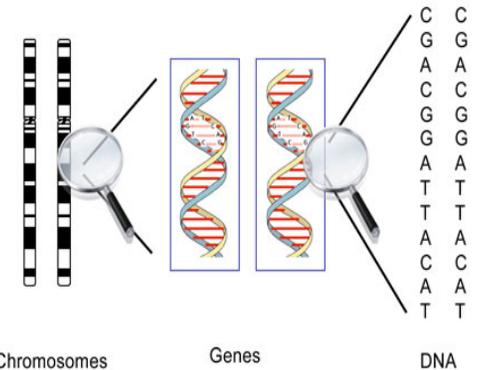
How does evolution occur?

Evolution is descent with modification from a common ancestor, but exactly what has been modified? **DNA**

DNA is made of smaller molecules called nucleotides (referred to as **A, T, G, C**), which are covalently bonded together in a certain order (or sequence) to form large DNA molecules, often referred to as chromosomes.

The sequence of nucleotides encodes the instructional messages held in the DNA of an organism.

Genes = specific sections of DNA that contain hereditary information that the cell uses to make RNA or protein molecules from, which in turn give the cell certain traits.



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How does evolution occur?

Because of DNA **mutations**, changes in the sequence of nucleotides in the DNA, a gene may exist as several different versions in a population of a species. Each gene version is called an **allele**.

Evolution occurs when there is a change in the gene's allelic frequency within a population over time - when some versions of the gene (certain alleles) for a particular character increase or decrease in frequency within a population.

Ex: The % of alleles for blue eyes in a POPULATION changes from 35% to 5% over several generations.

These genetic differences in DNA are **heritable** & can be passed on to the next generation—which is what really matters in evolution: **Long-term (trans-generational) change.**

Gene in the DNA	Various traits (versions) for the character "Eye Color;" result from inheriting alternative versions (alleles) for the eye color gene.
	 
Eye Color Gene	Brown Blue

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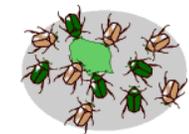
Which scenario illustrates "Descent with Modification"?

Descent with Modification? Scenario 1

Imagine a year or two of **drought** in which there are **few plants** that these beetles can eat.



All the beetles have the **same chances of survival and reproduction**, but because of **food restrictions**, the **beetles** in the population are a **little smaller** than the preceding generation of beetles.



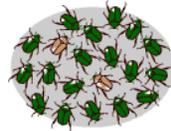
Beetles on a diet

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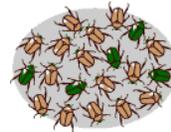
Which scenario illustrates “Descent with Modification”?

Descent with Modification? Scenario 2

Most of the beetles in the population (say 90%) have the **gene version (allele)** for bright green coloration and a few of them (10%) have a **gene version** that makes them more brown.



Some number of **generations later**, things have changed: **brown beetles** are more common than they used to be and **make up 70% of the population**.



Beetles of a different color

Which scenario illustrates “Descent with Modification”?

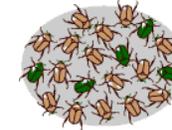
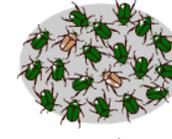
Which example depicts descent with modification — a change in gene frequency over time??????????????????

1. Smaller beetles due to lack of food or...
2. A change in the amount of green and brown beetles in the population



Beetles on a diet

OR

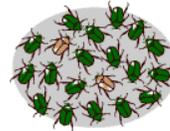


Beetles of a different color

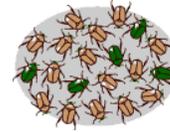
Which scenario illustrates “Descent with Modification”?

Which example illustrates descent with modification — a change in gene frequency over time?

The difference in weight in example 1 came about because of **environmental influences**—the low food supply—**not because of a change in the frequency of gene alleles**. Therefore, example 1 is **not evolution**.



Because the **small body size in this population was not genetically determined**, this generation of small-bodied beetles will produce beetles that will grow to normal size if they have a normal food supply.



Beetles of a different color

The changing color in example 2 is **definitely evolution**: these two generations of the same population are **genetically different**

MISCONCEPTION!

Though the effects of evolution are apparent by looking at an individual member of a species, **individual organisms do NOT evolve!!!**

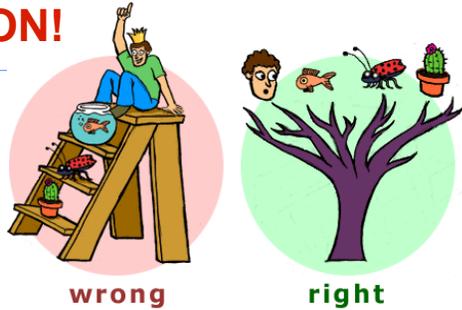


Organisms don't adapt (not in an evolutionary sense); Organisms **HAVE** adaptations.

MISCONCEPTION!

Evolution is **NOT** **GOAL-DIRECTED!**

No population chooses to evolve one way versus another.



wrong

right

The species that is able to survive long enough to reproduce the most will contribute more to the gene pool of the next generation compared to one that produces fewer or no offspring.

That's all...



<http://evolution.berkeley.edu/evolibrary/images/evolladdendtree.gif>

Evolution explains unity & diversity

So we see both **UNITY**, since we descend from a common ancestor, and **DIVERSITY** since species, in adapting to their environments, have experienced various modifications.

Unity

◆ what do organisms have in common & why do similarities exist?

- common biochemistry & physiology
- evolutionary relationships - connected through common ancestor

Diversity

◆ why are there differences?

- natural selection
- adaptations allow different individuals to survive in different environments

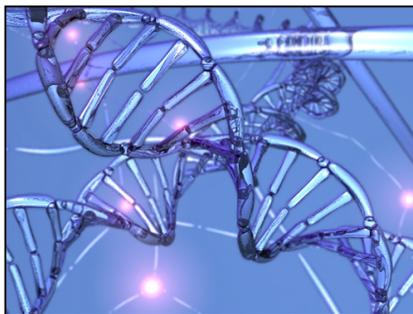


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Evolution explains unity & diversity

The best evidence of a common descent for all life is found in the universality of the genetic code.

ALL living organisms, from bacteria to humans, use nucleic acids in the form of **DNA** to store and transmit hereditary information.



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Organizing systems

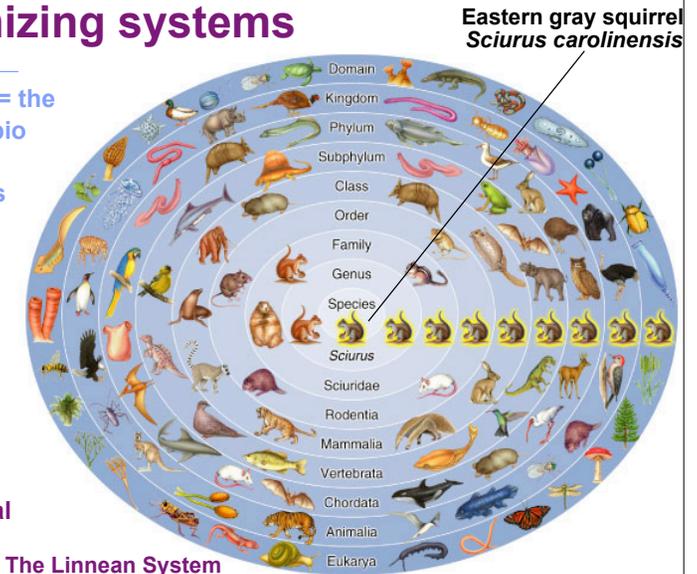
■ **Taxonomy** = the branch of bio that names & classifies species.

■ This helps make sense out of the diversity

■ **Biology** uses a **Hierarchical** scheme

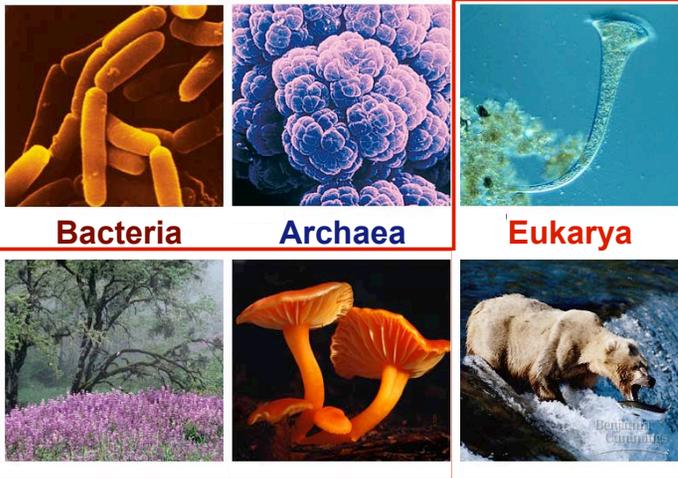
(Pictured = **The Linnean System**

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of Classification - groups species by increasing relatedness)

3 Domains of Life



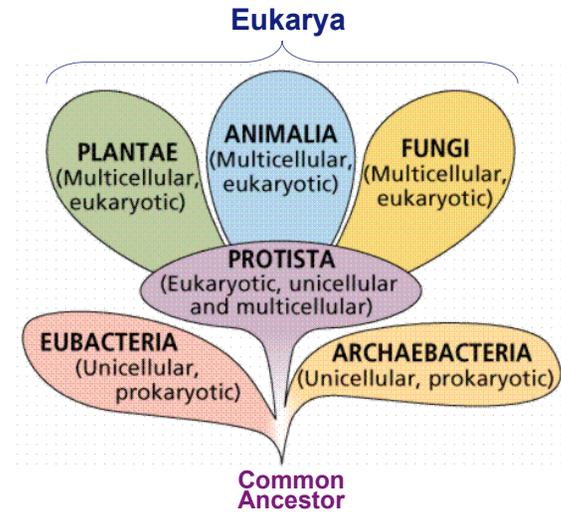
Bacteria

Archaea

Eukarya

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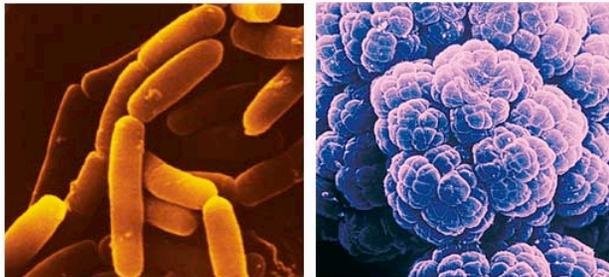
3 Domains of Life



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<http://www.emc.maricopa.edu/faculty/farabee/BIOBK/kingdoms.gd>

The Prokaryotes = Cells that lack a nucleus & membrane-bound organelles



BACTERIA - the most diverse and widespread prokaryote. Most are single-celled and most are microscopic.

ARCHAEA - Prokaryotes that live in extreme environments. Most are single-celled and most are microscopic.

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The Eukaryotes = Cells have a nucleus & membrane-bound organelles



Kingdom Protista = Unicellular and simple multi-cellular eukaryotes like paramecia. Some perform photosynthesis while others consume food from their surroundings.

Kingdom Plantae = Multi-cellular eukaryotes that carry out photosynthesis, converting light energy into chemical energy stored in the chemical bonds in sugars.

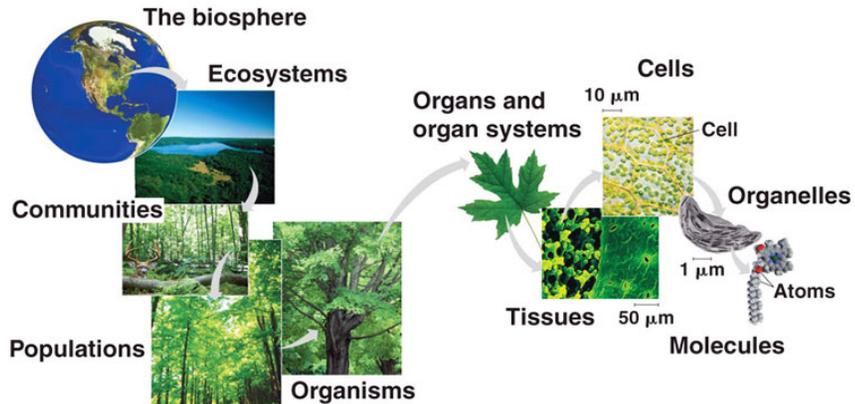
Kingdom Fungi = Eukaryotes defined by how they obtain nutrients. Mushrooms absorb nutrients from their surroundings. Some even decompose dead organisms and organic wastes.

Kingdom Animalia = Multi-cellular eukaryotes that ingest other organisms, digesting them and absorbing the nutrients from our digestive tract. Humans belong to this kingdom.

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New Properties emerge at each level in the biological hierarchy.

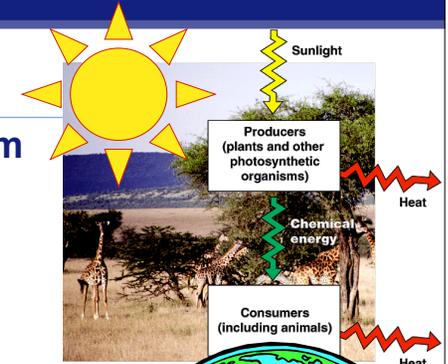
Emergent Properties = Properties that arise due to the arrangement and interactions of parts as complexity increases.



Energy transfer

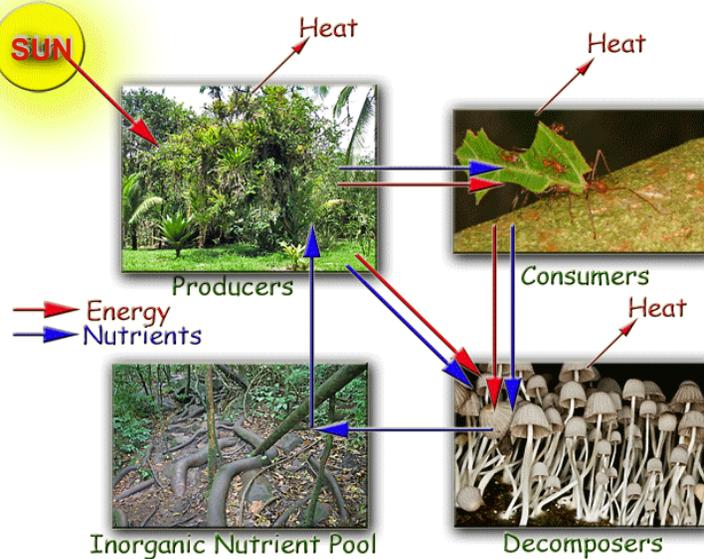
Life is an open system

- ◆ need input of energy
 - energy flows through an ecosystem
 - energy comes in, energy goes out
 - need a constant input
- ◆ need input of materials (atoms)
 - nutrients are recycled in an ecosystem



**DECOMPOSERS
RULE!**

Energy Flow Through The Ecosystem



Energy utilization



Give it a try... "Energy Transfer"

Like jackrabbits, elephants have many blood vessels in their ears that help them cool their bodies by radiating heat. Which of the following statements about this radiated energy would be accurate?

- A. The original source of the energy was the sun.
- B. The energy will be recycled through the ecosystem.
- C. The radiated energy will be trapped by predators of the elephants.
- D. More energy is radiated in cold conditions than in hot conditions.
- E. More energy is radiated at night than during the day.

Only the energy stored in tissues (body matter) is available for predators!
Not the energy lost as HEAT!

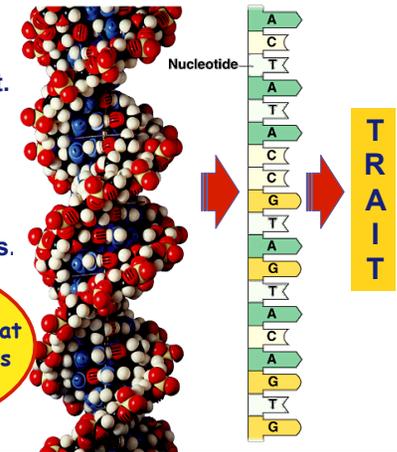


Continuity & Change

- Continuity of life is based on heritable information in the form of DNA

- ♦ **DNA** – the genetic material – carries biological information from one generation to the next.
- ♦ The blue print of an organism, It is only the sequence of nucleotides that reflects differences between organisms.

The entire set of genetic instructions that an organism inherits is called its **genome**



Form fits function

- The alignment of structure & function is seen at all levels of biology

Wing are aerodynamic to create lift



organism

Bones are hollow for light weight



organ

Far reaching neurons send signals to muscles



cell

Mitochondria have extensive surface area to make energy



organelle

Give it a try... "Form & Function"

The idea that form and function are related would be exemplified by which of the following examples?

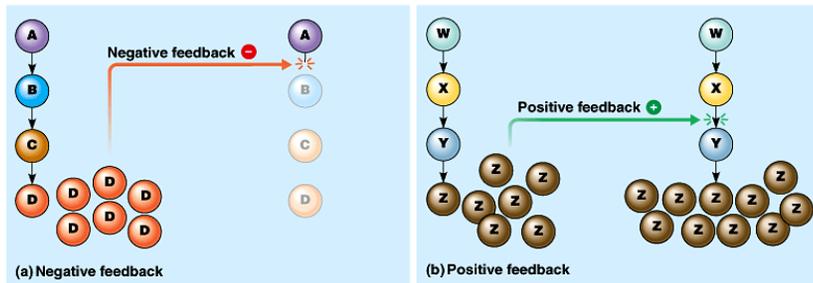
- A. Cells in the intestinal lining of vertebrates have many small projections that increase the surface area for absorption of nutrients.
- B. Plants that live in dry areas have large roots for absorbing water.
- C. Seeds that are dispersed by wind are very light.
- D. Fish that swim rapidly have bodies that are streamlined.
- E. All of the above.

Through natural selection, populations come to be dominated by adaptations, favorable characteristics that increase survivability and reproductive success.



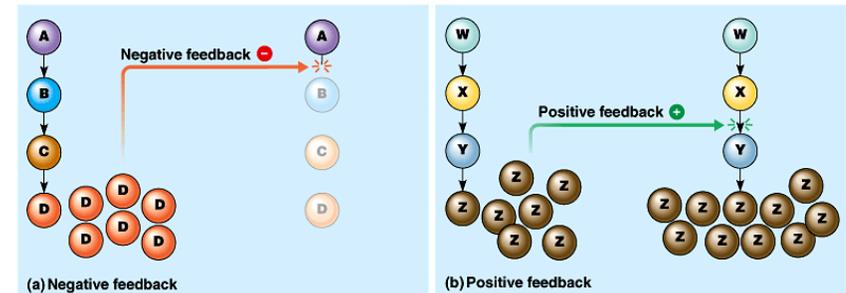
Regulation

- Organisms need to maintain a “steady state” in the face of changing conditions
 - This ‘steady state’ is termed **homeostasis**
 - We need to be able to stop something from occurring or when to encourage more of something to occur.
 - We achieve this through **feedback loops**
 - Enzymes (BIOLOGICAL CATALYSTS) are turned on or off as needed



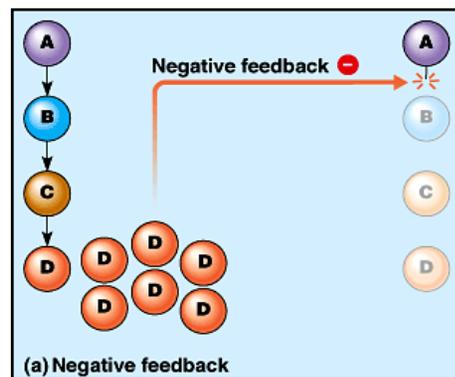
Two Types of Feedback Loops Exist

- Organisms need to maintain a “steady state” in the face of changing conditions
 - This ‘steady state’ is termed **homeostasis**
 - We often need to be able to stop something from occurring or encourage more of something to occur to maintain homeostasis or to deviate from homeostasis.
 - We achieve this through **feedback loops**
 - In a feedback loop, the **result** of an action controls whether more or less of that action will occur

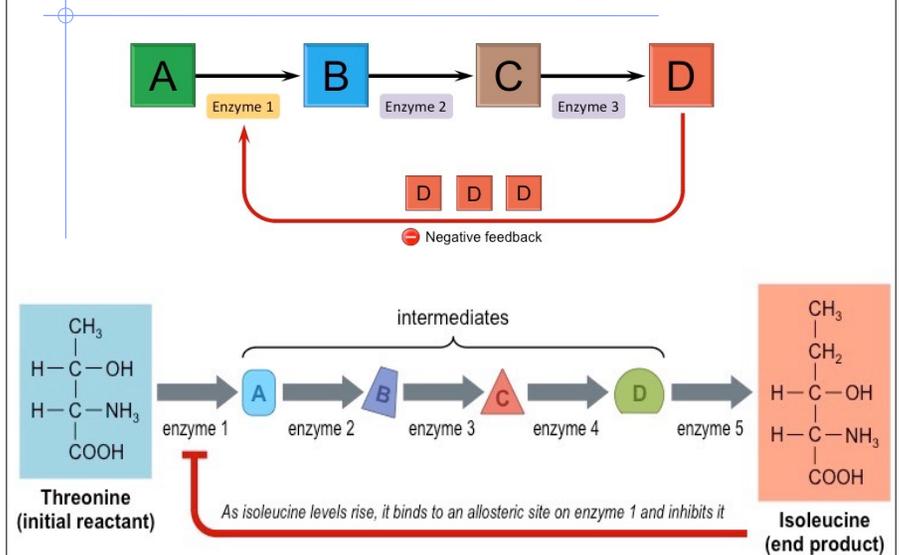


NEGATIVE Feedback Regulation Example

- Enzyme inhibition in biochemical pathways
 - Each type of enzyme catalyzes a **specific chemical reaction**.
 - These reactions are often linked into **chemical pathways**, each step in the pathway being catalyzed by its own enzyme.
- In **Negative Feedback**, accumulation of the **final product of a biochemical pathway inhibits an enzyme that works earlier in the pathway**, slowing down the production of the final product of the pathway.

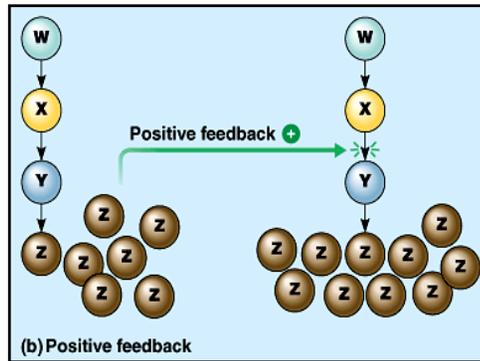


NEGATIVE Feedback Regulation Example



POSITIVE Feedback Regulation Example

- Enzyme activity enhancement in a biochemical pathway
- In **Positive Feedback**, however, the **product stimulates** (enhances the activity of) **an enzyme used earlier in a chemical pathway**.
- Whereas production of the end product is halted in negative feedback, positive feedback results in the production of **even more end product**.

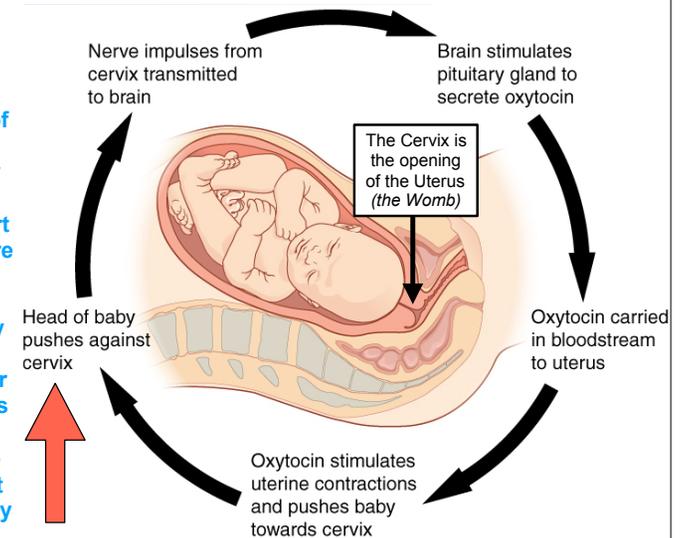


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POSITIVE Feedback Regulation Example

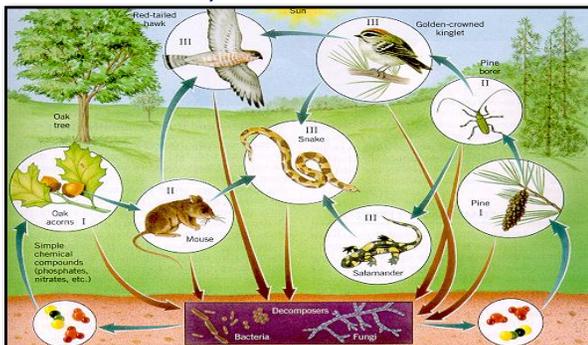
Human Childbirth

PRESSURE on the cervix, as a result of the fetus size and position, indirectly causes uterine contractions to start and, thus, even more pressure on the cervix, which, in turn, will eventually lead to even stronger and longer uterine contractions in a loop that continues until the fetus is pushed out of the mother's body during delivery.



Interdependence exists throughout nature

- No organism is an island standing alone - organisms interact and affect one another**
 - Population** (all of the organisms of one species living in a certain location), **communities** (composed of many species within a given area), **ecosystems** (all the biotic and abiotic factors within an area)



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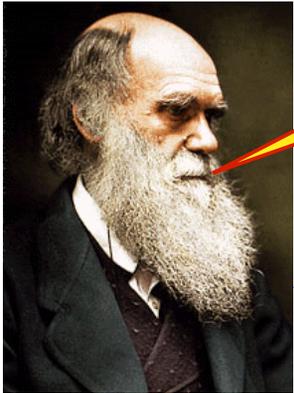
Science, technology & society

- Science is an intensely social activity with most scientists working in teams.**
 - Cooperation and competition characterize the field
 - Science & technology must function within the rules of society
- The goal of **science** is to *understand* natural phenomena while **technology** *applies* scientific knowledge for some specific purpose.



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**ANY
QUESTIONS?**