DEPARTMENT OF EDUCATION
SCHOOLS DIVISION OF NEGROS ORIENTAL
REGION VII
Kagawasan Ave., Daro, Dumaguete City, Negros Oriental

BASIC MECHANISM OF EVOLUTION

for General Biology 2 Grade11
Quarter 3/ Week 3

SELF-LEARNING KIT

NegOr_Q3_GenBio2_SLKWeek3_v2

FOREWORD

Dear students of Senior High School. Welcome back to this week's self-learning kit where you will journey to the new lesson. This learning kit will serve as a guide in understanding deeply the concepts on the biological evolution.

Evolution is the process by which modern organisms have descended from ancient ancestors. Evolution is responsible for both the remarkable similarities we see across all life and the amazing diversity of that life — but exactly how does it work?

Fundamental to the process is genetic variation upon which selective forces can act in order for evolution to occur. This learning kit examines the mechanisms of evolution.

OBJECTIVES:

At the end of this module, the learners will be able to:

K: explain the basic mechanisms of evolution: natural selection, mutation, genetic drift, and gene flow/ migration;

S: describe the effects of evolution on the diversity of the population; and

A: appreciate the major evolutionary forces that have created the variations in the species.

LEARNING COMPETENCY

- Explain the mechanisms that produce change in populations from generation to generation (e.g., artificial selection, natural selection, genetic drift, mutation, recombination) **(STEM_BIO11/12-IIIc-g-9)**

I. WHAT HAPPENED

CROSS-WORD Challenge!!

Directions: Locate the eight important words embedded on the grid below. These words are relevant to the variations in the species. Search the words in an upward, downward and sideward directions. List down the words in your activity notebook.

N	O	V	E	M	I	S	O	C	L	T	R	A	I	X	B
S	A	R	D	O	N	D	S	E	L	F	E	H	N	O	A
L	A	T	M	M	A	A	E	C	X	I	V	B	J	L	R
E	C	T	U	S	R	B	I	C	Z	R	O	R	I	N	B
A	O	D	T	R	S	I	C	A	E	D	W	A	N	D	S
N	A	B	A	R	A	G	E	F	A	V	E	G	M	D	Y
O	C	S	T	A	R	L	P	O	L	I	S	H	L	N	I
N	O	R	I	G	I	N	S	E	N	T	X	G	V	S	L
G	J	O	O	N	S	A	V	E	M	E	L	R	D	J	D
O	S	U	N	T	T	P	V	O	L	N	I	K	E	E	S
D	N	G	P	P	B	O	C	Z	F	E	N	C	H	S	O
A	D	H	I	B	L	U	S	G	U	G	C	C	I	M	P
L	L	T	D	U	S	L	Z	C	X	Y	R	T	A	E	M
O	C	R	T	W	D	A	R	W	I	N	B	V	I	S	V
N	M	I	Q	A	Z	T	Y	U	I	O	P	K	M	O	K
E	O	K	A	S	B	I	N	J	M	I	L	D	U	H	N
N	A	S	D	F	G	O	H	E	R	T	Y	U	M	K	I
G	O	A	L	M	E	N	W	U	R	K	S	M	U	R	T

Answer:

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________

II. WHAT I NEED TO KNOW

Mechanisms: The processes of evolution

Biological evolution, simply put, is descent with modification. This definition encompasses small-scale evolution (changes in gene — or more precisely and technically, allele — frequency in a population from one generation to the next) and large-scale evolution (the descent of different species from a common ancestor over many generations). Evolution helps us to understand the history of life.

Biological evolution is not simply a matter of change over time. Lots of things change over time: trees lose their leaves, mountain ranges rise and erode, but they aren't examples of biological evolution because they don't involve descent through genetic inheritance.
(https://evolution.berkeley.edu/evolibrary/article/evo_02)

Evolution is the process by which modern organisms have descended from ancient ancestors. Evolution is responsible for both the remarkable similarities we see across all life and the amazing diversity of that life — but exactly how does it work?

Fundamental to the process is genetic variation upon which selective forces can act in order for evolution to occur. This section examines the mechanisms of evolution focusing on:

- Descent and the genetic differences that are heritable and passed on to the next generation;
- Mutation, migration (gene flow), genetic drift, and natural selection as mechanisms of change;
- The importance of genetic variation;
- The random nature of genetic drift and the effects of a reduction in genetic variation;
- How variation, differential reproduction, and heredity result in evolution by natural selection; and
- How different species can affect each other's evolution through coevolution.
  (https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_14)

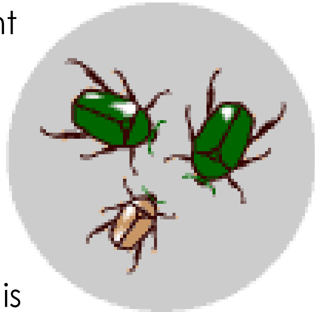
Populations evolve, but individual organisms do not. A population is an interbreeding group of individuals of one species in a given geographic area at the same time. A population evolves because the population contains the collection of genes called the gene pool. As changes in the gene pool occur, a population evolves.
(https://www.cliffsnotes.com/study-guides/biology/biology/principles-of evolution/mechanisms-of-evolution)

Mechanisms of change

Each of these four processes is a basic mechanism of evolutionary change.

1. Mutation

Mutation is a change in DNA, the hereditary material of life. An organism's DNA affects how it looks, how it behaves, and its physiology — all aspects of its life. So a change in an organism's DNA can cause changes in all aspects of its life.



A mutation could cause parents with genes for bright green coloration to have offspring with a gene for brown coloration. That would make genes for brown coloration more frequent in the population than they were before the mutation.

Mutation is a change in a DNA sequence, usually occurring because of errors in replication or repair. Mutation is the ultimate source of genetic variation. Changes in the composition of a genome due to recombination alone are not considered mutations since recombination alone just changes which genes are united in the same genome but does not alter the sequence of those genes.
(*https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_1)*

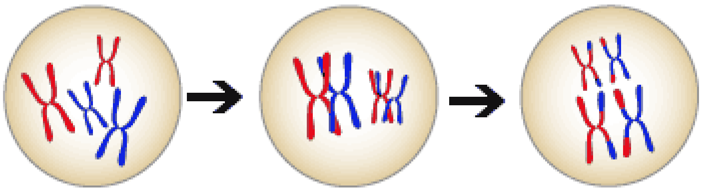
Sources of Genetic Variation

Without genetic variation, some of the basic mechanisms of evolutionary change cannot operate.

There are three primary sources of genetic variation, which we will learn more about:

1. **Mutations** are changes in the DNA. A single mutation can have a large effect, but in many cases, evolutionary change is based on the accumulation of many mutations.
2. **Gene flow** is any movement of genes from one population to another and is an important source of genetic variation.
3. **Sex** can introduce new gene combinations into a population. This genetic shuffling is another important source of genetic variation.

(https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_17)



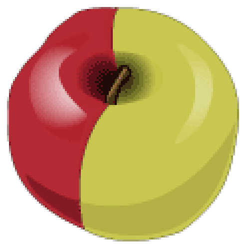
Genetic shuffling is a source of variation.

Source(https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_17)

Mutations are random

Mutations can be beneficial, neutral, or harmful for the organism, but mutations do not "try" to supply what the organism "needs." In this respect, mutations are random — whether a particular mutation happens or not is unrelated to how useful that mutation would be.

Not all mutations matter to evolution



Since all cells in our body contain DNA, there are lots of places for mutations to occur; however, not all mutations matter for evolution. Somatic mutations occur in non-reproductive cells and won't be passed onto offspring.

For example, the golden color on half of this Red Delicious apple was caused by a somatic mutation. The seeds of this apple do not carry the mutation.

The only mutations that matter to large-scale evolution are those that can be passed on to offspring. These occur in reproductive cells like eggs and sperm and are called germ line mutations.

A single germ line mutation can have a range of effects:

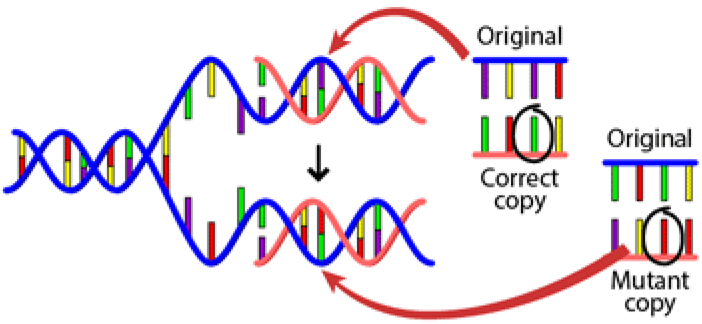
1. **No change occurs in phenotype**
   Some mutations don't have any noticeable effect on the phenotype of an organism. This can happen in many situations: perhaps the mutation occurs in a stretch of DNA with no function, or perhaps the mutation occurs in a protein-coding region, but ends up not affecting the amino acid sequence of the protein.
2. **Small change occurs in phenotype**
3. **A single mutation caused this cat's ears to curl backwards slightly.**

4. **Big change occurs in phenotype**
   Some really important phenotypic changes, like DDT resistance in insects are sometimes caused by single mutations. A single mutation can also have strong negative effects for the organism. Mutations that cause the death of an organism are called lethals — and it doesn't get more negative than that.

There are some sorts of changes that a single mutation, or even a lot of mutations, could not cause. Neither mutations nor wishful thinking will make pigs have wings; only pop culture could have created Teenage Mutant Ninja Turtles — mutations could not have done it.

Mutations happen for several reasons.

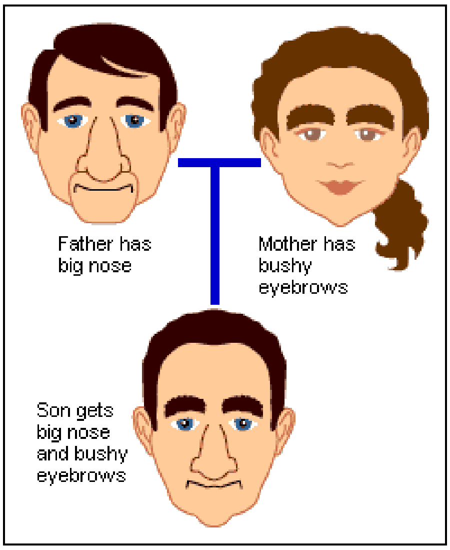
1. **DNA fails to copy accurately**
   Most of the mutations that we think matter to evolution are "naturally-occurring." For example, when a cell divides, it makes a copy of its DNA — and sometimes the copy is not quite perfect. That small difference from the original DNA sequence is a mutation.



2. **External influences can create mutations**
   Mutations can also be caused by exposure to specific chemicals or radiation. These agents cause the DNA to break down. This is not necessarily unnatural — even in the most isolated and pristine environments, DNA breaks down. Nevertheless, when the cell repairs the DNA, it might not do a perfect job of the repair. So the cell would end up with DNA slightly different than the original DNA and hence, a mutation.

Source (https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_20)

Sex and genetic shuffling



Sex can introduce new gene combinations into a population and is an important source of genetic variation.

You probably know from experience that siblings are not genetically identical to their parents or to each other (except, of course, for identical twins). That's because when organisms reproduce sexually, some genetic "shuffling" occurs, bringing together new combinations of genes. For example, you might have bushy eyebrows and a big nose since your mom had genes associated with bushy eyebrows and your dad had genes associated with a big nose. These combinations can be good, bad, or neutral. If your spouse is wild about the bushy eyebrows/big nose combination, you were lucky and hit on a winning combination!

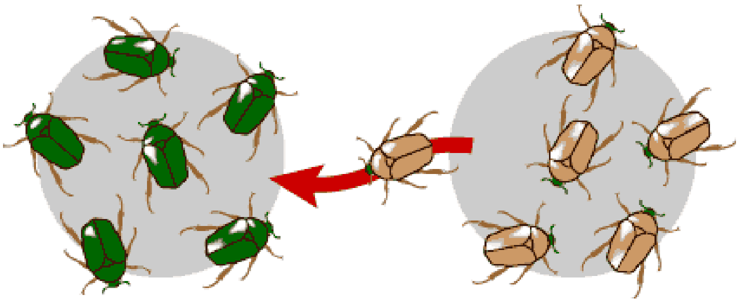
This shuffling is important for evolution because it can introduce new combinations of genes every generation. However, it can also break up "good" combinations of genes.

Source (https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_22)

2. Migration/ Gene flow

Gene flow — also called migration — is any movement of individuals, and/or the genetic material they carry, from one population to another. Gene flow includes lots of different kinds of events, such as pollen being blown to a new destination or people moving to new cities or countries. If gene versions are carried to a population where those gene versions previously did not exist, gene flow can be a very important source of genetic variation. In the graphic below, the gene version for brown coloration moves from one population to another.

Gene flow is the movement of genes between populations. This may happen through the migration of organisms or the movement of gametes (such as pollen blown to a new location).



Source (https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_21)

Some individuals from a population of brown beetles might have joined a population of green beetles. That would make genes for brown coloration more frequent in the green beetle population than they were before the brown beetles migrated into it.

3. Genetic drift

Another mechanism for evolution is genetic drift, which can occur when a small group of individuals leaves a population and establishes a new one in a geographically isolated region. Fitness of a population is not considered in genetic drift, nor does genetic drift occur in a very large population.
Source (https://www.cliffsnotes.com/study-guides/biology/biology/principles-of evolution/mechanisms-of-evolution)

Imagine that in one generation, two brown beetles happened to have four offspring survive to reproduce. Several green beetles were killed when someone stepped on them and had no offspring. The next generation would have a few more brown beetles than the previous generation — but just by chance. These chance changes from generation to generation are known as genetic drift. https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_16

Genetic drift — along with natural selection, mutation, and migration — is one of the basic mechanisms of evolution.

In each generation, some individuals may, just by chance, leave behind a few more descendent (and genes, of course!) than other individuals. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals. That, in a nutshell, is genetic drift. It happens to ALL populations — there's no avoiding the vagaries of chance

Source(*https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_16)*

Random Drift consists of random fluctuations in the frequency of appearance of a gene, usually, in a small population. The process may cause gene variants to disappear completely, thereby reducing genetic variability. In contrast to natural selection, environmental or adaptive pressures do not drive changes due to genetic drift. The effect of genetic drift is larger in small populations and smaller in large populations.

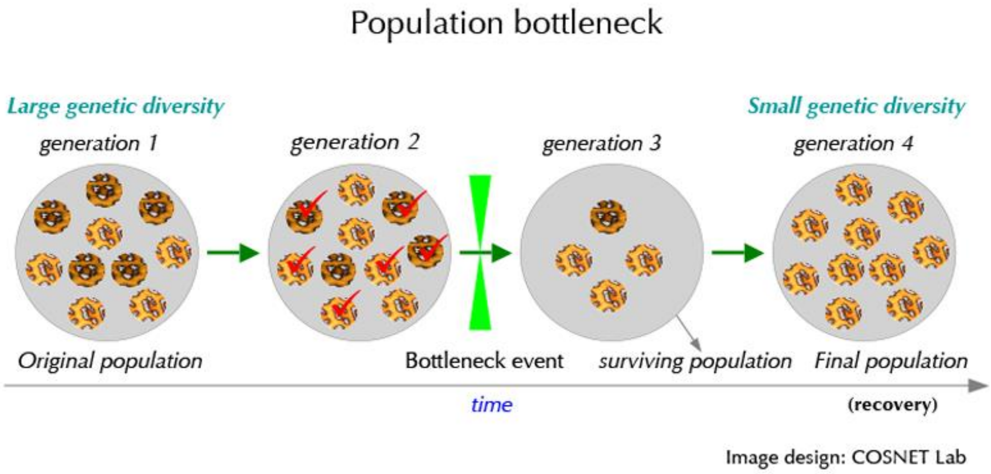
Genetic drift is a stochastic process, a random event that happens by chance in nature that influences or changes allele frequency within a population as a result of sampling error from generation to generation. It may happen that some alleles are completely lost within a generation due to genetic drift, even if they are beneficial traits that conduct to evolutionary and reproductive success. Allele is defined as any one of two or more genes that may occur alternatively at a given site (locus) on a chromosome. Alleles are responsible for variations in a trait.

The population bottleneck and a founder effect are two examples of random drift that can have significant effects in small populations. Genetic drift works on all mutations and can eventually contribute to the creation of a new species by means of the accumulation of non-adaptive mutations that can facilitate population subdivision.

Source(https://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change/)

Bottleneck effect occurs when there is a sudden sharp decline in a population's size typically due to environmental factors (natural disasters such as: earthquakes or tsunamis, epidemics that can decimate the number of individuals in the population, predation or habitat destruction, etc.). It is a random event, in which some genes (there is not any distinction) are extinguished from the population. This results in a drastic reduction of the total genetic diversity of the original gene pool. The small surviving population is considerably be farther from the original one in its genetic makeup.
Source(https://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change/)

Founder effect is the loss of genetic variation that occurs when a new population is established by a small number of individuals that are cleaved from a larger population. This new population does not have the genetic diversity of the previous one. Because the community is very small and also geographical or socially isolated, some genetic traits are becoming more prevalent in the population. This leads to the presence of certain genetic diseases in the next generations. In some cases, founder effect plays a fundamental role in the emergence of new species.
Source (https://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change/)

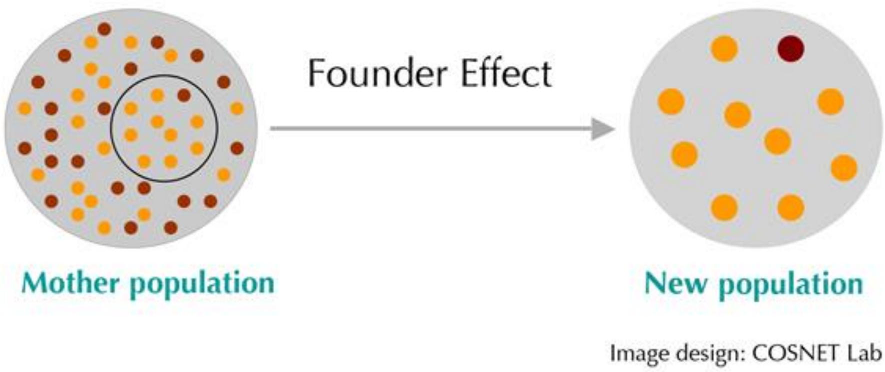


***Generation 1**:* The frequency of alleles in the population is the same.

Generation 2: Randomly and due to a catastrophic natural or man-made event, most of individuals of the population died (there is no influence of adaptive pressures).

Generation 3: As a result, the original large population is reduced to a small population composed by few individuals. This new surviving population subset contains much less genetic variability than the previous population.

Generation 4: Later, the drastic reduction in the population size is followed by an expansion (population is recovered). The final population is no longer genetically representative of the original one. In this particular case, an allele is completely removed from the gene pool.



A new population is established by a small number of individuals that are cleaved from the original population. This leads to a loss of genetic variability as the founders of the new colony are not genetically representative at all of the population from which they come from. The right figure shows an evident predominance of orange circles in the newly founded population. These orange circles may correspond to a given allele responsible for the variation in a trait (for example, specific eyes color). In extreme cases, founder effect also plays a fundamental role in the emergence of new species.

https://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change/

Genetic drift affects the genetic makeup of the population but, unlike natural selection, through an entirely random process. So although genetic drift is a mechanism of evolution, it doesn't work to produce adaptations.

4. Natural selection

Another mechanism for evolution is natural selection, which occurs when populations of organisms are subjected to the environment. The fittest creatures are more likely to survive and pass their genes to their offspring, producing a population that is better adapted to the environment. The genes of less-fit individuals are less likely to be passed on to the next generation. The important selective force in natural selection is the environment.

Imagine that green beetles are easier for birds to spot (and hence, eat). Brown beetles are a little more likely to survive to produce offspring. They pass their genes for brown coloration on to their offspring. So, in the next generation, brown beetles are more common than in the previous generation.

All of these mechanisms can cause changes in the frequencies of genes in populations, and so all of them are mechanisms of evolutionary change. However, natural selection and genetic drift cannot operate unless there is genetic variation — that is, unless some individuals are genetically different from others. If the population of beetles were 100% green, selection and drift would not have any effect because their genetic make-up could not change.

https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_16

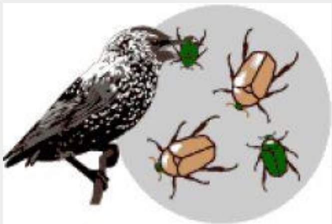
Natural selection is one of the basic mechanisms of evolution, along with mutation, migration, and genetic drift.

Darwin's grand idea of evolution by natural selection is relatively simple but often misunderstood. To find out how it works, imagine a population of beetles:

1. **There is variation in traits.**
   For example, some beetles are green and some are brown.

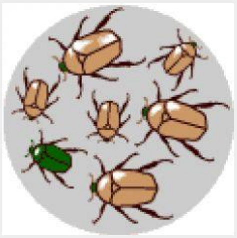
2. **There is differential reproduction.**
   Since the environment can't support unlimited population growth, not all individuals get to reproduce to their full potential. In this example, green beetles tend to get eaten by birds and survive to reproduce less often than brown beetles do.
3. **There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



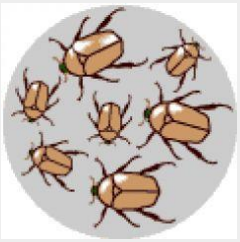
Natural selection : Differential reproduction

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.



Natural selection :Heredity

There is heredity. The surviving brown beetles have brown baby beetles because this trait has a genetic basis.

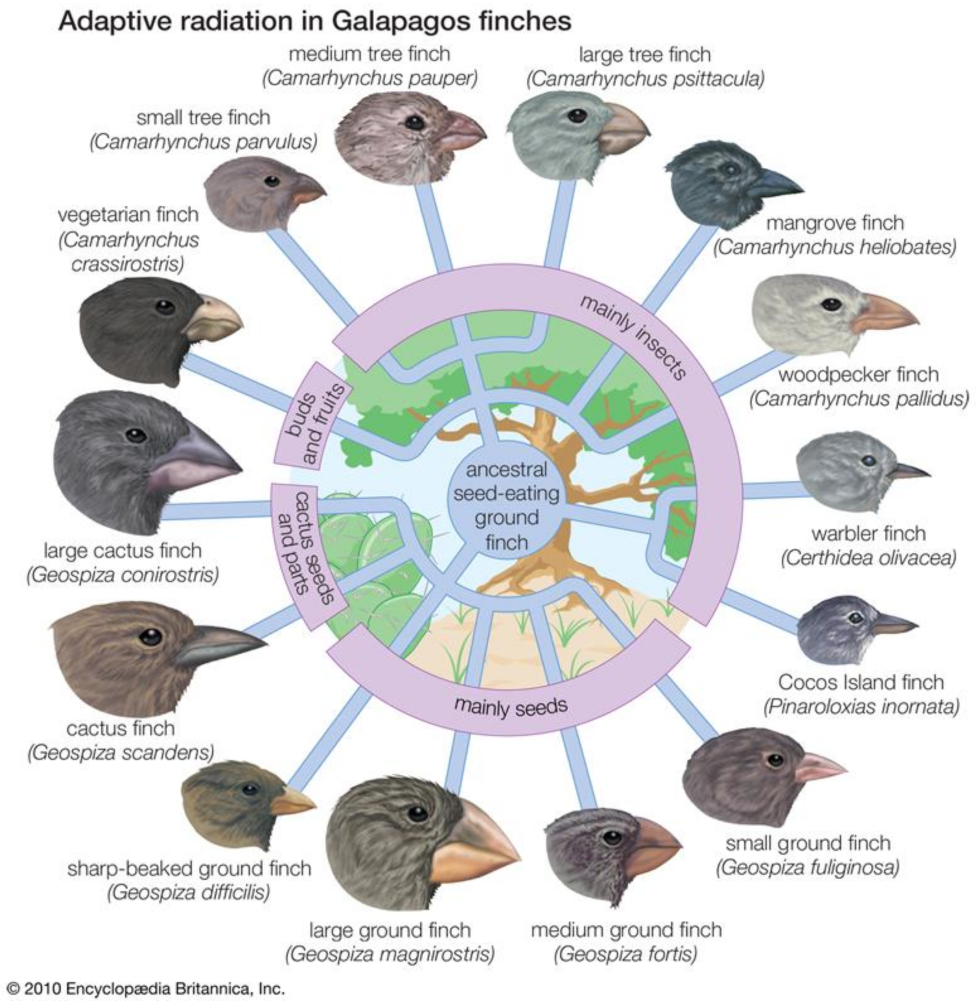


Natural selection : End result

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.

Natural Selection leads to an evolutionary change when some individuals with certain traits in a population have a higher survival and reproductive rate than others and pass on these inheritable genetic features to their offspring. Evolution acts through natural selection whereby reproductive and genetic qualities that prove advantageous to survival prevail into future generations. The cumulative effects of natural selection process have giving rise to populations that have evolved to succeed in specific environments. Natural selection operates by differential reproductive success (*fitness*) of individuals. https://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change/

The Darwin's Finches diagram illustrates the way the finch has adapted to take advantage of feeding in different ecological niches:



(https://nectunt.bifi.es/to-learn-more-overview/mechanisms-of-evolutionary-change)

Natural selection at work

Scientists have worked out many examples of natural selection, one of the basic mechanisms of evolution. Any coffee table book about natural history will overwhelm you with full-page glossies depicting amazing adaptations produced by natural selection, such as the examples below.

(a) (b) (c)

a. Orchids fool wasps into 'mating' with them.
b. Katydids have camouflage to look like leaves.
c. Non-poisonous king snakes mimic poisonous coral snakes.

Orchid and wasp image courtesy of Colin Bower; Heart Cockle image courtesy of Avril Bourquin; Katydid image © Greg Neise, GE Neise Digital Communication; Snake images courtesy of Neurotoxin; Blue-footed booby image courtesy of Ian Skipworth.

Behavior can also be shaped by natural selection. Behaviors such as birds' mating rituals, bees' wiggle dance, and humans' capacity to learn language also have genetic components and are subject to natural selection.

In some cases, we can directly observe natural selection. Very convincing data show that the shape of finches' beaks on the Galapagos Islands has tracked weather patterns: after droughts, the finch population has deeper, stronger beaks that let them eat tougher seeds.

In other cases, human activity has led to environmental changes that have caused populations to evolve through natural selection. A striking example is that of the population of dark moths in the 19th century in England, which rose and fell in parallel to industrial pollution. These changes can often be observed and documented.

Activity Time

Evolution via Natural Selection

In this simulation, you will model the effect of a predator (you) on the evolution of an insect population (toothpicks). This species of insect has 5 color variations: **red**, **blue**, **green**, **yellow**, and **tan**. You will "eat" the insects and record data. Work with a partner, and decide who Partner A is and who Partner B is before beginning. Your partner may be your parents or siblings who can count.

You should begin with: -Plastic bag: the "stomach" of the predator
-8 toothpicks of each color (40 total): the "insects"

Follow the steps:

1) Find an area outside (about 10ft x 10ft). It should be in grass, dirt, or leaves.
2) Partner A randomly scatters all 40 of the toothpicks around the area without Partner B looking.
3) Partner B is now the first predator! Collect the first 20 toothpicks you see and place them in the plastic bag. Make sure to look away from the ground after each toothpick is picked up. Partner A should help count the toothpicks to make sure exactly 20 are collected.
4) Count how many toothpicks of each color were collected and record it in your data table. Calculate how many toothpicks of each color are remaining in the habitat.
5) The insects reproduce! Each surviving insect in the habitat will produce one offspring. For each toothpick that is remaining in the habitat, add one new toothpick of the same color to the habitat. Record this in your data table. Partner B should scatter the offspring into the habitat while Partner A isn't looking. (Example: If 5 blue toothpicks remain in the habitat, add 5 new blue toothpicks to the habitat, and record 10 total remaining after reproduction in the data table)
6) Partner A is now the predator for Generation 2. Collect exactly 20 more toothpicks from the habitat while Partner B helps count.
7) Repeat steps 4 and 5 in which you record data and add offspring to the habitat.
8) Partner B is now the predator again for Generation 3. Collect 20 toothpicks and record the data as you did for the previous generations.
9) Do not put anymore toothpicks into the habitat. Clean up the toothpicks still remaining the habitat and return them to containers.

Generation 1

COLOR	NUMBER IN HABITAT	NUMBER COLLECTED	NUMBER REMAINING	TOTAL NUMBER REMAINING AFTER REPRODUCTION
Red	8			
Yellow	8			
Blue	8			
Green	8			
Tan	8			
TOTAL	**40**			

Generation 2

COLOR	NUMBER IN HABITAT	NUMBER COLLECTED	NUMBER REMAINING	TOTAL NUMBER REMAINING AFTER REPRODUCTION
Red				
Yellow				
Blue				
Green				
Tan				
TOTAL				

Generation 3

COLOR	NUMBER IN HABITAT	NUMBER COLLECTED	NUMBER REMAINING	TOTAL NUMBER REMAINING AFTER REPRODUCTION
Red				
Yellow				
Blue				
Green				
Tan				
TOTAL				

Answer the questions:

1. Describe a real example of this mechanism of evolution.
2. Does your data suggest that a certain color of toothpick is advantageous? Which color?
3. Why might some colors/phenotypes survive better than others in this particular habitat?
4. How might the results be different if this activity was performed in a habitat that is mostly red?

III. WHAT I HAVE LEARNED

POST TEST: MATCH ME IF YOU CAN!!!

Directions: Analyze the given statements below. Choose from the given words in the box which describes or corresponds to the concept of phrase being related to. Write the letters only in your notebook.

A. natural selection	***F. bottleneck effect***
B. evolution	***G. sex***
C. population	***H. genetic drift***
D. random drift	***I. behavior***
E. mutation	***J. gene flow***

1. A small group of individuals leaves a population and establishes a new one in a geographically isolated region.
2. The ultimate source o f genetic variation.
3. Movement of genes from one population to another.
4. The fittest creatures are more likely to survive and pass their genes to their offspring, producing a population that is better adapted to the environment.

5. Birds' mating rituals, bees' wiggle dance, and humans' capacity to learn language .
6. There is a sudden sharp decline in a population's size typically due to environmental factors .
7. Modern organisms have descended from ancient ancestors.
8. Genetic "shuffling" occurs, bringing together new combinations of genes.
9. The process may cause gene variants to disappear completely, thereby reducing genetic variability.
10. An interbreeding group of individuals of one species in a given geographic area at the same time.

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Biological evolution, simply put, is descent with modification. This definition encompasses small-scale evolution and large-scale evolution. There are different mechanisms how evolution takes place in a population. Mutation is a driving force of evolution, is a random change in an organism's genetic makeup, which influences the population's gene pool. Mutations give rise to new alleles; therefore, they are a source of genetic variation in a population. Another mechanism of evolution may occur during the migration of individuals from one group or location to another. When the migrating individuals interbreed with the new population, they contribute their genes to the gene pool of the local population. Another mechanism for evolution is genetic drift, which can occur when a small group of individuals leaves a population and establishes a new one in a geographically isolated region. Lastly is natural selection, which occurs when populations of organisms are subjected to the environment. The fittest creatures are more likely to survive and pass their genes to their offspring, producing a population that is better adapted to the environment. The genes of less-fit individuals are less likely to be passed on to the next generation. The important selective force in natural selection is the environment.

ANSWER KEY

PRE-TEST: Crossword

Natural selection,
Evolution, Darwin,
Mutation, Population,
Species, Origin,
Genetic drift,

POST TEST: Match Me if You Can

1. H
2. E
3. J
4. A
5. I
6. F
7. B
8. G
9. D
10. C

ABOUT THE AUTHOR

BERNADETTE NOVEM I. SARDON, is a licensed professional teacher. She is a graduate of University of San Carlos with the degree of Bachelor of Science in Biology. She is currently teaching at San Miguel National High School as a Senior High teacher, at the same time the Teacher-in-Charge of the same school. She has earned units in Masters in Biology and Master of Education major in Guidance and Psychology.