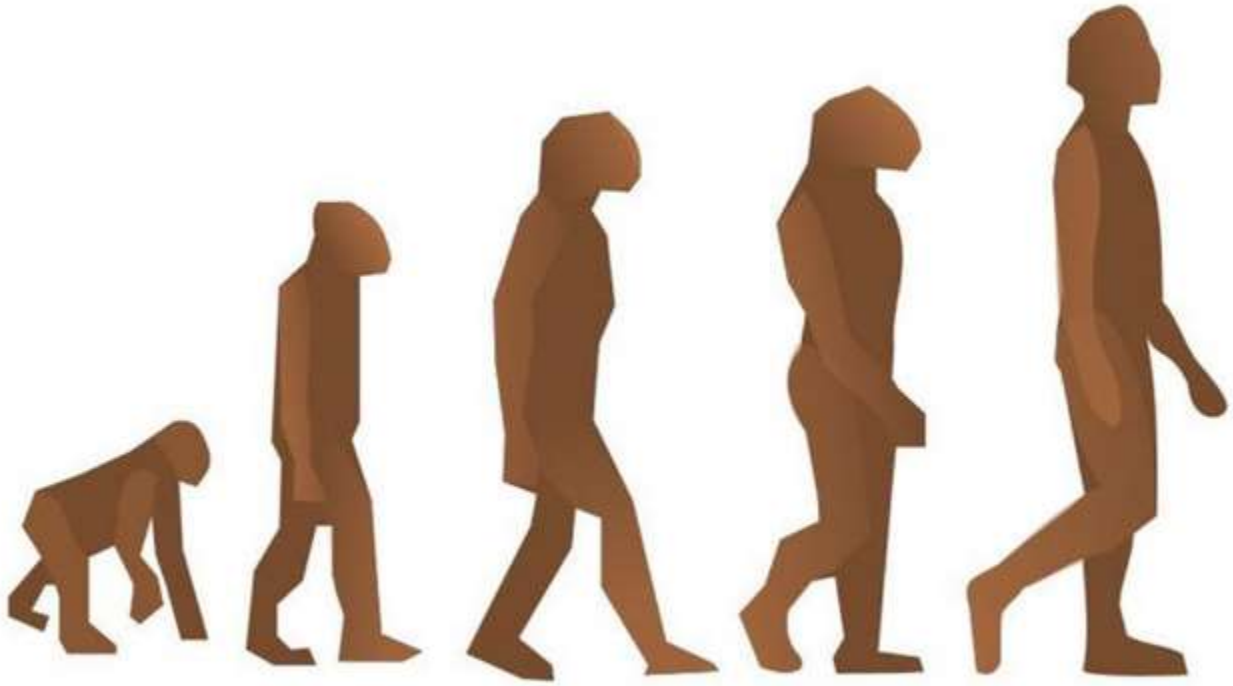
Unit 1: DNA & the Genome



1.7 Evolution

What you should already know from National 5

- Mutations are random changes to genetic material and are the only source of new alleles.
- Mutation can result in a change in the characteristics of an organism.
- Mutations may be neutral or give an advantage or disadvantage to the organism.
- The occurrence of mutations may be increased by environmental factors such as radiation or chemicals.

- Natural selection is when organisms that are better suited (adapted) to the environment survive and breed and those less well suited die off (**survival of the fittest**).

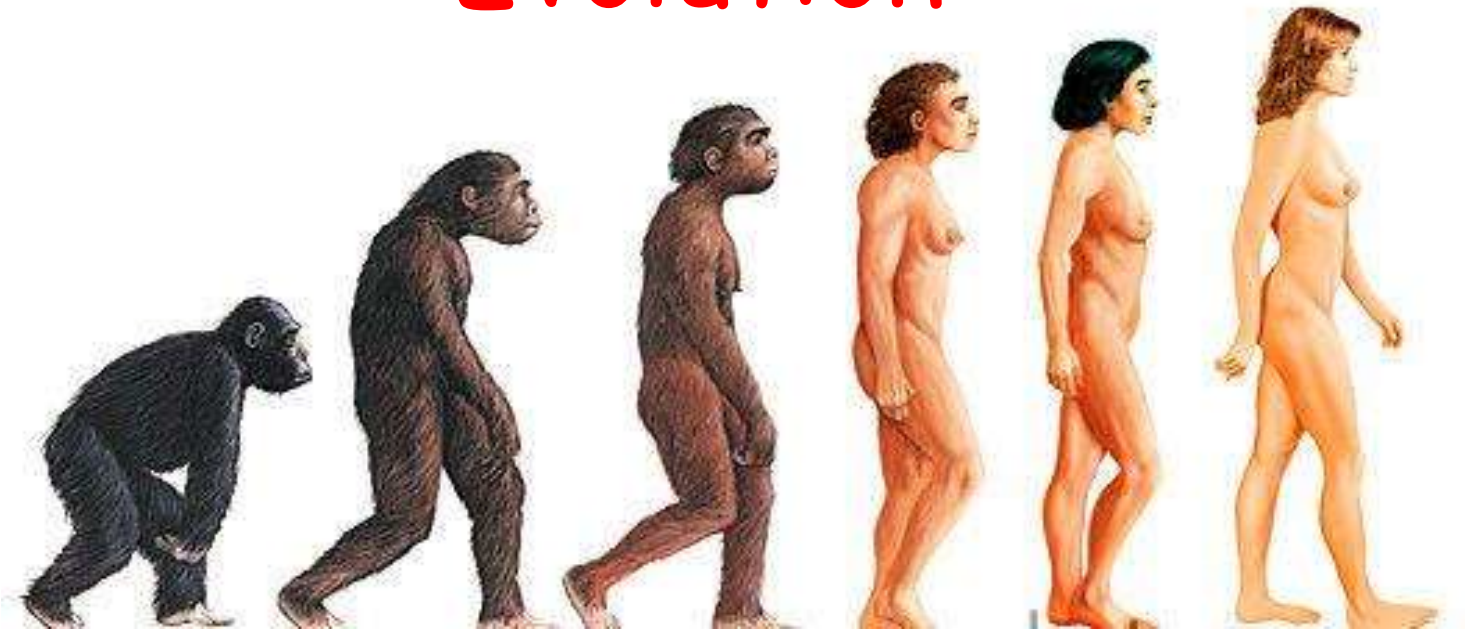
- A species is a group of organisms able to interbreed to form fertile offspring.
- The process of speciation involves:

1. Separation of a population that stops breeding.
2. Two populations subjected to different selection pressures.
3. Different mutations occurring in different populations to give new characteristics (alleles).
4. Natural selection favouring different characteristics (alleles) in both populations.
5. Characteristics (alleles) of populations changing over time.
6. Two species have been formed if when the barrier to breeding is removed no fertile offspring are produced.

Learning Intentions

1. State what "evolution" is.
2. Explain what vertical transfer of genetic material is, and give an example.
3. Explain what horizontal transfer of genetic material is, and give an example.

Evolution



Watch the stated clearly "Evolution" clip (9 min).

Evolution =

the changes in organisms over generations as a result of genomic variations.

Gene Transfer

Genes can be transferred (inherited) between organisms either

1. vertically or
2. horizontally.

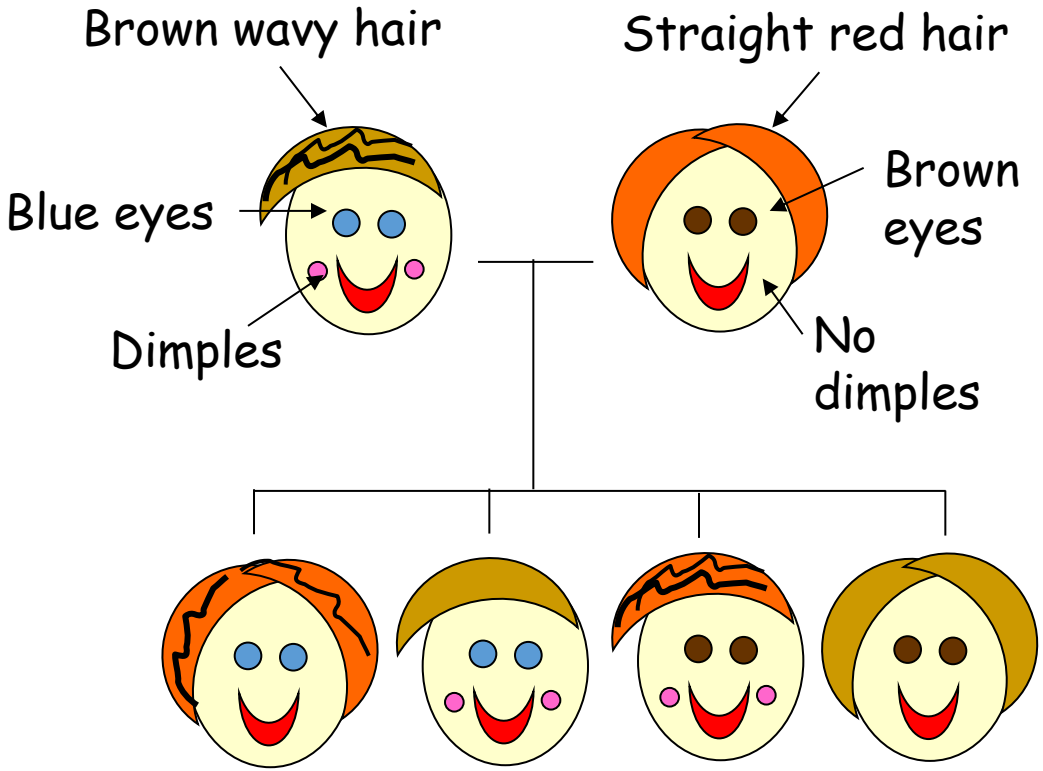
1. Vertical Gene Transfer

- Genes may be transferred vertically from parents to offspring.
- Also known as, therefore, vertical inheritance.
- This can happen as a result of
  - a) sexual or
  - b) asexual reproduction

a)Sexual reproduction

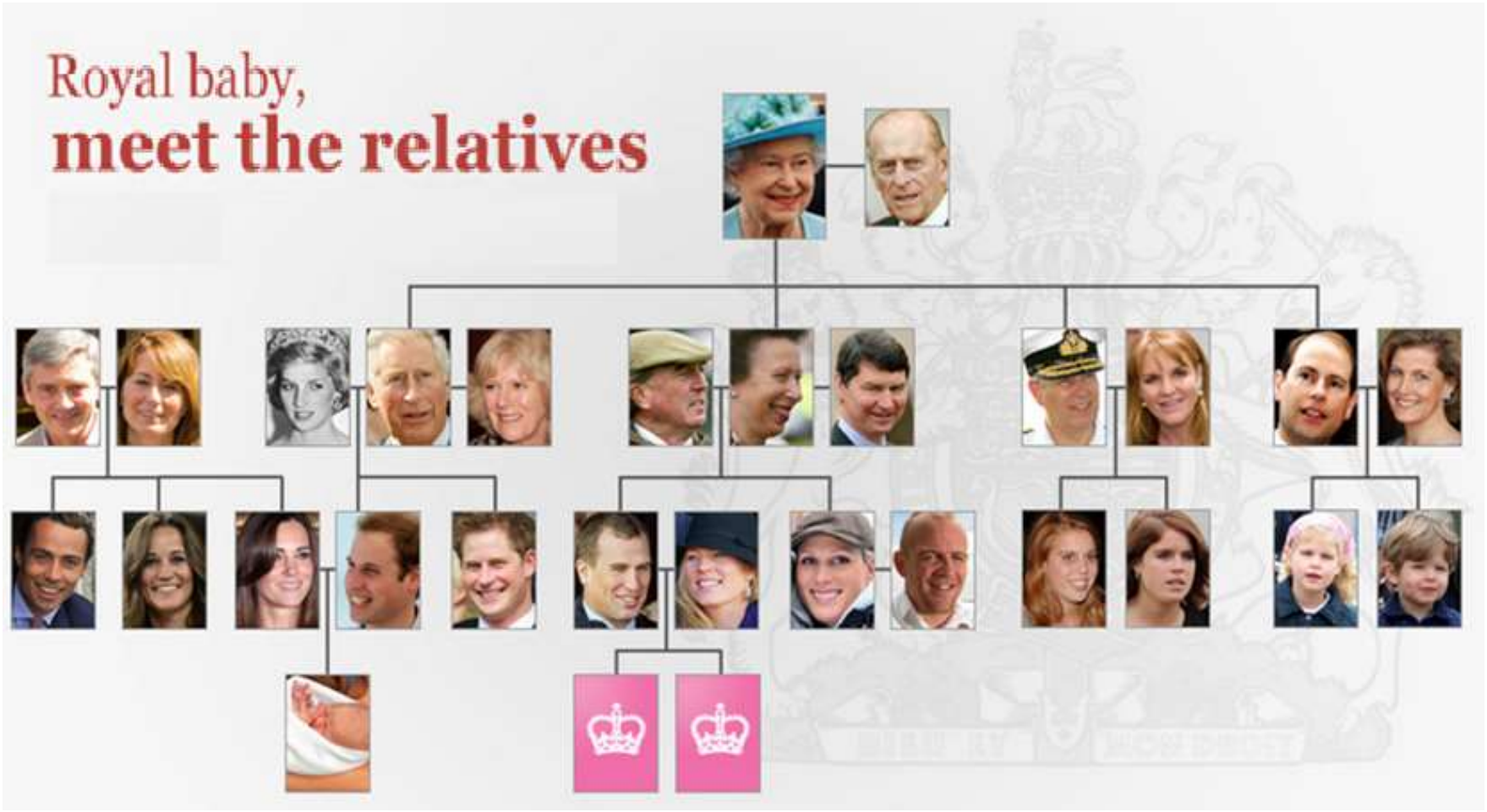
In eukaryotes

This involves **two parents** who differ from one another genetically.



Offspring inherit different combinations of genes from each parent.

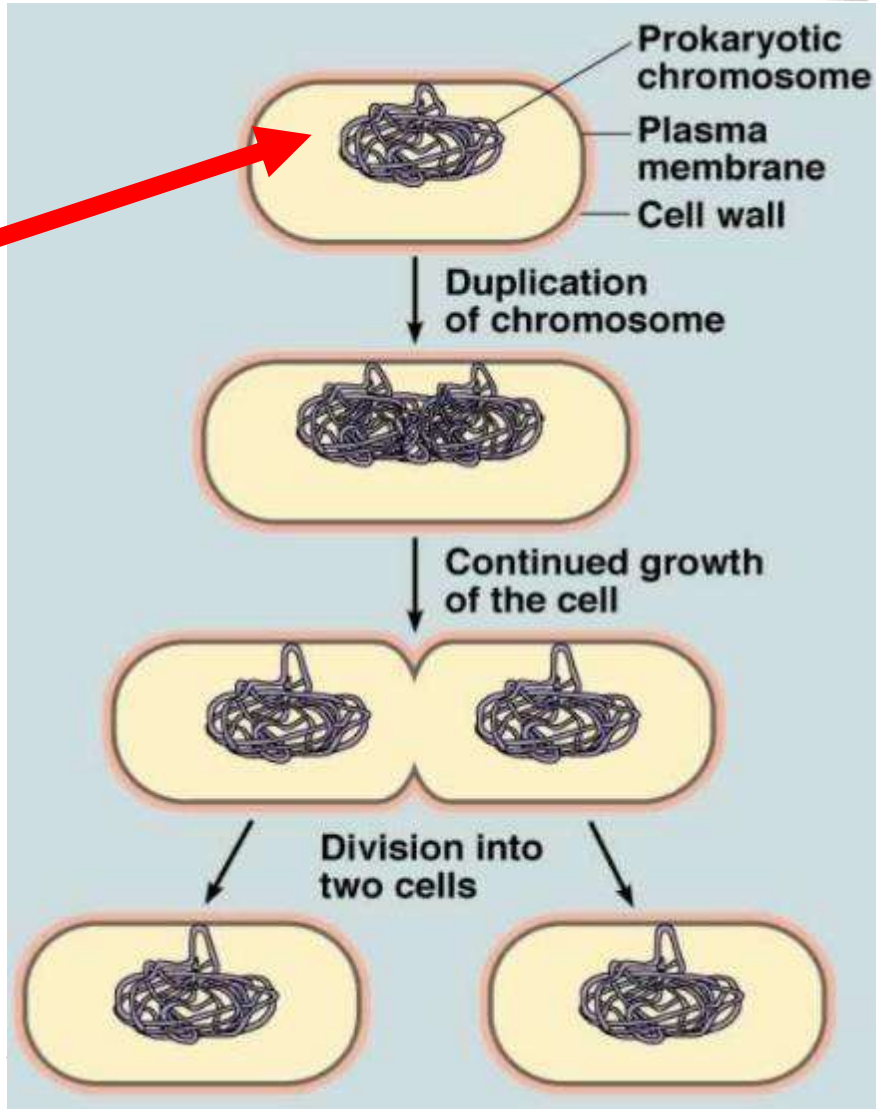
Vertical inheritance in humans is represented as a family tree.



b)Asexual Reproduction

In eukaryotes e.g. potatoes and daffodils

In prokaryotes e.g. Yeast



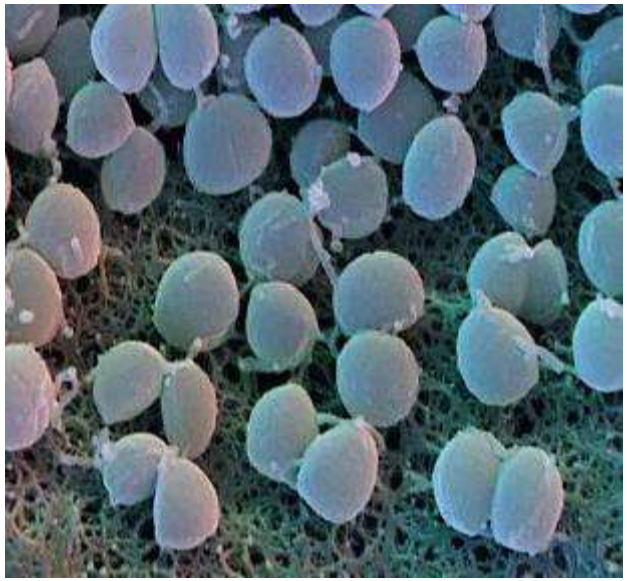
Offspring have <u>exactly the same</u> genome as parent (genetically identical).

No variation through generations

Examples-Asexual reproduction

2. Horizontal Gene Transfer

Prokaryotes and viruses can transfer sequences horizontally into the genomes of other prokaryotes and eukaryotes.



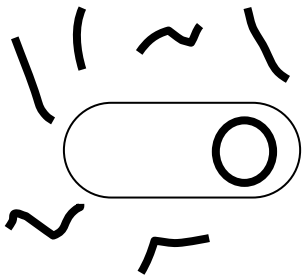
In humans this would be like giving useful genes to your friends.
(do not copy!)

The horizontal exchange of genetic material between prokaryotes can result in rapid evolutionary change.

bacteria

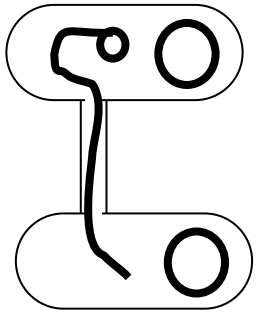
chromosome

Transformation
DNA fragments



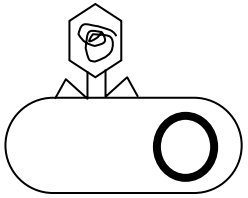
DNA fragments possibly from the lysis of another cell. Direct uptake into the cell. If taken into the chromosome, part of the inheritance now available

Conjugation
Using F plasmid



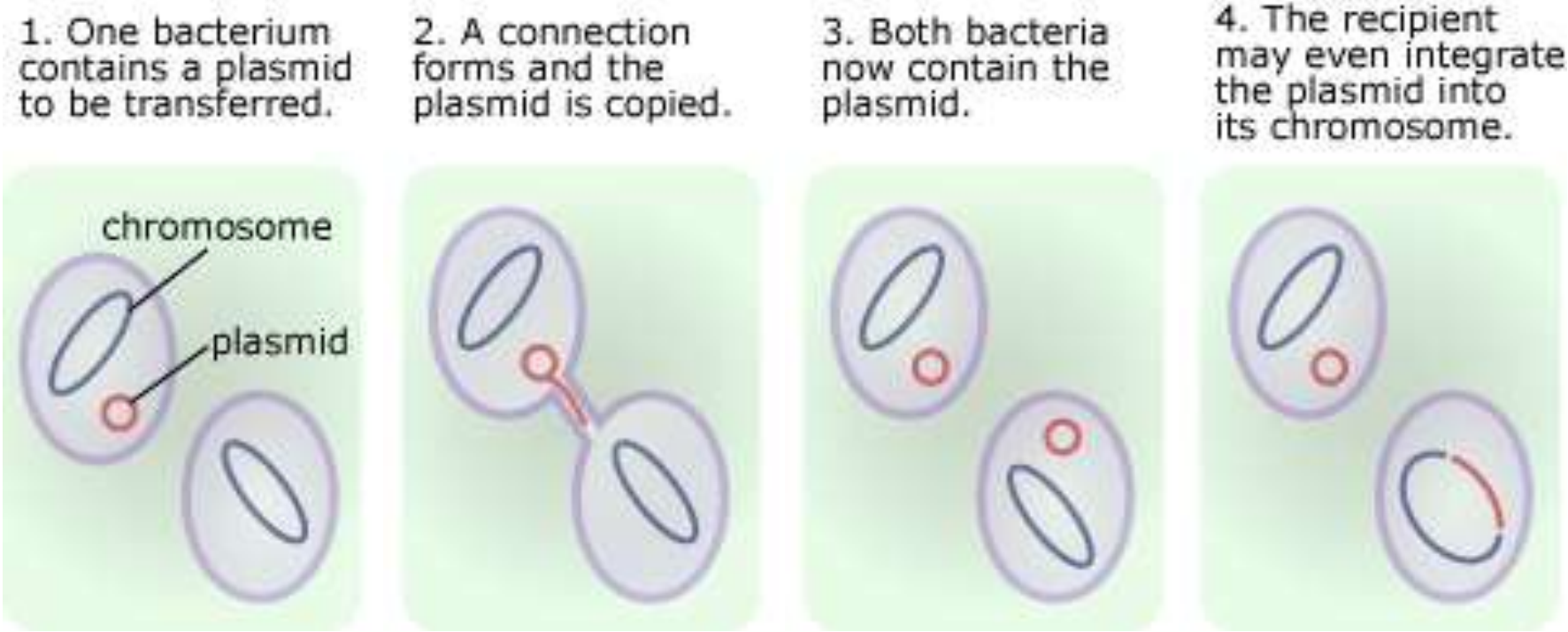
Cells containing the F plasmid can modify a pilus to transfer a copy of sections of the chromosome across to another cell.

Transduction
by virus



Bacteriophage (virus), contain nucleic acid which is injected, copied into the chromosome and so can become part of the bacterial chromosome

Bacteria can exchange plasmids carry the genes that confer resistance to antibiotics from one bacterial species to another.



This has resulted in strains of bacteria emerging that are resistant to several antibiotics ("Superbugs")

Example 1-MRSA bacteria

(Prokaryote to Prokaryote)

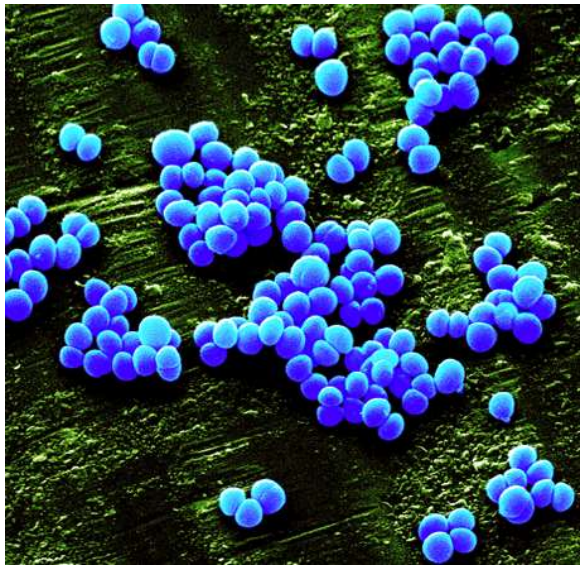
Methicillin- resistant *Staphylococcus aureus*

- Can exchange genes to make them resistant to antibiotics.

- Common hospital infection.
- Difficult to treat - 10 deaths in Scotland in 2012.

Symptoms of MRSA infection

MRSA bacteria



Total knee collapse

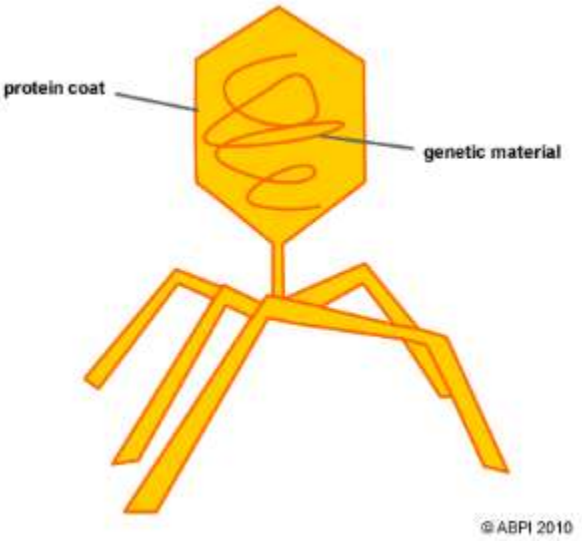
Very difficult to cure and sometimes can be fatal.

Example 2 - *agrobacterium tumefaciens*

(Prokaryotes to eukaryotes)

The bacterium, found in soil, can transfer a plasmid of its DNA into the genome of wounded plant cells.

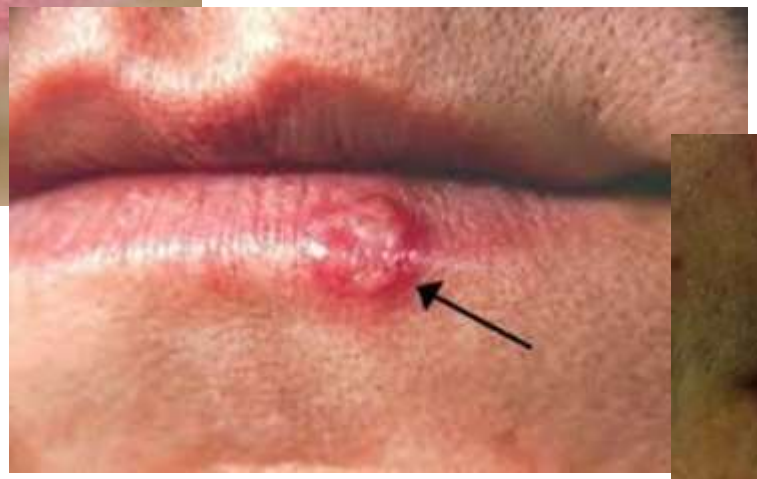
Example 3 – Herpes Virus



From viruses

After initial infection, the herpes virus can integrate its DNA into the genome of human.

It remains dormant as a "provirus", becoming active again when an individual is in poor health (It is hidden but still there!)



herpes virus

- *Hidden but still there!.*

Learning Intentions

4. Explain what "natural selection" is.
5. Explain what "sexual selection" is.
6. Describe how 3 different types of selection (stabilising, directional and disruptive) affect the frequency of a trait within a population.

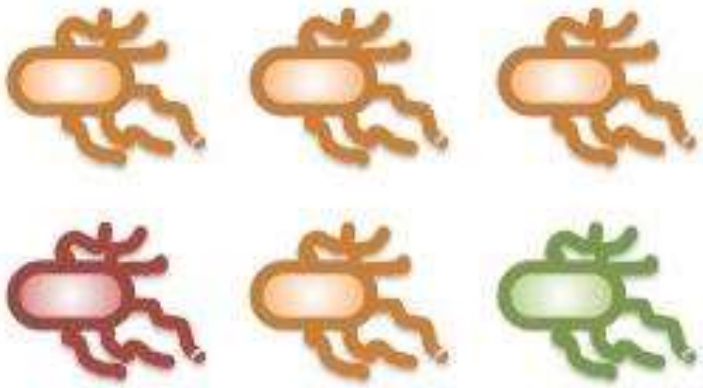
Selection

(a) Natural selection is the **non-random increase in frequency of DNA sequences** that increase survival.

(b) Sexual selection is the **non-random increase in frequency of DNA sequences** that increase the rate of successful reproduction among the members of a species.

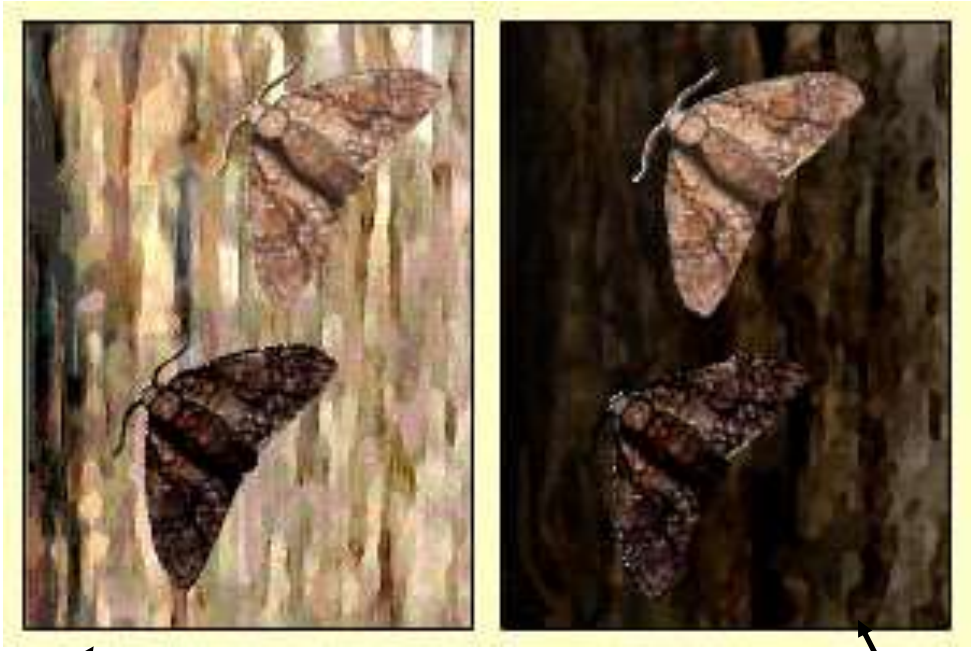
Natural Selection examples….

Natural Selection in Bacteria



Mutations create variation in bacteria.

Natural Selection – more examples



pre-industrial revolution

white peppered moth dominates

post-industrial revolution

black peppered moth dominates

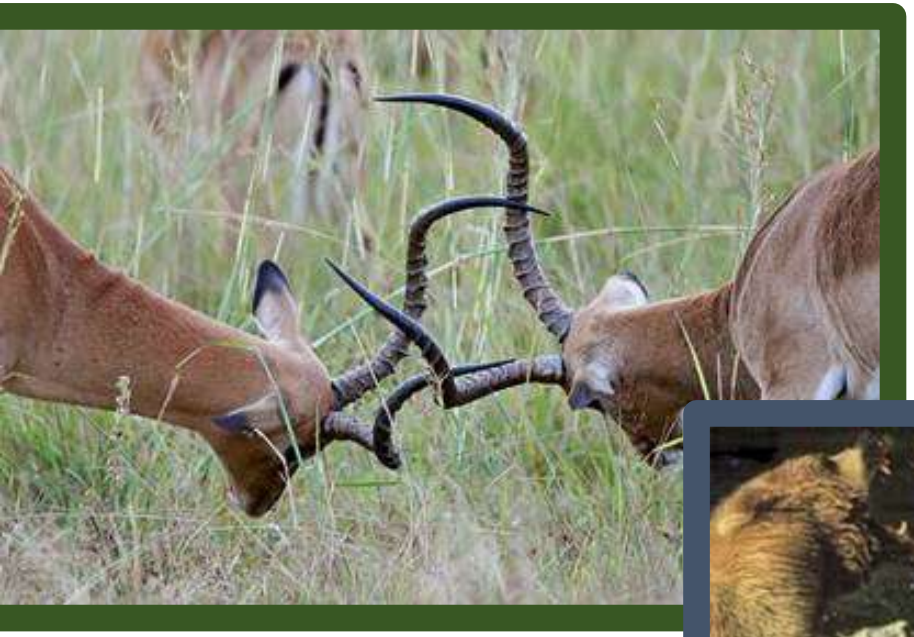
(b) Sexual Selection

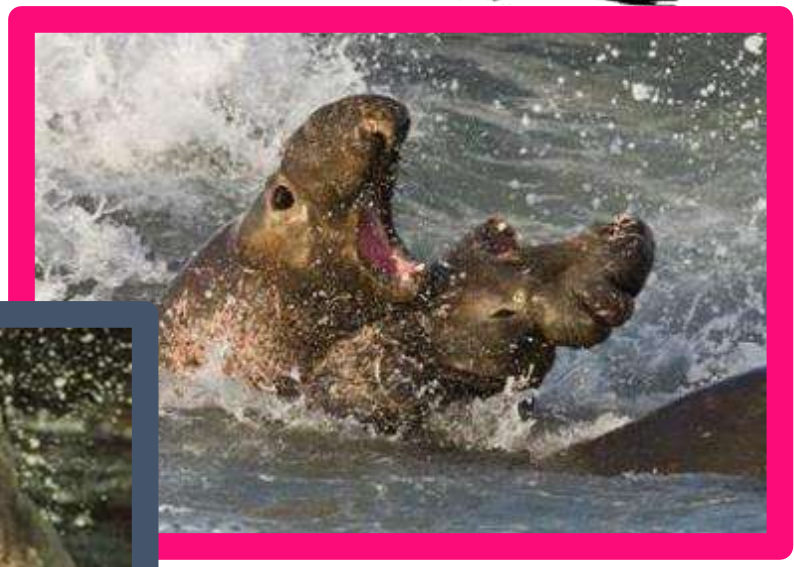
Male animals produce many sperm, whereas females invest a lot of energy in producing only a few eggs.

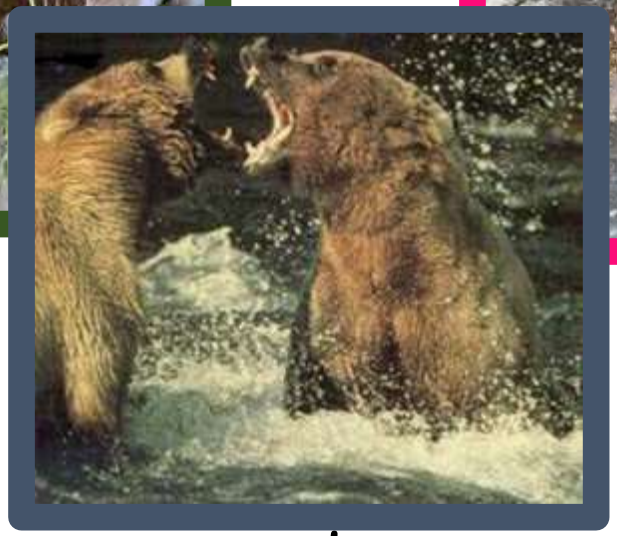
Females are, therefore, selective and choose one male of high quality.

Male animals often find themselves in competition for females.

Male to male competition







- The largest, strongest, and most aggressive males with the best weapons successfully mate with the females and pass the alleles for these characteristics on to the next generation.

Male to male competition

- http://www.bbc.co.uk/programmes/p00l714p mating rights for elephant seals

Female choice

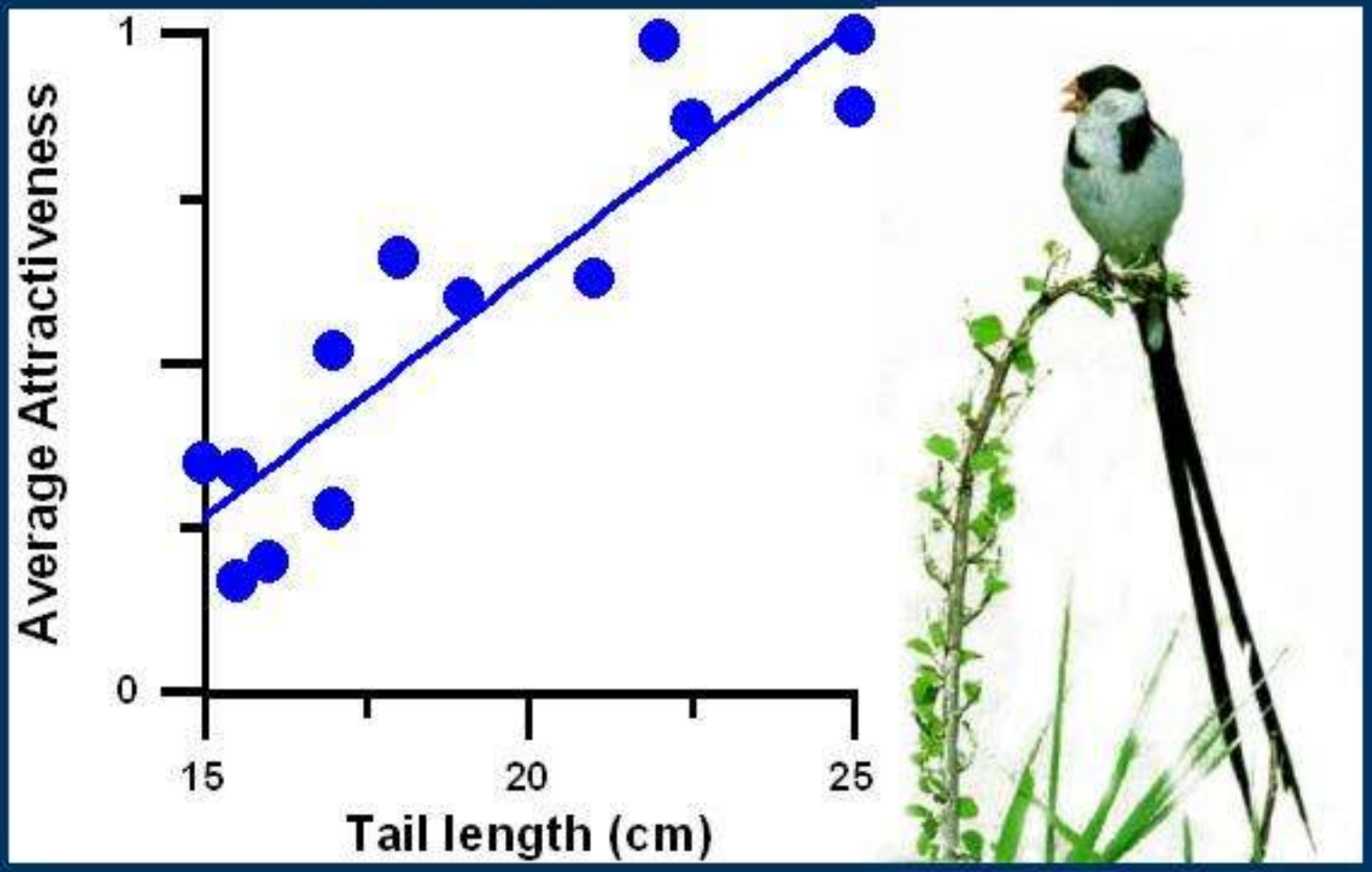
- Where the male is unable to control access to females the onus is on the female to select a male that she considers to be of high quality based on the traits that he displays.
- May take the form of 'ornaments' (bright plumage), calls, and displays in male birds.

Female choice

http://www.viralforest.com/bower-bird/

Birds of Paradise

Sexual Selection



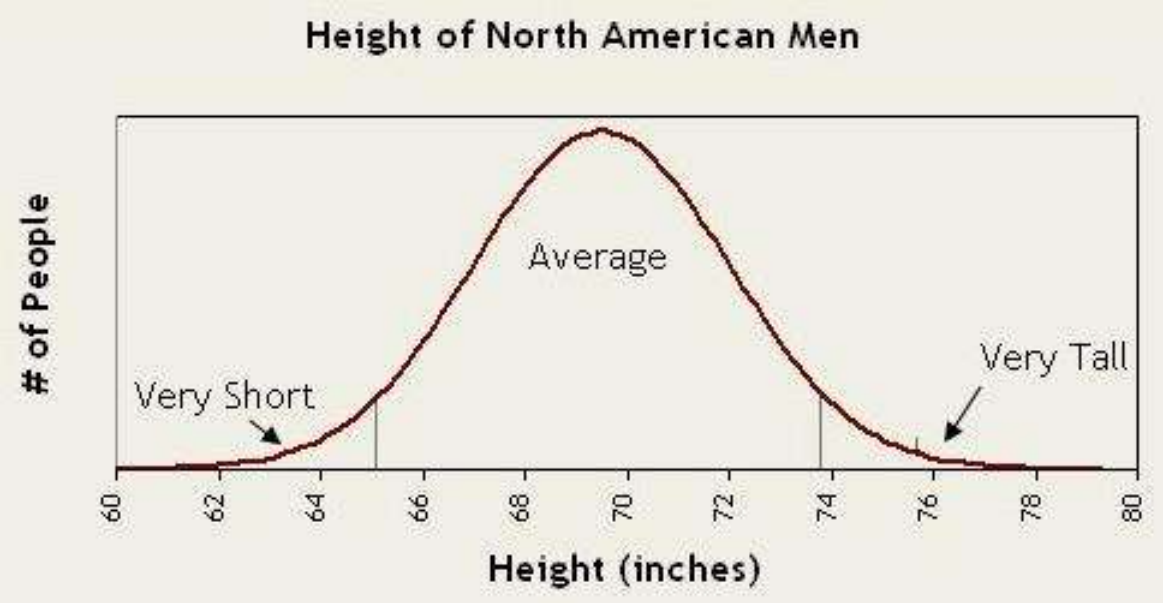
In the African bird, the pin-tailed whydah, you can see how the males with the longest tails are going to be the most successful, and so over time you would expect a change in tail length.

The results of sexual selection

- Male-to-male competition and female choice both result in ***the non-random increase in frequency of DNA sequences*** *that increase the rate of successful reproduction among the members of a species*.

Polygenic Traits

Polygenic (or quantitative) traits are controlled by the interaction of several genes and can be measured on an increasing scale e.g. human height.



Graphing normal distribution of polygenic traits produces a bell shape. Natural selection affects the distribution of these traits in 3 different ways.

Natural selection affects the distribution of these traits in 3 different ways.

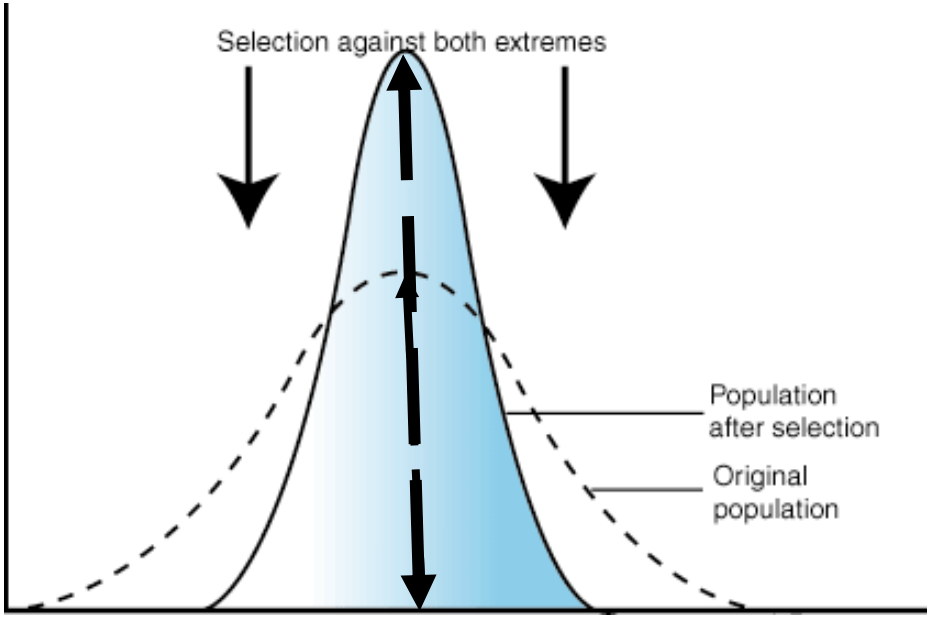
1. Stabilising Selection

2. Directional Selection

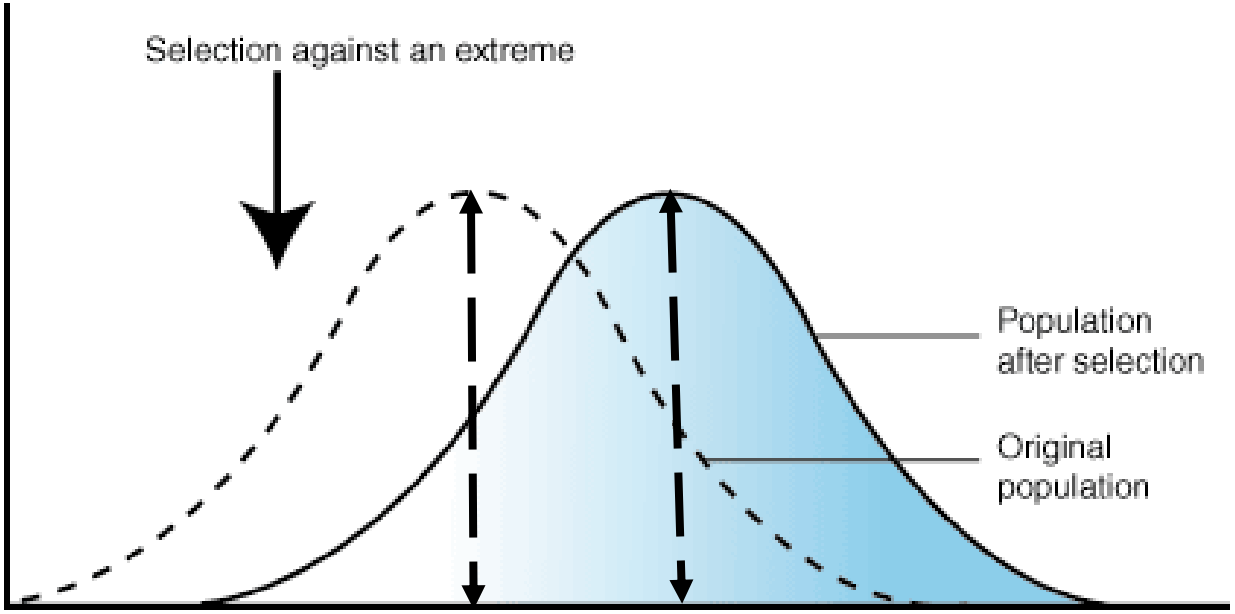
3. Disruptive Selection

1. Stabilising selection

- Selection exerts pressure against the extreme variants of the trait
- Favours intermediate versions of the trait.
- It leads to a reduction in genetic diversity without a change in the mean value.

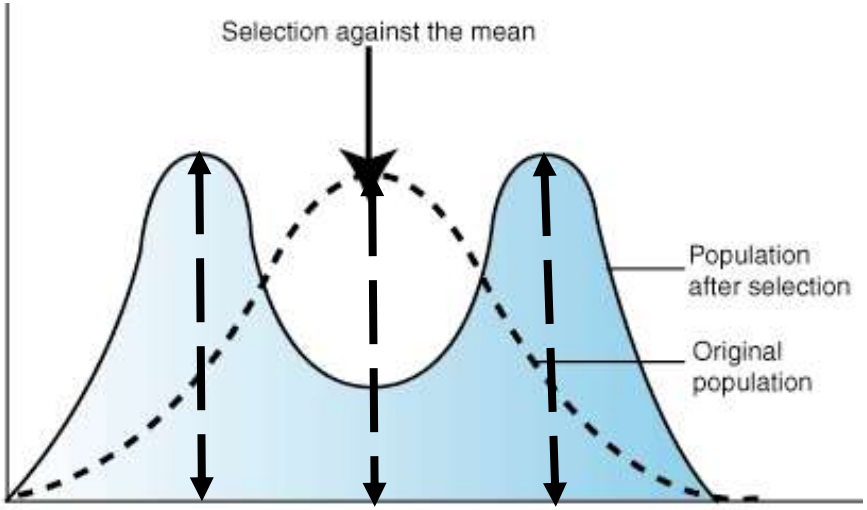


2. Directional selection



- Most common during a period of environmental change.
- Selection pressure against one extreme of the trait only
- It favours a version of a characteristic that was initially a less common form
- Results in a progressive shift in the population's mean value for the trait.

3. Disruptive selection



- Selection exerts pressure on the intermediates of a trait
- The extreme versions of a trait are favoured.
- It results in the population becoming split into two distinct groups each with its own mean value. This drives speciation.
- It occurs when two different habitats or types of resources become available.

Problem 1

- A group of early giraffes lives in a lush forest with many trees and shrubs of different heights to feed on. These giraffes have necks of various lengths, with most giraffes having a medium length neck. Then a blight passed through the area, killing off all of the low growing plants, leaving only tall trees whose leaves are far off the ground. Giraffes with shorter necks now have a hard time getting food, while those with longer necks can feed on the high-growing leaves. After several generations, the giraffes in this area all have longer necks than those before the blight. What type of selection has occurred in this giraffe population?

Directional

Problem 2

- A population of finches lives on an island with an abundant food supply. These finches have highly variable beak lengths, allowing them to feed on different types of food. Then several other species of birds move into the area, making food supplies scarce. The only types of food left for the finches are small seeds and nectar from long tubular flowers. Finches with small beaks can easily grasp and crack the seeds. Finches with long beaks can reach inside the long flowers to reach the nectar. However, some finches have beaks that are too large to deal with the small seeds, but too small to reach inside the flowers. After several generations, there are two populations of finches: those with short beaks and those with long beaks. What kind of selection has acted on these finches?

Disruptive

Problem 3

- A population of arboreal rodents lives in one species of pine tree. These pine trees have very evenly spaced branches of uniform thickness. Rodents that are too small cannot reach between the branches to move around in the tree. Rodents that are too big and heavy break through the branches and fall out of the trees. The rodent population contains adults of very uniform size. What type of selection has created this uniform size distribution in these rodents?

Stabilising

Problem 4

- What type of distribution would you expect for a trait on which there is no selection pressure? On which there is stabilizing selection pressure? Disruptive selection pressure? Directional selection pressure?
- The distribution of a trait on which there is no selection pressure should form a smooth bell-shaped curve.
- If there is stabilizing selection pressure, the curve should be narrower, but with the same mean.
- If there is disruptive selection pressure, the curve should be bimodal (have two peaks).
- If there is directional selection pressure, the mean of the curve should shift up or down the scale, depending on the direction of selection.

Genetic drift

Gene pool –

The total of all the different genes in a population.

Genetic drift

The **random** increase and decrease* in frequency of DNA sequences, particularly in small populations, as a result of:

- neutral mutations;
- founder effects.

* In a small population, genetic drift can cause an allele to disappear completely thus reducing genetic variation.

Neutral mutations

Most mutations are neutral.

These mutations do not affect how well adapted the individual becomes to its environment and are, therefore, not subject to natural selection.

However they are affected by genetic drift.

Neutral effects

Neutral mutations are liable to genetic drift because they are not liable to natural selection.

Explain this statement

- Mutations that are not involved in selective pressures, will be subject to random effects.
- They have no impact on the selection itself instead they will increase or decrease in a totally random way.

What is meant by genetic drift?

- Genetic drift is the random increase/decrease in the frequency of DNA sequences within small populations.

Founder effects

The founder effect is a special case of genetic drift.

It occurs when a small group of organisms (a splinter group) becomes isolated from the rest of the population and "founds" a new population.

The members of the splinter group possess a random set of alleles which **does not** represent the alleles of the original population.

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5.14, page 85

Creating a new species

Learning Intentions

1. Explain what "speciation" is.
2. Describe how geographical barriers lead to "allopatric speciation".
3. Describe how behavioural and ecological barriers lead to "sympatric speciation".
4. Explain what a "hybrid zone" is.

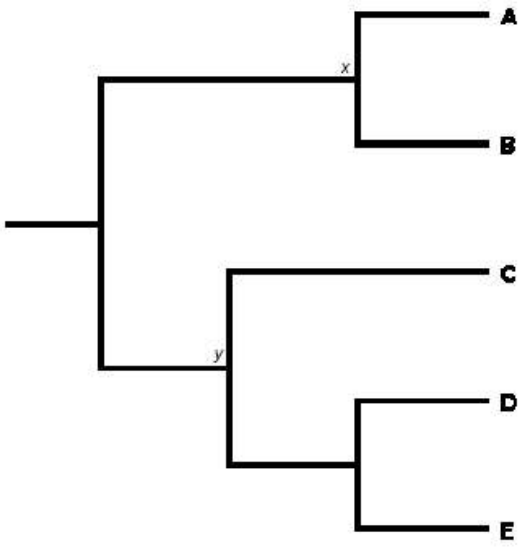
Revision-What does the term species mean?

A species is a group of organisms capable of interbreeding and producing fertile offspring.

Mule……..species or not?

Speciation

- Forming a new species by mechanism called evolution
- divergence of lineage from common ancestor



How does Speciation occur

1. Isolating mechanism
2. Random Mutation occurs on one side of barrier
3. Natural Selection

New species formed
(cannot interbreed to produce fertile offspring)

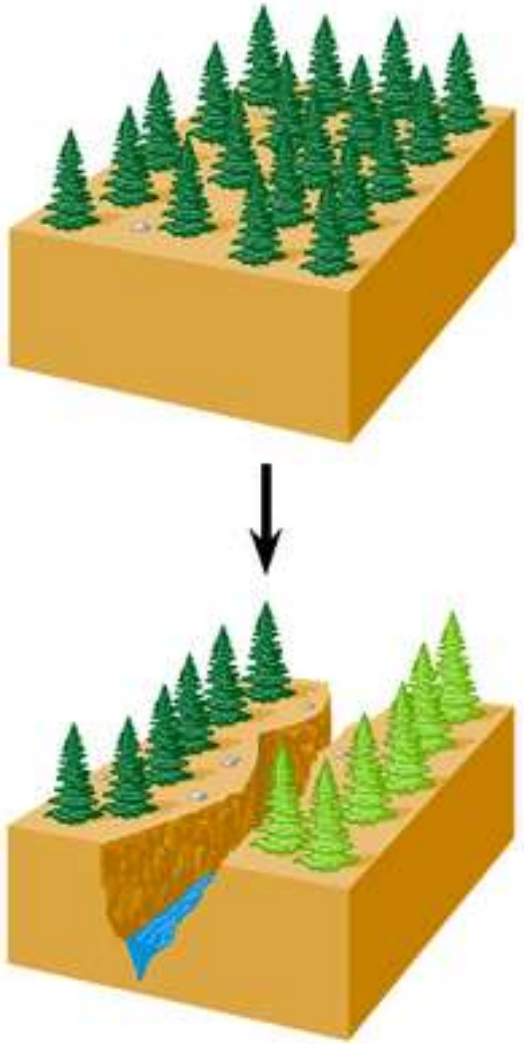
Types of Speciation

- 1. Allopatric (different areas)
- 2. Sympatric (same area)

Allopatric Speciation

- Sub populations isolated by geographical barriers.

- Now in two Different places

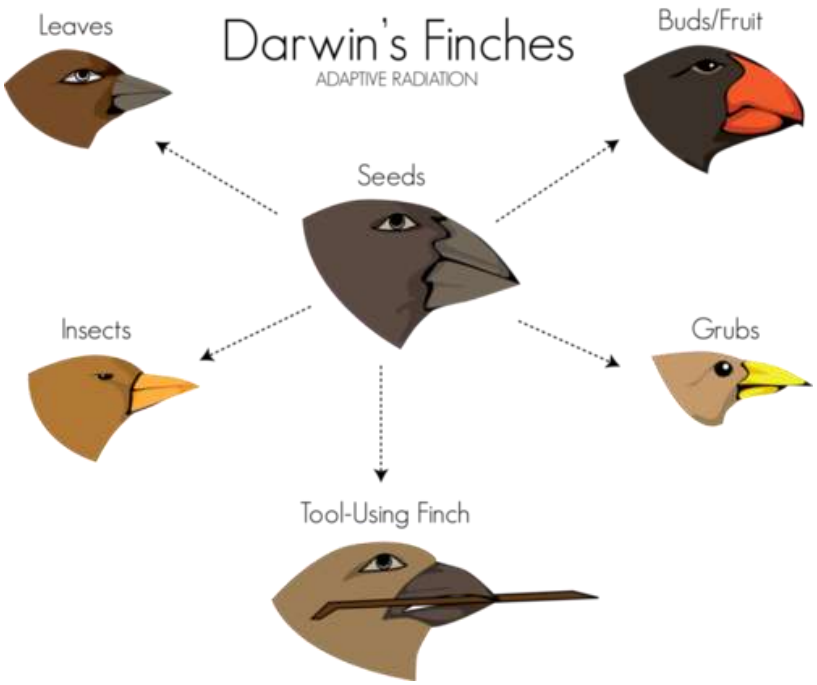


(a) Allopatric speciation

Geographical barriers

Finches in Galapagos Islands

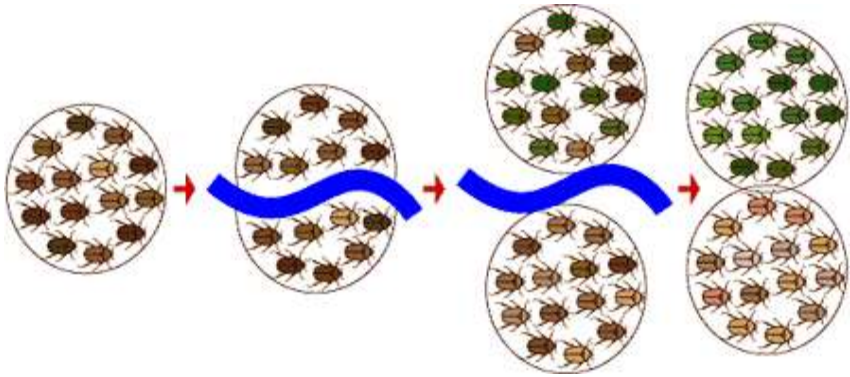
- Water separated mainland finches from Galapagos Finches




NORTH AMERICA
CARIBBEAN
North Atlantic Ocean
North Pacific Ocean
Caribbean Sea
CENTRAL AMERICA
0°
EQUATOR
SOUTH AMERICA
Galapagos Islands
23°5'S
TROPIC OF CAPRICORN
South Pacific Ocean
South Atlantic Ocean
1000 m
1000 km
90°W
worldatlas

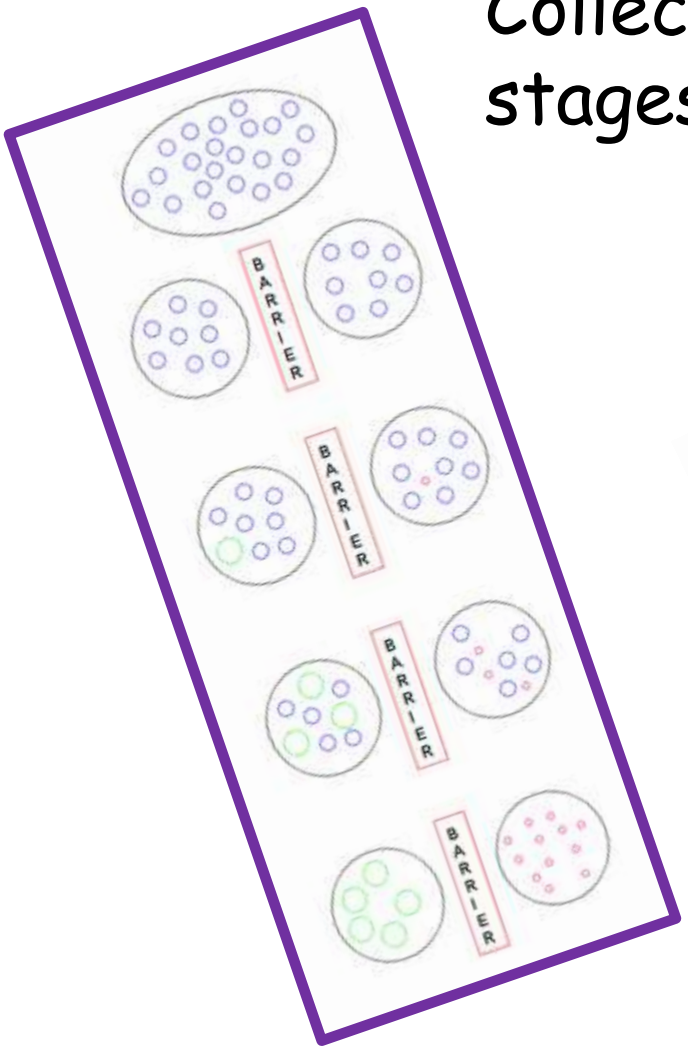
Allopatric Speciation

- No gene flow between sub-populations
- Different mutations either side
- Natural selection
- 2 new species formed

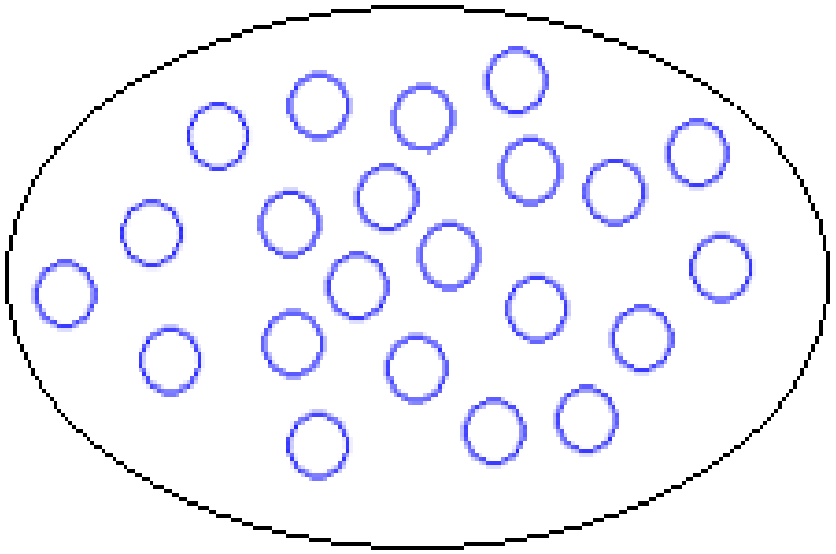


2. Allopatric speciation

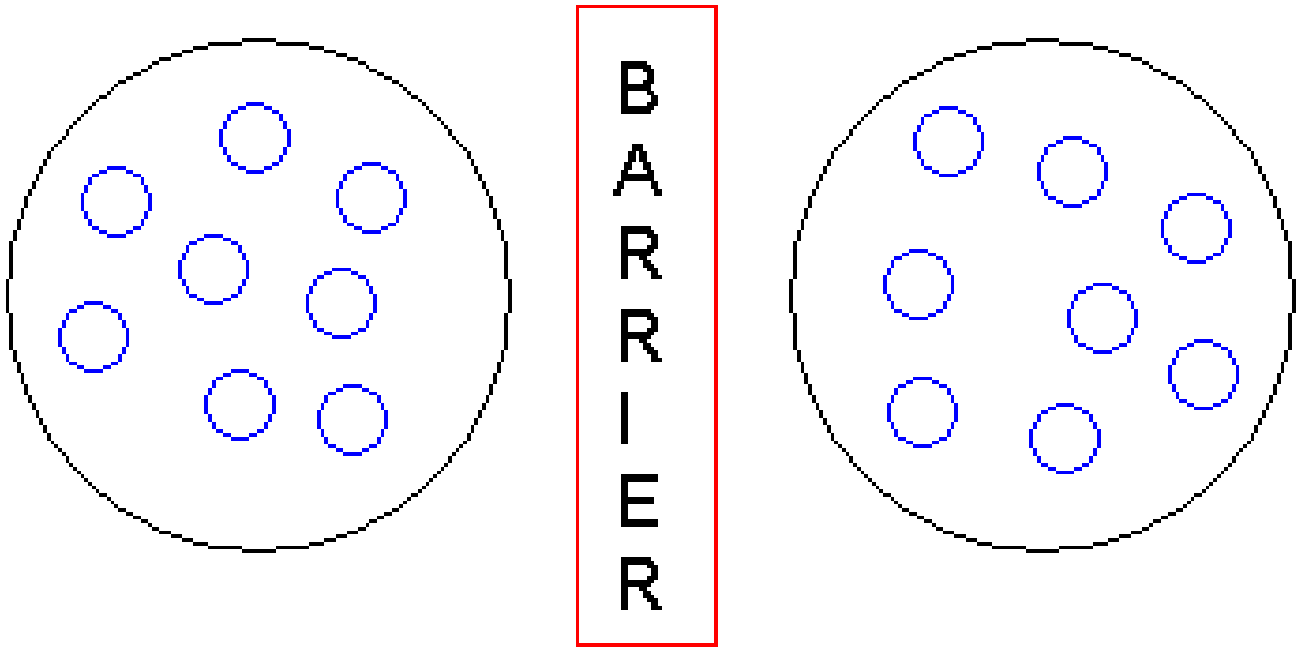
Collect a diagram and label the stages in Allopatric Speciation



In summary -Allopatric speciation



Large interbreeding population

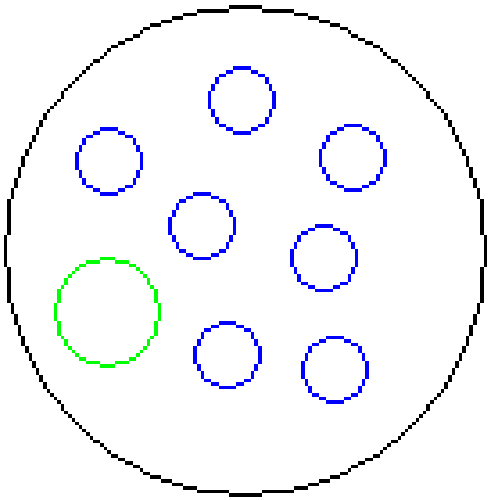


Isolation of populations

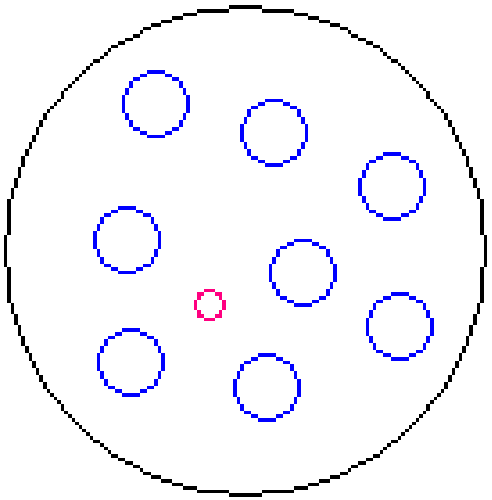
(interruption of gene flow)

Population A

Population B



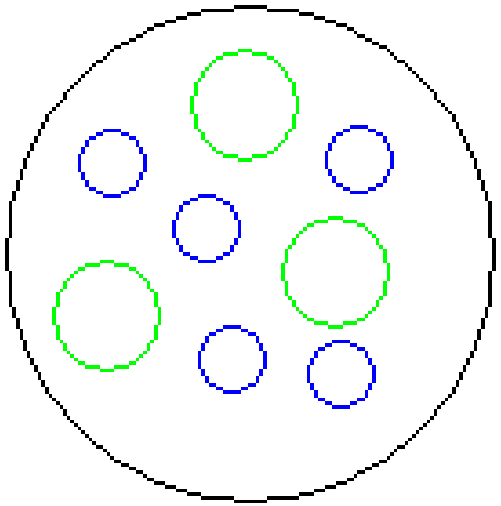
BARRIER



Separate populations mutate randomly – new variation

Large mutant

Small mutant



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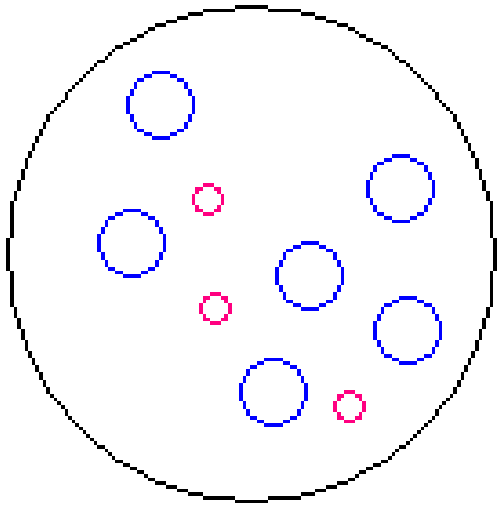
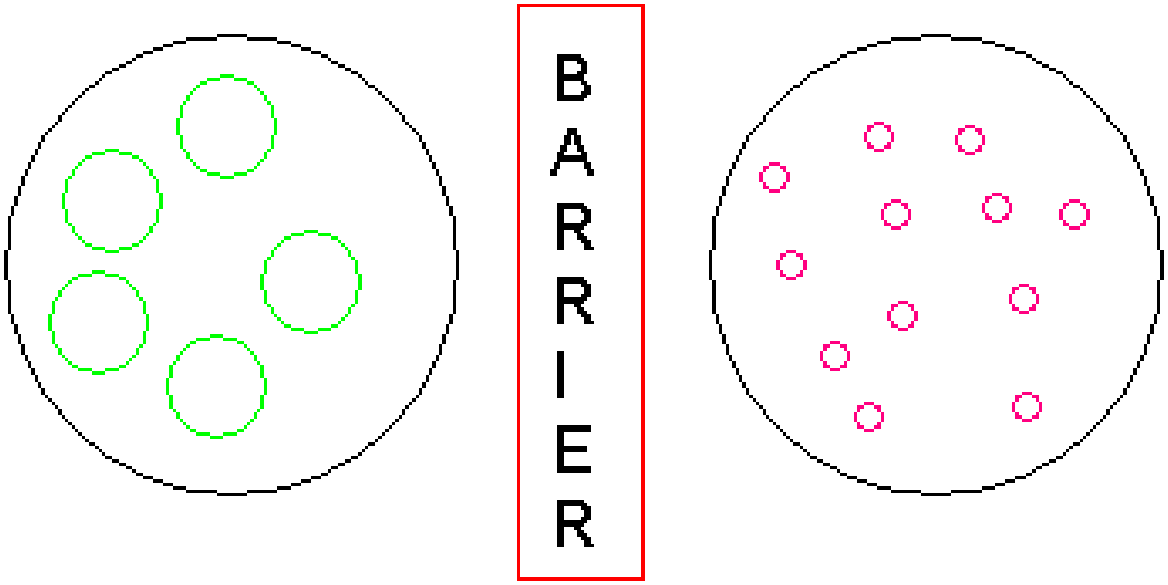


Natural selection favours mutants

e.g. Large mutant may favour dry conditions

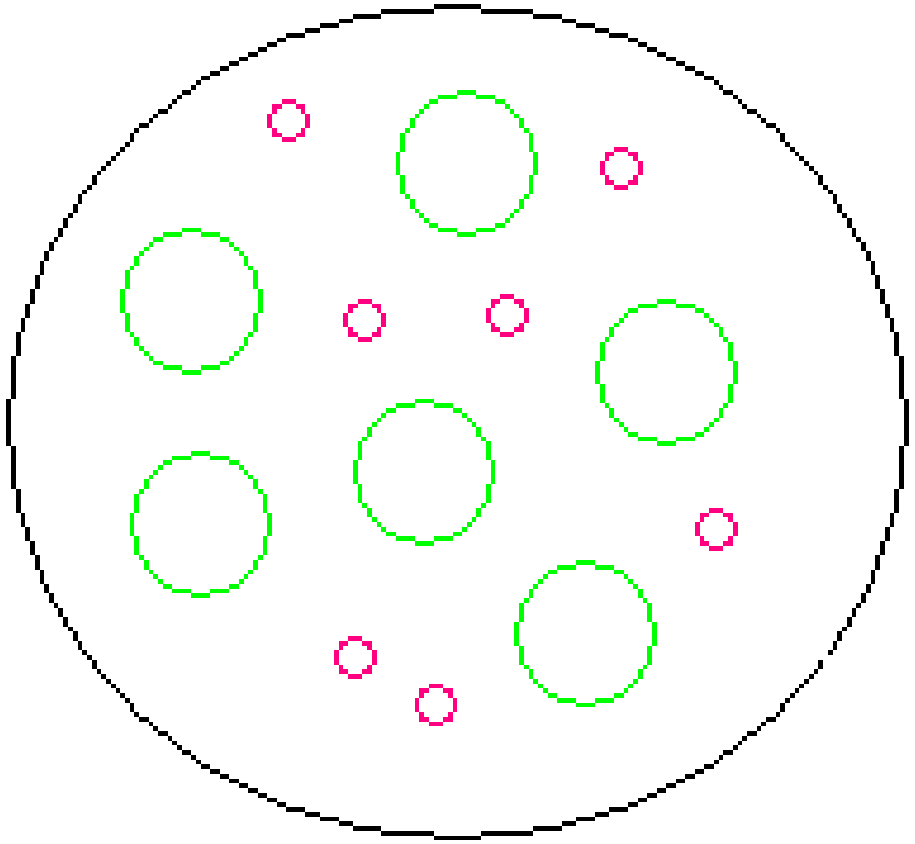
e.g. Small mutant may favour wet conditions



Species A

Species B

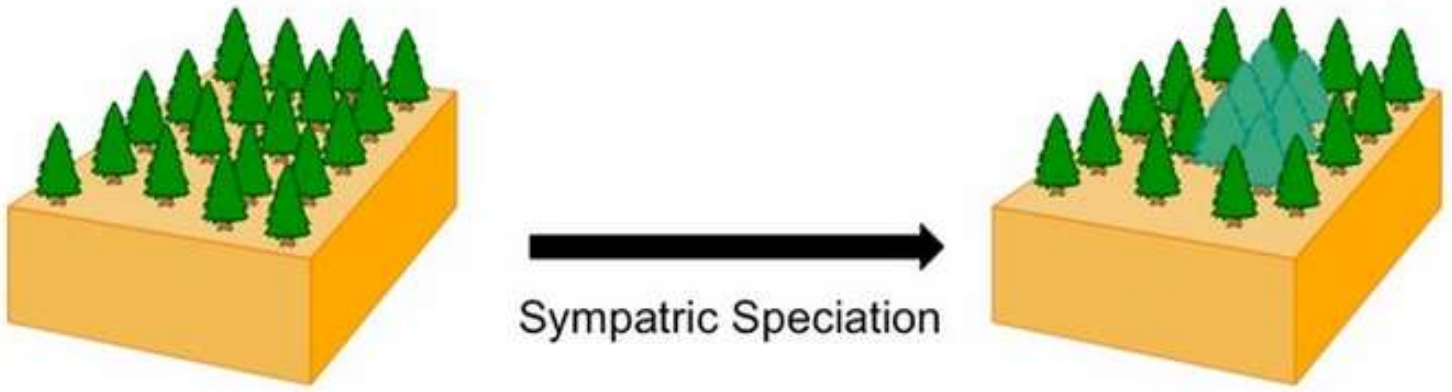
Over a long period of time natural selection increases frequency of new alleles



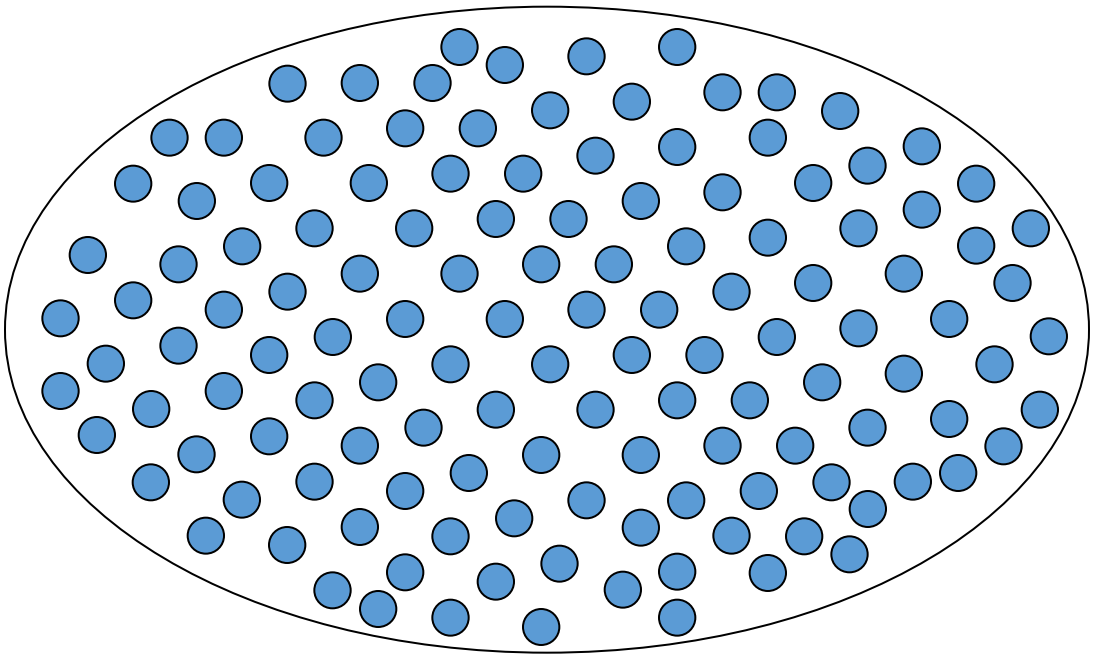
Speciation has occurred.
Species A and B cannot interbreed even if barrier is removed

Sympatric Speciation (same place)

Sub populations isolated by ecological/reproductive/behavioural barriers

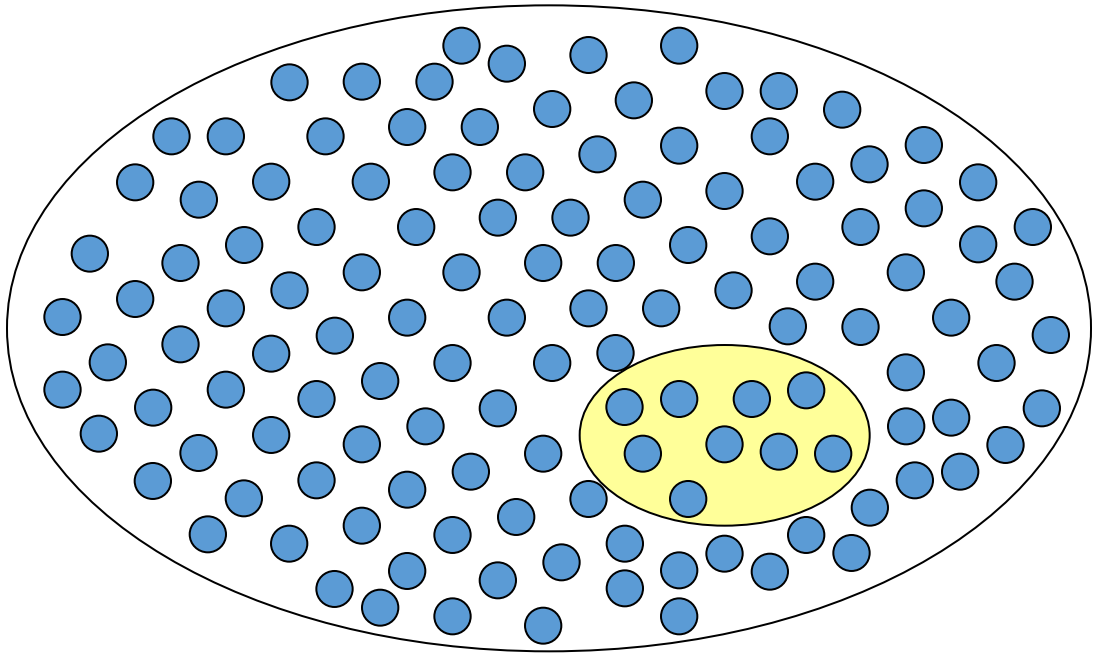


Sympatric Speciation



Large interbreeding population sharing the same ecological niche.

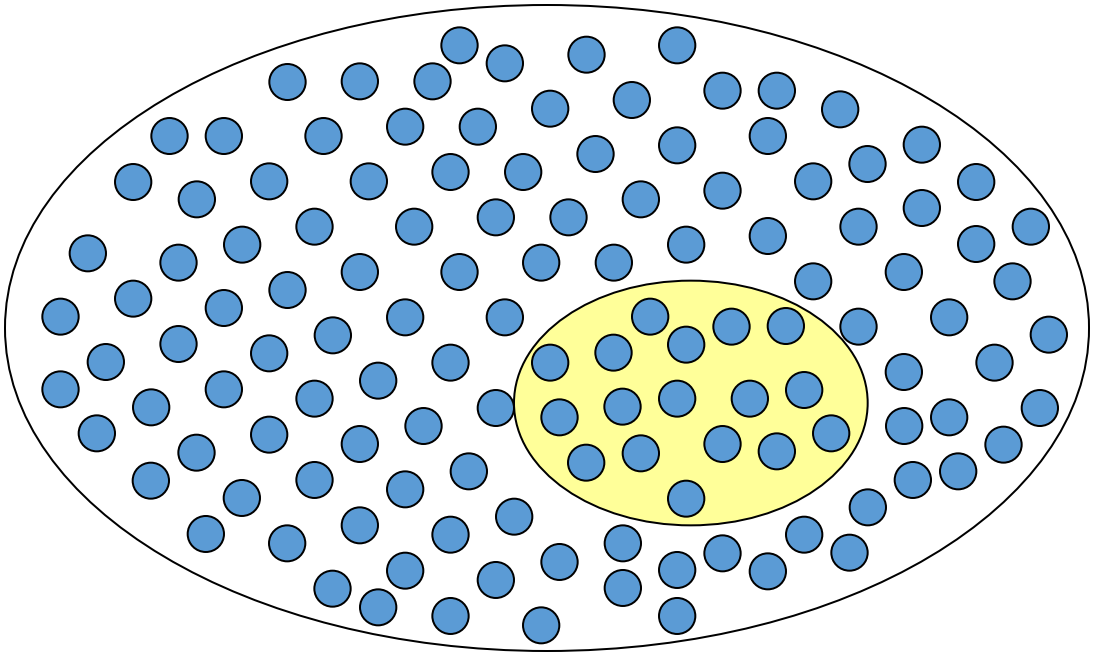
(e.g. Fruit flies living on hawthorn bushes)



Alternative ecological niche appears.

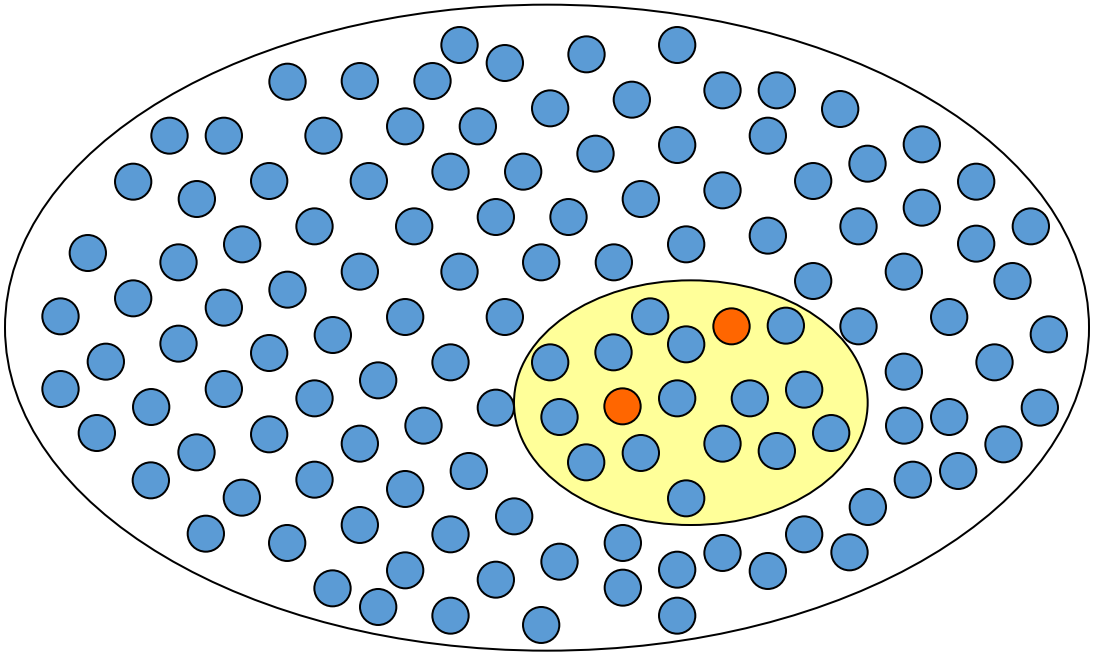
(e.g. new species of apple tree introduced by humans)

Some members of the population start to exploit the new niche



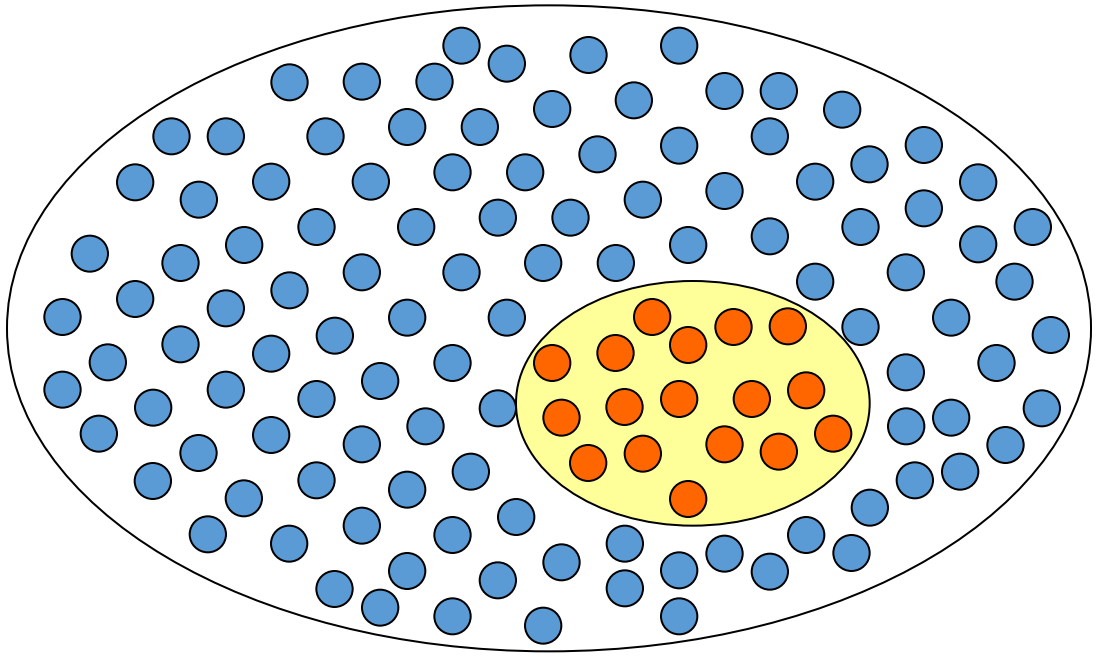
The two populations now exploit different resources (e.g. food source) and no longer interbreed.

Behaviour has become an isolating barrier and *has interrupted the gene flow* between the 2 populations.



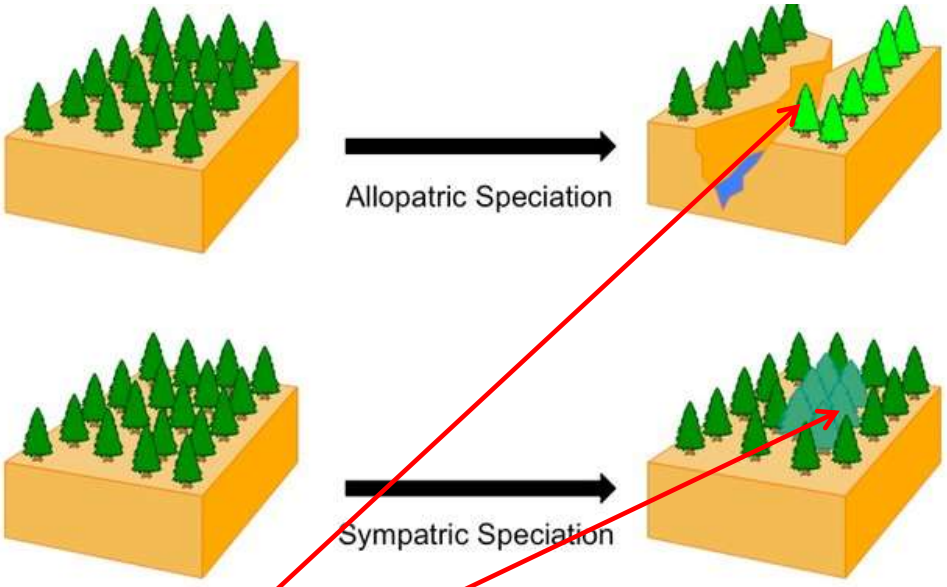
Mutants better adapted to exploit the new resources appear and successfully breed.

(e.g. better camouflaged on apples)



Natural selection favours the new mutants and eventually over a period of time <u>two genetically distinct species</u> are formed which can no longer interbreed.

Allopatric Speciation versus Sympatric Speciation



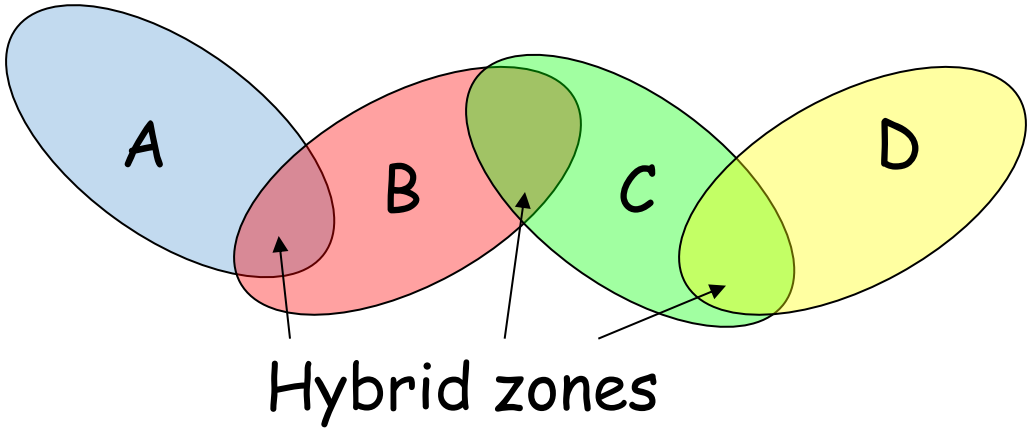
Similarities:

- Both involve the formation of a new species via isolation of the genetic pool from an existing species
- Both occur when natural selection creates genetic divergence between the new and ancestral populations

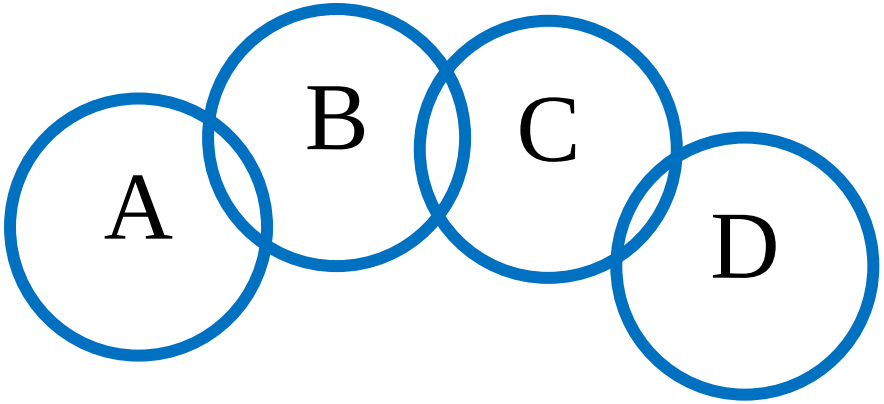
Differences:

Allopatric Speciation	Sympatric Speciation
Involves the physical separation of populations	Involves a reproductive or behavioural separation
Populations occupy different geographical areas	Populations occupy same geographical areas
Example: Adaptive radiation of Galapagos finches	Example: Polyploidy in wheat strains

Hybrid zones

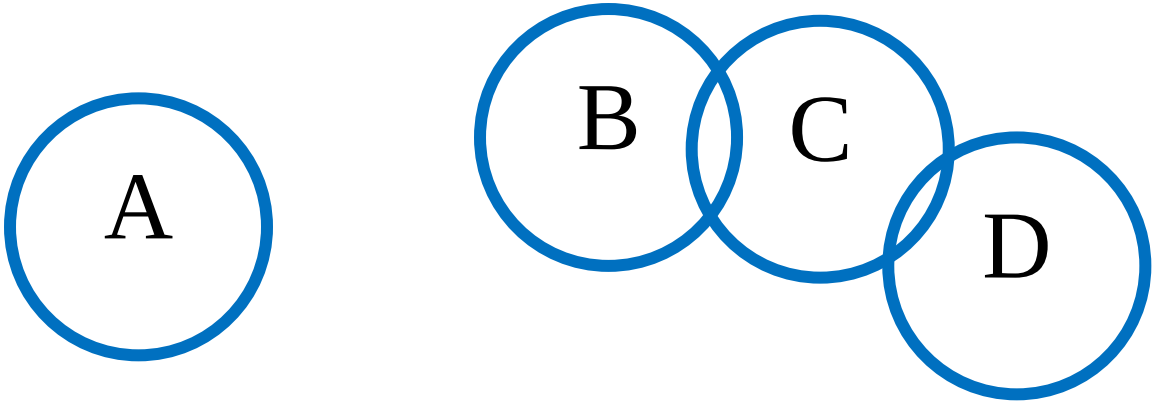


Hybrid zones exist where interbreeding is possible and as a result genes are able to flow between the sub-populations.



- These four population belong to the same species because each population can breed with it's immediate neighbour

- This allows genes to flow from A to B, B to C and C to D.

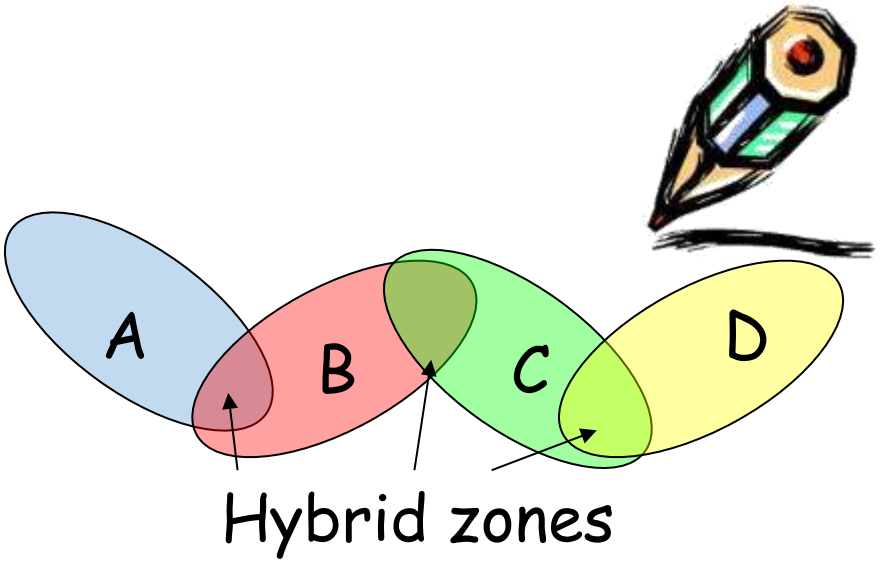


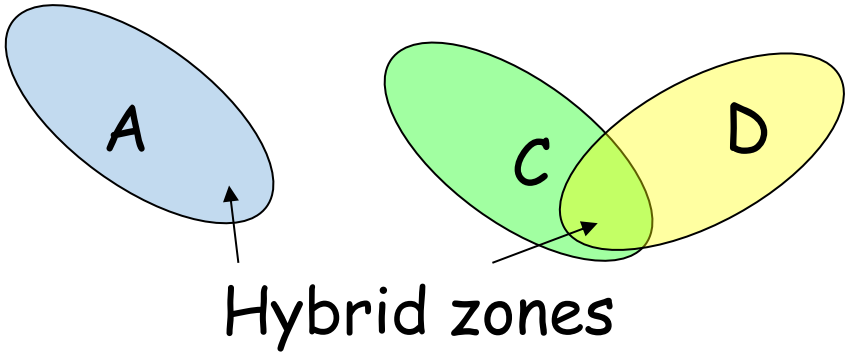
- In this diagram, there are <u>2 species</u>.

- There has been an interruption to the gene flow (by a barrier) and can no longer interbreed.

- Speciation has occurred and population A's gene pool is now genetically distinct and isolated to B, C and D.

If populations B or C become extinct, gene flow is disrupted and populations A and D cannot <u>breed</u> together and therefore become two separate <u>species</u> .





Example- Finches –Galapagos Islands

Which type of speciati… first?
What was the …

THINK……

-Allopatric Speciation
-The sea acted as geographical barrier

In addition, within populations living on the same island ,it is probable that some groups underwent sympatric speciation by becoming adapted to suit, for example a particular type of food available in an unoccupied ecolochical niche.

Evolution song…oh dear!!! OPTIONAL!

- http://www.youtube.com/watch?v=r5Y_ILQB-Kg

NEXT SLIDE may be used for revision only…..may not use