# POPULATION GENETICS

**SPECIATION**

- **ISOLATING MECHANISMS**

# 2 POPULATION GENETICS

**POPULATION GENETICS** is the branch of biology that deals &provides the mathematical structure for the study of micro evolutionary process.

**Microevolution** refers to the change in one gene pool or the allele frequencies that occur within a population over time. Mainly due to mutations, genetic drift, gene flow, selection (natural and artificial), gene flow for example industrial melanism, microevolution of resistance to antibiotics, pesticides, herbicides etc. **Macroevolution** refers to speciation or evolutionary changes at a level higher than the species level, resulting into formation of a higher taxonomic group such as class or genus.

***Qn; Describe the different forms of microevulation that occur within a population.*** ***(8marks)***

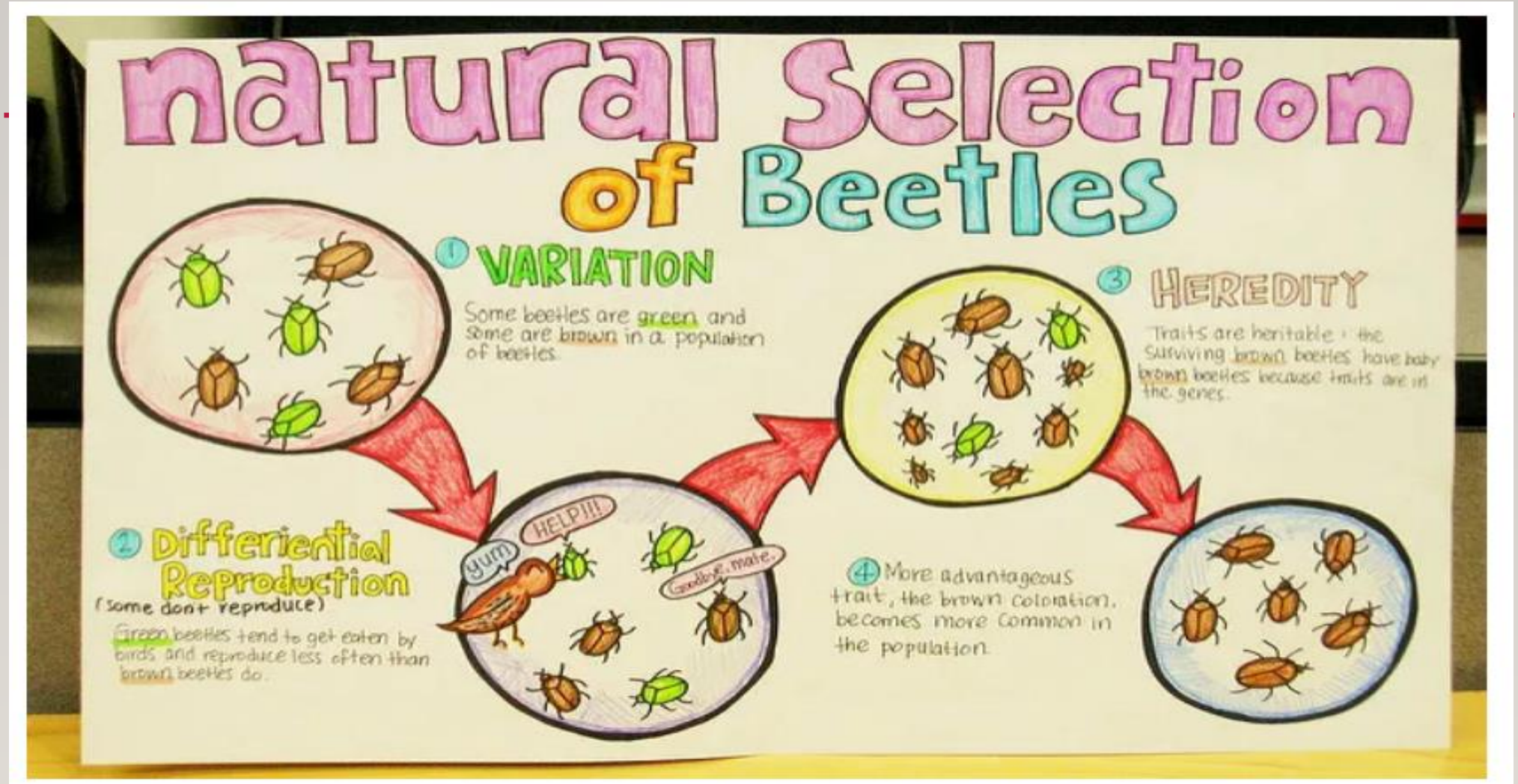
# KEY TERMINOLOGIES

- GENE POOL
- ALLELE FREQUENCY as discussed using HERDY WEINBERG'S PRINCIPLE OF GENETIC EQUILIBRIUM
- GENOTYPIC FREQUENCY

# CAUSES OF ALLELE FREQUENCY IN POPULATIONS

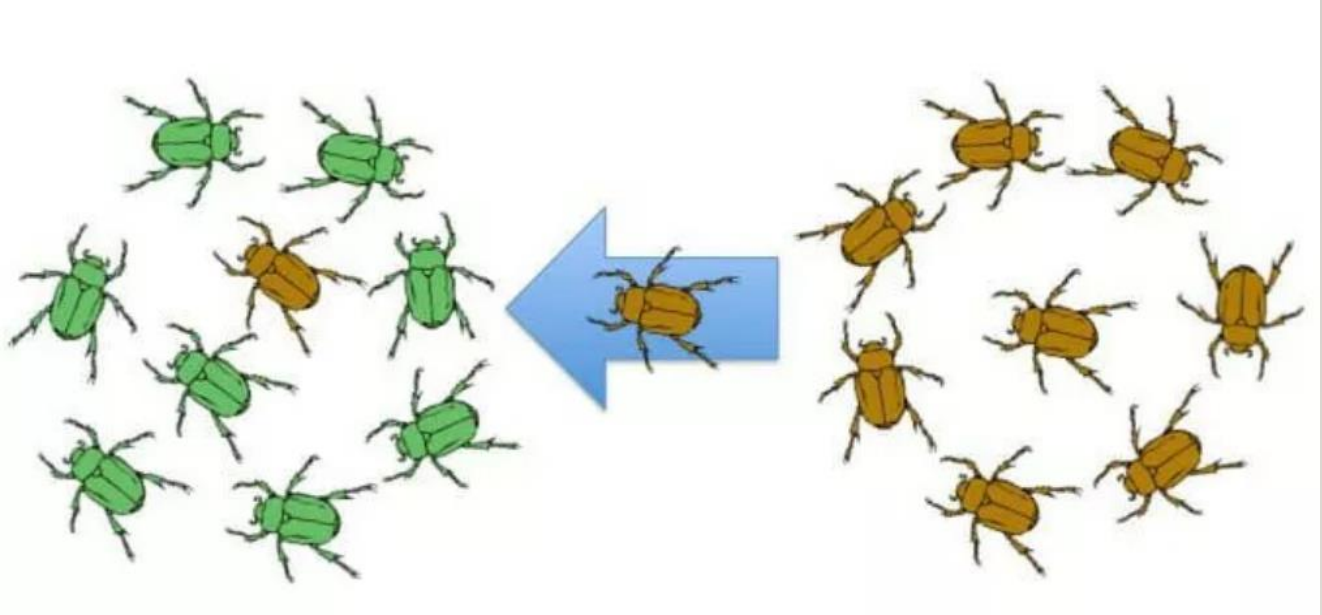
- ☐ Crossing over during meiosis
- ☐ Independent segregation during meiosis
- ☐ Random fertilization
- ☐ Mutation
- OTHERS INCLUDE , GENEFLOW, NON RANDOM MATING, GENETIC DRIFT

# 5 MICRO EVOLUTION

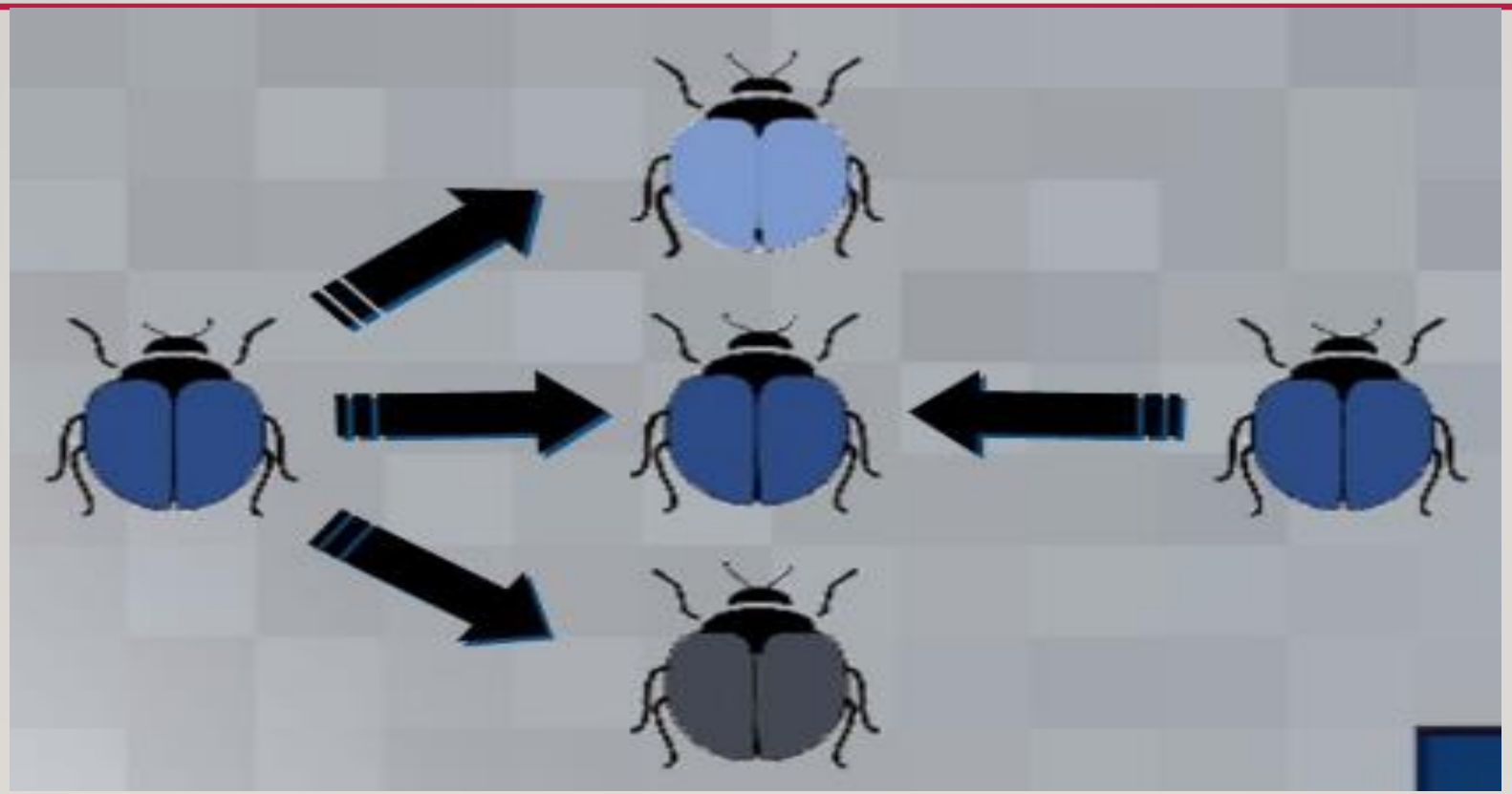


# GENE FLOW

- **Gene flow** is the exchange of alleles between two or more populations. For this reason it is sometimes referred to as *allele flow* or *gene migration*. While migrating animals often carry new alleles from one population to another, they must interbreed with the new population for gene flow to occur.



# NON RANDOM MATING

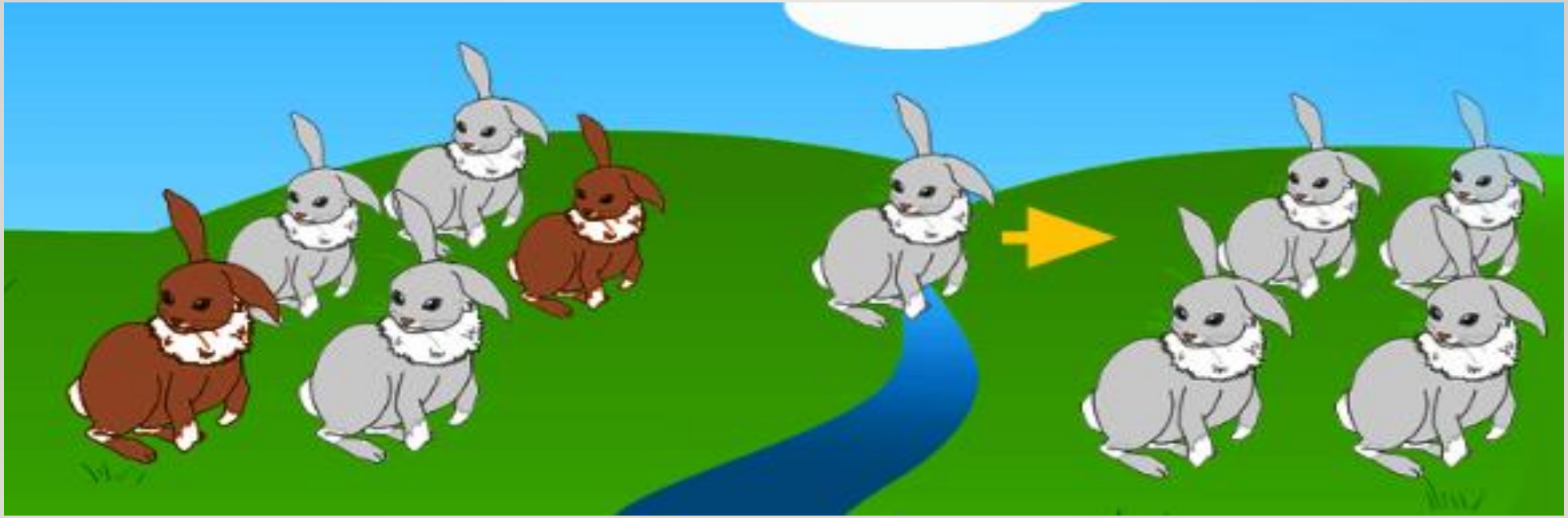


# 8 GENETIC DRIFT

- variation in the relative frequency of different genotypes in a **small population**, owing to the chance disappearance of particular genes as individuals die or do not reproduce.
- Key terms: **FOUNDER EFFECT** & **BOTTLE NECK EFFECT**
- ***Random genetic drift may lead to the following;***
- Total loss of some alleles from the population, due to death of the few individuals carrying such alleles
- Total extinction of the population
- The population becoming much better adapted to the environment
- Wide divergence of the population from the parent population, and all these occur just by chance rather than natural selection

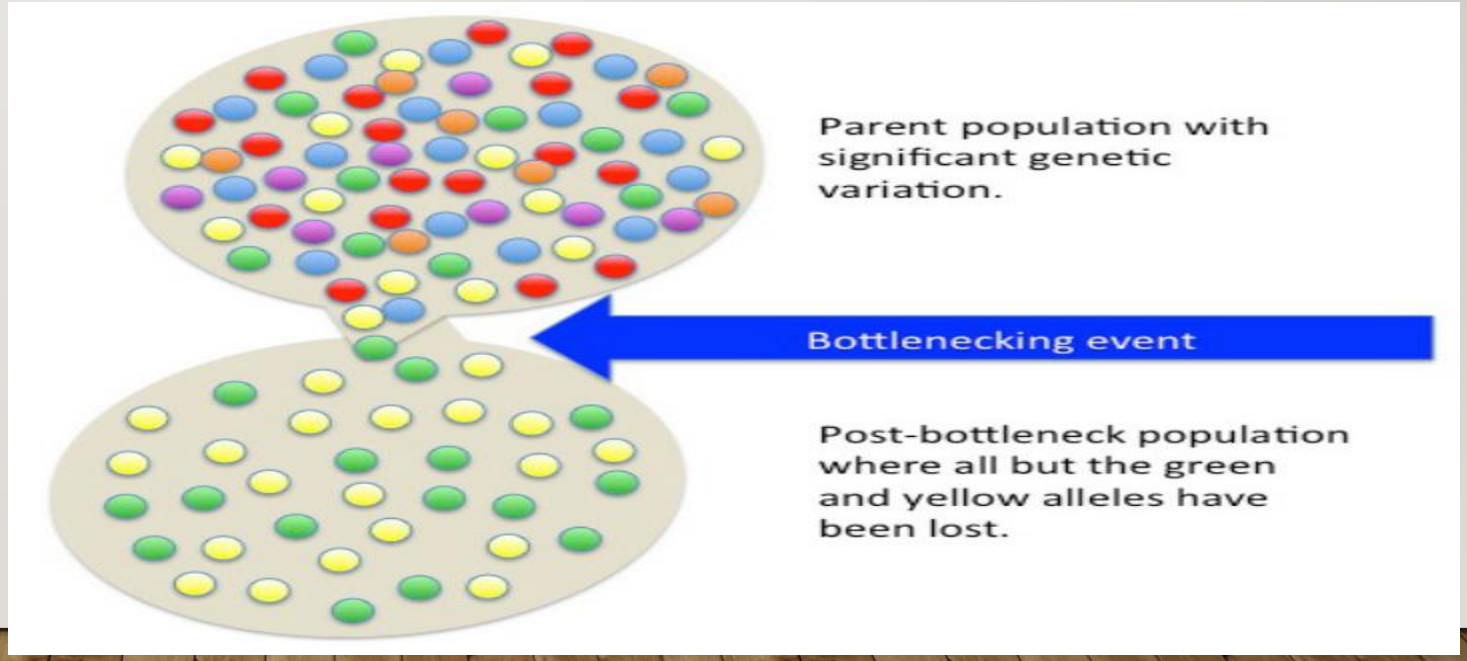
# 9 FOUNDER EFFECT

- **the reduction in genomic variability that occurs when a small group of individuals becomes separated from a larger population.**



# 10 BOTTLENECK EFFECT

- **Reduction in populations genepool due mainly environmental factors**. Events like natural disasters (earthquakes, floods, fires) can decimate a population, killing most individuals and leaving behind a small population



# 11 GENETIC LOAD

- This is the existence within the population of disadvantageous alleles in heterozygous genotypes. Very many disadvantageous alleles are able to exist in populations in heterozygous forms as in this form they are rarely expressed phenotypically for possible elimination by environmental selection, for example **albinism, colour blindness, sickle-cell anemia**, etc. The maintenance of fairly high frequencies of a recessive allele which may be potentially hazardous in a homozygous recessive state is referred to as the heterozygous advantage.

# SPECIATION

**Candidates should know!**

- Definition
- Causes
- Process
- Types
- Examples

# SPECIATION

***definition: the process by which new species may arise from pre-existing species.***

**Intraspecific speciation** is when a single species gives rise to new species. If this occurs when the whole population is occupying the same geographical area, its referred to as **sympatric speciation** whilst;

**allopatric speciation** occurs when the populations are occupying geographically isolated habitats. In some cases, commonly in flowering plants, two species may give rise to a new species; this is known as interspecific hybridization.

# SUMMARY OF THE CAUSES OF SPECIATION

- **-Cross-fertilization** between two individuals of different species leading to formation of sterile hybrid.
- **-Isolation-**Reproductive or geographical leading to demes evolving along different lines
- **-Natural selection-**Operating differently in the different gene pools/subpopulation due to differences in climate or ecology.
- **-Other drivers** occurring differently in the different demes causing upset in the allele frequencies ie Mutation, Genetic drift and Non-random mating.

# 15 SYMPATRIC SPECIATION

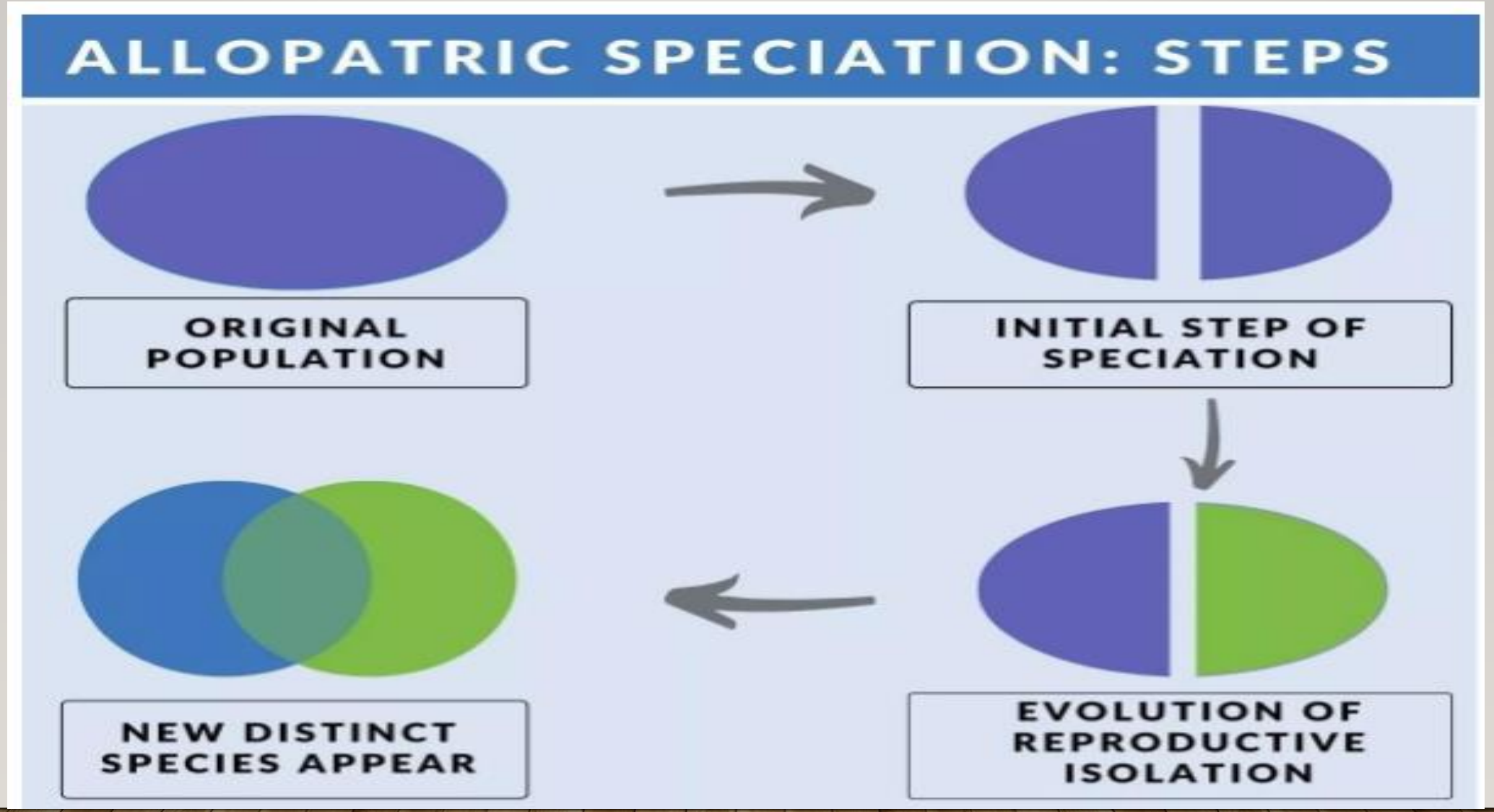
- A form of speciation occurring inside a continuous population and caused by mechanisms apart from the geographical barrier; resulting to genetic isolation, and subsequent reproductive isolation; between original population and the new species in the same geographical region.

# EXAMPLE OF SYMPATRIC SPECIATION

- *Parent plants produce offspring that are polyploid. Hence, the offspring live in the same environment as their parents but are reproductively isolated.*

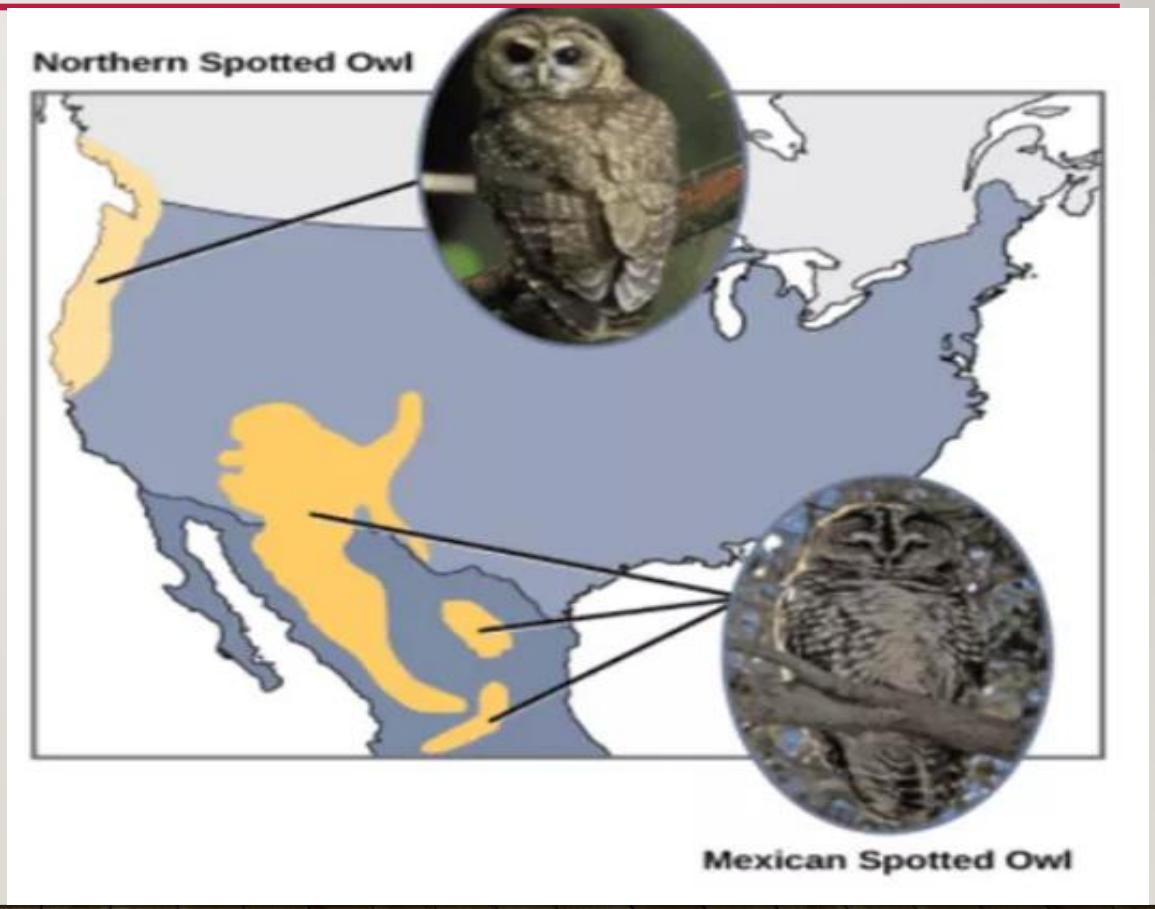
# 17 ALLOPATRIC SPECIATION

- **Allopatric speciation** is a type of speciation in which biological populations are physically isolated by an extrinsic barrier and evolve **intrinsic** (**genetic**) **reproductive isolation**, such that if the barrier breaks down, individuals of the population can no longer interbreed.
- *Example: Charles Darwin's Galápagos Finches.*
- *NB-The Galapagos finches are closely related to each other and their mainland predecessors due to similar breeding behaviours and internal anatomy but differ significantly in the shapes of their beaks and feeding habits.*
- extrinsic/physical bariires include; rivers, deserts, considerable distances, or mountains.


ALLOPATRIC SPECIATION: STEPS
ORIGINAL POPULATION
INITIAL STEP OF SPECIATION
EVOLUTION OF REPRODUCTIVE ISOLATION
NEW DISTINCT SPECIES APPEAR

# 19 EXAMPLE OF ALLOPATRIC SPECIATION

1. ***THE MEXICAN SPOTTED OWL*** and ***THE NORTHERN SPOTTED OWL*** being separated by rivers, and therefore isolated from each other by geographical barrier resulted in allopatric speciation. They acquired features that differ from each other as they evolved and adapted independently over time as they inhabited different geographical locations with distinct climates and ecosystems.

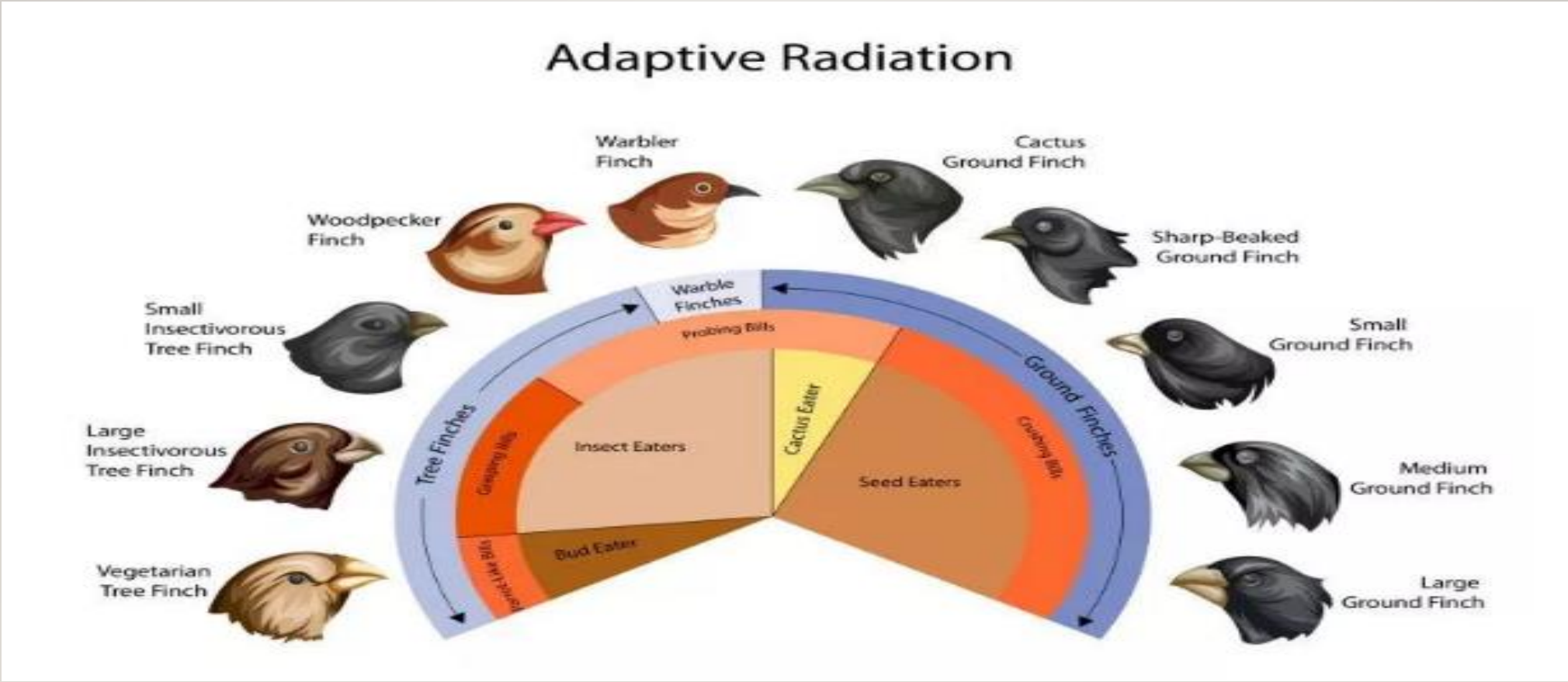


# EXAMPLE OF ALLOPATRIC SPECIATION
# 2. ***CHARLES DARWIN'S GALÁPAGOS FINCHES.***

CATEGORIES OF DARWINS FINCHES

- Ground finches
- Cactus ground finches
- Insectivorous finches
- Vegetarian tree finches
- Warbler finches-found on trees
- Wood pecker finches-found on trees

# GALAPAGOS ISLAND FINCHES – ADAPTIVE RADIATION.



# KEY TERMS

- **Adaptive radiation**-Rapid process where ancestral species evolves into different species filling different ecological niches; modification of structures of the same origin to fill a variety of ecological niches
- **Divergent evolution**-process where populations that share same ancestral origin develop different biological traits due to differences in the environmental conditions.
- **Geographical Isolation-**Population split into demes/small populations/subpopulations due to presence of geographical/physical barrier eg Ocean/seas/desert/river/mountains etc
- **Oceanic island**-an island that has never had any connection with the main land

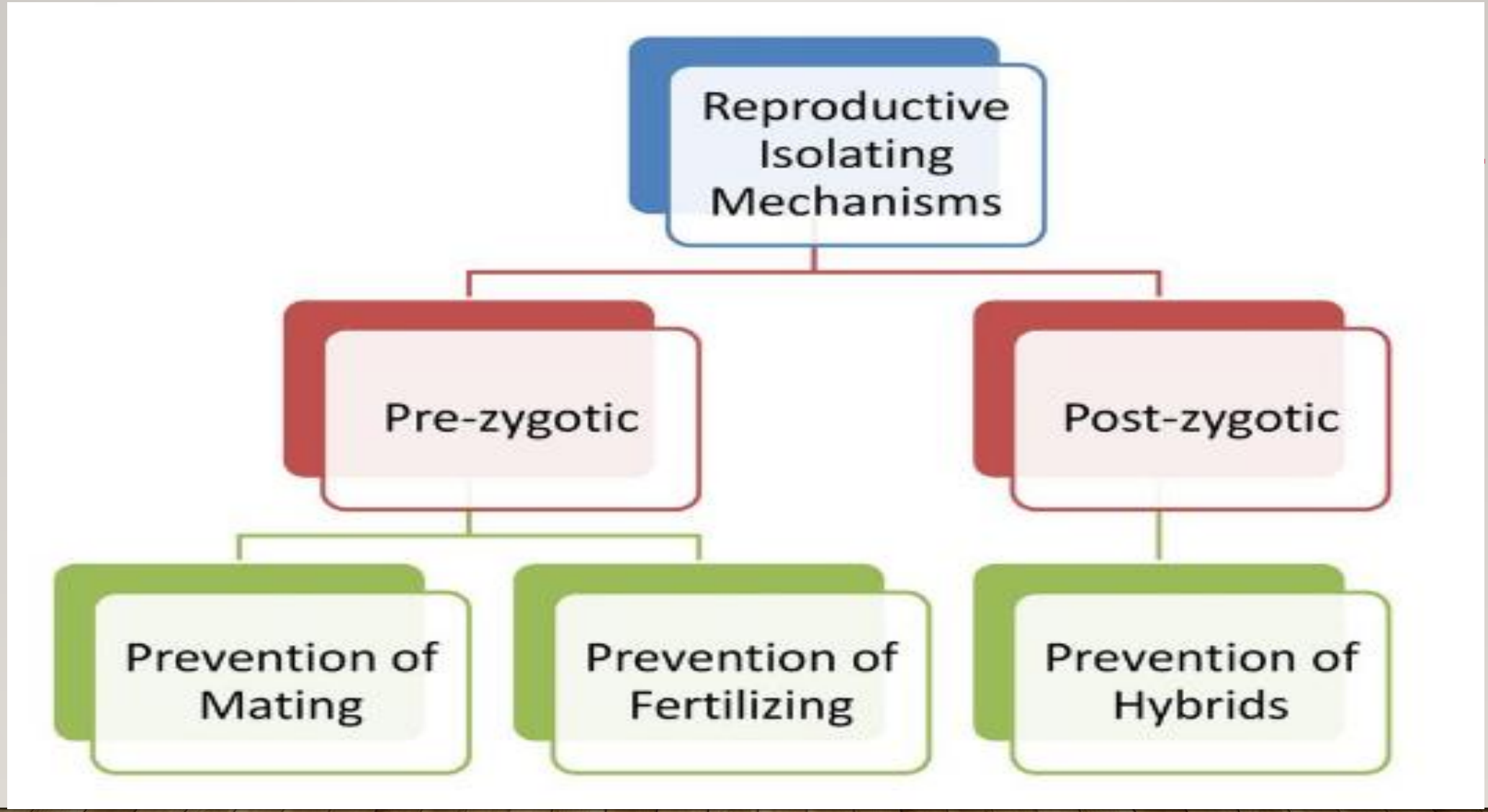
# ISOLATING MECHANISMS/ REPRODUCTIVE ISOLATION MECHANISMS

**Reproductive isolation/ isolating mechanism;** refers to a set of mechanisms that prevent species or the members of the same group from breeding or mating with each other.

# 24 MAIN CATEGORIES OF ISOLATING MECHANISMS

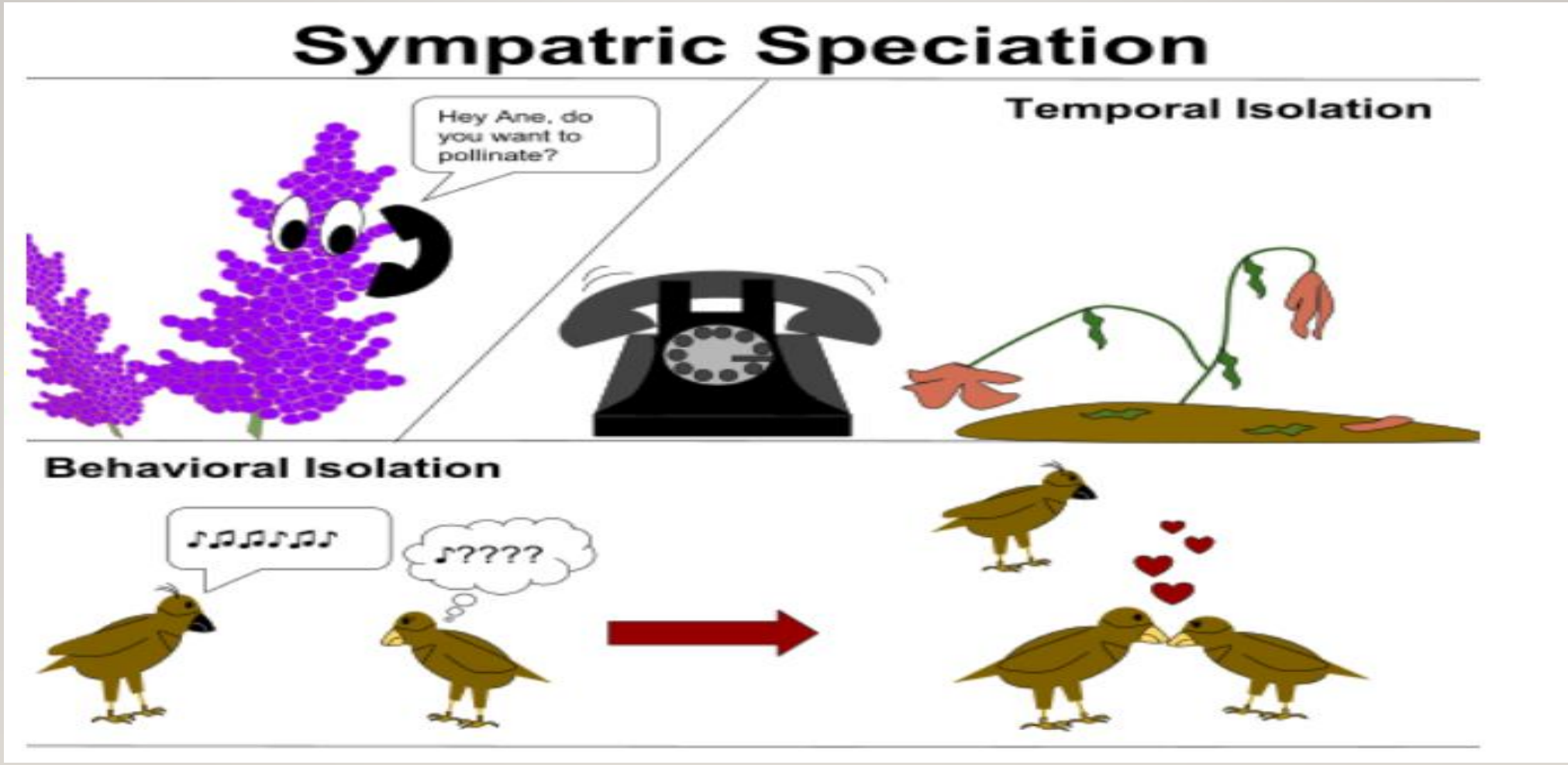
1) PREZYGOTIC ISOLATION MECHANISMS

2) POSTZYGOTIC ISOLATION MECHANISMS


Reproductive Isolating Mechanisms
Pre-zygotic
Post-zygotic
Prevention of Mating
Prevention of Fertilizing
Prevention of Hybrids

# 1. PREZYGOTIC ISOLATION MECHANISMS

- Prezygotic reproductive isolation is a mechanism of reproductive isolation that prevents the fertilization of the eggs. There are different categories of prezygotic isolation mechanism. They are behavioural isolation, habitat isolation, mating seasons, mechanical isolation, temporal isolation, gamete isolation, etc. When the two species live in a completely different two habitats where they cannot meet with each other, it prevents the fertilization, and it is known as habitat isolation.
- Furthermore, when the mating seasons differ among the species, they don't prefer to mate with each other, and it will also prevent the union of sperms and eggs. Individuals may not mechanically fit with each other, or their gametes can be incompatible on some occasions. Both these reasons also can prevent the fertilization. Behavioural isolation occurs when the species are not aware of the mating rituals or when there is no sexual attraction, etc.


Sympatric Speciation
Hey Ane, do you want to pollinate?
Temporal Isolation
Behavioral Isolation
♪♫♫♪♫♪
♪????

# 28 ECOLOGICAL/HABITAT ISOLATION

- Ecological, or habitat, isolation occurs when two species that could interbreed do not because the species live in different habitats. For example,
- In India both the lion and tiger exist and are capable of interbreeding; however, the lion lives in the grasslands and the tiger lives in the forest.
- The common garter snake lives near water and the northwest garter prefers open areas.
- The two species live in different habitats and will not encounter one another: each is isolated from the other species; and so do not  mate

# 29 SEASONAL/ TEMPORAL ISOLATION

- Temporal isolation is when species that could interbreed do not because the different species breed at different times. This temporal difference could occur at difference times of day, different times of the year, or anything in between. For example, the field crickets Gryllus pennsylvanicus and G. veleti become sexually mature at different seasons, one in the spring and the other in the autumn.

# BEHAVIOURAL/ ETHOLOGICAL ISOLATION

- Behavioral isolation refers to the fact that many species perform different mating rituals. This is a common barrier between animals. For example, certain species of crickets will only mate with males that produce a particular mating song. Other species rituals may include a mating dance or emitting a scent. These clues are ignored by species not accustomed to the ritual.

# MECHANICAL/ CHEMICAL ISOLATION

- **Mechanical isolation** is caused by structures or chemical barriers that keep species isolated from one another. For example,
- Example:
- Genitals may not fit together, (incompatible anatomic structures)
- Gametic Isolation: If the gametes from 2 species meet they will rarely fuse to make a zygote.
- Could be due to failure of the male gametes to survive in the female reproductive tract.
- In plants, pollen of one species usually do not germinate on the stigma of another species.

# 32 GEOGRAPHICAL ISOLATION

- Geographical isolation refers to the physical barriers that exist that keep two species from mating. For example, a species of monkey that is located on an island cannot breed with another species of monkey on the mainland. The water and distance between the two species keep them isolated from one another and make it impossible for them to breed.

# 2. POSTZYGOTIC ISOLATION MECHANISMS

- Postzygotic is another mechanism of reproductive isolation that prevents the formation of viable or fertile offspring even though the fertilization is completed.
- **Hybrid inviability, Hybrid breakdown**, **Hybrid sterility** are the major reasons for postzygotic isolation.
- The zygote which produced by the fertilization can be incapable of sustaining its life.
- Furthermore, the produced zygote may not be mature enough to produce an offspring (immature zygote).
- Though the zygote matures into an adult, that adult may possess very low fertility level, hence incapable of giving birth to an offspring. All these factors can be responsible for the postzygotic isolation and prevention of the producing a fertile offspring.

# 34 HYBRID INVIABILITY

- Hybrid Inviability: Genetic incompatibility of the interbred species may stop development of the hybrid zygote during its development. Due to genetic incompatibility which prevents normal mitosis after the fusion of the gametes.

# 35 HYBRID STERILITY

- Hybrid Sterility; 2 species mate and produce a viable offspring but the offspring can not reproduce.Meiosis in these individuals fails to produce normal gametesExample: mule (female horse x male donkey)

# HYBRID BREAKDOWN/ F2 BREAKDOWN

- Hybrid Breakdown: The 1st generation hybrids are viable and fertile but when they mate with each other or an individual from the original species, they produce sterile or weak offspring. Example:
- Different cotton species can produce fertile hybrids, but hybrid breakdown occurs in the next generation when offspring of hybrids die as seeds or grow into weak and defective plants.

# END FOR NOW

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# UNEB 2019

**Which one of the following could result in evolution? When**

A. Organisms have adapted to new environment

B. There is inbreeding

C. Genetic equilibrium is upset

D. There is no gene flow in a population

42. (a) Explain the effects of the following:

(i) Heterozygote advantage in a population with increasing gene flow. **(04marks)**

(ii) Isolation of individuals of a population **(02marks)**

(iii) Explain why the sickle cell trait is prevalent in malaria prone areas. **(04marks)**

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# UNEB 2016

**Qn. All alleles present in the population of species are called the population's**

A. Gene frequency

B. Gene pool

C. Genome

D. genotype

40

# UNEB 2015

Qn. In a humans, albinism is caused by an autosomal recessive allele. On average, 1 person in 10,000 is an albino.

(a) Give to characteristics of an albino. **(2marks)**

(b) Using the Hardy Weinberg formula, p2+2pq+q2 = 1, determine the;

(i) Frequency of the albino allele in the human population. **(2marks)**

(ii) Frequency of the heterozygous genotype in the population **(2marks)**

(iii) Explain why it is difficult to eliminate recessive alleles from a population. **(4marks)**

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# UNEB 2014

**Qn. Insects and some vertebrates living on land, have jointed limbs for locomotion. This is an example of**

A. Convergent evolution
B. Adaptive radiation
C. Divergent evolution
D. Natural selection

**Qn. Which of the following factors is least likely to contribute to the development of new species?**

A. Gene mutation
B. Reproductive isolation
C. Geographical isolation
D. Stabilizing selection

42

# UNEB 2013

Qn. Sickle cell aneamia is caused by a double recessive gene and sufferers usually die before maturity. The continued existence of the sickle cell allele among human populations demonstrates;

A. Drug resistance

B. Heterozygous advantage

C. In breeding

D. Genetic drift

Qn. Which one of the foolowing may cause adaptive radiation to a carierty of species?

A. Stablizing selection

B. Directional selection

C. Ceasation os selection to occur

D. Disruptive selection

Qn. Which one of the following may occur to a community of organisms as a result of natural selection?

A. Increase in number of species

B. Extinction of species

C. Reduction in level of mutation

D. Adapting to the environment by all organisms

# UNEB 2013

Qn. (a) Distinguish between **hybrid** and **hybrid vigour**. **(2marks)**

(b) Explain how each of the following may alter the gene frequency.

(i) Closeness of populations. **(4marks)**

(ii) Small population size. **(4marks)**

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# UNEB 2012

Qn. The occurrence of a genetic defect among individuals of an isolated population in percentage higher than expected is likely to be a result of;

A. Natural selection

B. Adaptation

C. Speciation

D. Genetic drift

Qn. 42. when extensive lakes that existed in Bunyoro were reduced to isolated pools many years ago, four species of fish evolved as a result.

(a) Suggest the drying up of the lake system to isolated pools could have resulted in the evolution of the four new fish species. **(4marks)**

(b) Describe how environmental factors acts as stablising forces to natural selection in an isolated pool after the evolution of a new species**.** **(3marks)**

(c) Suggest what would happen to the fiish species if water rose and the isolated pools once again formed an extensive lake system.

**(3marks)**

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# UNEB 2011

Qn. (a) explain the principle of Hardy-Weinberg equilibrium principle. **(1mark)**

(b) State four conditions that must fulfilled in order for the principle to hold true.

**(2marks)**

(c) Brown eyes in a human population, 84% of the people have brown eyes, using Hardy Weinberg formula, determine the percentage of the population who are;

(i) Heterozygous for eye colour. Show your working. **(4marks)**

(ii) Homozygous dominant for eye colour. Show your working, **(3marks)**