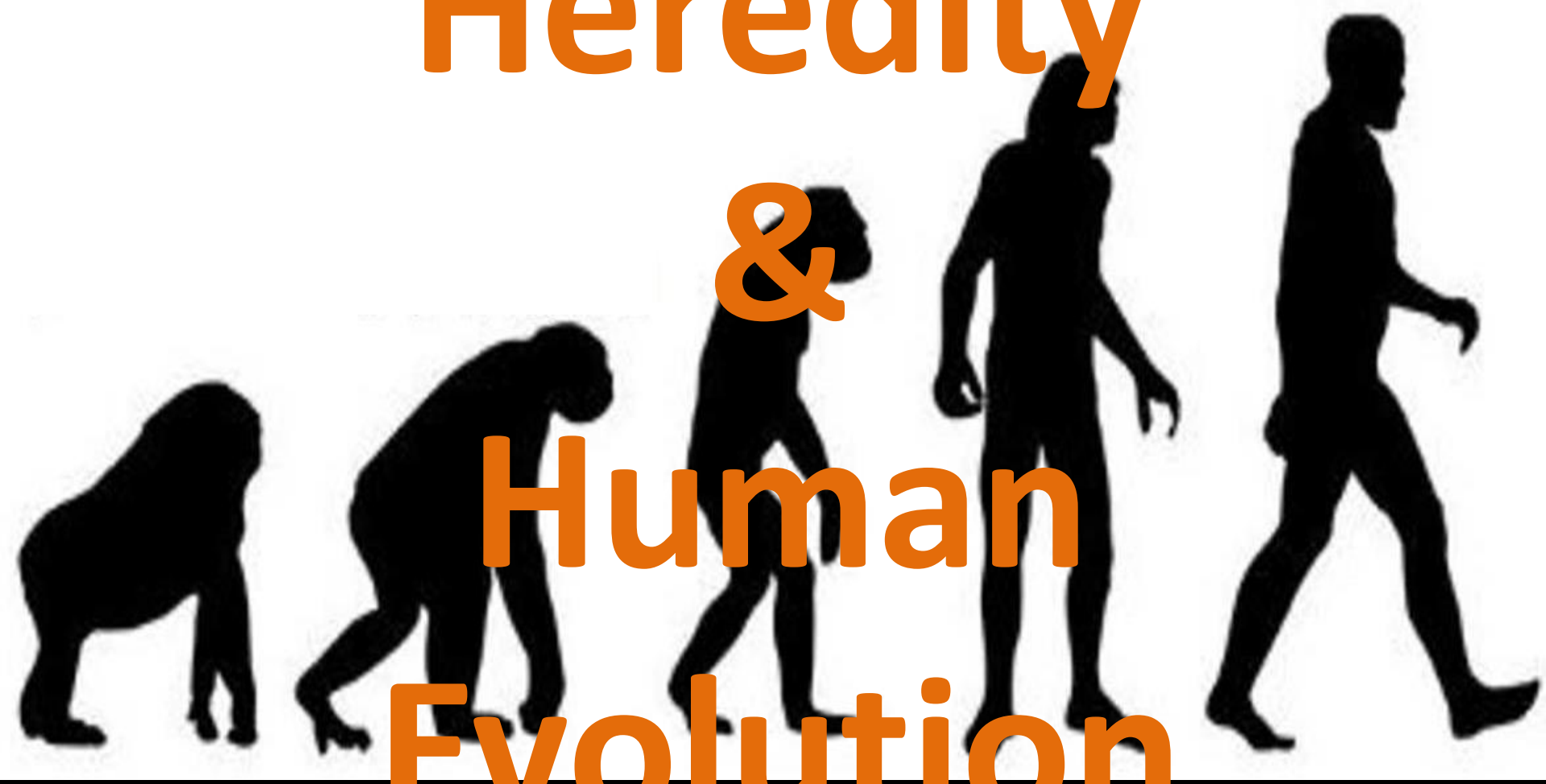
CHAPTER 9

Heredity & Human Evolution



Acknowledgment

- Images & video clips have been taken from various sources on the internet.
- Some images and video clips have been modified according to the syllabus.

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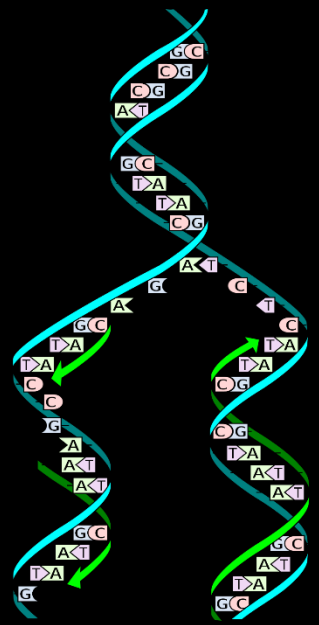
Contents

Variations

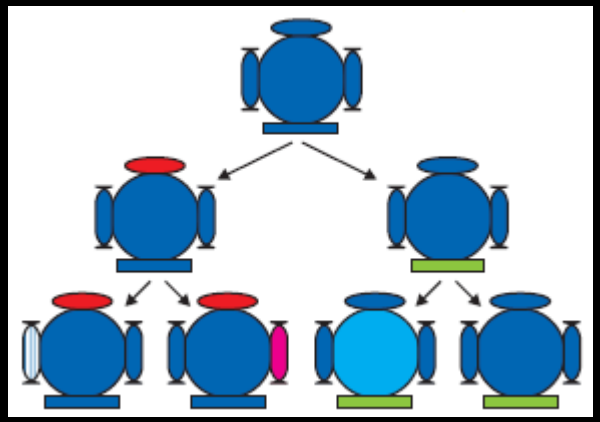
How is diversity achieved in asexual reproduction?

In asexual reproduction, the individuals generated would be very similar and only have minor differences between them due to small inaccuracies in DNA copying.



Do all variations in a species have equal chance of surviving in the environment in which they live?

No, depending on the nature of variation, different individuals would have different kinds of advantages.



What is the basis for evolutionary processes?

Selection of variants by environmental factors forms the basis for evolutionary processes.

How does the creation of variations in a species promote survival?

During reproduction (also inaccuracies in DNA replications), many variations occur in the offspring. Some individuals have more favourable variations than the other. Such individuals survive and pass these variations to the next generation.

How do asexually reproducing organisms produce variation among their progeny?

In asexually reproducing organisms variation occurs due to inaccuracies in DNA copying at the time of nuclear division.

For example: One bacteria divides, it will give rise to two bacteria. These daughter bacteria would be similar in body design but will have slight differences. The resultant bacteria divide again, and each bacterium will give rise to two bacteria in the next generation. The four individuals will be different from each other.

Heredity

Heredity

The process by which traits and characteristics are passed from the parents to the offsprings is called heredity.

Genetics

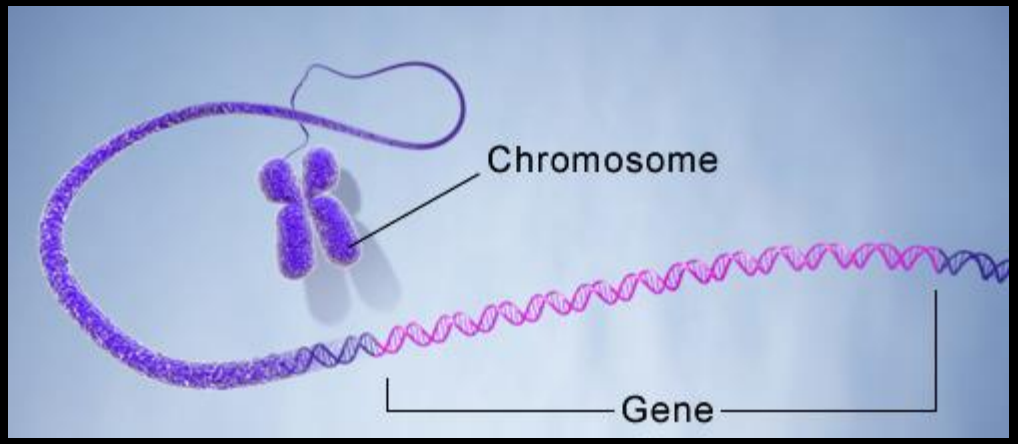
The branch of biology which deals with heredity and variations is known as genetics.

DNA & Genes

DeoxyriboNucleic Acid (DNA)

Gene

Gene is a functional segment of DNA on a chromosome occupying specific position which carries out a specific biological function.

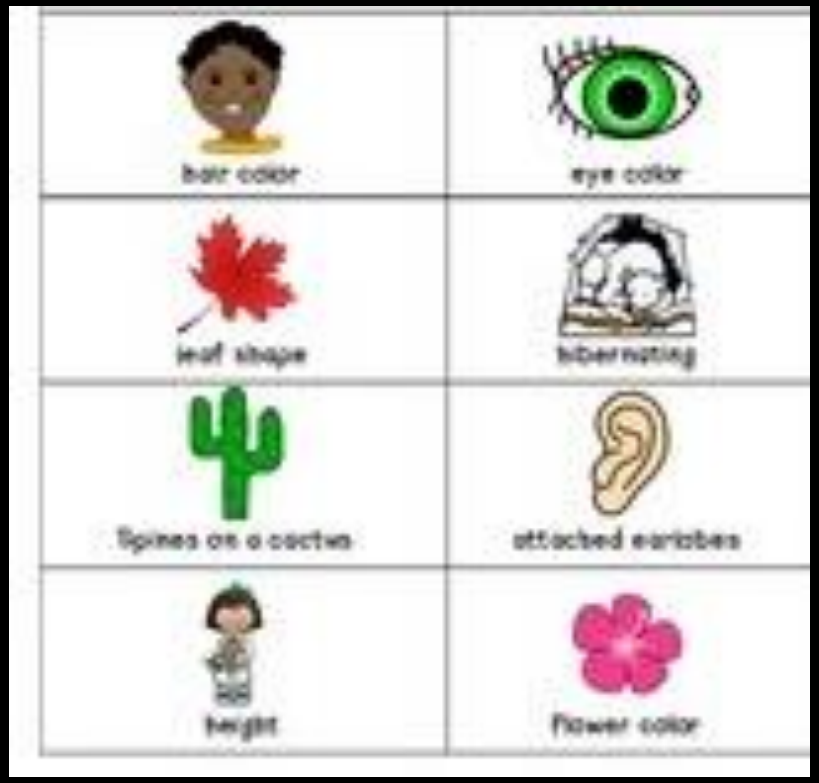


Traits

Trait is a distinguishing quality or characteristic belonging to a person.

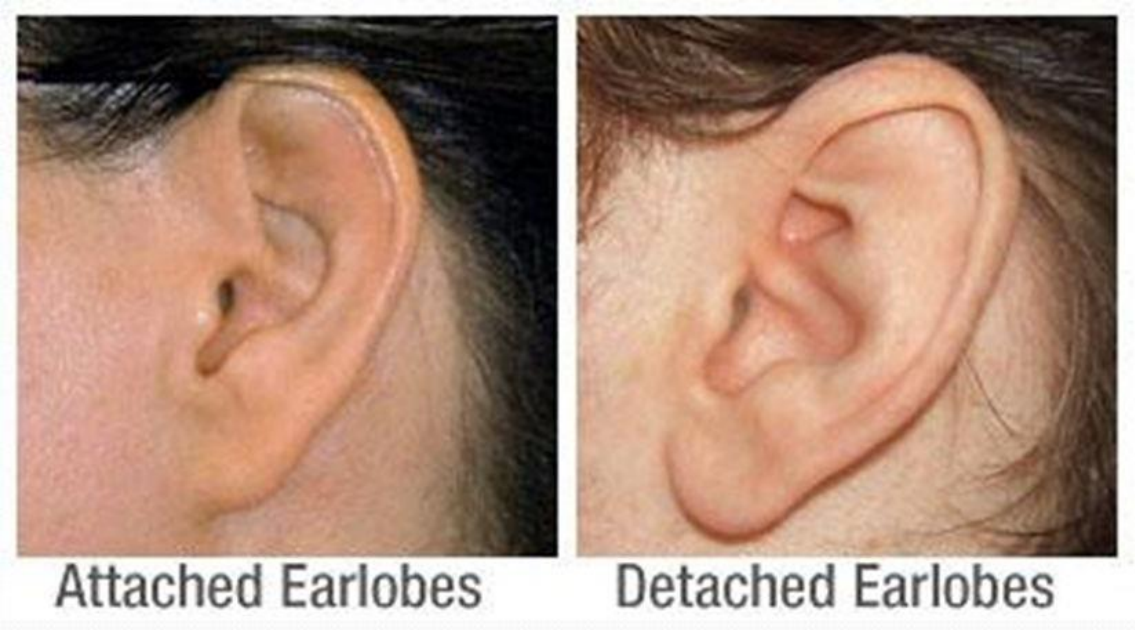
Inherited Traits

The traits which are obtained by the off-springs from parents are called inherited traits.



Activity (9.1) - To study the earlobes of students in the class.

Observation: It is observed that the lowest part of the ear, called the earlobe, is closely attached to the side of the head in some of the students, and not in others. Hence, free and attached earlobes are two variants found in human populations.



Father of Modern Genetics

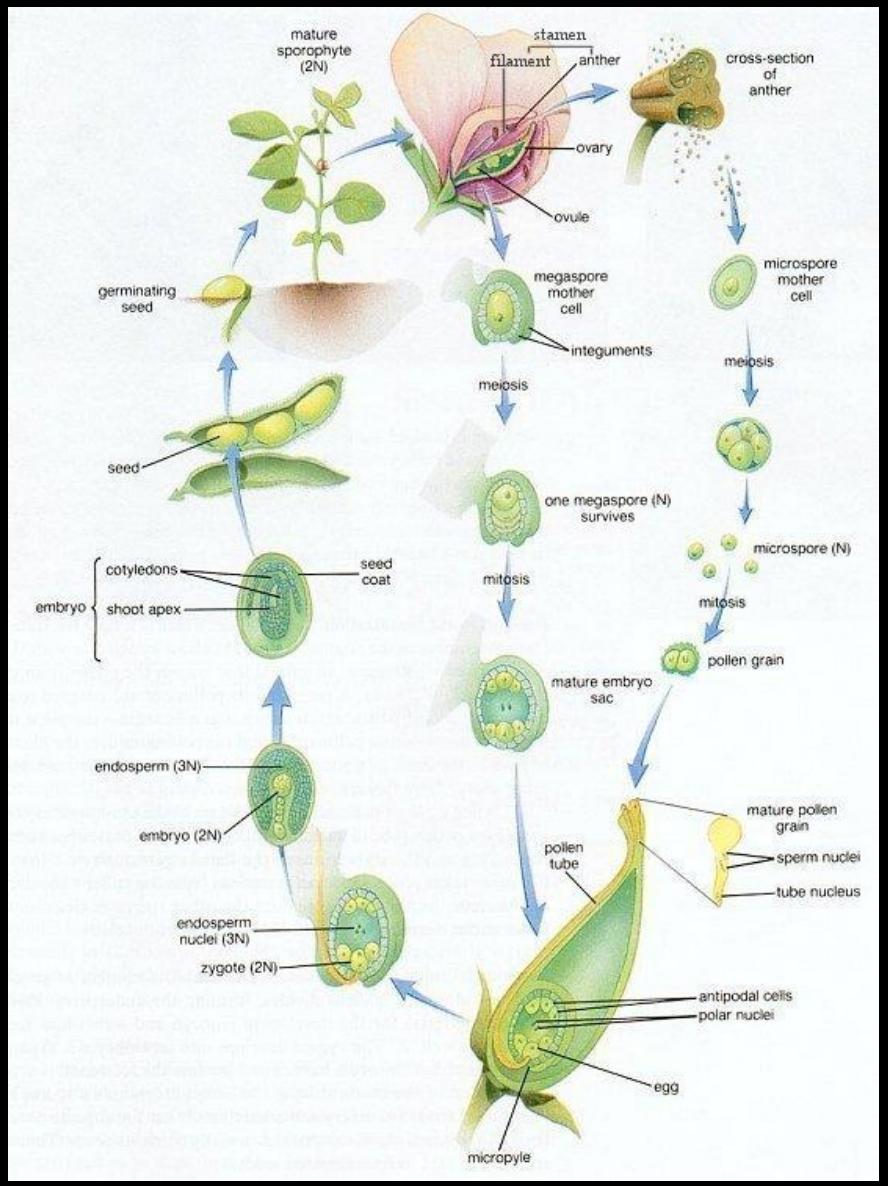
Gregor Johann Mendel is regarded as the 'Father of modern Genetics'

Why Mendel chose pea plants?

1. Pea plants can be easily grown in open ground or even in pots.

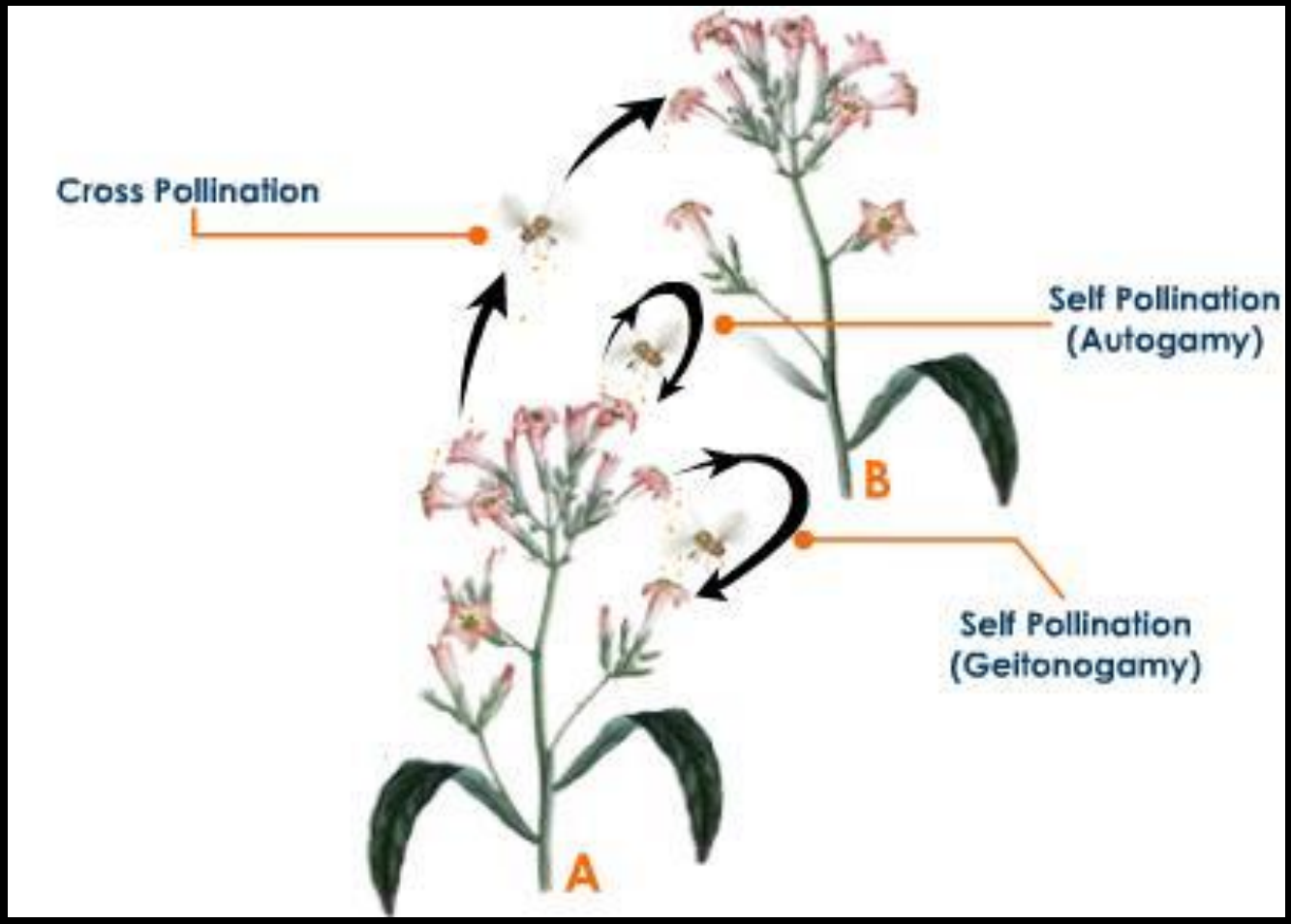
Why Mendel chose pea plants?

2. They have a short growth period & life cycle.



Why Mendel chose pea plants?

3. They give self-pollinating flowers. It is easy to cross pollinate also.



Why Mendel chose pea plants?

4. They produce large number of seeds.

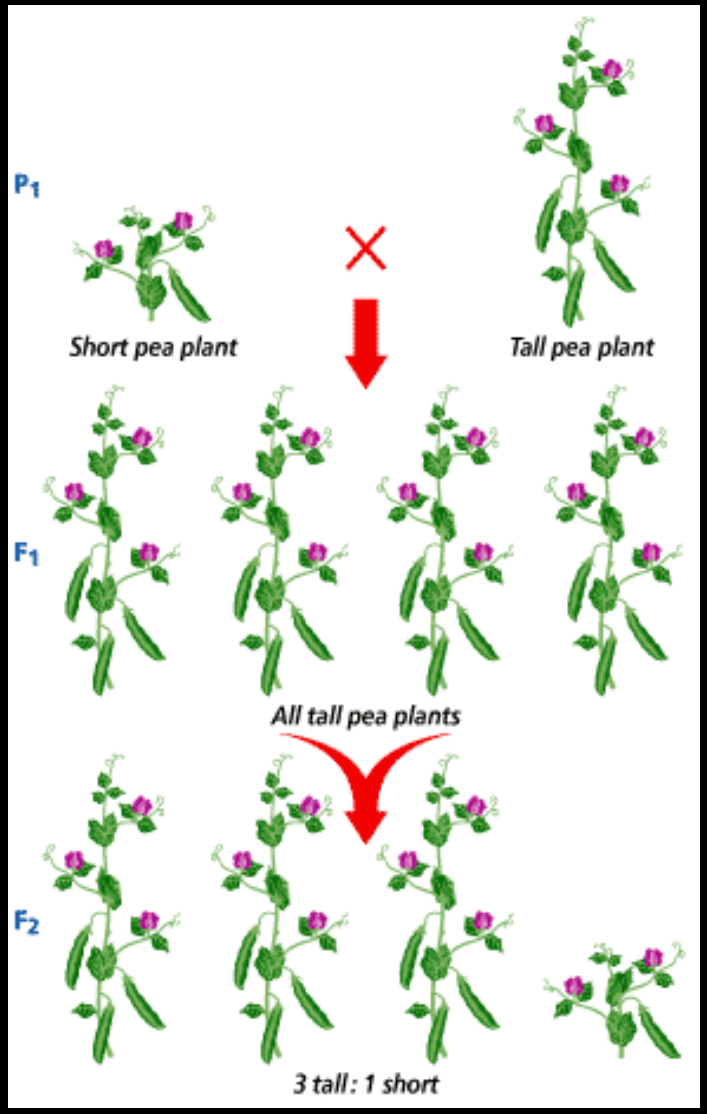
Why Mendel chose pea plants?

5. They show contrasting heritable characteristics.

Shape of Seeds	Color of Seeds	Color of Pods	Shape of Pods	Plant Height	Position of Flowers	Flower Color
Round 	Yellow	Green 	Full 	Tall 	At leaf junctions 	Purple 
Wrinkled 	Green 	Yellow 	Flat, constricted 	short 	At tips of branches 	White 

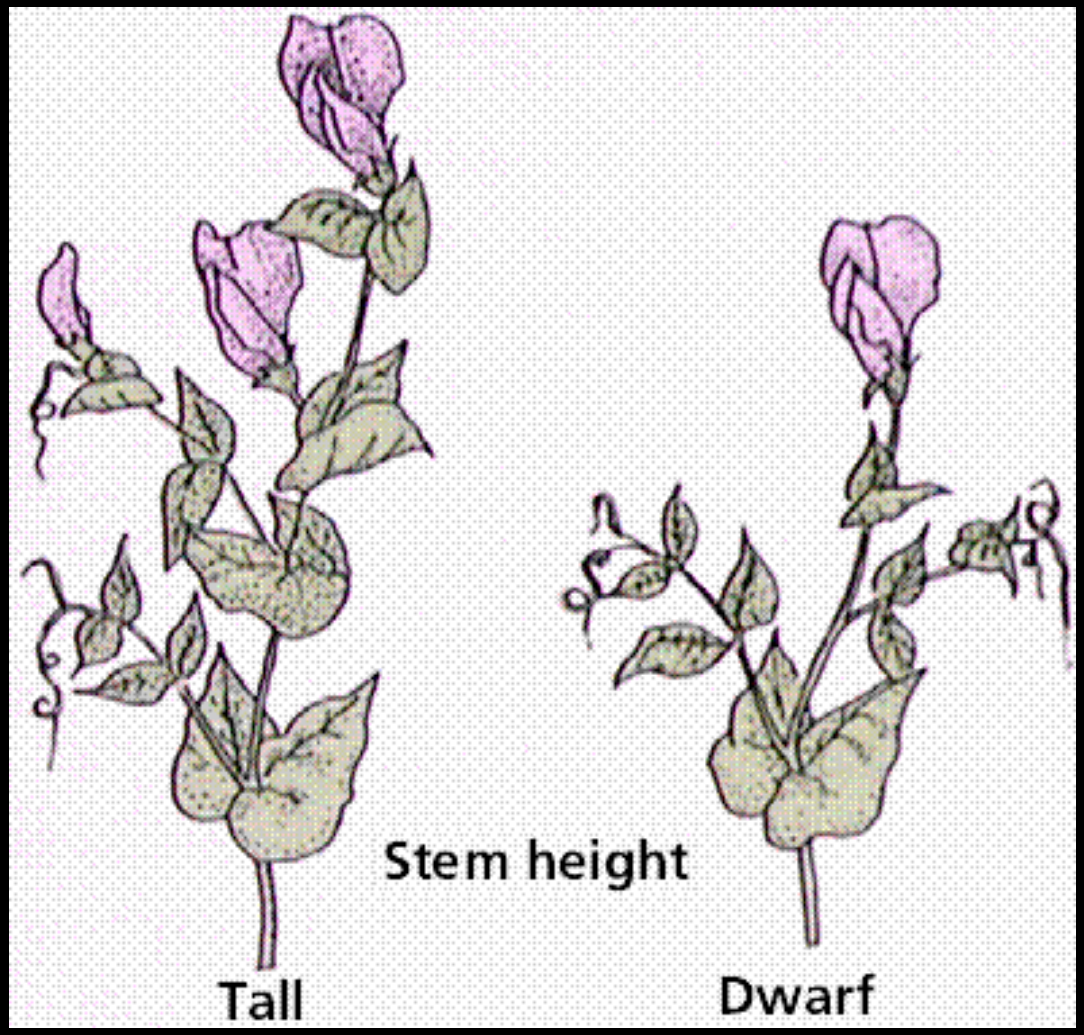
Why Mendel chose pea plants?

6. They produce fertile hybrids on cross pollination.



7 Contrasting characteristics of pea plants.

1. Stem length – Tall & Dwarf



7 Contrasting characteristics of pea plants.

2. Seed colour – Yellow & Green

7 Contrasting characteristics of pea plants.

3. Shape of seed : Round & wrinkled

7 Contrasting characteristics of pea plants.

4. Colour of seed coat: Grey & White

7 Contrasting characteristics of pea plants.

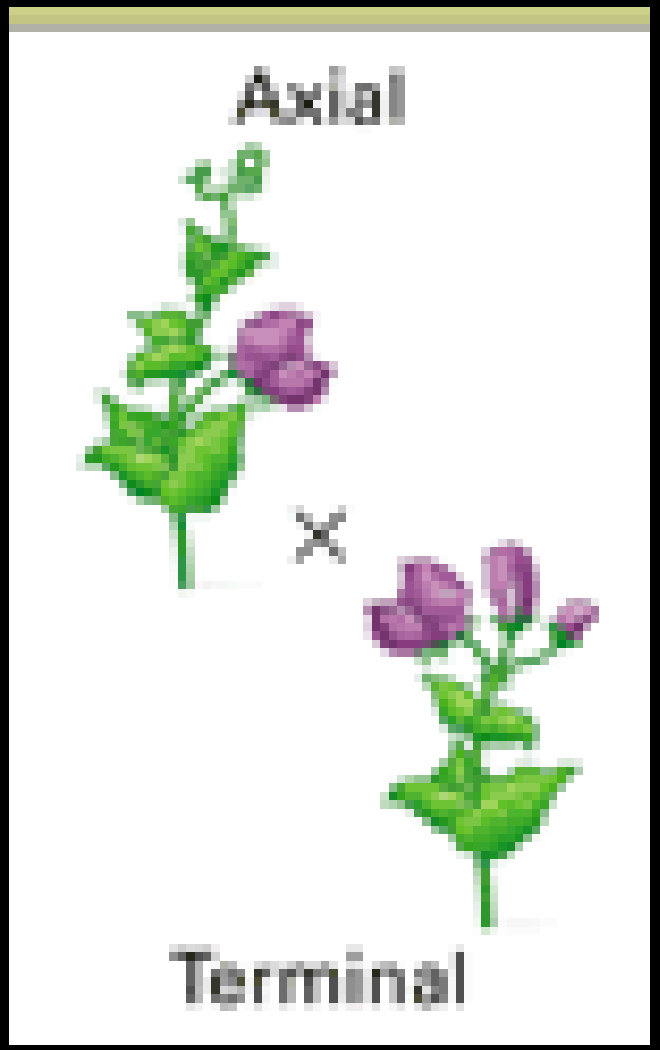
5. Colour of pod: Green & Yellow

7 Contrasting characteristics of pea plants.

6. Nature of the pod: Inflated & constricted

7 Contrasting characteristics of pea plants.

7. Position of flower: Axial & Terminal



7 Contrasting characteristics of pea plants.

Seed		Flower	Pod		Stem	
Form	Cotyledons	Color	Form	Color	Place	Size
						
Grey & Round	Yellow	White	Full	Yellow	Axial pods, Flowers along	Long (6-7ft)
						
White & Wrinkled	Green	Violet	Constricted	Green	Terminal pods, Flowers top	Short (~1ft)
1	2	3	4	5	6	7

Monohybrid cross

A cross between two pea plants which differ in one character is called monohybrid cross.

Monohybrid ratio

The ratio of plants obtained in the F2 generation (3:1) is called monohybrid ratio.

Dominant Factor

The factor which expresses itself in the generations is called dominant trait/factor.

Example: In the F_2 generation of pea plants, the factor for tallness is called as dominant factor.

Recessive Factor

The factor which remains hidden or concealed in the generations is called recessive trait/factor.

Example: In the F_2 generation, the factor for dwarfness remained hidden so it is called recessive factor.

F1 Generation

F1 generation is the first generation of offspring produced by a set of parents.

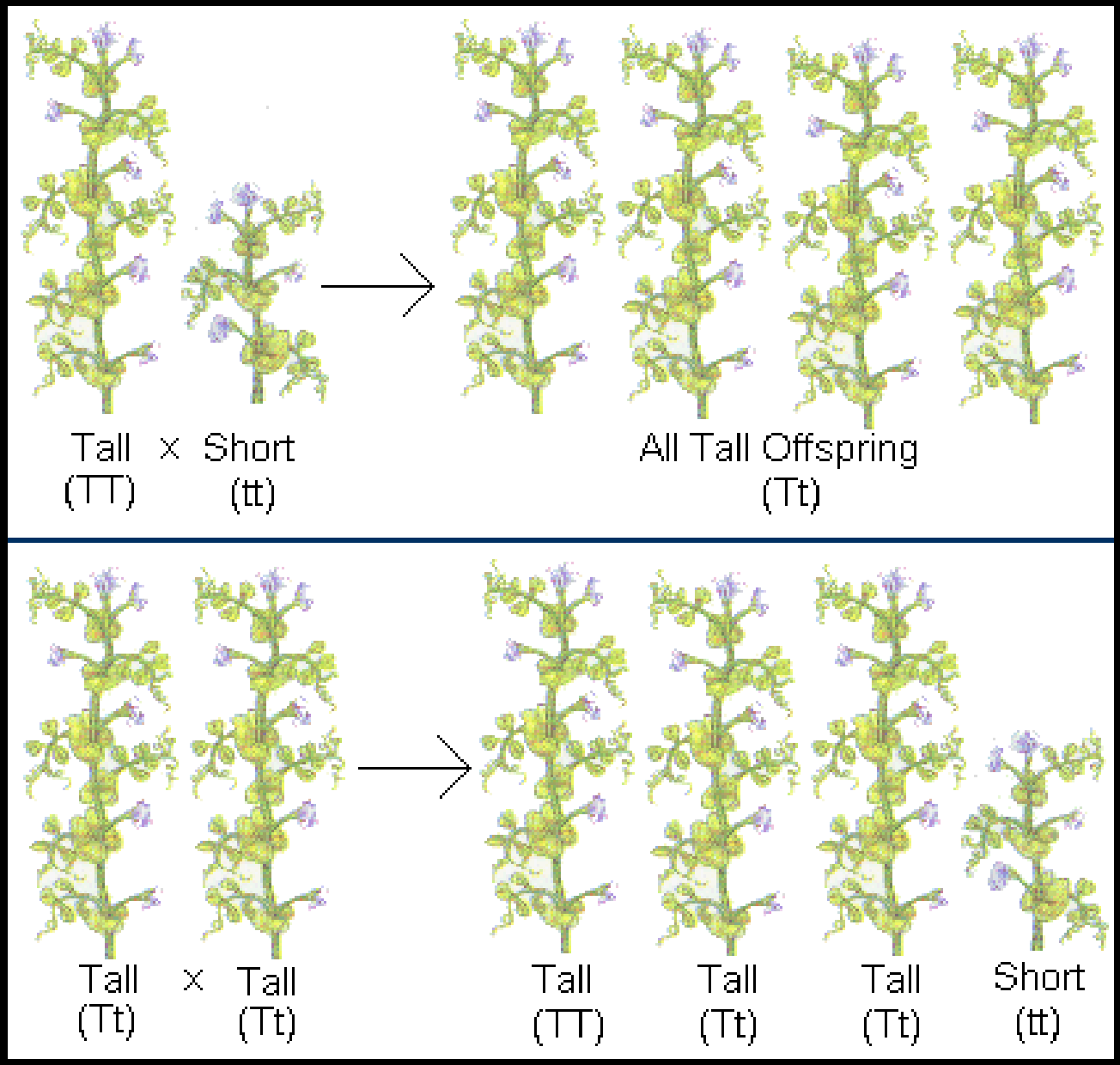
F2 Generation

F2 or second filial generation is the generation produced as a result of interbreeding between individuals of F1 generation.

Conclusion of Mendel experiment

Mendeleian experiments showed when pea plants one tall and one dwarf are self-pollinated then all the offsprings were tall. In the F2 generation when two tall pea plants were allowed to reproduce then all plants were not tall. One quarter of them are short. This indicates that both the tallness and shortness traits were inherited in the F1 plants but only the tallness trait was expressed.

Mendel's experiment on monohybrid cross



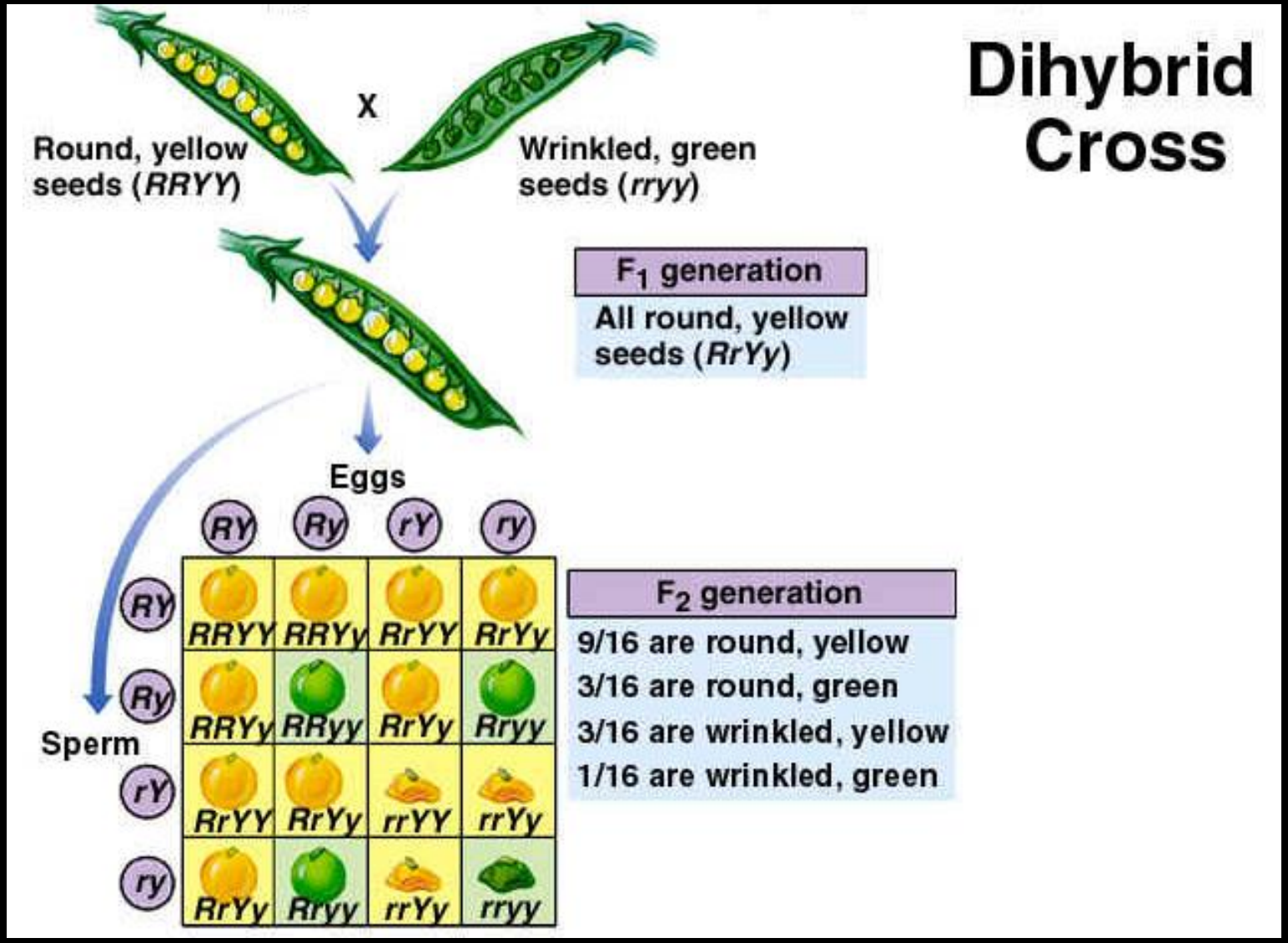
(Activity 9.2) What experiment would we do to confirm that the F2 generation did in fact have a 1:2:1 ratio of TT, Tt and tt trait combinations?

F3 generation may be raised by allowing self-pollination of F2 generation plants respectively.
Tall plants which produced only tall plants (TT). Tall plants which produced both tall and dwarf pea plants which are hybrid (Tt).
Dwarf plants produced only dwarf plants (tt). The ratio 1:2:1 of TT, Tt and tt trait combination in F2 generation is seen.

Dihybrid cross

A cross between two plants which differ in two specific characters is called dihybrid cross.

Mendel's experiment on Dihybrid cross



Dihybrid cross

When pea plants with round and green seeds are crossed with wrinkled and yellow seed, F1 generation plants have round and yellow seed. When F1 plants allowed to self-pollinate, we get a ratio of 9:3:3:1. It means, F2 generation shows four types of individuals–9/16 with both dominant trait, 3/16 with one dominant and second recessive, 3/16 second dominant and first recessive, 1/16 with both recessive traits.

How do proteins control the characteristics inherited?

Let us take the example of tallness as a characteristic. We know that plants have hormones that can trigger growth. Plant height can thus depend on the amount of a particular plant hormone. The amount of the plant hormone made will depend on the efficiency of the process for making it. Consider now an enzyme that is important for this process. If this enzyme works efficiently, a lot of hormone will be made, and the plant will be tall. If the gene for that enzyme has an alteration that makes the enzyme less efficient, the amount of hormone will be less, and the plant will be short. Thus, genes control characteristics, or traits.

Chromosomes in human beings & sex chromosomes

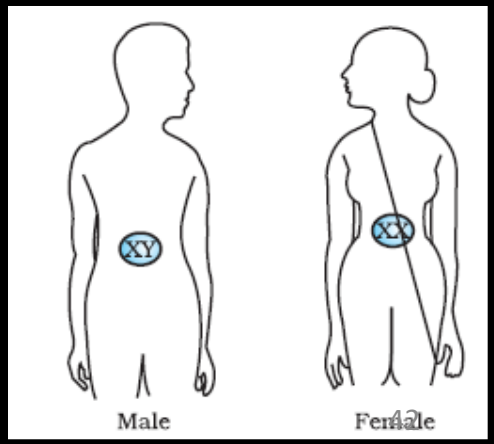
There are 23 pairs of chromosomes present in human beings.

Out of these 23 pairs, one pair is of sex chromosomes.

There are two types of sex chromosomes found in human beings X and Y.

A female has 2 X chromosomes.

A male one X and one Y chromosome.



Sex determination

a) In some animals the temperature at which fertilised eggs are kept determines whether the animals developing in the eggs will be male or female.

b) In snails, individuals can change sex, indicating that sex is not genetically determined.

c) A child who inherits an X chromosome from her father will be a girl, and one who inherits a Y chromosome from him will be a boy.

Sex determination

In human beings, the females have two X chromosomes and the males have one X and one Y chromosome. Therefore, the females are XX and the males are XY.

The gametes receive half of the chromosomes. The male gametes have 22 autosomes and either X or Y sex chromosome.

Type of male gametes: 22+X OR 22+ Y.

Since the females have XX sex chromosomes, their gametes can only have X sex chromosome.

Type of female gamete: 22+X

Thus, the mother provides only X chromosomes. The sex of the baby is determined by the type of male gamete (X or Y) that fuses with the X chromosome of the female.

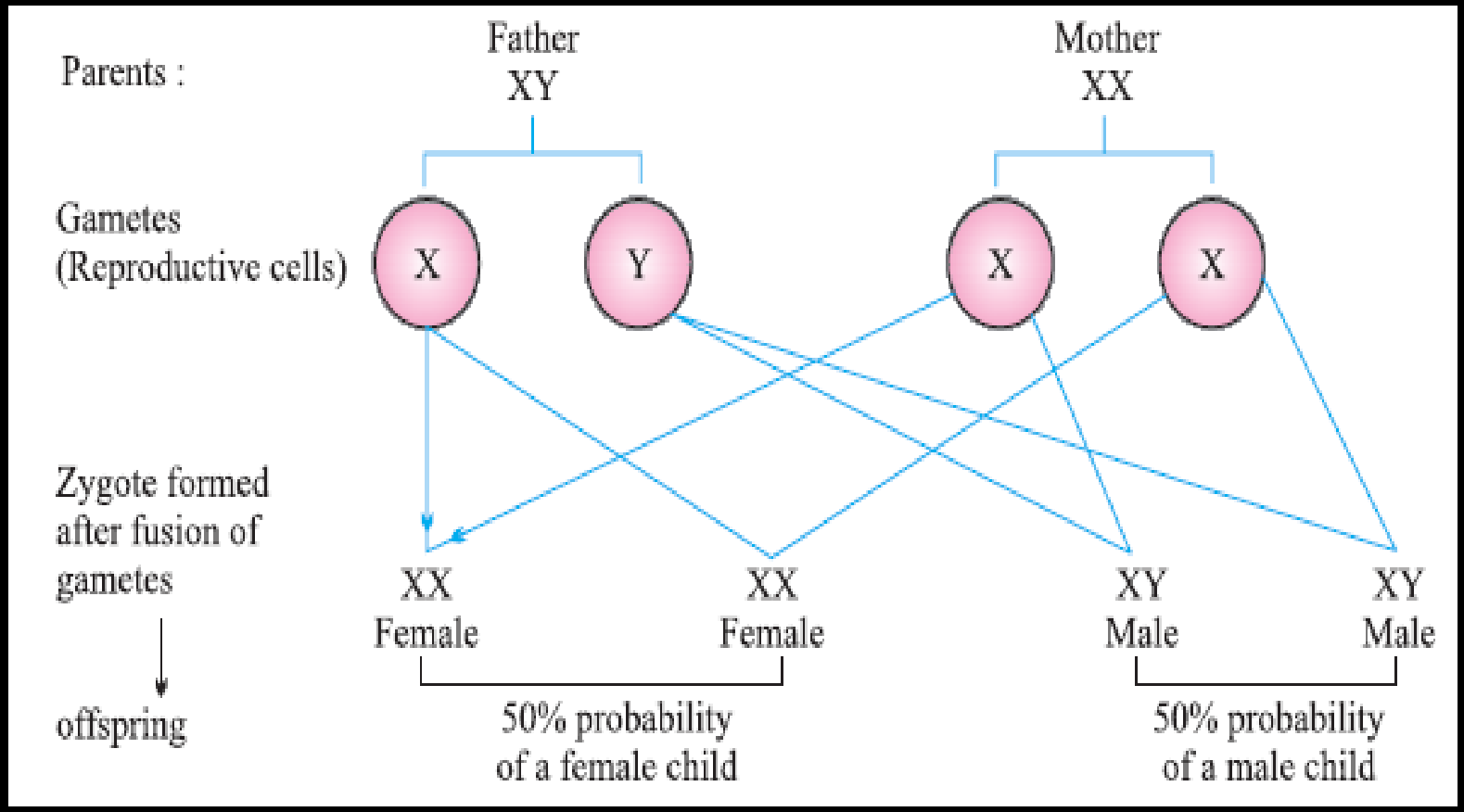
It is a matter of chance whether a couple will give birth to a boy or a girl".

When a sperm carrying X-chromosome fertilises an egg, the zygote (XX) will develop into a girl.

When a sperm carrying Y-chromosome fertilises an egg, the zygote (XY) will develop into a boy.

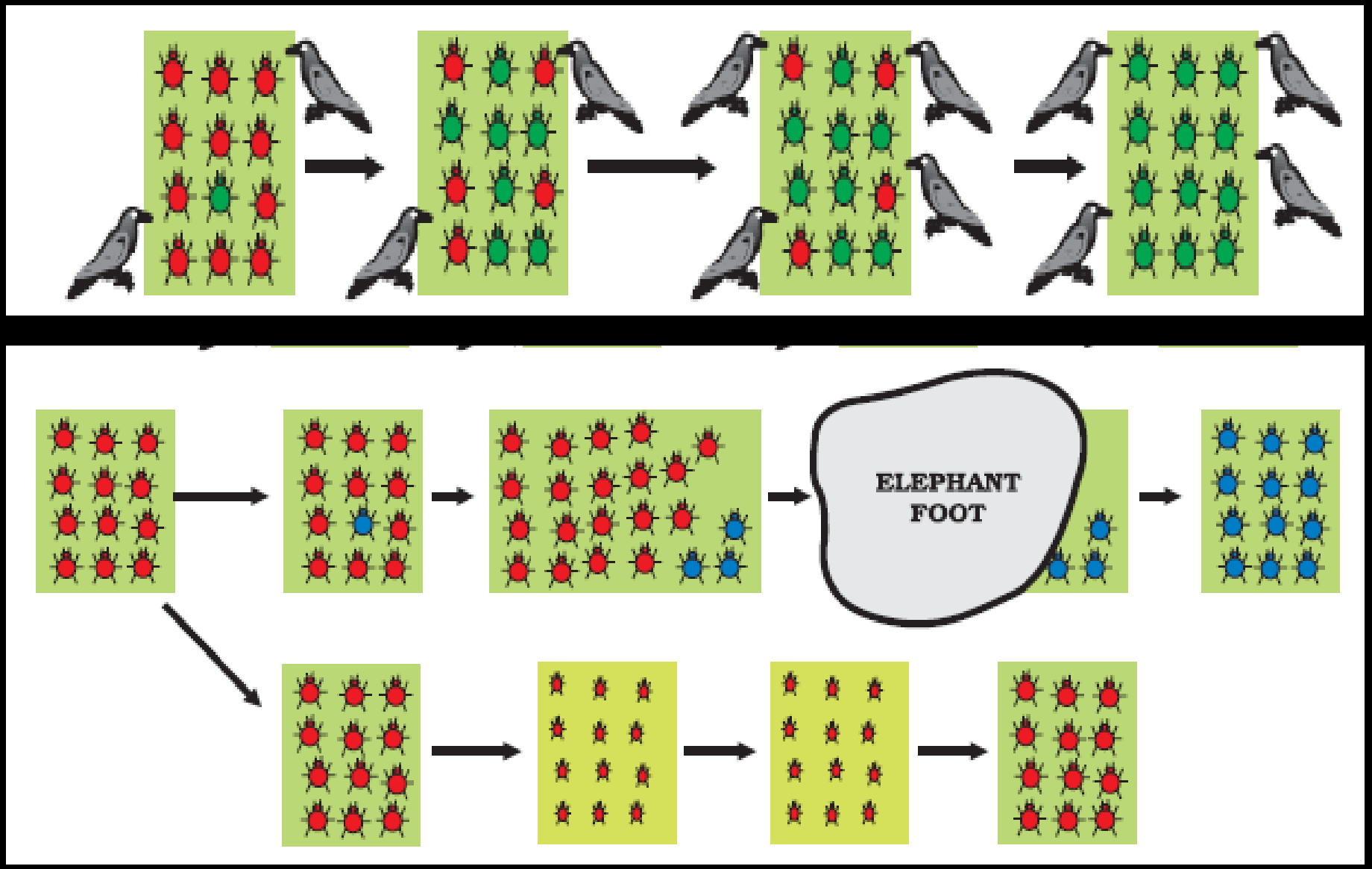
Thus it is only the father or male who is responsible for the sex of a new born child.

It is a matter of chance whether a couple will give birth to a boy or a girl".



Evolution

Variation in population



Acquired traits

The characteristics which are developed during the lifetime of an individual is called acquired traits.

Ex: larger muscle size, skills like painting, singing, swimming, dancing etc.

Acquired traits Vs Inherited traits

Acquired traits	Inherited traits
Characteristics which are developed during the lifetime of an individual	Characteristics which are transmitted from parent to the offspring.
The characteristics do not get inherited to another generation.	The characteristics get inherited to another generation.

Different ways in which individuals with a particular trait may increase in a population

Individuals with a particular trait may increase in a population as a result of the following:

(i) Natural selection: When that trait offers some survival advantage.

(ii) Genetic drift: When some genes governing that trait become common in a population.

(iii) When that trait gets acquired during the individual's lifetime.

Speciation

The process of origin of a new species is called speciation.

Species

A species is a group of organisms in which most of the characters are similar and members of a species are able to breed among themselves.

Factors responsible for speciation

a) Genetic drift: Sudden change in the frequency of genes.

b) Mutation: Sudden change in genetic makeup of any organism.

c) Natural selection: It is selection of particular type of species.

d) Migration: Shifting of one particular organism of a species in the other group of organisms of the same population but with different characteristics.

Genetic drift

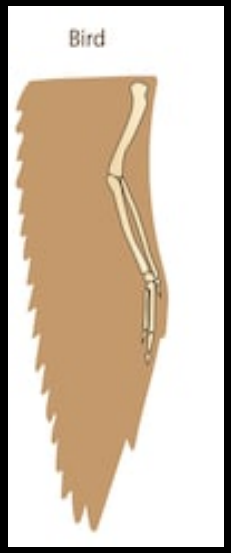
Speciation can happen if two groups of the same species are somehow prevented from interbreeding for several generations. This can happen because of geographical segregation or because of some genetic changes. Evolution of new species, because of geographical segregation is called genetic drift.

Homologous organs

Organs which have common design but serve different functions in different animals are called homologous organs.

Homologous organs

For example: The forelimbs of frogs are adapted to a jumping movement, the forelimbs of birds are used for flying and those of humans are used for handling tools. This shows that frogs, birds and humans have evolved from a common ancestor.



Homologous organs

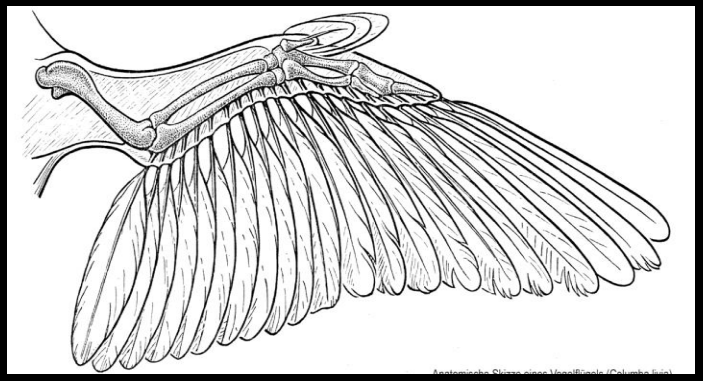
Wings of bats are skin folds stretched mainly between elongated fingers. But the wings of birds are a feathery covering all along the arm. The designs of the two wings, their structure and components, are thus very different. They look similar because they have a common use for flying, but their origins are not common.

Analogous organs

Organs which have different design but serve a common function in different animals are called analogous organs.

Analogous organs

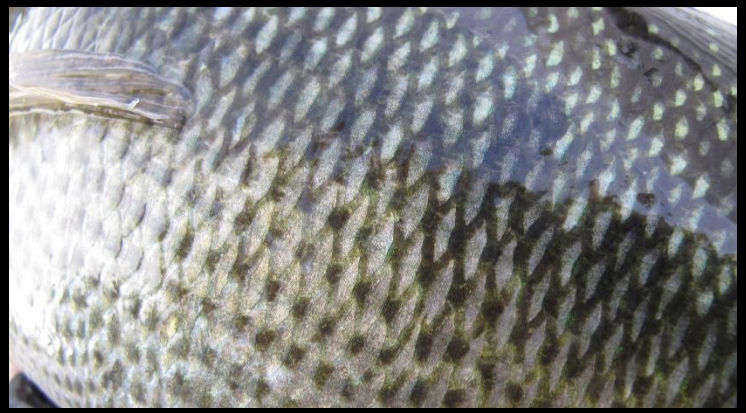
The wings of bird and an insect perform the same function of flying. The wings of a bird have a support of skeleton, flesh and feathers but insects have a fold of membrane as wing associated with a few muscles. Wings of birds and an insect are structurally different. So they are analogous organs.



Suggest with reason, which of the following are homologous and which are the analogous organs?

i) Scales of fishes and shell of mollusc.

Scales of fish and shell of mollusc are analogous structure because both are protective in structure in nature but differ in origin.



Suggest with reason, which of the following are homologous and which are the analogous organs?

ii) Trunk of elephant and hand of chimpanzee.

Trunk of elephant and hand of chimpanzee are analogous organs because both perform the same function but differ in origin and structure.

Suggest with reason, which of the following are homologous and which are the analogous organs?

iv) Nails of human and claw of cat.

Nails of human and claw of cat are homologous organs because they are similar in origin but differ in functioning.

Suggest with reason, which of the following are homologous and which are the analogous organs?

v) Ginger and sweet potato.

Ginger and sweet potato are analogous structures because both are storage structures but ginger is stem modification while potato is root modification.

Homologous Vs Analogous organs

Homologous organs	Analogous organs
1. Organs with similar origin but different in function	1. Organs with similar function but different in function.
2. They show divergent evolution.	2. They show convergent evolution.

Fossils

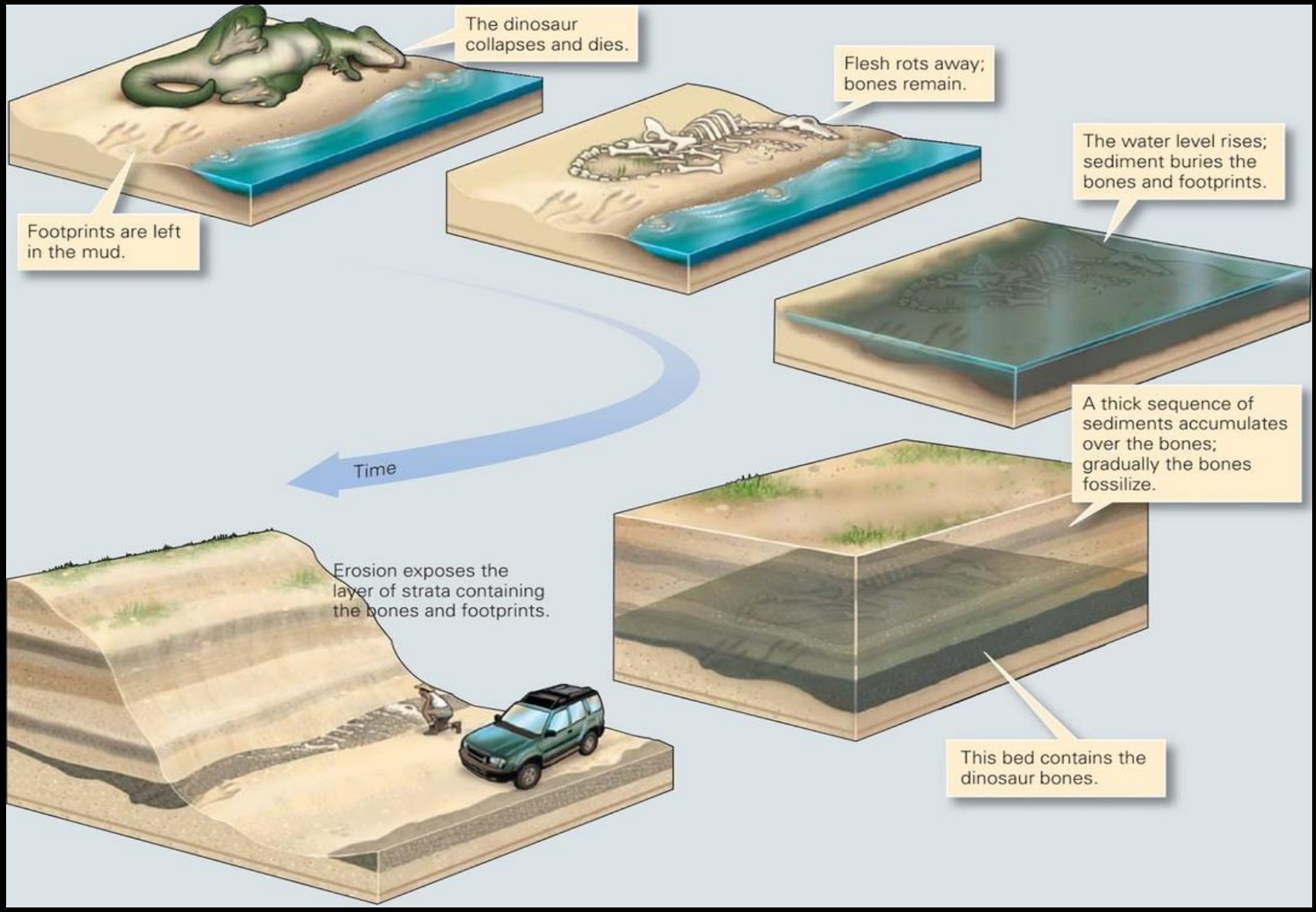
Fossils

The preserved remains of animals or plants or other organisms from the distant past are called fossils.

How are fossils formed?

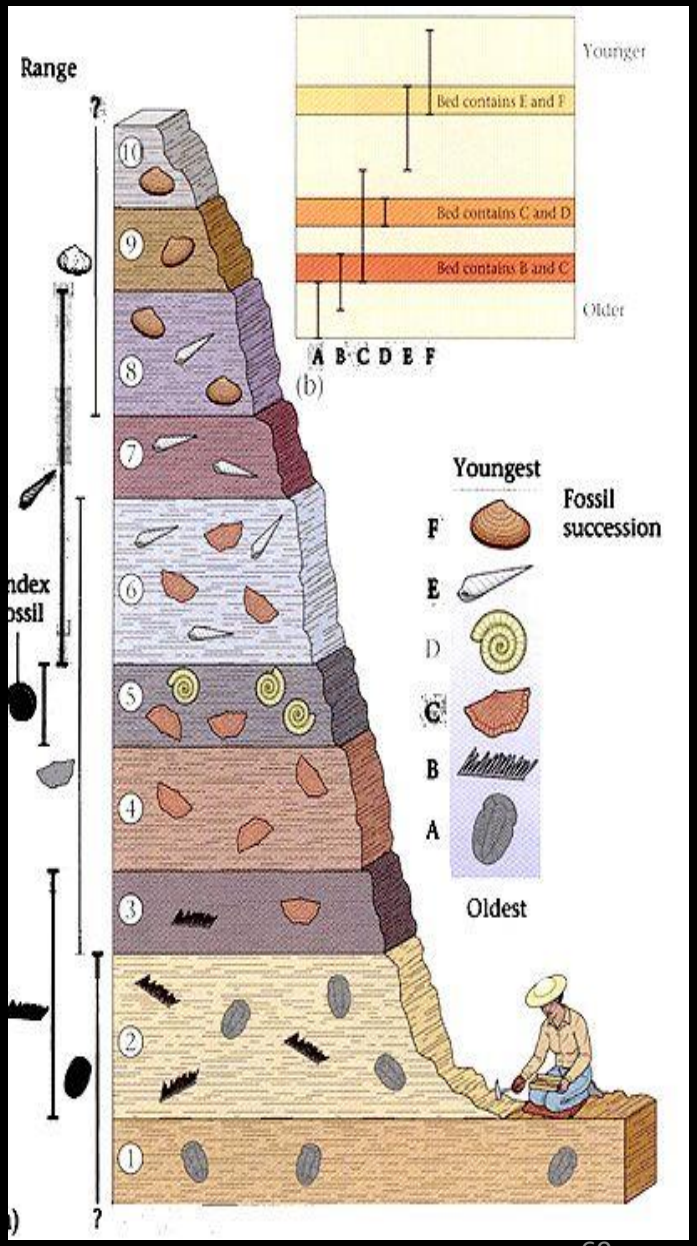
When organisms die, their bodies will decompose and be lost. But body or at least some parts may be in an environment that does not let it decompose completely. For example, if a dead insect gets caught in hot mud, it will not decompose quickly, and the mud will eventually harden and retain the impression of the body parts of the insect.

How are fossils formed?



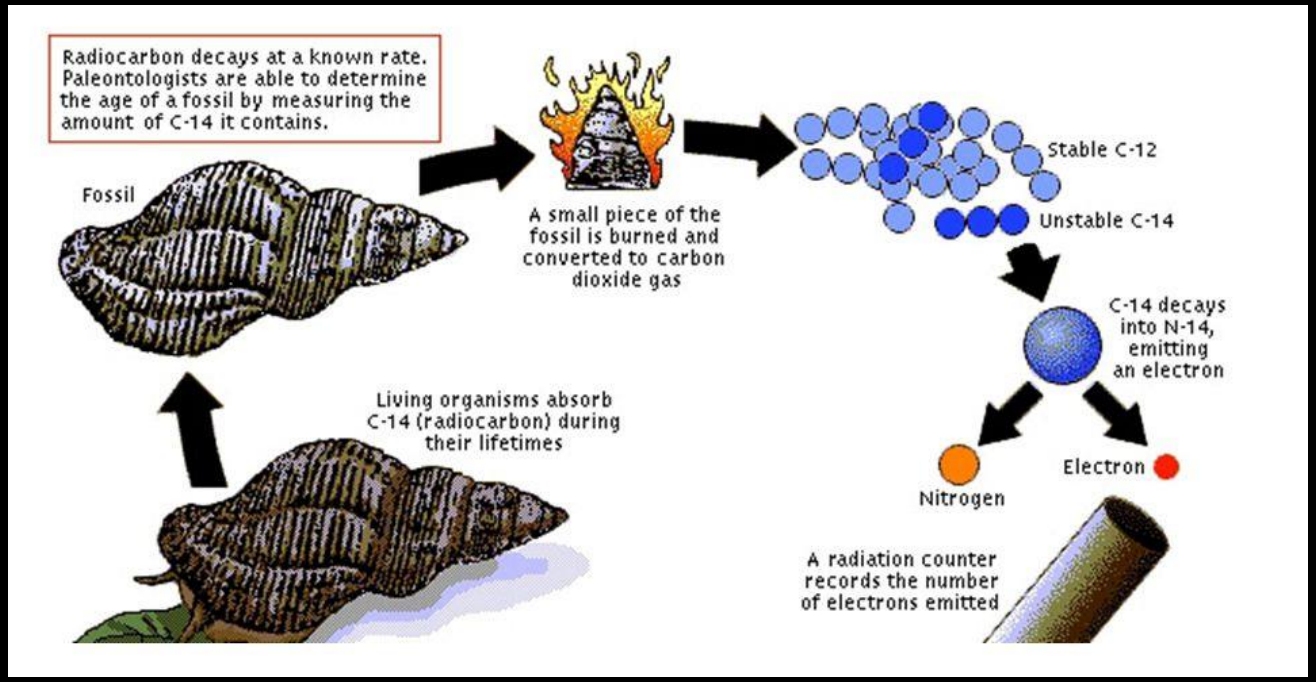
Age of fossils

There are two methods of finding the age of fossils:
a) Relative depth method: If we dig into the earth and start finding fossils, suppose that the fossils we find closer to the surface are more recent than the fossils we find in deeper layers.



Age of fossils

b) Dating of fossil: Dating fossils is by detecting the ratios of different isotopes of the same element in the fossil material.



What do fossils tell us about evolution?

They represent the ancestors of plants and animals that are alive today.

They provide evidences of evolution by revealing the characteristics of the past organism and the changes that have occurred in these organisms to give rise to the present organisms.

Types of fossils

Fossil – tree trunk

Fossil – invertebrate (Ammonite)

Fossil – invertebrate (Trilobite)

Fossil – fish (Knightia)

Fossil – dinosaur skull (Rajasaurus)

Relation between reptiles and birds

a) Archaeopteryx is the link between reptiles and birds.

b) Reptiles: i) Presence of tail ii) Presence of teeth in mouth.

Birds: i) Presence of feathers ii) presence of beak.

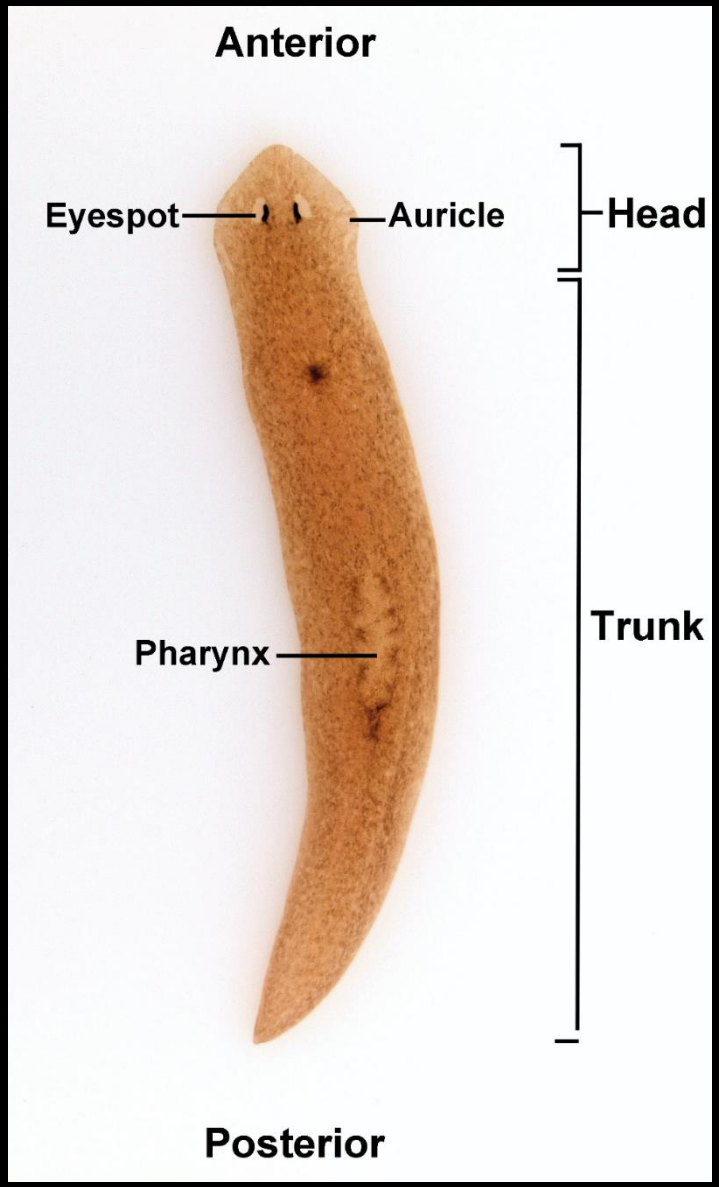
Evolution in stages

The process of evolution has took place over a long period time. The complex organs are created bit-by-bit over generations. There was increasing complexity of the organs. For example, eye was present in the earliest organism as eyespot which got development into a more complex and evolved eye.

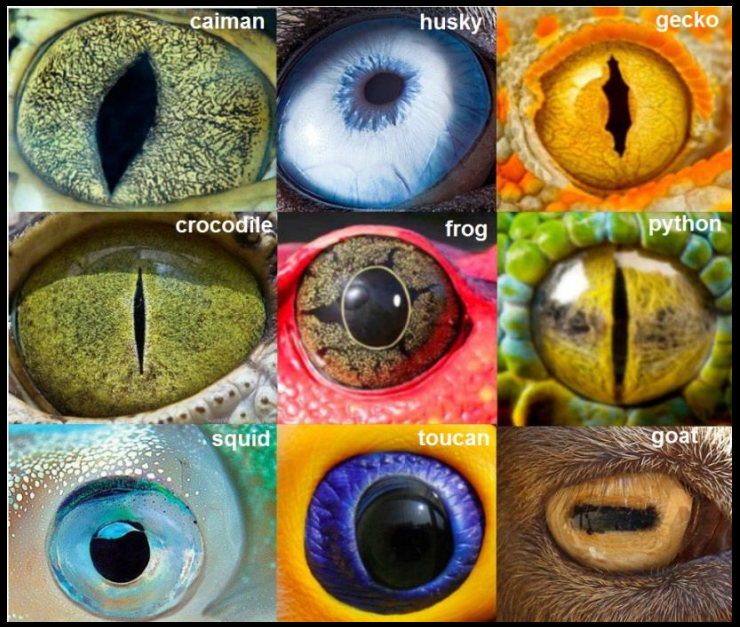
There are some organs in the human body which are present in the reduced form and do not perform any function. Ex: Nictitating membrane, vermiform appendix, wisdom tooth.

Eyespots of Planaria

Some planarian species have two eye-spots that can detect the intensity of light, while others have several eye-spots. The eye-spots act as photoreceptors and are used to move away from light sources.

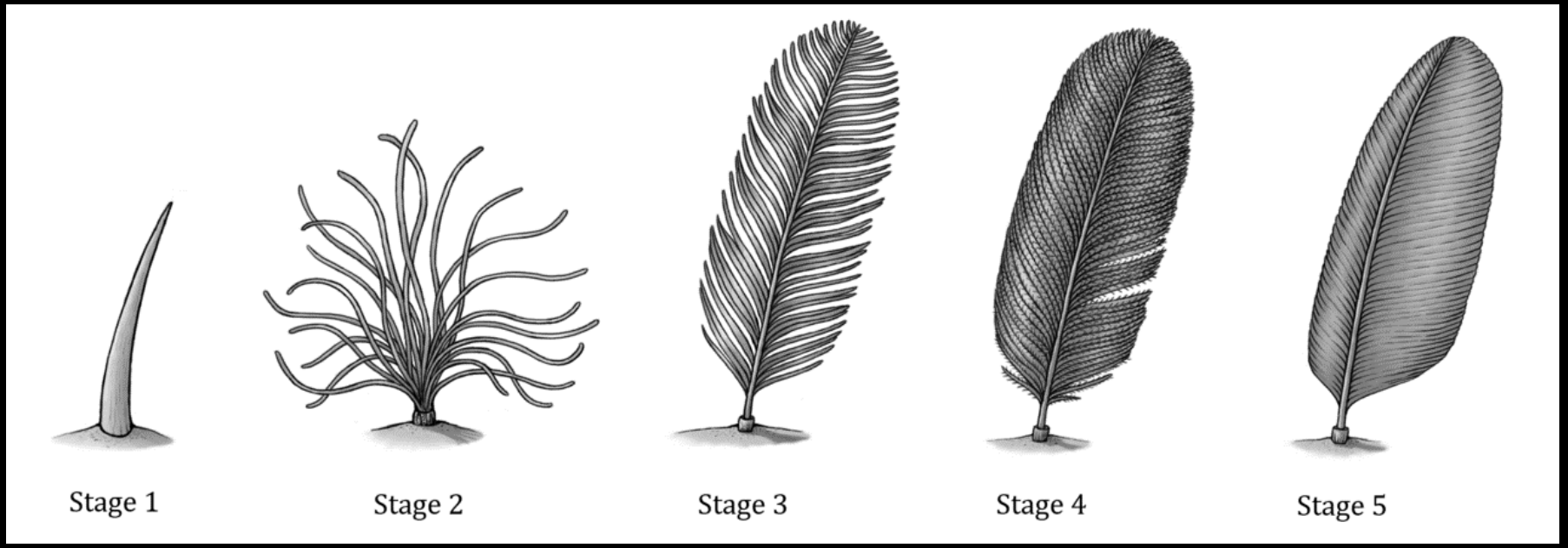


Evolution of eyes



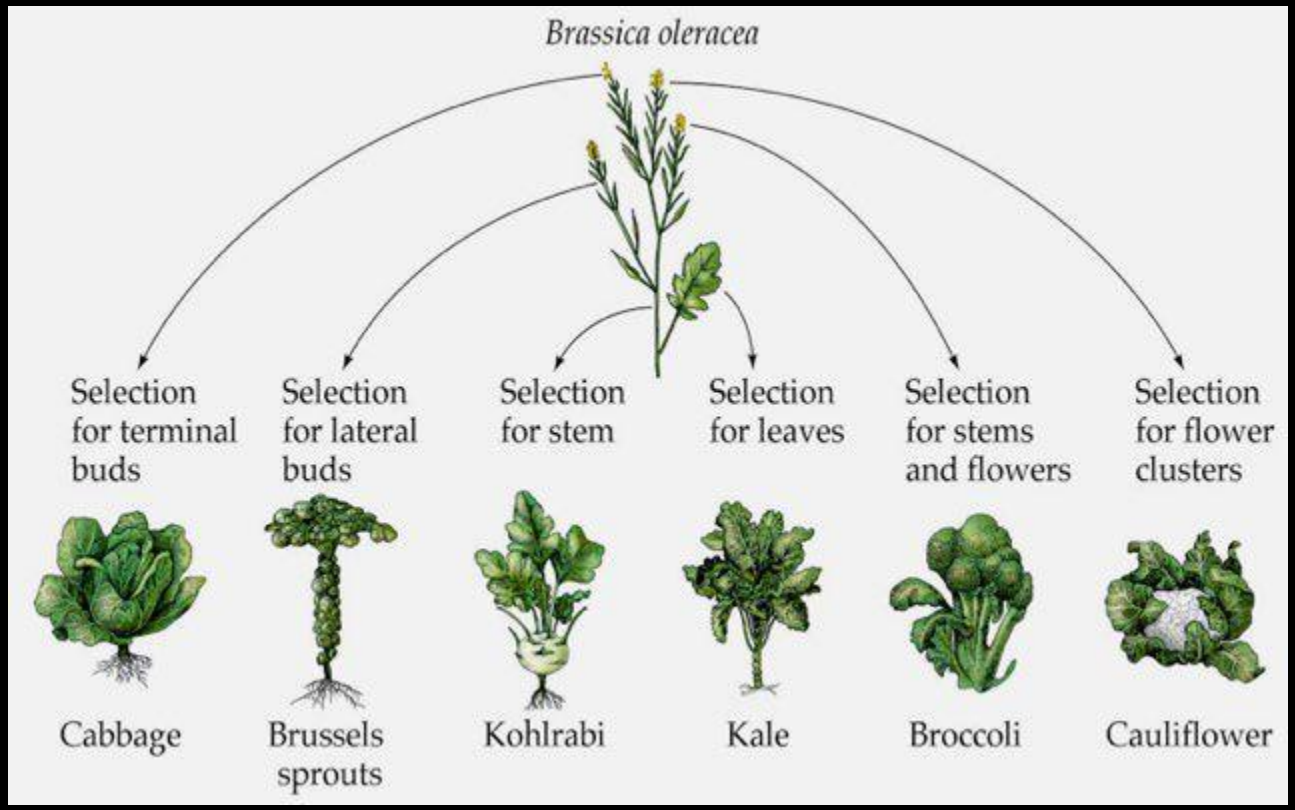
Eye is a complicated organ. It cannot be generated by a single DNA change. Such complex organs will be created bit-by-bit over generations.

Evolution of feathers



Feathers started as structures that provide insulation in cold weather. Later, they might become useful for flight. Some dinosaurs had feathers, although they could not fly using the feathers. Birds seem to have later
adapted the feathers to flight.

Evolution of cabbage



Some farmers wanted to select for very short distances between leaves, and have bred the cabbage. Some wanted to select for arrested flower development, and have bred broccoli, or for sterile flowers, and have made the cauliflower. Some have selected for swollen parts, and come up with kohlrabi. Some have simply looked for slightly larger leaves, and come up with a leafy vegetable called kale.

Evolution of cabbage

Farmers generated different vegetables from wild cabbage by artificial selection. Name the vegetables obtained for the following desired traits.

a) Arrested flower development - Broccoli

b) Sterile flowers - Cauliflower

c) Very short distance between leaves - Cabbage

d) Swollen parts - Kohlrabi

e) Larger leaves - Kale

Natural selection Vs Artificial selection

Natural selection	Artificial selection
The process by which nature selects the favourable traits for the species in its environment.	The process by which the human selects the useful trait to be inherited in the next generation
It is a natural phenomenon.	It is an artificial process.
The traits selected for evolution are beneficial to the species.	The traits selected are for improvement of species and beneficial to man.
It takes place over a long period of time.	It takes place in a short period.

Evolution & classification are interlinked

In classification of species, the characteristics of organisms is compared with the other species. Then the species is placed at suitable level of classification.

By identifying the hierarchical level of characteristics between species, we can identify the evolutionary relationship of species.

Human Evolution

Human Evolution

Human evolution is a part of biological evolution concerning the emergence of humans as a distinct species.

Tracing Human Evolution

One method of tracing evolutionary relationships is changes in DNA during reproduction. It is a basic events in evolution. Comparing the DNA of different species should give us a direct estimate of how much the DNA has changed during the formation of these species. This method is now extensively used to define evolutionary relationships.

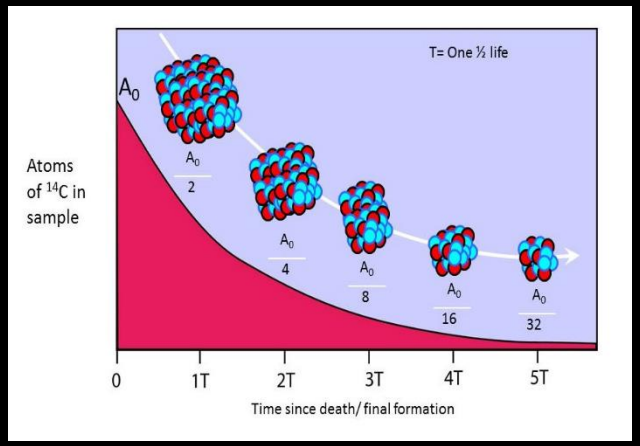
Evolution is not progress from lower to higher forms

Evolution is simply the generation of diversity and the shaping of the diversity of environmental selection.

There is no real progress in the idea of evolution. The only progressive trend in evolution seems to be that more complex body designs have emerged over time. It is not as if the older designs are inefficient. So many of the older and simpler designs still survive.

Tools to study evolution

Excavating, time-dating, studying fossils, determining DNA sequences have been used for studying human evolution.



The modern human being have originated in Africa.
a) Which evidence suggest this fact?
b) If an animal is similar to its ancestors, what does it imply?

a) Excavating, time dating and study of fossils as well as determining DNA sequences suggest that the modern beings have originated in Africa.

b) The animal has evolved from its ancestors and both have the same common ancestor.

Human beings who look so different from each other in terms of size, colour and looks said to belong to the same species

Skin colour, looks, and size are all variety of features present in human beings.

These features are generally environmentally controlled

There is no biological basis to this concept of races.

All human beings are a single species as humans of different colour, size, and looks are capable of reproduction and can produce a fertile offspring.

Can we say which among bacteria, spiders, fish and chimpanzees have a 'better' body design?

Evolution cannot always be equated with progress or better body designs. Evolution simply creates more complex body designs. Bacteria having a simple body design are still the most cosmopolitan organisms found on earth. They can survive hot springs, deep sea, and even freezing environment. Therefore, bacteria, spiders, fish, and chimpanzees are all different branches of evolution.

Origin of life from inanimate matter

Life must have developed from the simple inorganic molecules which were present on Earth soon after it was formed.

The first primitive organism would have arisen from further chemical synthesis.

The organic molecules were assembled in an atmosphere similar to that thought to exist on early Earth over water.

At the end, carbon was converted to simple compounds of carbon including amino acids which make up protein molecules.

Exercise (MCQ)

1. A Mendelian experiment consisted of breeding tall pea plants bearing violet flowers with short pea plants bearing white flowers. The progeny all bore violet flowers, but almost half of them were short. This suggests that the genetic make-up of the tall parent can be depicted as

A) TTWW
B) TTww
C) TtWW
D) TtWw

2. An example of homologous organs is

A) Our arm and a dog's fore-leg.
B) Our teeth and an elephant's tusks.
C) Potato and runners of grass.
D) all of the above.

3. In evolutionary terms, we have more in common with

A) A Chinese school-boy.
B) A chimpanzee.
C) A spider.
D) A bacterium.

END