D.N.R.COLLEGE, BHIMAVARAM

DEPARTMENT OF ZOOLOGY

II B.SC. PRACTICAL MANUAL

Semester-III

Paper III- CELL BIOLOGY, GENETICS, MOLECULAR BIOLOGY AND EVOLUTION

D.N.R. COLLEGE (AUTONOMOUS), BHIMAVARAM

(Affiliated to Adikavi Nannaya University)

II B.Sc.Zoology practical syllabus (w.e.f 2020-21) admited batch

Semester-III

Paper- CELL BIOLOGY, GENETICS, MOLECULAR BIOLOGY AND EVOLUTION

Total Hours-24 **Hours per week-02** **Total credits-01**

UNIT I . Cell Biology

1. Preparation of temporary slides of Mitotic divisions with onion root tips
2. Observation of various stages of Mitosis and Meiosis with prepared slides
3. Mounting of salivary gland chromosomes of *Chiranomous*

II. Genetics

1. Study of Mendelian inheritance using suitable examples and problems
2. Problems on blood group inheritance and sex linked inheritance
3. Study of human karyotypes (Down‟s syndrome, Edwards, syndrome, Patau syndrome, Turner‟s syndrome and Klinefelter syndrome)

III. Evolution

1. Study of fossil evidences
2. Study of homology and analogy from suitable specimens and pictures
3. Phylogeny of horse with pictures
4. Study of Genetic Drift by using examples of Darwin‟s finches (pictures)
5. Visit to Natural History Museum and submission of report

D.N.R. COLLEGE (AUTONOMOUS), BHIMAVARAM

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II B.Sc.Zoology practical Examination

Semester-III

Paper III- CELL BIOLOGY, GENETICS, MOLECULAR BIOLOGY AND EVOLUTION

Model question paper and scheme of valuation

(w.e.f 2020-21 admited batch)

Duration :3 hrs Max.Marks:50

I. Identify the following slides/ spotters 3x5=15 M

Identification-1M; Diagram-1M; Comments-3M

A) B) C)

II. Problems from genetics /Syndrome 3x5=15M

1)

2)

3)

III. Spotters from evolution 2x5=10M

Identification- 1M; Diagram – 2M; Comments -2M

A)

B)

IV. Vivavoce 5M

V. Record 5M

CAPTIONS

ZOOLOGY RECORD

CELL BIOLOGY

GENETICS

EVOLUTION

ZOOLOGY RECORD

CELL BIOLOGY

1. SQUASH PREPARATION OF ONION ROOT TIP FOR MITOTIC STAGES

Aim: To understand the process and different stages of mitosis and to visualize different phases of mitosis.

Principle: The genetic information of all organisms resides in the individual DNA molecules or chromosomes. An onion cell possesses eight chromosomes whereas human cells possess forty six chromosomes.

An onion root tip is a rapidly growing part of the onion and thus many cells will be in different stages of mitosis. The onion root tips can be prepared and squashed in a way that allows them to be flattened on a microscopic slide, so that the chromosomes of individual cells can be observed easily. The super coiled chromosomes during different stages of mitosis present in the onion root tip cells can be visualized by treating with DNA specific stains, like Feulgen stain and Acetocarmine stain.

Materials required: Onion plant with root, acetocarmine stain, 1 N HCl, Scissors, Forceps, Razor blade, Microscopic slides and cover slips, Water bath, Light Microscope.

Procedure: 1. Cut the tip 5 to 8 mm from the tip of the freshly sprouted root. Discard the rest of the root.

2. Wash them in water on a clean microscope slide.

3. Place one drop of 1N HCL on the root tip and add 2-3 drops of acetocarmine stain to the slide.

4. Warm the slide gently over the alcohol lamp for about one minute. (Do not allow the slide to get hot to the touch; you don't want to cook either your fingers or the root. Do not let the root dry out).

5. Carefully blot the excess stain with a blotting paper.

6. After (10 to 20 seconds) put one or two drops of water and blot them carefully using blotting paper.

7. Again put a drop of water on the root tip and mount a cover slip on it avoiding air bubbles.

8. Squash the slide with your thumb using a firm and even pressure. (Avoid squashing with such force that the cover slip breaks or slides).

9. Observe it under a compound microscope in 10x objective. Scan and narrow down to a region containing dividing cells and switch to 40x for a better view.

The process of Mitosis is divided into four stages: Prophase, Metaphase, Anaphase and Telophase.

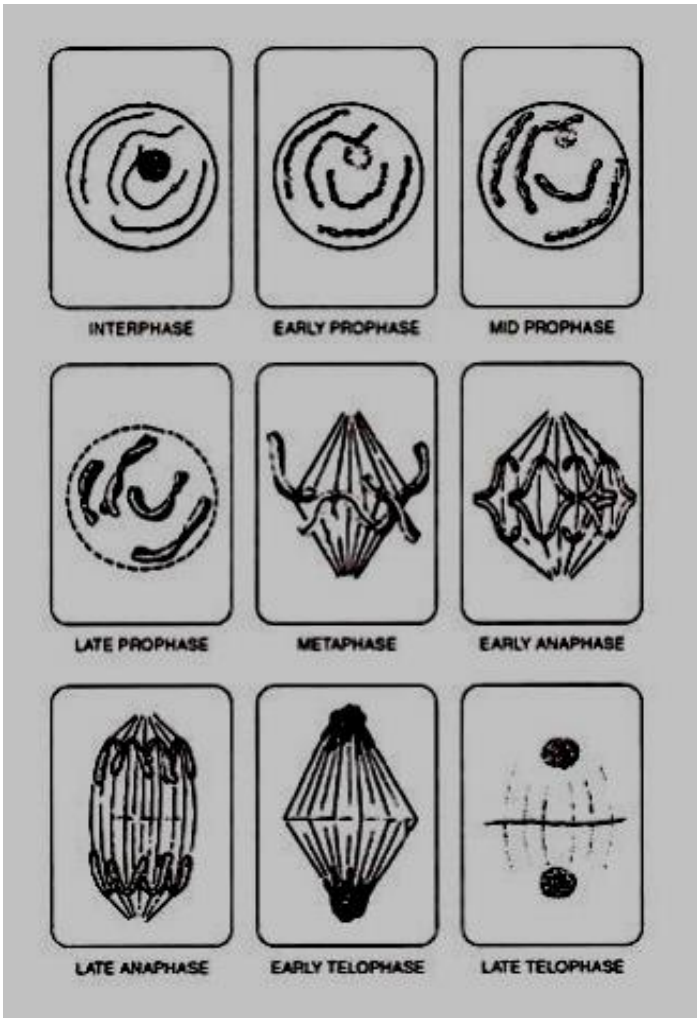
Prophase: During this stage, the chromosomes super coil, condense and become visible for first time during the cell cycle. The spindle fibers start forming. The nuclear membrane starts disintegrating.

Metaphase: During this stage, the spindle fibers reach and attach to centromere of each sister chromatids. The chromosomes align along the center plane of the cell. The nuclear membrane disintegrates completely.

Anaphase: During this stage, the centromeres start splitting and the sister chromatids begin to migrating towards the opposite poles of the cell.

Telophase: During this stage, the chromosomes are clustered on the either end of the cell. The nuclear membrane starts reforming. The cell plate (new cell wall) starts to form between the two daughter nuclei.

This will be followed by cytokinesis



2. Various stages of Mitosis

Main stages are:

1. Interphase
2. Prophase
3. Metaphase
4. Anaphase
5. Telophase

Interphase:

The interphase is the preparation phase for mitosis and it is also the longest phase in the cell cycle. The interphase takes place in the cytoplasm and the cell nucleus
The cells are mostly rectangular, oval or even circular in shape, with almost centrally situated densely stained nucleus.
The chromatic (coloured) material of the nucleus is homogeneous and looks granular.
The boundary of the nucleus is distinct. One or few nucleoli (sing: nucleolus) can also be observed inside the nucleus

2.Prophase:

This is the longest phase in mitosis.
The nucleus takes a dark colour with nuclear specific stains and also with acetocarmine / orcein.
The size of the nucleus is comparatively big and the chromosomes that are thin thread and uncoiled in the initial stages slowly thicken and shorten by a specific process of coiling called relational coiling.
An important feature of prophase is that the two chromatids of each chromosome are held at centromere and can be seen under light microscope.
The nuclear membrane and nucleolus disintegrates at the end of prophase and before the cell enters into metaphase.

3) **Metaphase**:

After the disintegration of nuclear membrane in prophase, the sphindle fibres are formed and the centromere of each chromosome is arranged on the equatorial plate.
The chromosomes remain attached to sphindle fibres at the centromere.
This type of orientation of centromeres on the equator is known as auto-orientation.
The chromosomes at this stage are shortest and thickest. Hence, chromosomes are clearly visible in metaphase.
The chromatids of a chromosome are held together at the point of centromeres and the relational coils are at its minimum.

4) **Anaphase**:

The centromere of each chromosome separates first and the sister chromatids or daughter chromosomes of each chromosome moves towards opposite poles due to contraction of sphindle fibres.

Depending on the position of the centromeres (metacentric, acrocentric and telocentric), the chromosomes show ` V `, ` L ` and ` I ` shapes respectively as the anaphase progresses.

The chromosome number is constant but the quantity of each chromosome is reduced to half.

5**) Telophase**:

Spindle fibres disintegrate.

Chromosomes loose their identity and become a mass of chromatin.

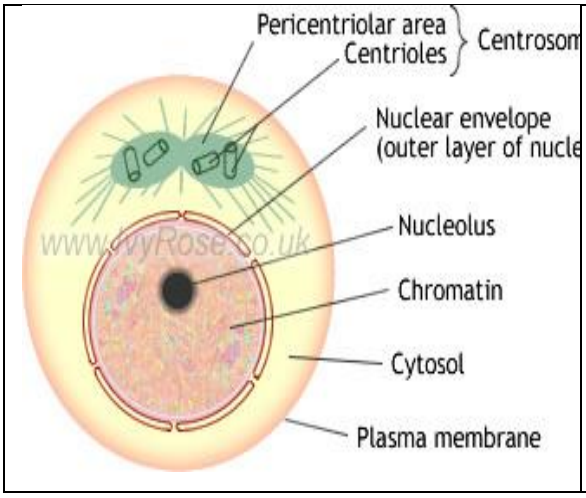
The nucleus along with nucleoli will be re-organized at each pole. The division of one nucleus into two is known as Karyokinesis. Karyokinesis is followed by cytokinesis.

Cytokinesis: It is the division of cytoplasm that usually occurs between late anaphase and end of telophase.

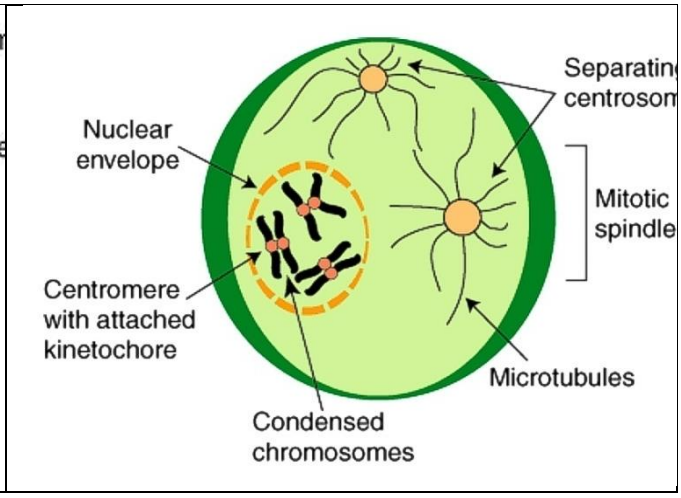
In plants, cytokinesis takes place through the formation of cell plate by golgi apparatus, which begins in the centre of the cell and moves towards the periphery in both sides dividing the cytoplasm into two daughter cells.

In animal cells, cytokinesis occurs by furrowing of plasma lemma in the equatorial region.

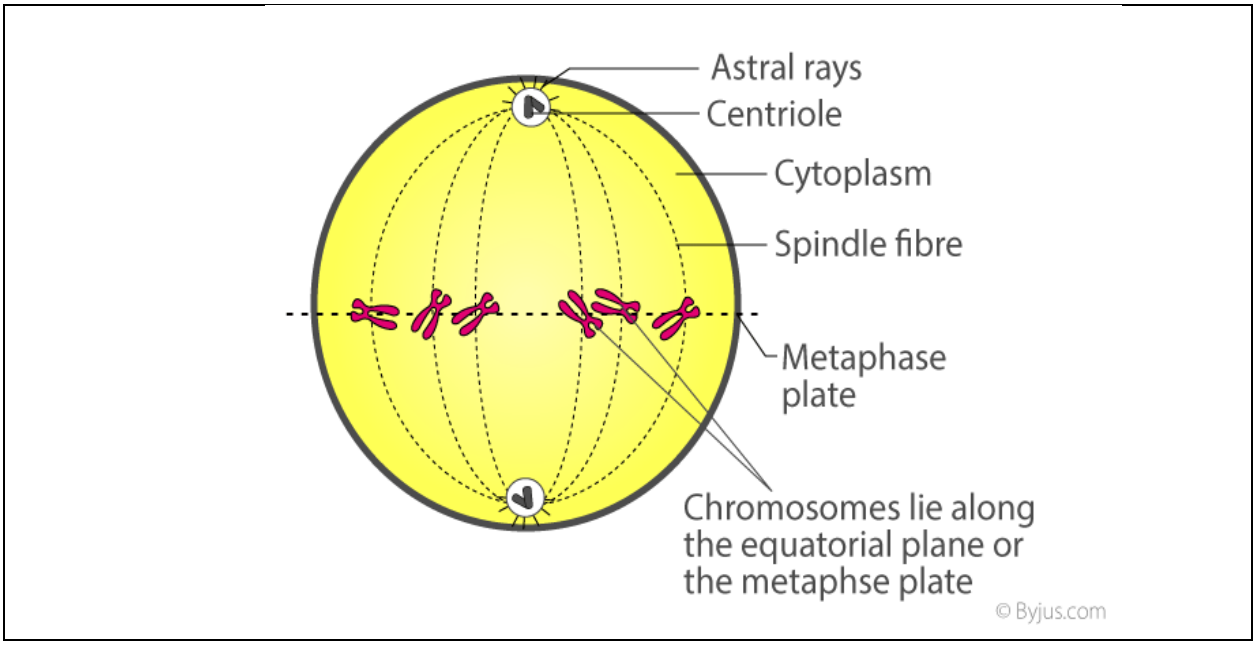
INTERPHASE



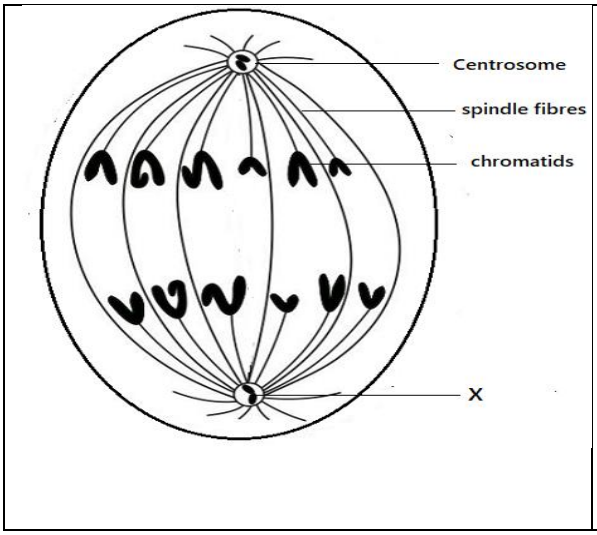
PROPHASE



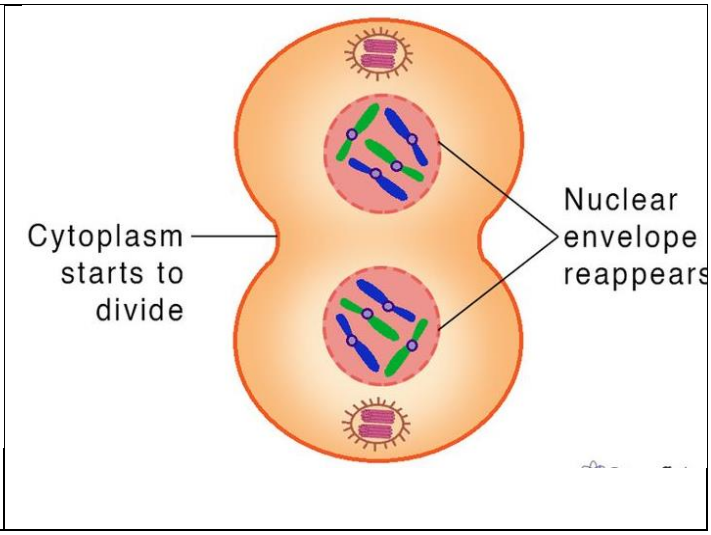
Metaphase



ANAPHASE



TELOPHASE



3. Various stages of Meiosis

Prophase I is divided into five sub stages

i. Leptotene:

In the leptotene stage, chromosomes become visible in the form of thread-like structures (leptos = thin threads). Chromomeres, the beads-like structure can be seen.

The Leptotene stage is also known as the bouquet stage due to the specific alignment of chromosomes in the nucleus. Chromosomes converge to one side of the nucleus towards the centrosome.

Duplication of centriole takes place and they move to opposite poles of the nucleus, where they undergo further duplication.

ii. Zygotene:

Chromosomes becomes short and stumpy

Two homologous chromosomes approach each other and begin to pair

This pairing is called synapse.

Nucleolus increases in size

iii. Pachytene stage:

Each individual chromosome of each bivalent begins to split longitudinally into two similar chromatids

Each bivalent now contains four chromatids. This is called Tetrad stage.

Homologous chromosomes remain attached at some point forming 'X' arrangement called Chiasmata. Chromatids break at this point.

The inter change of chromatin material describes as crossing over.

Diplotene:

Diplotene is the fourth stage of meiosis prophase-1 (a five-stage process).

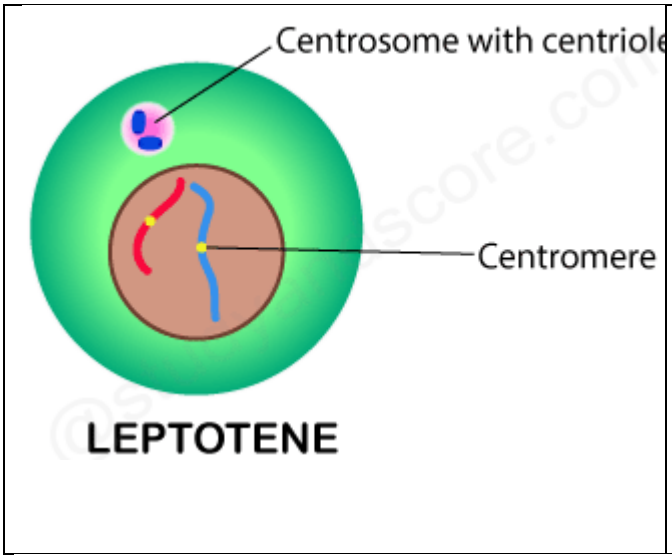
It is preceded by the crossing over in the pachytene stage. Diplotene stage is characterized by desynapsis and chiasmata formation.

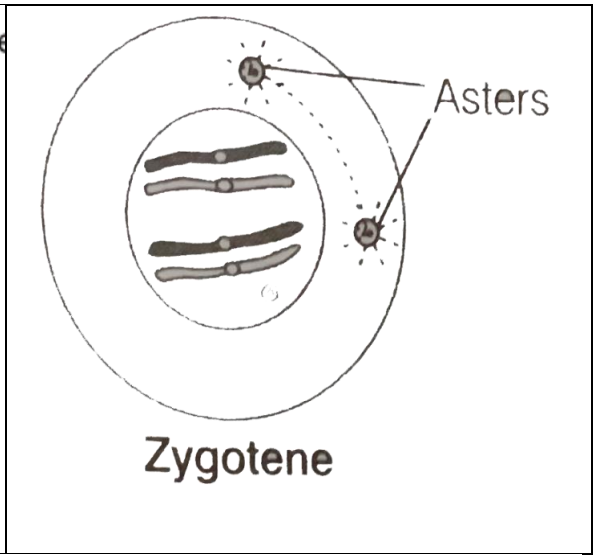
In the diplotene stage synaptonemal complex formed during zygotene dissolve and desynapsis of homologous chromosomes start.

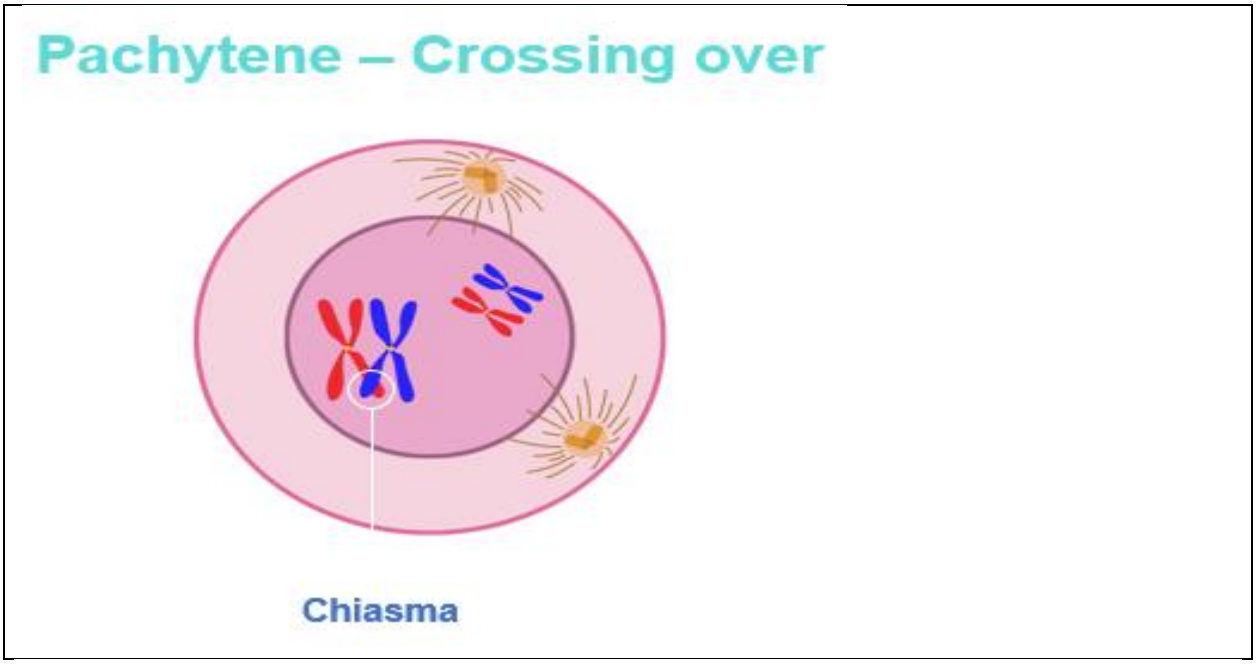
Homologous chromosomes separate from each other except at the sites of crossing over called **chiasmata.** The chiasmata are x-shaped.

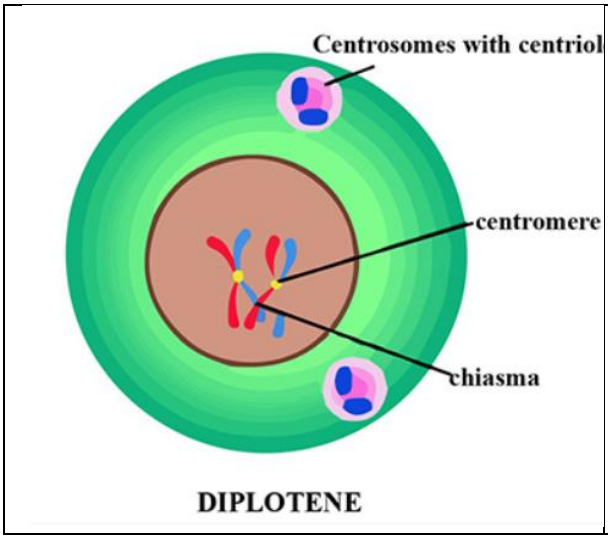
Metaphase I:

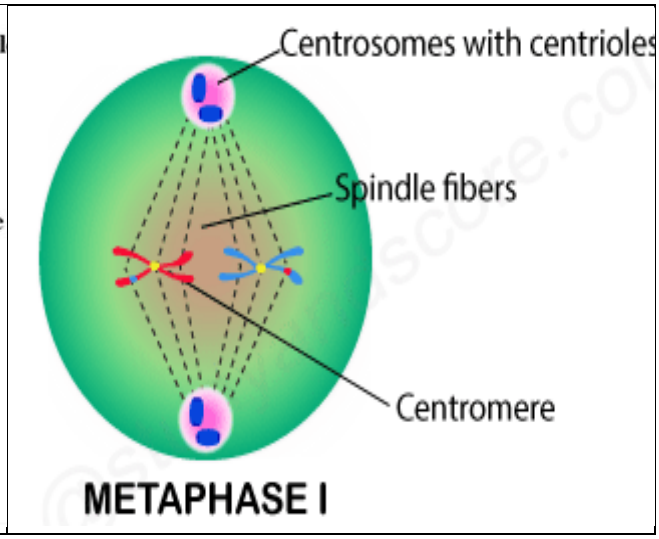
- The nuclear membrane disappears
- Centrioles reach the opposite poles
- The spindle fibres become prominent and get connected to the centromere of the homologous chromosomes.
- The bivalents align on the equatorial plane


Centrosome with centriole
Centromere
LEPTOTENE


Asters
Zygotene


Pachytene – Crossing over
Chiasma


Centrosomes with centriol
centromere
chiasma
DIPLOTENE


Centrosomes with centrioles
Spindle fibers
Centromere
METAPHASE I

Anaphase I

During anaphase, each pair of chromosomes separates into two identical but independent chromosomes.

Each of these chromosomes gets separated by mitotic spindles known as microtubules, attached to the chromosomes at both ends of the cell.

Separation occurs simultaneously at the centromere and each separated chromosome gets pulled by the spindles to the opposite poles of the cell.

The function of anaphase is to ensure that each daughter cell receives identical sets of chromosomes before the final phase of the cell cycle, which is telophase.

Telophase I

During this phase, the sister chromatids reach the opposite poles of the cell.

The small nuclear vesicles in the cell start to reform around the chromosomes at the end of the cell.

The nuclear envelope reforms by associating with the chromosomes, forming two nuclei in one of the new cells.

The nuclear membrane and nucleolus reappear and thus two daughter nuclei are formed.

Prophase II

Chromosomes appear distinct with two chromatids

Centromere devides, centrioles and astral rays move apart to opposite poles

Nucleolus and nuclear membrane disappear

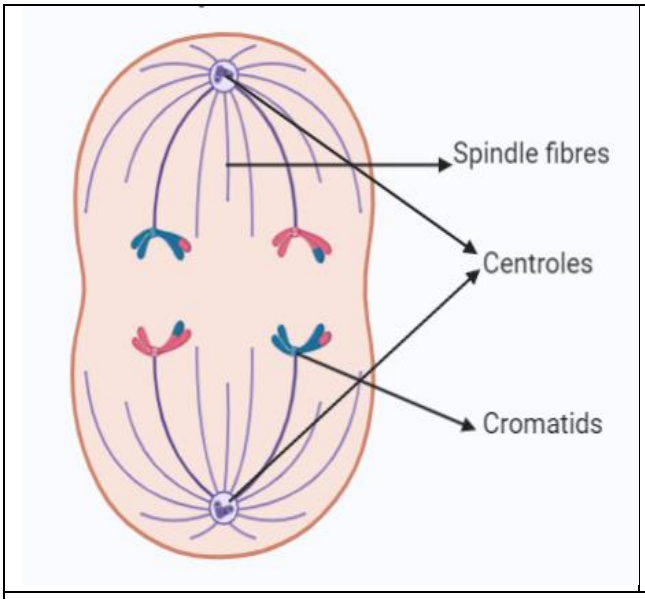
Metaphase II

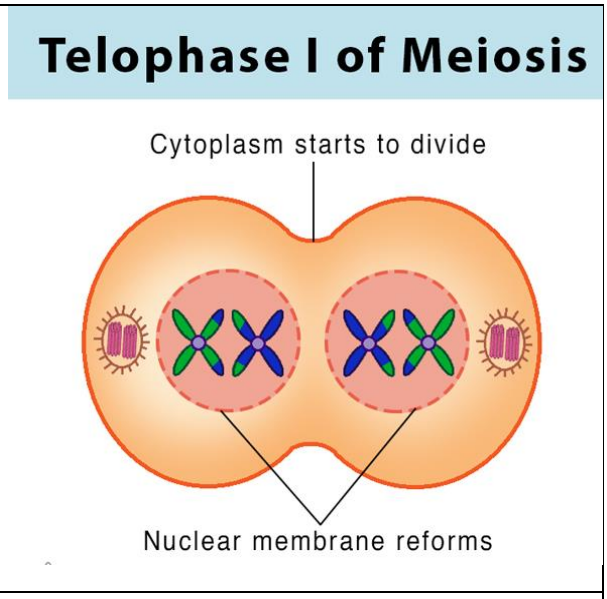
Chromosomes gets arranged on the equator

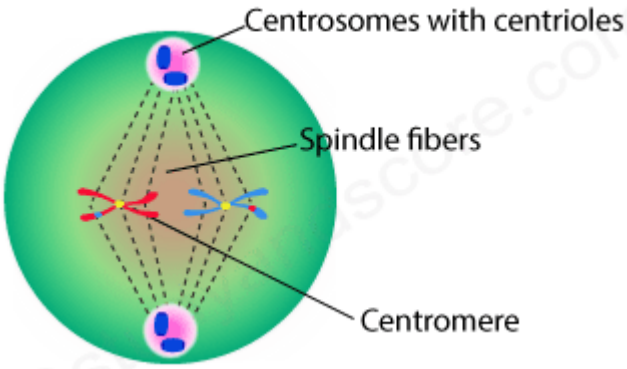
Centromere devides into two hence chromatids are separated into individual chromosomes.

Spindle fibres are attached to centromere.

Anaphase I

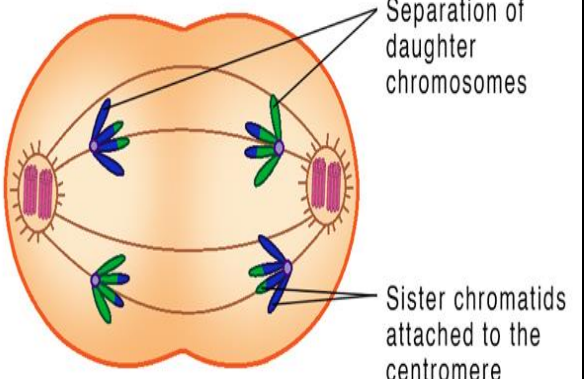




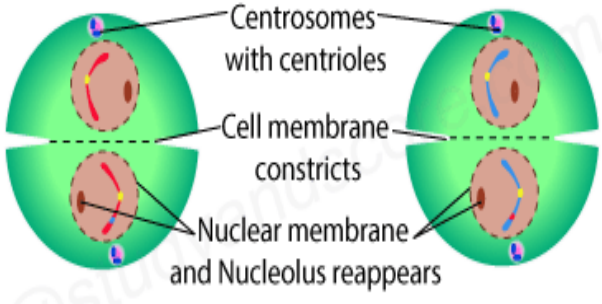


Metaphase

Anaphase



Telophase



Mounting of salivary gland chromosomes of *Chiranomous*

The salivary glands of Dipteran insect larvae have nuclei which are in perpetual interphase. They were described by Balbiani in 1881, These nuclei have chromosomes which arc abnormally large as compared to the chromosomes of the other body cells. Because of their size they come to be known as giant chromosomes.

A. Preparing Salivary Squashes

1. Place a drop of 0.7% saline on a clean microscope slide. Transfer an appropriate larva (see above) to the slide and place it on the stage of a dissecting microscope.

2. Using the enhanced detail afforded by the microscope, firmly grasp the posterior end of the larva with forceps and use a dissecting needle, or another pair of forceps to pierce through the head, just behind the darkly pigmented mouthparts. Using a continuous motion, pull the needle (and attached head) away from the body.

The salivary glands are recognized by the following features:

They are paired and each is identical in size and shape.

They have a glistening, translucent appearance.

Each gland should have an opaque fat body associated with it.

3. While continuing to observe under the dissecting microscope, separate the salivary glands from any extraneous material, such as the fat bodies or parts of the digestive tract. Be careful not to damage the salivary glands themselves.

4. Once cleaned, remove the used saline and debris from the slide. Add fresh saline and allow the glands to soak for ten minutes.

There are two ways to perform the next step. The first is preferred since you can prepare two slides from one salivary gland. However, it is sometimes difficult to transfer each delicate gland to a separate slide. If you have trouble transferring the gland to a slide without damaging it, use step 5b.

5a. Obtain two fresh slides and add two drops of aceto-orcein stain to the center of each. Carefully pick up one of the salivary glands and transfer it to the drop of stain on one slide; transfer the second gland to the stain on second slide.

5b. Using a laboratory tissue, blot the saline from the slide containing the salivary glands in saline. Be careful not to touch the glands with the tissue as they will stick and it will not be possible to recover them. Place two drops of aceto-orcein stain directly on the glands.

6. Place the slides in a petri dish containing a moist filter paper (this prevents the stain from evaporating during incubation). Incubate for fifteen minutes.

7. Carefully blot excess stain away from the salivary gland. Be careful not to touch the glands with the tissue as they will stick. Add one drop of fresh stain and incubate for two minutes. (If you made two separate slides, leave the second gland soaking in the petri dish while you process the first).

8. Apply a cover slip to the stained salivary gland and place a paper towel or folded laboratory tissue over the cover slip. Using steady, moderate pressure, press down on the cover slip in a vertical direction. Do not twist the cover slip or allow it to move laterally; this will shear the chromosomes.

9. Observe the salivary gland squash at high-dry magnification with a compound microscope. Make sure that the optics are properly adjusted for Köhler illumination. A good preparation will reveal elongated chromosomes with distinct banding patterns.

B. Observing Heat Shock-induced Chromosomal Puffing.

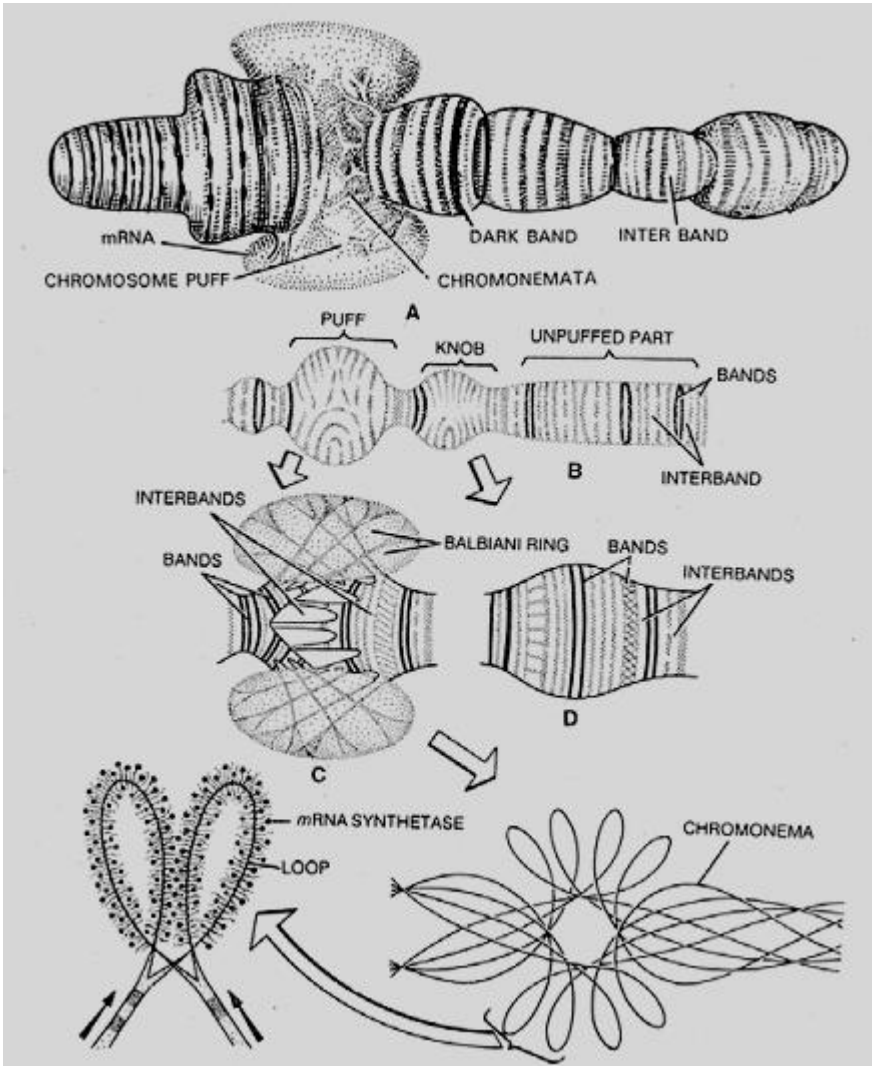
1. Using a new, live larva, prepare salivary glands as described in steps 1 though 3 above. You should make two slides. One is labeled RT (room temperature) and the other labeled HS (heat shock).

2. Add fresh saline to each gland and incubate each in a humid petri dish. Place the HS slide in a 37°C incubator; the RT slide is incubated on the laboratory bench. Incubate the slides for 40 minutes. Do not exceed 40 minutes incubation.

3. Following incubation, carefully blot excess saline from the glands and stain as described in steps 5 and 6.

4. Squash the salivary gland on each slide as described in step 8 above.

5. Observe the chromosomes as described in step 9 above. You may have to scan several fields in order to identify chromosomes that show puffing. Compare the number of puffs in the RT and HS slides.


mRNA
CHROMOSOME PUFF
DARK BAND
INTER BAND
CHROMONEMATA
A
PUFF
KNOB
UNPUFFED PART
BANDS
INTERBAND
B
INTERBANDS
BANDS
BALBIANI RING
BANDS
INTERBANDS
D
C
mRNA SYNTHETASE
LOOP
CHROMONEMA

GENETICS

Q1 . A Cross made between Brown eyed man with Blue eyed female. In F_1 generation, all are Brown eyed. When we interbreed in F_2 generation, 36 Brown eyed and 13 Blue eyed children are formed.

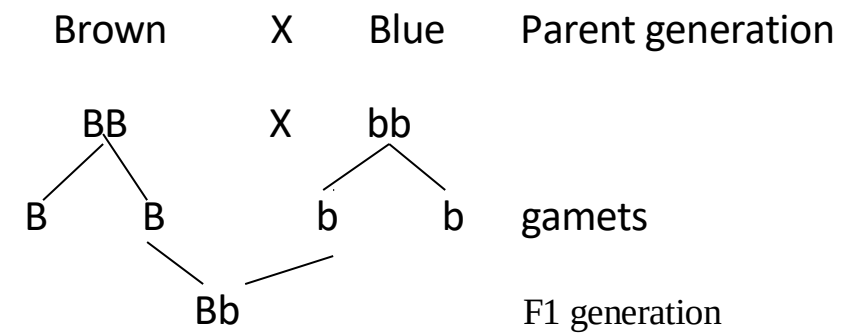
a) Which law it follows?

b) Give appropriate symbols and explain with checker board.

Ans: In this experiment clearly shows that it follows Mendel's Ist law ie. Law of dominance.

1. Each character is controlled by distinct units called factors, which occur in pairs.
2. If both the factors are present in the organism, one act as dominant over the other.

This law states that in a heterozygous condition, the allele whose characters are expressed over the other allele is called the dominant allele and the characters of this dominant allele are called dominant characters. The characters that appear in the F1 generation are called as dominant characters. The recessive characters appear in the F2 generation.

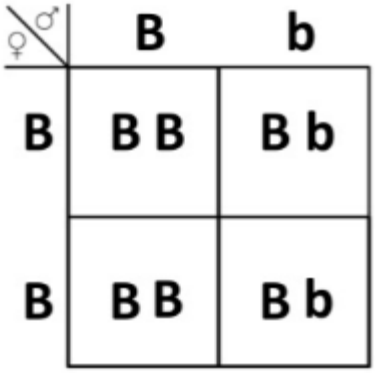


Brown

Bb X Bb

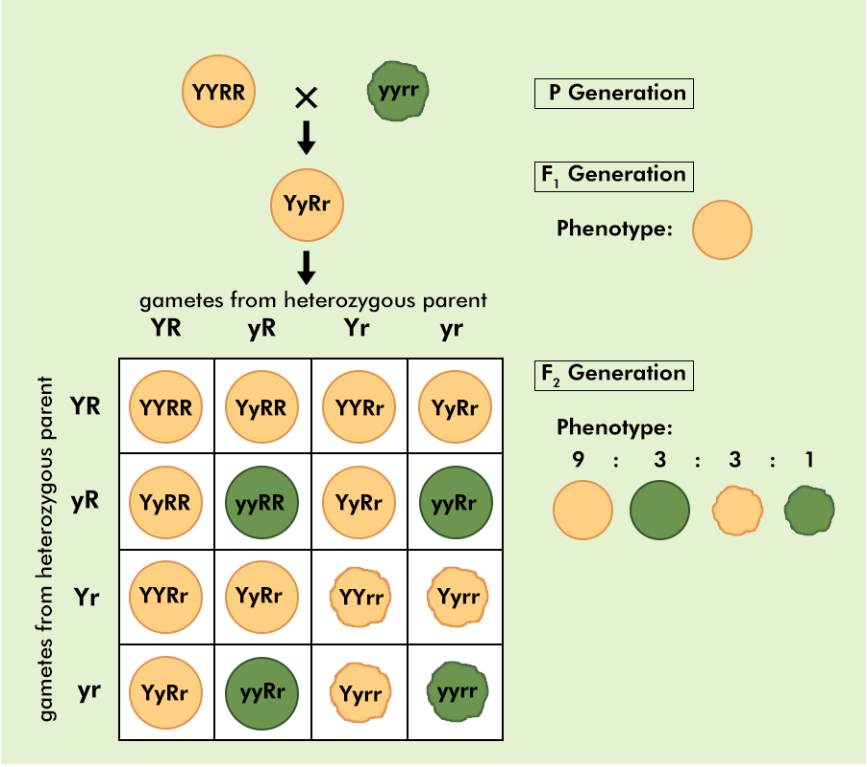
BB Bb Bb bb F2 generation

Brown Blue



Q2: What will be the result of selfing the F_1 generation in a cross when round and yellow seeded pea plants (YYRR) are crossed with green and wrinkled (yyrr) seeded pea plant?

Ans: Cross made between yellow, round seeded pea plant with green wrinkled pea plant, in F1 generation, all are yellow, round seeded pea plants. When we interbreed, The result will be yellow round (9), yellow wrinkled (3), green round (3) and green wrinkled (1). So it shows the ratio of 9: 3: 3: 1.



Q3: A woman with type **A** blood marries a man with type **AB** blood. Which of the following blood types would be impossible for their first child to have?

The blood group of the woman is type A. This means her genotype is I^AI^A either or I^Ai.

The blood group of the man is type AB which means his genotype is I^AI^B

The cross can be represented as shown in the figure.

If the genotype of woman is I^AI^A

		Woman: I^A	Woman: I^A
Man	I^A	I^AI^A TYPE A	I^AI^A TYPE A
	I^B	I^AI^B TYPE AB	I^AI^B TYPE AB

If the genotype of woman is I^Ai

		Woman: I^A	Woman: i
Man	I^A	I^AI^A TYPE A	I^Ai TYPE A
	I^B	I^AI^B TYPE AB	I^Bi TYPE B

Hence the blood which would be impossible for their first child to have is type O.

So, the correct answer is 'Type O'.

Down's syndrome (Trisomy 21)

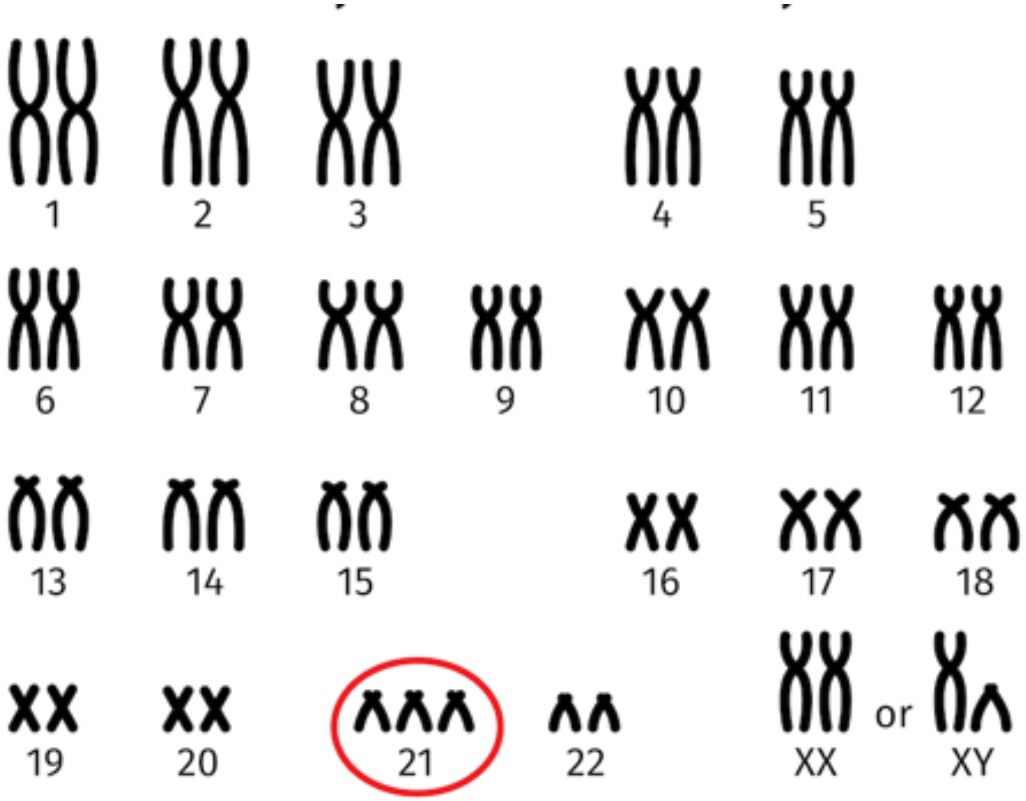
Causes: It is an Autosomal disorder. There is one extra chromosome 21. The total number of chromosome present is 47 instead of the normal 46 chromosomes.

The main cause of trisomy is Nondisjunction of chromosome

Diagnosis: Down syndrome can be diagnosed by the **amniocentesis** technique

Symptoms:

- Short stature and stunted growth
- Fold of the skin above the eye, slanted eyes
- Protruding furrowed tongue, flattened nose
- Mental retardation
- Cardiac deformities
- Single transverse palm crease and hand is broad and short
- Poor muscle tone and excessive flexibility
- Small head, short neck and abnormal teeth
- Delay in language development
- Cognitive impairment may be mild to moderate



Edwards' syndrome (trisomy 18)

Causes: It is an Autosomal disorder caused by a triplication of the 18th chromosome

Diagnosis : Edwards syndrome can be suspected and diagnosed during pregnancy, during or after 10 to 14 -weeks by a pregnancy ultrasound and blood test

Symptoms:

• Developmental delays and severe learning disability

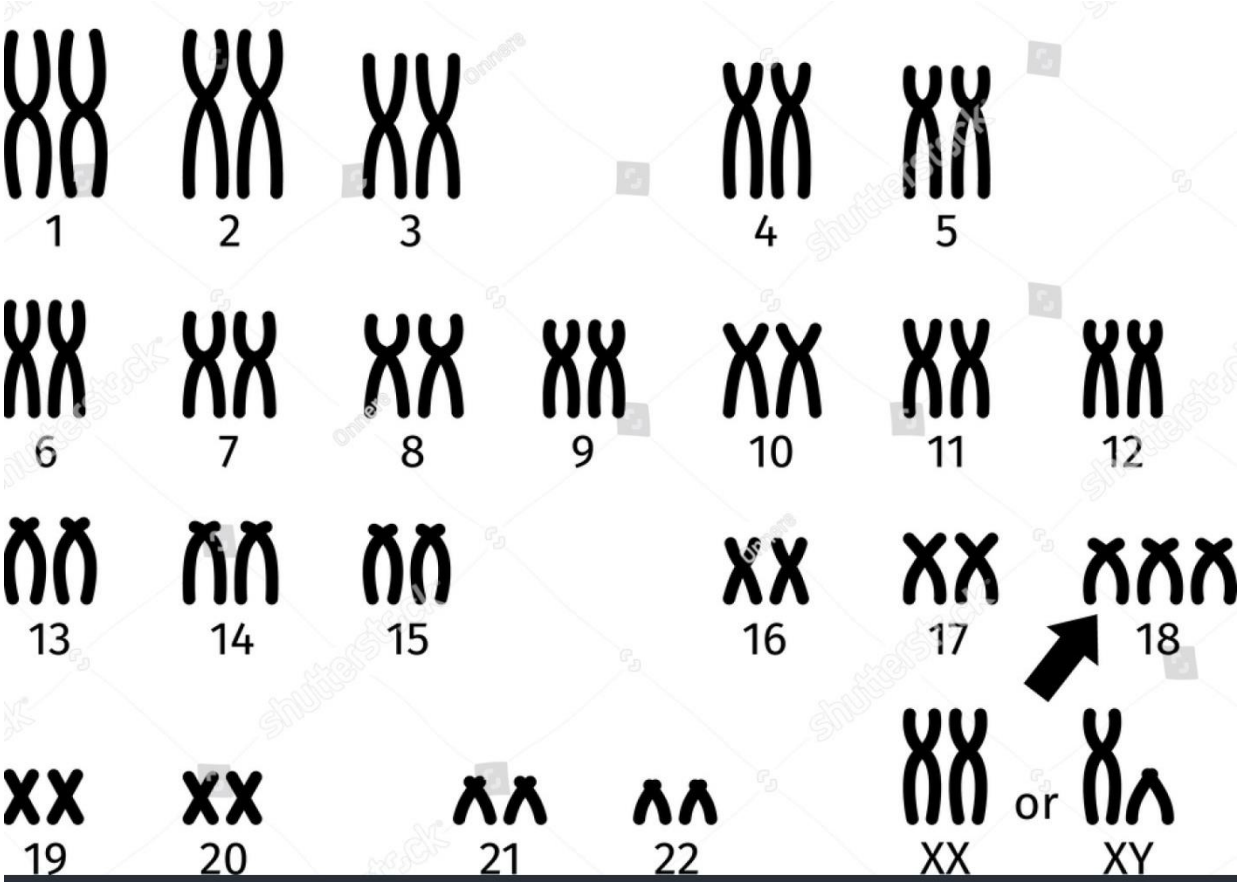
• Slow to grow and gain weight and severe feeding difficulties

• Low muscle tone (floppy) and episodes where breathing may stop

• A prominent back part of the head, low-set, differently shaped ears, an unusually small jaw, a small mouth with an unusually narrow roof, an upturned nose, narrow eyelid folds, widely spaced eyes, and drooping of the upper eyelids and undescended testes in boys

• Unusually developed hands and feet which may include overlapping fingers and clenched fist, webbing of the toes, a deformity causing the heels to turn inwards and the soles flexed (clubfeet)

• A small pelvis with limited hip movement and a short breastbone



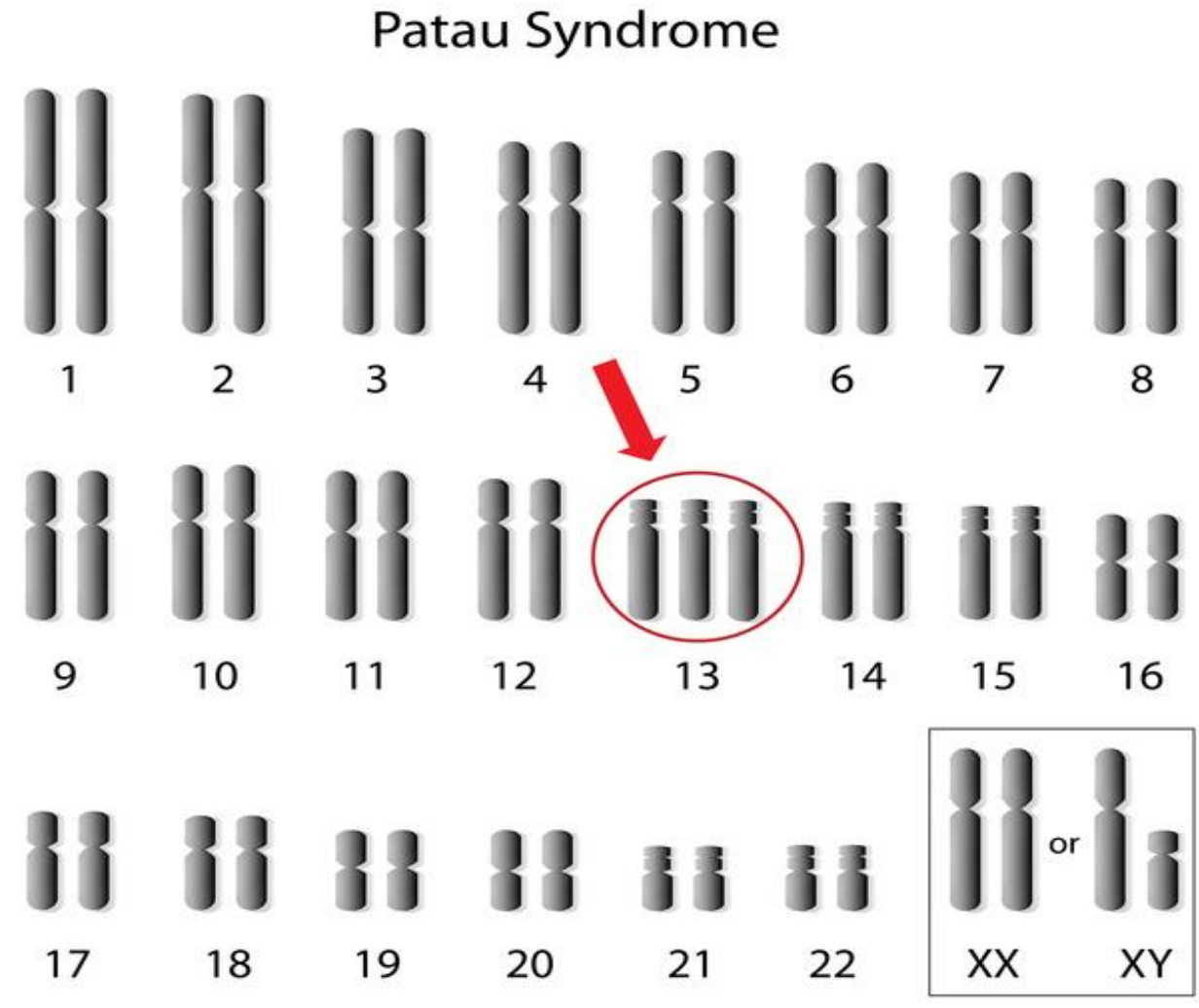
Patau syndrome (Trisomy 13)

Causes: It is a chromosomal disorder that results from an extra (third) copy of chromosome 13

Diagnosis : Diagnosis can be made prenatally with chorionic villi sampling, amniocentesis, or fetal free DNA analysis.

Symptoms:

- Cleft lip or cleft palate.
- Difficulty gaining weight.
- Extra fingers or toes (polydactyly).
- Ears forming low on the head.
- Growth abnormalities in the arms and legs.
- Low muscle tone (hypotonia).
- Small head and lower jaw.
- Very small, close together or underdeveloped eyes.



Turner Syndrome

Causes:

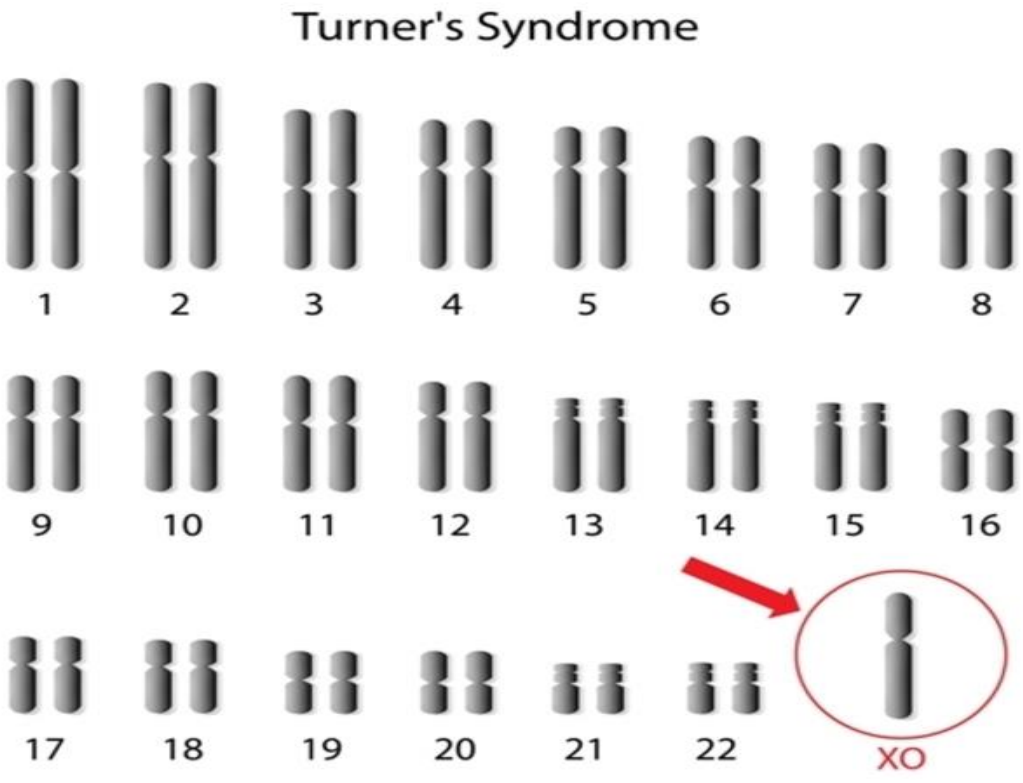
Turner syndrome is a genetic condition found in females only. Usually, a woman has two X chromosomes. However, in women with Turner's syndrome, one of these chromosomes is absent or abnormal.

Diagnoses:

- amniocentesis and chorionic villus sampling (before birth)
- clinical history
- physical examination
- psychological and educational assessment
- blood tests and chromosome analysis

Symptoms:

- short stature – average adult height is 143 cm (4' 8")
- infertility – due to underdeveloped ovaries
- congenital heart defects – in about 50 per cent of affected women
- spatial awareness issues – problems with tasks such as maths
- absence of menstruation (amenorrhoea)
- hearing problems.



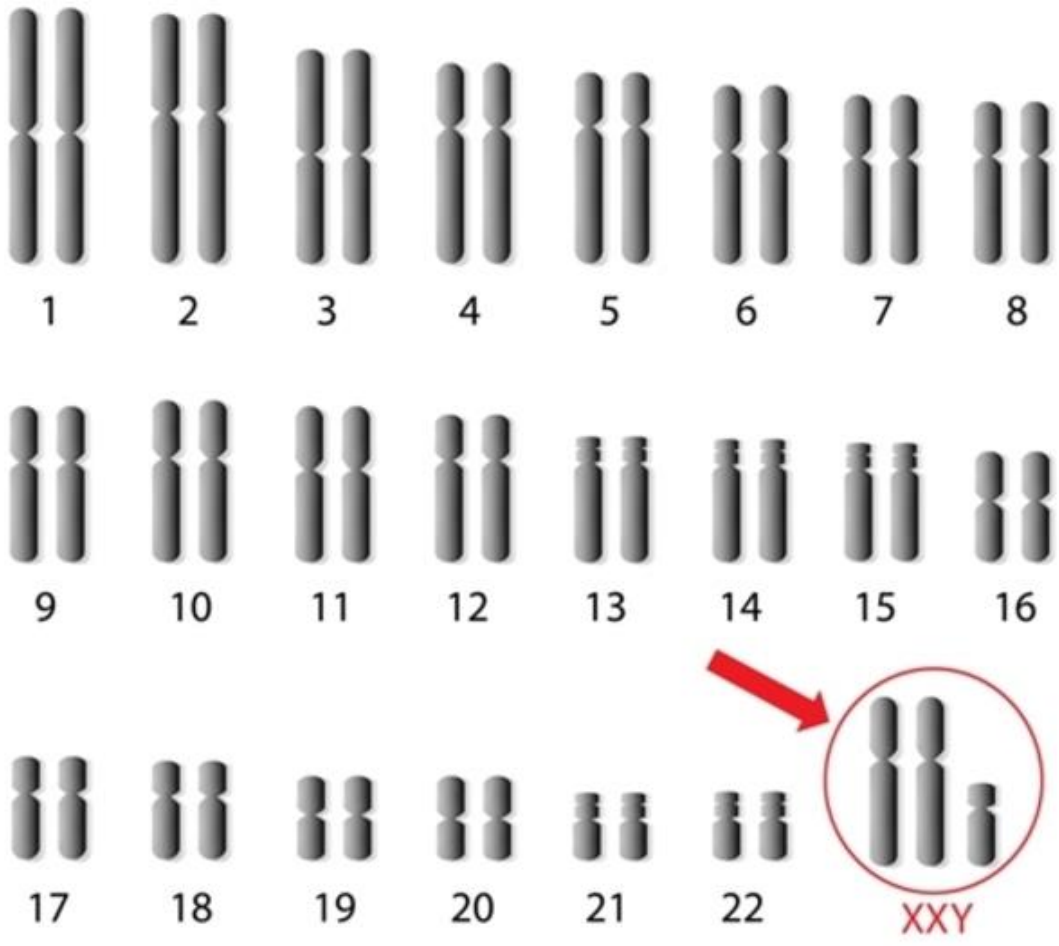
Klinefelter syndrome

Causes: Klinefelter syndrome is a genetic condition in which a boy is born with an extra X chromosome. Instead of the typical XY chromosomes in men, they have XXY, so this condition is sometimes called XXY syndrome.

Diagnosis: Blood or urine samples can reveal abnormal hormone levels that are a sign of Klinefelter syndrome. Chromosome analysis. Also called karyotype analysis, this test is used to confirm a diagnosis of Klinefelter syndrome.

Symptoms:

- Taller than average stature.
- Longer legs, shorter torso and broader hips compared with other boys.
- Absent, delayed or incomplete puberty.
- After puberty, less muscle and less facial and body hair compared with other teens.
- Small, firm testicles.
- Small penis.
- Enlarged breast tissue (gynecomastia)
- Weak bones.



EVOLUTION

Study of fossil evidences

The study of fossils is known as paleontology.

Paleontology helps us in finding the relation between the organisms, that are present and extinct

A fossil provides evidence for evolution.

Fossils are the preserved remains or traces of animals, plants, and other organisms from the past. Fossils range in age from 10,000 to 3.48 billion years old. The observation that certain fossils were associated with certain rock strata led 19th century geologists to recognize a geological timescale. Like extant organisms, fossils vary in size from microscopic, like single-celled bacteria, to gigantic, like dinosaurs and trees.

Fossils Formation:

Living things (typically aquatic) perish and are buried under layers of sand, dirt, clay, or ash. The soft components usually decay away, leaving only the hard elements. Ammonites are among the most frequent fossils known. As time goes on, more and more silt accumulates.

Pressure, heat, and chemical processes cause the sediments to harden into sedimentary rock. Movements in the earth's crust push the sedimentary rock layers back up to higher ground. Finally, erosion caused by weather, wind, and water exposes the fossils at the surface.

The five types of fossils are:

- Body Fossils
- Molecular Fossils
- Trace Fossils
- Carbon Fossils
- Pseudofossils

Permineralization

Permineralization is a process of fossilization that occurs when an organism is buried. The empty spaces within an organism (spaces filled with liquid or gas during life) become filled with mineral-rich groundwater. Minerals precipitate from the groundwater, occupying the empty spaces. This process can occur in very small spaces, such as within the cell wall of a plant cell. Small-scale permineralization can produce very detailed fossils. For permineralization to occur, the organism must be covered by sediment soon after death, or soon after the initial decay process.

The degree to which the remains are decayed when covered determines the later details of the fossil. Fossils usually consist of the portion of the organisms that was partially mineralized during life, such as the bones and teeth of vertebrates or the chitinous or calcareous exoskeletons of invertebrates. However, other fossils contain traces of skin, feathers or even soft tissues.

Fossils provide solid evidence that organisms from the past are not the same as those found today; fossils show a progression of evolution. Fossils, along with the comparative anatomy of present-day organisms, constitute the morphological, or anatomical, record. By comparing the anatomies of both modern and extinct species, paleontologists can infer the lineages of those species. This approach is most successful for organisms that had hard body parts, such as shells, bones or teeth. The resulting fossil record tells the story of the past and shows the evolution of form over millions of years.

How Are Fossils Helpful in Developing Evolutionary Relationships?

Over the years, palaeontologists have recovered and studied fossil remains of several thousands of organisms that lived in the past. This fossil record shows that several extinct organisms were different in form from any their present counterparts. The record also shows successions of organisms through time, and through that, it can be determined their transition from one form to another.

When an organism dies, it is generally decomposed by other forms of life and by the weathering processes. However, on certain occasions, some body parts of the deceased organism, specifically hard ones such as shells, teeth, or bones are preserved as they are buried in mud or protected in some other way from decomposers and the environment. Eventually, they are petrified and preserved indefinitely with the rocks in which they are embedded.

Methods such as radiometric dating indicate that the earth was formed almost 4.5 billion years ago and the earliest fossils resemble microorganisms such as bacteria and cyanobacteria. Fossils of these microorganisms appear in rocks and are more than 3.5 billion years old The oldest known animal fossils over 700 million years old and come from the Edicara fauna which are small wormlike creatures with soft bodies.

Fossils of the first vertebrates show that they appeared about 400 million years ago and the first mammals appeared around less than 200 million years ago. However, the fossil record is incomplete. Only a tiny section of the fossils available on earth have been recovered and studied by palaeontologists and in that only in some cases has the succession of forms been reconstructed in detail. One example is the evolution of the horse.

The horse can be traced to an animal which has the size of a dog with several toes on each foot and teeth appropriate for browsing. The animal is called the dawn horse (genus Hyracotherium) and is supposed to have lived more than 50 million years ago. The most recent form, the modern horse (Equus), is much larger, has only one toe and teeth appropriate for grazing. The transitional forms of this animal are well preserved as fossils, as are many other kinds of extinct horses that evolved in different directions and left no living descendants.

Recovered fossils also help palaeontologists reconstructed examples of radical evolutionary transitions in form and functions of different animals. For example, the lower jaw of reptiles contains many bones, but that of mammals only has one. Similarities between the other bones in the reptile jaw and the bones in the mammalian ear have been found and it has been established that they have been evolved from the former.

Such a transition might seem unlikely as it is hard to imagine what function such bones could have had during their intermediate stages. Yet, palaeontologists have discovered two transitional forms of mammal-like reptiles which they called therapsids, having a double jaw joint. One joint consists of the bones that persist in the mammalian jaw whilst the other joint is composed of the quadrate and articular bones, which eventually became the hammer and anvil of the mammalian ear.

Homologous organs

Homologous organs: The organs found in different organisms which have a common origin and same basic structure but differ in the functions they carry out are called homologous organs

These structures have the same origin and basic structure but differ in the functions they perform.

Pentadactyl limb: A limb with five digits such as a human hand or foot is called pentadactyl limbs. This pattern of limb bones is an example of homologous structures.

1. Pentadactyl limbs are found in all classes of tetra pods that are from amphibians to mammals
2. The limb has a single proximal bone (humerus), two distal bones (radius and ulna), a series of carpals (wrist bones), a series of metacarpals (palm bones), and phalanges (digits).
3. Throughout the tetrapods, the basic structure of pentadactyl limbs is the same, indicating that they originated from a common ancestor.

The forelimbs of frog, lizard, bird, and man all have a similar arrangement of bones. They consist of a humerus (upper arm bone), radius and ulna (lower arm bones), carpals (wrist bones), metacarpals (palm bones), and phalanges (finger bones). The number and length of these bones may differ, but the basic structure remains the same.

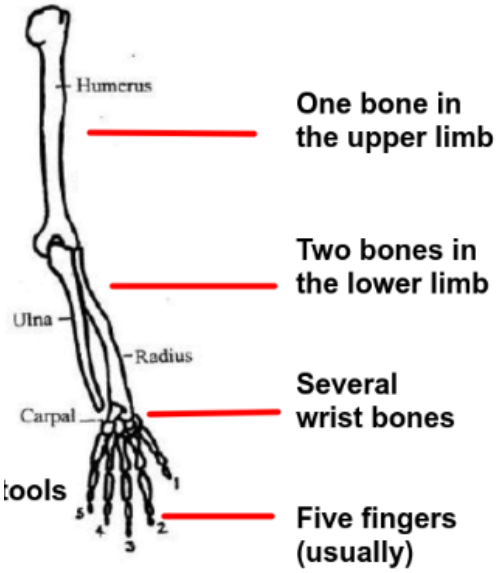
Frog: Frogs use their forelimbs for jumping and propping

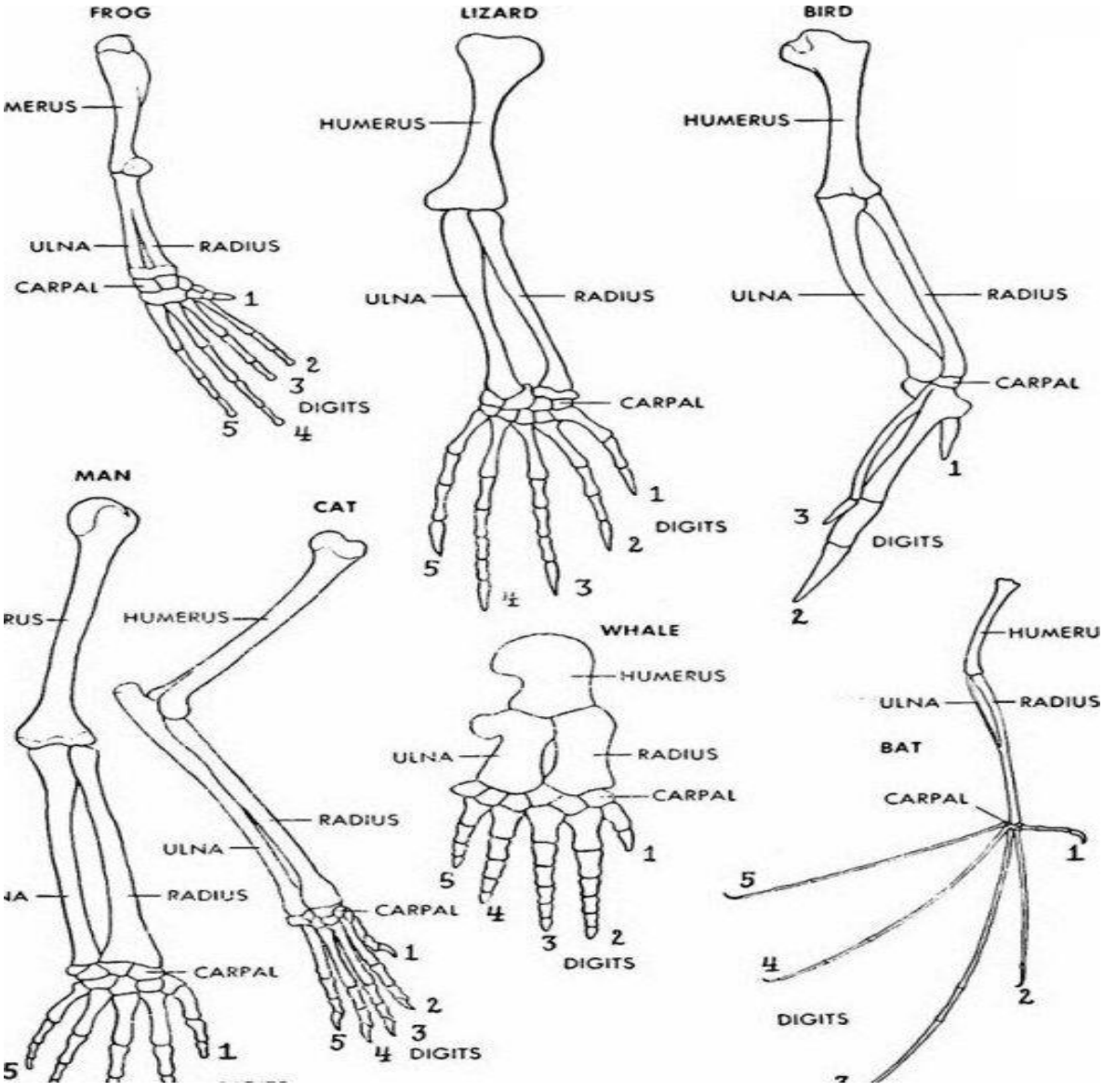
Lizards: Lizards have forelimbs adapted for climbing, with strong and flexible toes for gripping surfaces.

Birds: Birds have forelimbs modified into wings for flight, with feathers and specialized bones to support and control their aerial movements.

Humans: Use their forelimbs for writing, eating, and holding objects.

Typical pentadactyl forelimb





Analogous organs

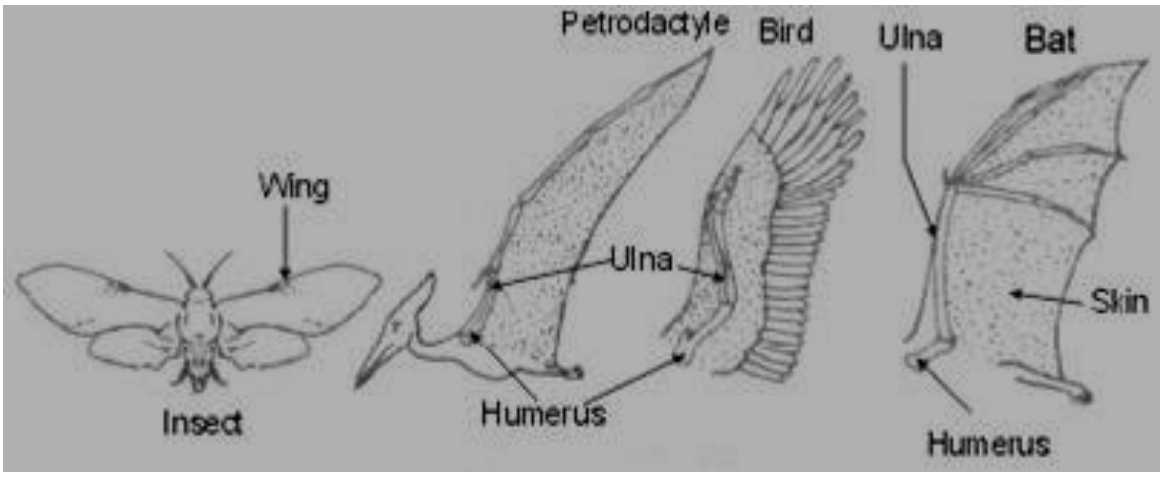
Analogous organs have similar functions but different origins.

An example of an analogous trait would be the wings of insects, bats and birds that evolved independently diverging from an ancestor without wings.

The wings of insects originate from the inner or outer surface of the insect's body.

Feathers of birds originate from their forelimbs

The wings of bats originate from both the forelimb and the membranous skin of the abdomen.



EVOLUTION OF HORSE

The evolutionary trends of horse evolution are summarized below:

1. Increase in size.
2. Increase in the length of limbs.
3. Increase in the length of the neck.
4. Increase in the length of preorbital region (face).
5. Increase in the length and size of III digit.
6. Increase in the size and complexity of brain.
7. Molarization of premolars. Olfactory bulb Hyracotherium Mesohippus Equus
8. Development of high crowns in premolars and molars.
9. Change of plantigrade gait to unguligrade gait.
10. Formation of diastema.
11. Disappearance of lateral digits.
12. Enlargement of hoof on the middle digit.
13. Development of springing mechanism.
14. Straightening and stiffening of back.
15. Transition from browsing habit to grazing habit.

Evolutionary Sequence of Horse

1. EOHIPPUS (genus Hyracotherium)

a) Nicknamed "Dawn Horse". Lived about 56 million to 33.9 million years ago

b) Looked like a deer in skin, most likely for camouflage.

c) Had 5 toes on frontal feet, and three on hind feet.

d) Toes ended in a strong, thick, horny type nail and their tips.

e) had little or no lateral vision.

f) teeth were similar to a pig, short and crowned for eating plants.

g) stood about 14 inches high at his shoulder and weighed around 12 lbs 2.

2. MESOHIPPUS

a) 35 to 40 million years ago

b) Stands 18-24 inches at the shoulder.

c) Longer snout, legs, and neck, compared to Eohippus.

d) Less arched back.

e) Three toes on each foot.

f) Larger limbs and legs caused the Mesohippus to run faster, eliminating the need for camouflage.

3. MIOHIPPUS

a) Ankle joint changed.

b) Slight dish, concave, to it's face. S

c) tood at a minimum of 24 inches at the shoulder.

d) Weighed much more then the Mesohippus.

e) Head longer. Incisor teeth form.

f) Mesohippus and the Miohippus species overlapped for more then 4 million years.

g) 5 million years until another change occured

4. MERYCHIPPUS

a) 30 million years ago

b) Looked very similar to today's horses

c) Stood over 36 inches tall at shoulder.

d) Still had three toes, outside toe became weaker.

e) Head changed, the eye moved, allowing better vision.

f) Longer neck, for easier grazing.

g) Developed defenses.

h) Developed a better sense of smell.

5. PILOHIPPUS

a) 12-6 million years ago

b) Considered direct link to the Equus, which is, in short, the horse we know today.

c) First single toed, or hooved horse.

d) Strong leg ligaments, to increase speed and power.

e) Had a dished face.

f) Resembled a pony in many features.

6. EQUUS

a) 5 million years ago

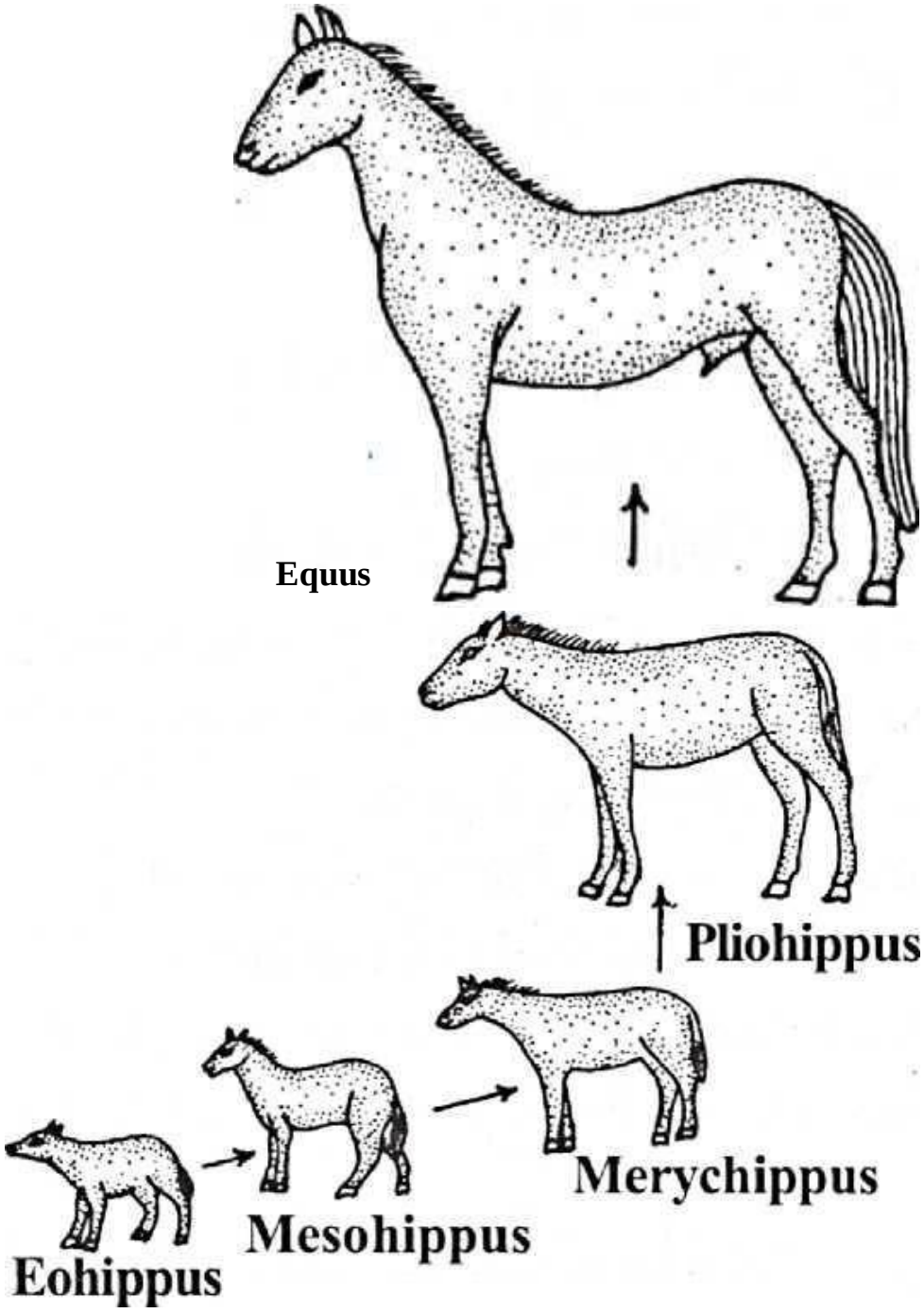
b) This is the horse we know today

c) Does not have a dished face

d) Many strands of horses arose after the Pilohippus, the Equus was the only to survive.

e) About 3,000 years ago, the modern day horse was used for migration, farming, warfare, sport, communication, and travel.

Evolution of horse



Study of Genetic Drift by using examples of Darwin's finches (pictures)

Genetic drift is an evolutionary change in allelic frequencies of a population as a matter of chance. It occurs in very small populations, but its effects are strong. It occurs due to an error in selecting the alleles for the next generation from the gene pool of the current generation. It does not occur due to any environmental influences.

Genetic Drift Example

- A bird has an allele for two different sizes of beaks. Genetic drift might eliminate one of the beak sizes from the population, thus reducing the genetic variations of the gene pool of birds.

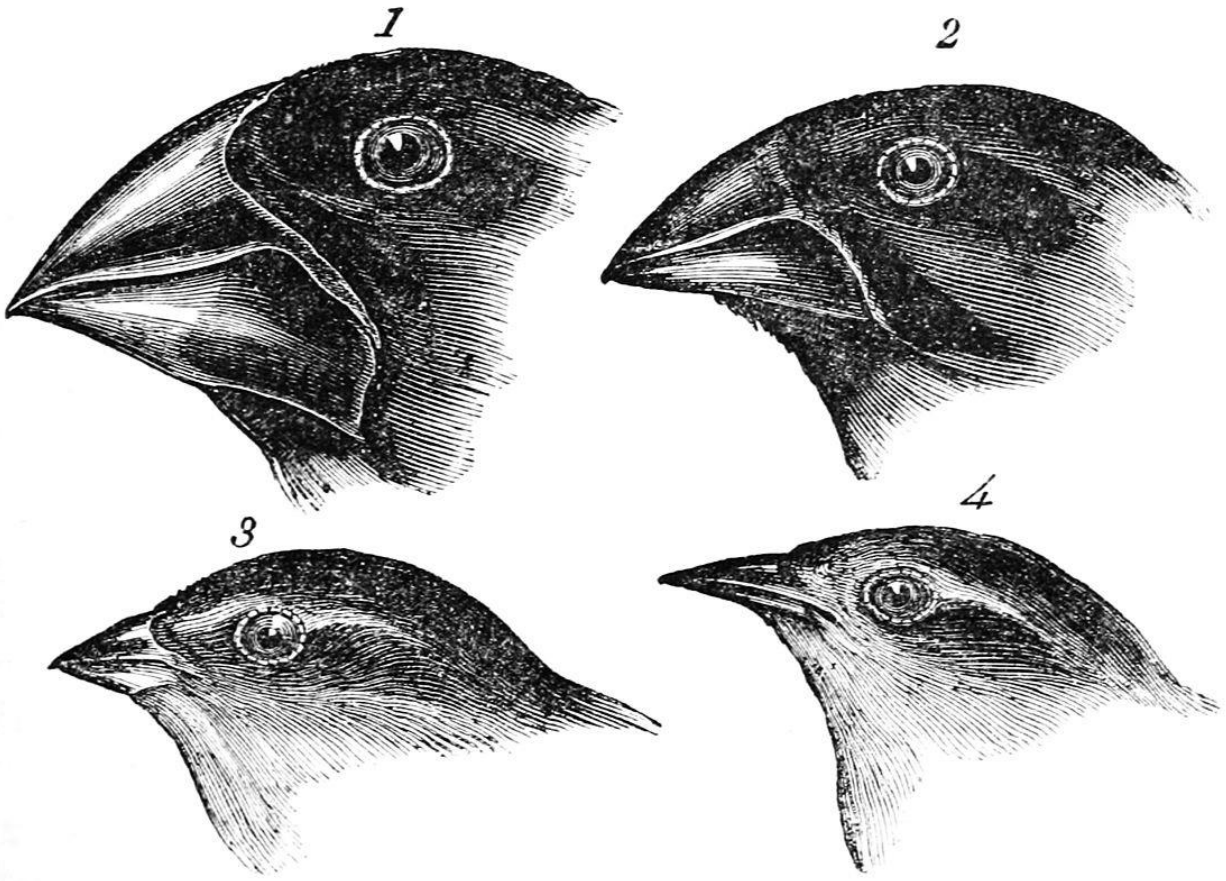
Charles Darwin observed a group of small sparrow-like black birds with strong, short beaks that are known today as Darwin's finches. These finches varied on different islands, but they were closely related to one another. He observed those finches and concluded that they came from an ancestral stock that had previously migrated from the mainland to the volcanic islands and had undergone profound changes under the different conditions of the individual island.

Here, let's look at the finches that he observed on the Galapagos islands that once inhabited the South American mainland.

These finches belong to the largest family of passerine birds called the Fringillidae. These birds show a remarkable diversification in their beak based on their chief food.

These finches evolved from a common ancestor to have different beaks well-suited for different types of food they feed on. Usually, **long and pointed** beaks are more fitted for seed and cactus feeders. Even some **short-beaked** finches tear up the base of the cactus and feed on its pulp. Most finches that feed on seeds on the ground (ground finches) have **short and stout** beaks. **Slender and sharp** beaks are common in insect-eating finches. This adaptation helps them occupy and survive in different niches. Most of them evolved from regular seed-eating finches to insectivorous and plant-eating finches. The process by which they successfully evolved and radiated to different habitats is termed as **adaptive radiation**.

Darwin speculated that these sparrow-like birds came to the Galapagos by the wind. Thereafter, evolution took place, leading to different groups based on their different diets. At present, these finches are considered as emblems of evolution.



1. Geospiza magnirostris.
2. Geospiza fortis.
3. Geospiza parvula.
4. Certhidea olivacea.