Western Cape Government
Education

Directorate: Curriculum FET

LIFE SCIENCES

GRADE 12

TELEMATICS INTERACTIVE TEACHING AND LEARNING

APRIL TO SEPTEMBER 2015

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LIFE SCIENCES PROGRAMME FOR GRADE 12

Date	Time	Topics
Thursday 30 April 2015	15:00 – 16:00	Hypothesis testing • Variables • Validity / Reliability
Wednesday 17 June 2015	15:00 – 16:00	Genetic crossings
Monday 3 August 2015	15:00 – 16:00	Sense organs
Monday 7 September 2015	15:00 – 16:00	Human evolution

Hypothesis testing

Teachers in Grades 10, 11 and 12 must ensure that their SBA tasks include an investigation in which skill 7 is emphasised. Special attention should be paid to the following:

- the stating of a hypothesis;
- dependent and independent variables;
- precautionary measures;
- reliability; and
- validity.

What is a hypothesis?

A hypothesis is an attempt to explain some event or observation using whatever information is currently available.

How to state a hypothesis

A hypothesis must:

(a) have two variables (dependent and independent variables);
(b) state the relationship between the two variables;
(c) be testable; and
(d) state the independent variable first (cause) and then the dependent variable (effect).

An example of a hypothesis question is as follows:

The peppered-moth, *Biston betularia*, has two phenotypes for body colour, dark (blackish) and pale (whitish). The trunks of the trees on which the moths rest are black in polluted environments compared to the white trunks of trees in unpolluted environments. In both unpolluted and polluted environments, birds are the predators of the moths. An investigation was carried out to determine the number of dark and pale peppered moths present in polluted and unpolluted environments, using a sampling technique.

Formulate a hypothesis for the above investigation.

More √/fewer dark peppered moths √/ pale peppered moths survive in the polluted √/unpolluted environment

OR

No difference √ in the number of dark √ / pale peppered moths that survive in both √ environments

Teachers need to teach learners to differentiate between validity and reliability in scientific investigations, because the principles of validity and reliability are fundamental cornerstones of the scientific method.

What is reliability?

- The idea behind reliability is that any significant results of an investigation must be more than a once-off finding and be repeatable.
- Other researchers must be able to perform exactly the same experiment, under the same conditions, and generate the same results.
- This would reinforce the findings of the experiment and ensure that the wider scientific community accepts the hypothesis.
- For the questions which required learners to state how the **reliability** of the investigation could have been improved, the following answers apply: Repeat the investigation OR Increase the sample size.

What is validity?

- Validity questions show how the experiment/investigation was carried out. It is important to be sure that all the factors/variables have been controlled/fixed except the variable/factor being tested.
- The samples must be chosen randomly.
- The design for the investigation must be appropriate.
- Validity therefore speaks to whether the scientific research method was used with the appropriate degree of care and diligence.
- In questions which require learners to suggest some factors that might have decreased the validity of an investigation, the answers should centre on the criticism of the scientific process; for example, some factors/variables that were not fixed/controlled when carrying out the investigation.

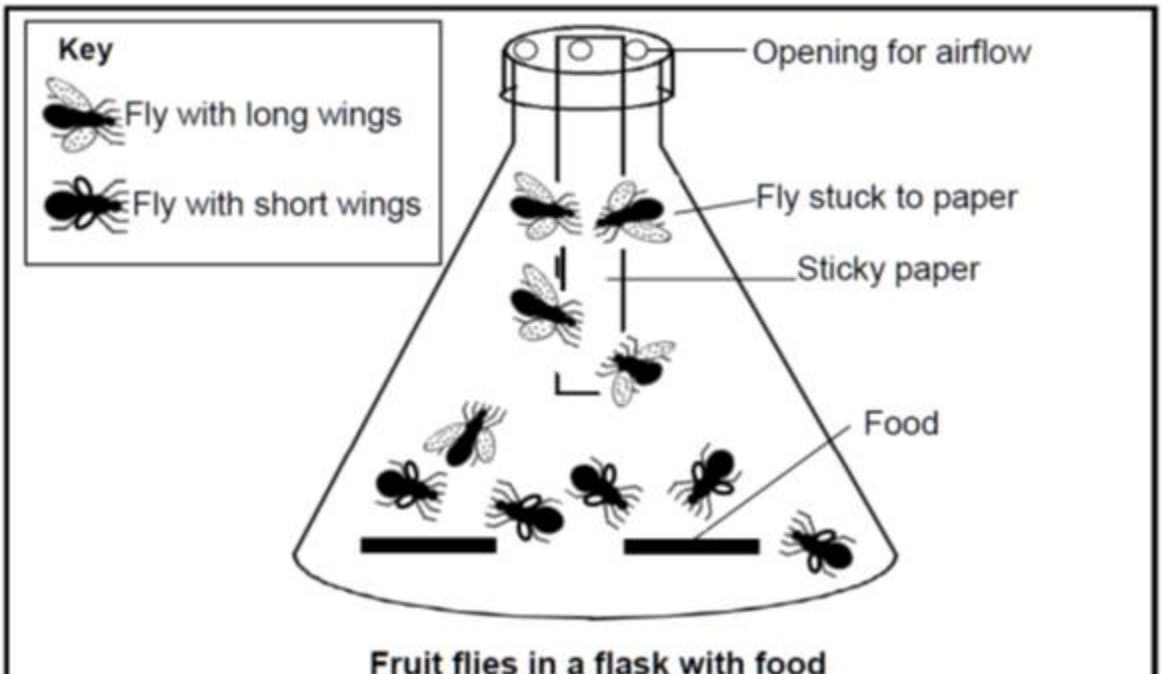
Example of a question

There is variation in the wing length of fruit flies (*Drosophila melanogaster*).
Some have long wings and can fly while others have short wings and cannot fly.
An investigation was conducted to determine which flies would survive under certain conditions.

The following steps were carried out:

1. Five flies with short wings and five flies with long wings were placed in a flask.
2. Food was placed at the bottom of the flask.
3. The lid of the flask allowed airflow.
4. Sticky paper was suspended from the top of the flask. Flies that got stuck to the paper died.
5. The apparatus was left for 24 hours.

The results of the investigation are shown in the diagram below.



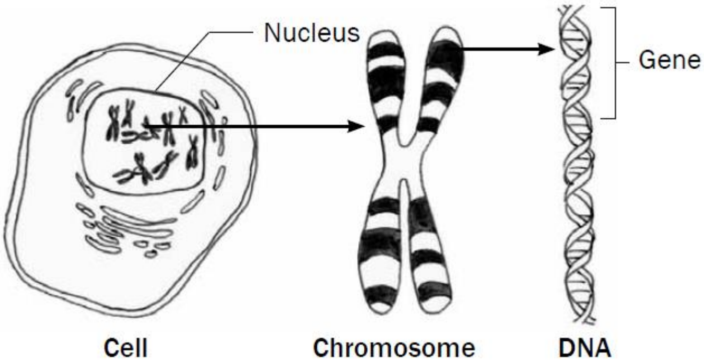
Fruit flies in a flask with food

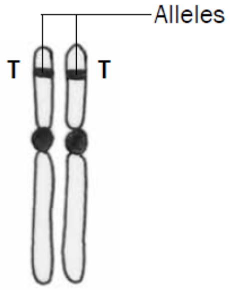
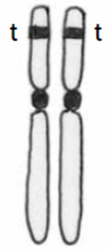
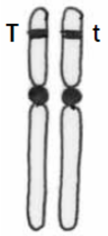
[Adapted from *Biology: Investigate Life on Earth* – Vernon L Avila, 1995]

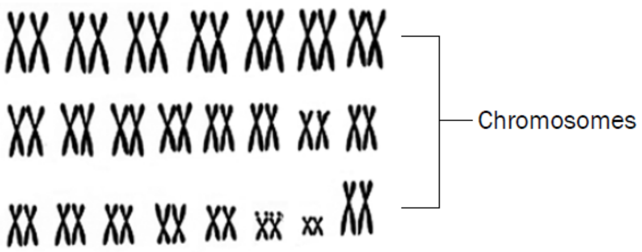
1 Formulate a hypothesis for the investigation. (3)
2 Explain why it is necessary to have openings for airflow. (3)
3 State TWO ways in which the reliability of the investigation could be improved. (3)
4 Other than the opening for airflow, explain TWO other precautions that should be taken in this investigation. (4)

GENETIC CROSSINGS

Key concepts

Term	Explanation	Diagram/Additional notes
Gene	A small portion of DNA coding for a particular characteristic.	

<table>
<tr><td>Alleles</td><td>Different forms of a gene which occur at the same locus (position) on homologous chromosomes.</td><td rowspan="7">Dominant allele (T) – tall plant
Recessive allele (t) – short plant

• Homozygous dominant (both alleles are dominant)
• Genotype TT
• Phenotype – tall

• Homozygous recessive (both alleles are recessive)
• Genotype tt
• Phenotype – short

• Heterozygous (one dominant and one recessive allele)
• Genotype Tt
• Phenotype – tall</td></tr>
<tr><td>Genotype</td><td>Genetic composition (make-up) of an organism.</td></tr>
<tr><td>Phenotype</td><td>The physical appearance of an organism determined by the genotype, e.g. tall, short.</td></tr>
<tr><td>Dominant allele</td><td>An allele that is expressed (shown) in the phenotype when found in the heterozygous (Tt) and homozygous (TT) condition.</td></tr>
<tr><td>Recessive allele</td><td>An allele that is masked (not shown) in the phenotype when found in the heterozygous (Tt) condition. It is only expressed in the homozygous (tt) condition.</td></tr>
<tr><td>Heterozygous</td><td>Two different alleles for a particular characteristic, e.g. Tt.</td></tr>
<tr><td>Homozygous</td><td>Two identical alleles for a particular characteristic, e.g. TT or tt.</td></tr>
</table>

Term	Explanation	Diagram/Additional notes
Monohybrid cross	Only one characteristic or trait is being shown in the genetic cross.	*Example*: Flower colour only, e.g. yellow flower or white flower **OR** shape of seeds only, e.g. round seeds or wrinkled seeds.
Complete dominance	A genetic cross where the dominant allele masks (blocks) the expression of a recessive allele in the heterozygous condition.	In this type of cross the allele for tall (T) is dominant over the allele for short (t). The offspring will therefore **be tall** because the dominant allele (T) masks the expression of the recessive allele (t). Tall (TT) × short (tt) Tall (Tt)
Incomplete dominance	A genetic cross between two phenotypically different parents produces offspring different from both parents but with an intermediate phenotype.	*Example:* If a red-flowered plant is crossed with a white-flowered plant and there is incomplete dominance – the offspring will have **pink flowers (intermediate colour).** Red flower – White flower Pink flowers
Co-dominance	A genetic cross in which both alleles are expressed equally in the phenotype.	*Example:* If a red-flowered plant is crossed with a white-flowered plant and there is co-dominance the offspring has **flowers with red and white patches.** Red flower × White flower Flowers with red and white patches
Multiple alleles	More than two alternative forms of a gene at the same locus.	*Example:* Blood groups are controlled by three alleles, namely I^A, I^B and i.
Sex-linked characteristics	Characteristics or traits that are carried on the sex chromosomes.	*Examples:* Haemophilia and colour-blindness The alleles for haemophilia (or colour-blindness) are indicated as superscripts on the sex chromosomes, e.g. X^HX^H (normal female), X^HX^h (normal female), X^hX^h (female with haemophilia), X^HY (normal male), X^hY (male with haemophilia).
Karyotype	The number, shape and arrangement of all the chromosomes in the nucleus of a somatic cell.	
Cloning	Process by which genetically identical organisms are formed using biotechnology.	*Example:* Dolly the sheep was cloned using a diploid cell from one parent; therefore it had the identical genetic material of that parent.
Genetic modification	The manipulation of the genetic material of an organism to get desired changes.	*Example:* The insertion of human insulin gene in plasmid of bacteria so that the bacteria produce human insulin.
Human genome	The mapping of the exact position of all the genes in all the chromosomes of a human.	*Example:* Gene number 3 on chromosome number 4 is responsible for a particular characteristic.

GENETIC CROSSING TEMPLATE

Use the following genetic **problem format or template** to solve all monohybrid genetic problems:

	P_1	Phenotype	× ✓
		Genotype	× ✓
		Meiosis	
✓	✓	**Gametes**	× ✓
		Fertilisation	
	F_1	Genotype	✓
		Phenotype	✓

OR

Gametes		

1 mark for correct gametes
1 mark for correct genotypes

[6]

Example (Study the question and the steps on the next page)

Solution to genetic problem 1

	P_1	Phenotype	Tongue-roller	×	Non-tongue-roller✓	......**Step 1**
		Genotype	Tt	×	tt✓	..................**Step 2**
		Meiosis				
✓	✓	**Gametes**	T and t	×	t ✓	..................**Step 3**
		Fertilisation				..................**Step 4**
	F_1	Genotype	Tt		tt ✓	................**Step 4**
		Phenotype	Tongue-roller		Non-tongue-roller✓	.... **Step 5**

(Max 6 marks)

e.g. Genetic problem 1

In humans the ability to roll the tongue is due to a dominant allele. A man who is heterozygous for tongue-rolling and a woman who cannot roll her tongue have children. Use the symbols **T** and **t** for the alleles of the tongue-rolling characteristic and represent a genetic cross to determine the possible genotypes and phenotypes of the children. **(6)**

Read the problem carefully and note the following steps:

- Identify the **phenotypes** of the man and the woman (**parents/P$_1$**), i.e. the man is a tongue-roller and the woman is a non-tongue-roller. ....**Step 1**
- Identify the **genotypes** of the two parents, i.e. the man is **heterozygous** (Tt) and the woman can only be a non-tongue-roller if she is **homozygous recessive** for this characteristic, i.e. she must have the genotype (tt) .... **Step 2**
- The next step is to show how the alleles are separated through the process of **meiosis** into separate **gametes**, i.e. in the man the gametes (sperm) will contain either the 'T' allele or the 't' allele. In the woman the egg can only contain the 't' allele.................**Step 3**
- The next step shows that **fertilisation** takes place. Indicate all possible combinations of how sperm cells fuse with a possible egg cell to show the possible **genotypes** of the **F$_1$ generation** that could arise ....**Step 4**
- Interpret the **phenotypes** of all the possible genotypes from the cross ....**Step 5**

Inheritance of sex-linked characteristics

Sex-linked characteristics are characteristics (traits) that are carried on the sex chromosomes.

Example of question

Haemophilia is a sex-linked hereditary disease that occurs as a result of a recessive allele on the X-chromosome (X^h). A normal father and heterozygous normal mother have children. Represent a genetic cross to determine the possible genotypes and phenotypes of their children.

The alleles for haemophilia are indicated as **superscripts** on the sex chromosomes, e.g. X^HX^H (normal female), X^HX^h (carrier/heterozygous normal female), X^hX^h (female with haemophilia), X^HY (normal male), X^hY (male with haemophilia).

Solution to the problem

P_1	Phenotype	normal father	x	heterozygous/carrier normal mother✓	.... **Step 1**
	Genotype	X^HY	x	X^HX^h ✓	.... **Step 2**
	Meiosis				
✓ ✓	**Gametes**	X^H and Y	x	X^H and X^h✓	.... **Step 3**
	Fertilisation				.... **Step 4**
F_1	Genotype	$X^H X^H$, $X^H X^h$,		$X^H Y$, $X^h Y$✓	...... **Step 4**
	Phenotype	2 normal daughters		1 normal son, 1 son with haemophilia✓	**Step 5**

DIHYBRID CROSS

- A dihybrid cross involves the inheritance of two characteristics. Mendel explained the results obtained from dihybrid crosses according to his Law of Independent assortment.
- According to the Law of Independent Assortment, alleles of a gene for one characteristic segregate independently of the alleles of a gene for another characteristic. The alleles for the two genes will therefore come together randomly during gamete formation.
- This means that the two characteristics are transmitted to the offspring independently of one another.
- The above law only applies if the genes for the two characteristics are not on the same chromosome.

Example of a dihybrid crossing question

In pea plants, the allele for tallness (T) is dominant and the allele for shortness (t) is recessive. The allele for purple flowers is dominant (P) and the allele for white flowers is recessive (p). Two plants, heterozygous for both tallness and purple flowers, were crossed.

Steps you should follow in working out a dihybrid cross:

STEP	What to do generally	What to do in this problem
Step 1	Identify the phenotypes of the two plants for each of the two characteristics.	According to the statement of the problem, both parents are tall and have purple flowers.
Step 2	Choose letters to represent the alleles for the gene responsible for each characteristic.	Use the letters, e.g. **T** for tall, **t** for short, **P** for purple, and **p** for white as provided in the question.
Step 3	Write the genotypes of each parent.	According to the statement of the problem, both parents are heterozygous for each characteristic. Their genotype will therefore be **TtPp**.

Step 4	• Determine the possible gametes that each parent can produce. • Remember that each parent will have two alleles for each gene. • The gametes of each parent will have only one allele for each gene because of segregation during meiosis. • Remember that because of the principle of independent assortment an allele for one gene could appear in the same gamete with any of the alleles for the other gene.	• Each parent has the genotype TtPp. • If we represent the alleles for each gene in the following format, then we can see how these alleles could come together randomly (principle of independent assortment) to form the four types of gametes: TP; Tp; tP and tp as shown below.
Step 5	Enter the possible gametes at the top and side of a Punnett square.	Please refer to the solution that follows.
Step 6	• Because of random fertilisation, gametes from both parents could fuse in different combinations to form the offspring. • In the punnet square, write down the genotypes of the offspring that will result from each possible combination of gametes.	Please refer to the solution that follows.
Step 7	Determine the phenotypes of the offspring from the genotypes obtained in the punnet square.	Please refer to the solution that follows.

Alleles	T	t
P	**TP**	**tP**
p	**Tp**	**tp**

Solution to the problem

P_1 Phenotype Tall, Purple × Tall, Purple .... **Step 1**

Genotype TtPp × TtPp .... **Step 2,3**

Meiosis and Fertilisation

gametes	**TP**	**Tp**	**tP**	**tp**
TP	TTPP	TTPp	TtPP	TtPp
Tp	TTPp	TTpp	TtPp	Ttpp
tP	TtPP	TtPp	ttPP	ttPp
tp	TtPp	Ttpp	ttPp	ttpp

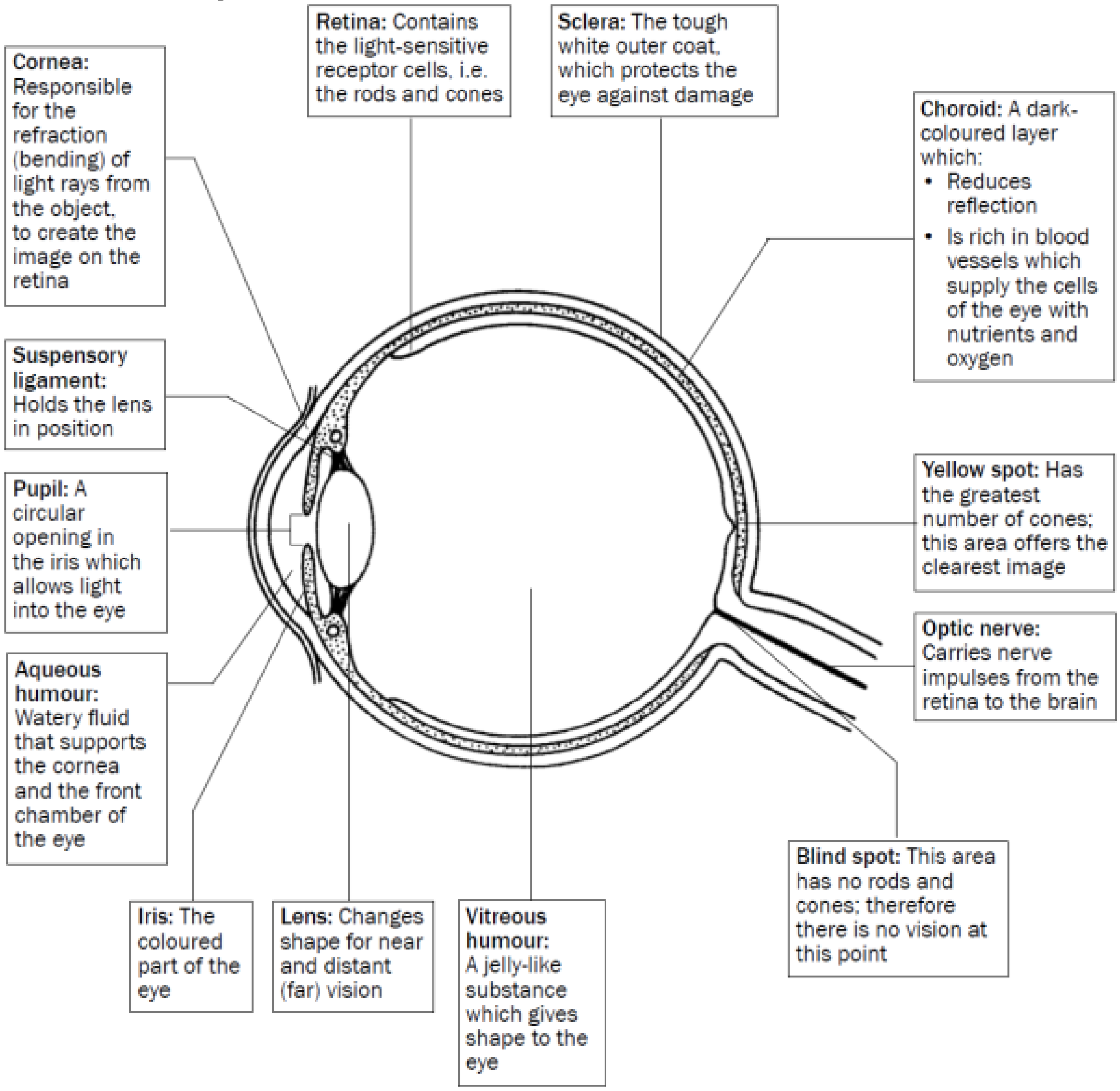
Steps 4-6

F_1 Genotype 9 different genotypes, as in the table above

Phenotype 9 tall, purple flowered plants (T–P–);
3 short, purple flowered plants (ttP–);
3 tall, white flowered plants (T–pp), and
1 short, white flowered plant (ttpp)......... **Step 7**

SENSE ORGANS

Structure of the eye



Eye accommodation

Distant vision (objects further than 6 m)	Near vision (objects closer than 6 m)
1. Ciliary muscles relax	1. Ciliary muscles contract
2. Suspensory ligaments tighten (become taut)	2. Suspensory ligaments slacken
3. Tension on **lens** increases	3. Tension on **lens** decreases
4. **Lens** is less convex (flatter)	4. **Lens** becomes more convex (more rounded)
5. Light rays are refracted (bent) less	5. Light rays are refracted (bent) more
6. Light rays are focused onto the retina	6. Light rays are focused onto the retina

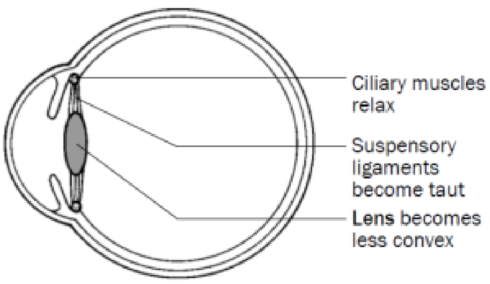


Figure 6.8 Distant vision

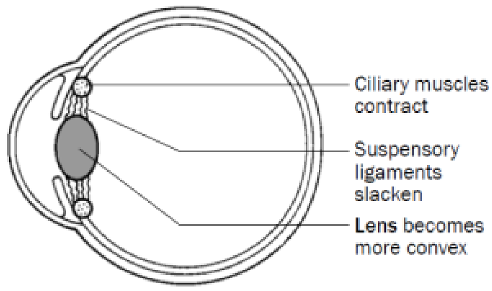
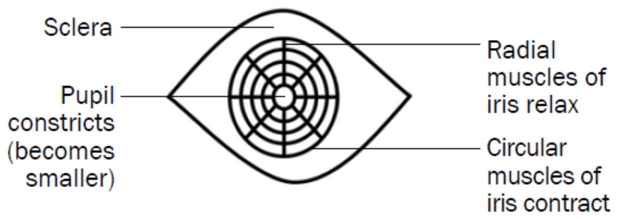


Figure 6.9 Near vision

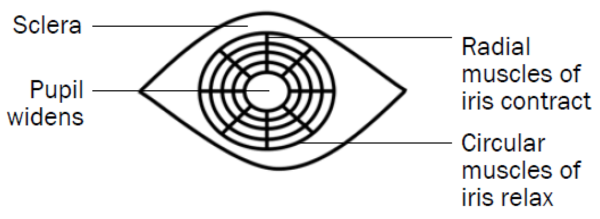
Please turn over

Pupillary mechanism

Light is bright	Light is dim
1. Radial muscles of the iris relax	1. Radial muscles of the iris contract
2. Circular muscles of the iris contract	2. Circular muscles of the iris relax
3. Pupil constricts (gets smaller)	3. Pupil widens (gets bigger)
4. Less light enters the eye	4. More light enters the eye

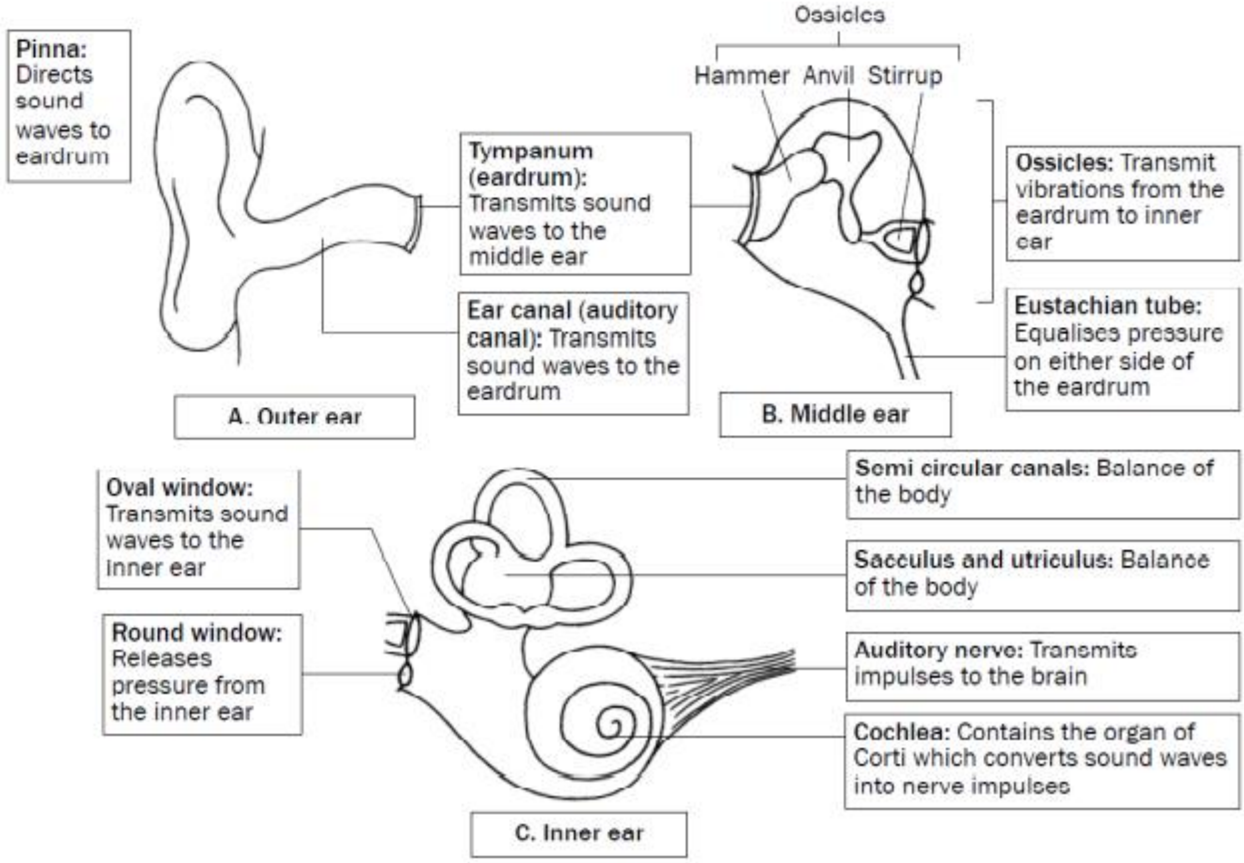


The pupil in bright light



The pupil in dim light

Structure and functions of the ear



Part of ear	What it does during the hearing process
Pinna	Traps the sound waves and directs them into the auditory canal.
Tympanic membrane	Vibrates and transmits the vibrations to the ossicles in the middle ear.
Ossicles	The ossicles amplify the vibrations and carry them via the middle ear to the membrane of the oval window.

Oval window	Vibrates and causes pressure waves in the inner ear.
Cochlea	These vibrations cause the sensory cells in the organ of Corti to be stimulated in the cochlea and nerve impulses are generated.
Auditory nerve	Transmits nerve impulses to the cerebrum to be interpreted.

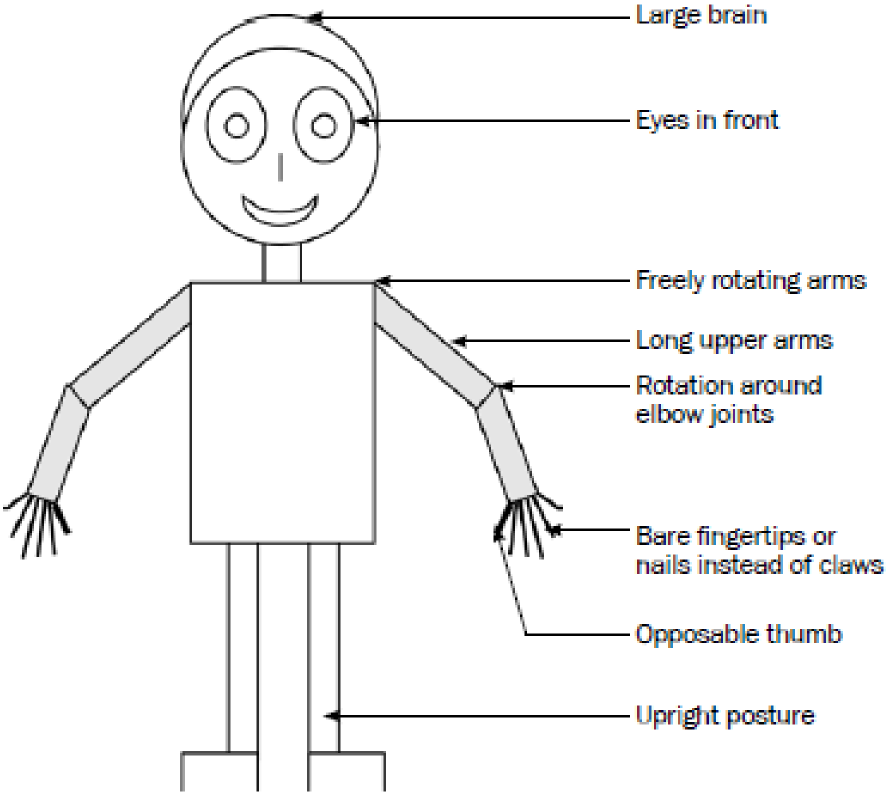
Balance

1. The cristae in the semicircular canals are stimulated by changes in the direction and speed of movement
2. The maculae in the sacculus and utriculus are stimulated by changes in the position of the head

When stimulated, the cristae and maculae convert the stimuli received into nerve impulses. The nerve impulses are transported along the auditory nerve to the cerebellum to be interpreted. The cerebellum then sends impulses to the muscles to restore balance.

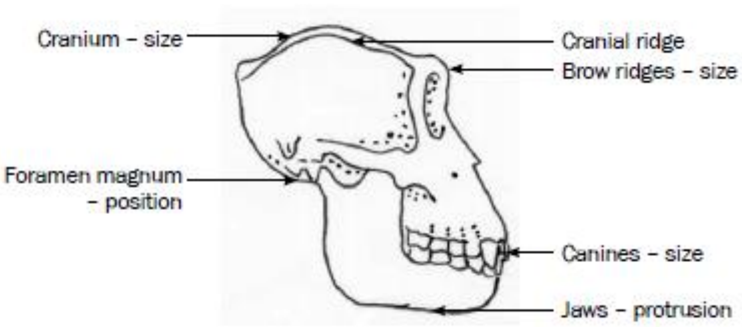
HUMAN EVOLUTION

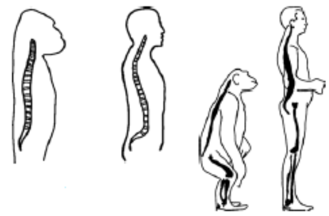
Diagram below shows characteristics of humans that are **similar** to that of African apes.



The table below illustrates the anatomic **differences** between Humans and African Apes

FEATURE	Humans (*Homo sapiens*)	African Apes
Cranium	Large cranium/brain	Small cranium/brain
Brow Ridges	Brow ridges are not well developed	Brow ridges well developed
Spine	More curved spine (S-shaped spine)	Less curved spine (C-shaped spine)
Pelvic girdle	Short, wide pelvis	Long, narrow pelvis
Canines	Small canines	Large canines
Palate shape	Small and semi-circular	Long and rectangular
Jaws	• Small jaws • Less protruding jaws/less-prognathous	• Large jaws • More protruding jaws/more prognathous
Cranial ridges	No cranial ridge	Cranial ridge across the top of the cranium
Foramen Magnum	Foramen magnum in a forward position	Foramen magnum in a backward position





Out of Africa hypothesis

The 'Out of Africa' hypothesis states that modern humans originated in Africa and then migrated out of Africa to the other continents.
The following lines of evidence have been used to support this hypothesis:

- The oldest fossils of australopithecines/*Homo habilis*/bipedal organisms have been found in Africa.
- The oldest fossils of *Homo erectus* have been found in Africa.
- Analysis of mutations in mitochondrial DNA shows that the oldest female ancestors of humans are from Africa.

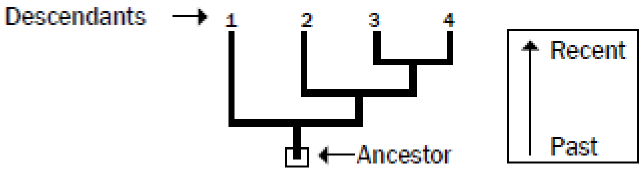
Phylogenetic trees

A phylogenetic tree (or evolutionary tree) represents the possible evolutionary relationships among a set of organisms or groups of organisms. The tips of the tree represent descendants (often species) and the points where the tree branches represent the common ancestors of those descendants.

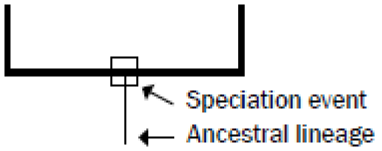
Interpreting a Phylogenetic tree

Hints on interpreting phylogenetic trees

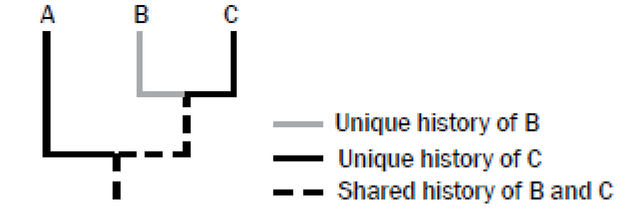
Reading a phylogenetic tree is similar to understanding a family tree. The root of the tree represents the **ancestor** and the tips of the branches represent the **descendants** of that ancestor. As you move from the root of the tree to its tips, you are moving forward in time.



When speciation occurs, it is represented as branching on the tree.
A single ancestral lineage gives rise to two or more daughter lineages.



Each lineage has a part of its history that is unique and parts that are shared with other lineages.



Similarly, each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.