Western Cape Government
Education

Directorate: Curriculum FET

TELEMATICS 2016

LIFE SCIENCES
Grade 12

LIFE SCIENCES PROGRAMME FOR GRADE 12

Date	Time	Topics
Tuesday 16 February 2016	15:00 – 16:00	Protein synthesis
Wednesday 09 March 2016	15:00 – 16:00	Meiosis and abnormal meiosis
Tuesday 05 April 2016	15:00 – 16:00	Genetics – genetic crosses
Wednesday 11 May 2016	15:00 – 16:00	Evolution: natural selection, punctuated equilibrium and speciation
Thursday 21 July 2016	15:00 – 16:00	Human Evolution
Tuesday 06 September 2016	15:00 – 16:00	Sense organs and homeostasis

INTRODUCTION

Life Sciences is the scientific study of living things from molecular level to their interactions with one another and their environments. To be successful in the subject you need to understand the processes of scientific inquiry, problem-solving, critical thinking and applying your knowledge. To assist you in developing these skills in preparation for your examinations, the telematics platform will allow you an opportunity to interact with expert teachers in a stimulating and fully interactive virtual learning space.

This Life Sciences telematics resource provides you with:

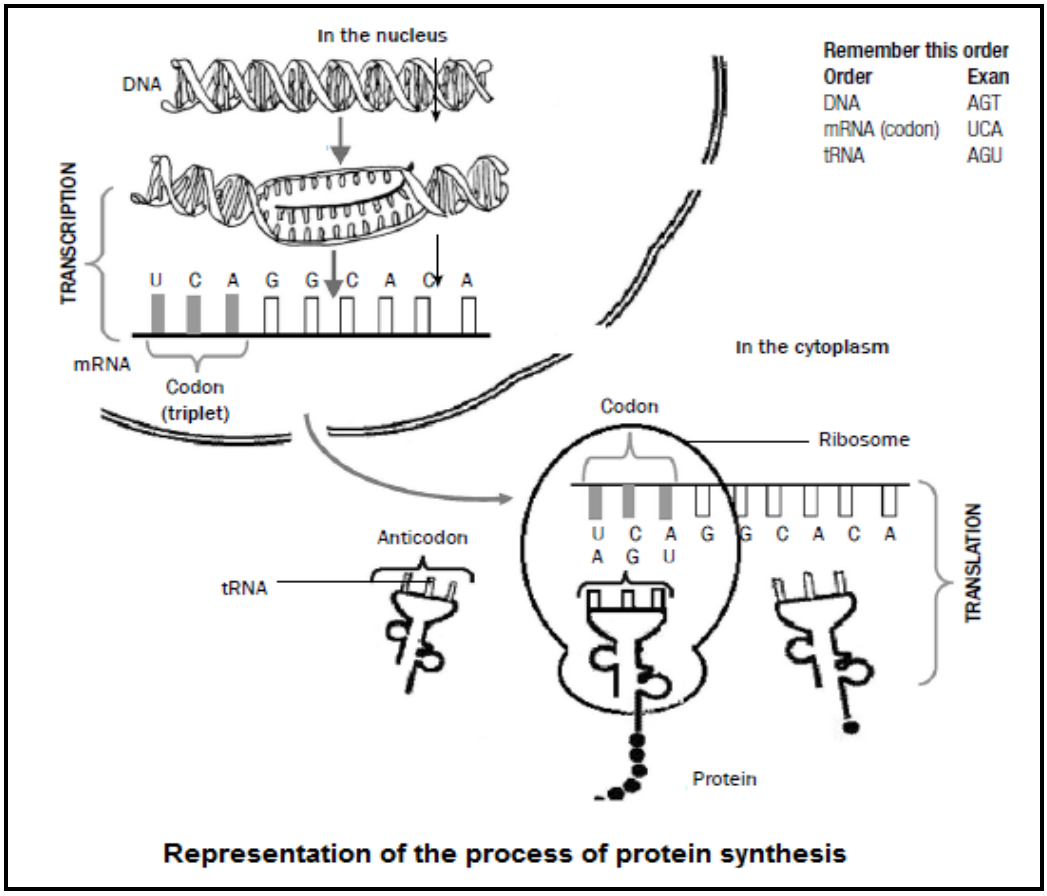
- Key summaries including diagrams of some of the content areas which were identified as challenging in the final examination of 2014.
- Sample questions and answers that will assist you in answering different types of questions.

Life Sciences learners are expected to bring the following to each session:

- A Life Sciences textbook
- Mind the Gap Study Guide (2015)
- National Examination Guideline document for Life Sciences
- Notebook, pen and pencil
- Non-programmable calculator, protractor and compass for possible calculations, drawing of graphs and diagrams.

PROTEIN SYNTHESIS (Tuesday 16 February 2016)

Protein synthesis is the process whereby proteins are made in living cells of an organism to form enzymes, hormones and new structures for cells. **Amino acids** are the basic building blocks of proteins. The nucleic acids DNA and RNA are involved in protein synthesis. The main steps of protein synthesis are **transcription** and **translation.**



Representation of the process of protein synthesis

Transcription (takes place in the nucleus of a cell)

- Double stranded DNA unwinds and unzips
- Weak hydrogen bonds break
- One strand is used as a template
- to form a complementary mRNA strand
- using free RNA nucleotides from the nucleoplasm
- mRNA now has the coded message for protein synthesis

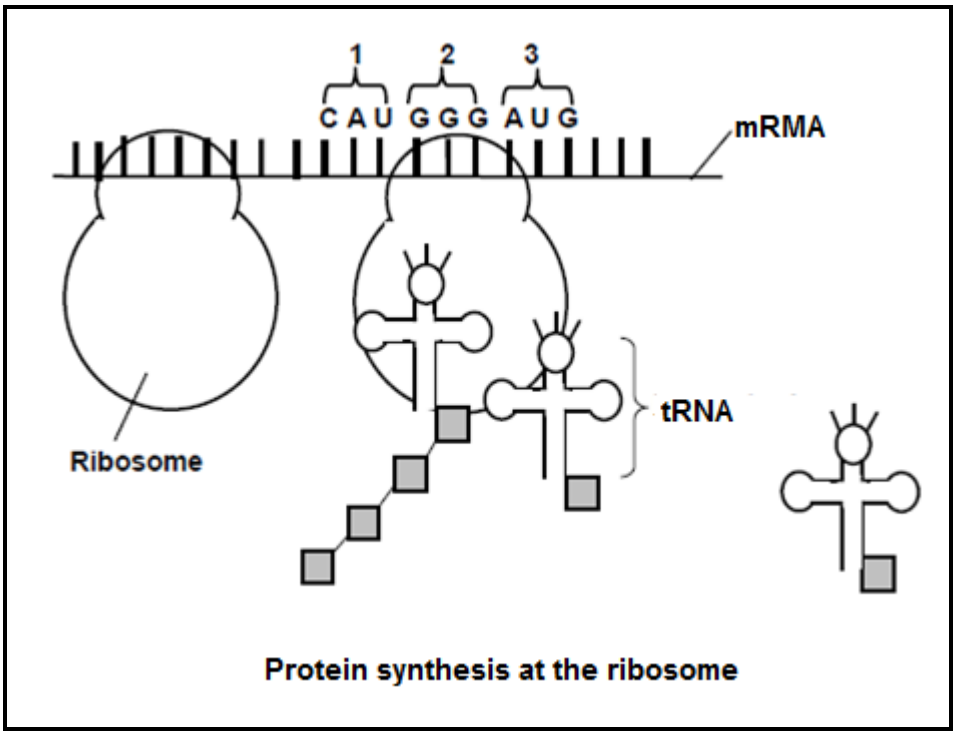
- mRNA leaves the nucleus through the nuclear pores to the cytoplasm and attaches to the ribosome

Translation (takes **place in the cytoplasm at the ribosome)**

- According to the codons on the mRNA
- tRNA with matching/complementary anticodons
- bring the required amino acids to the ribosome
- Amino acids become are joined by peptide bonds
- to form the required protein.

An example of a question on protein synthesis:

1.1 The diagram below shows a part of the process of protein synthesis:



Protein synthesis at the ribosome

1.1.1 Identify the stage of protein synthesis that is shown in the diagram above. (1)

1.1.2 Describe how a mutation on the DNA molecule (not shown in diagram) will affect the structure of the protein formed by the stage illustrated above. (4)

1.1.3 The table below shows the DNA base triplets that code for different amino acids found in human proteins

AMINO ACID	BASE TRIPLET IN DNA
Leucine	GAA
Proline	GGG
Lycine	TTT
Histidine	GTA
Serine	TCA
Methionine	TAC
Glycine	CCC
Glutamine	GTC

Using the information in the table and diagram above, write down the sequence of the amino acids that correspond with structures 1,2 and 3. (3)

Possible answers:

1.1.1 Translation✓

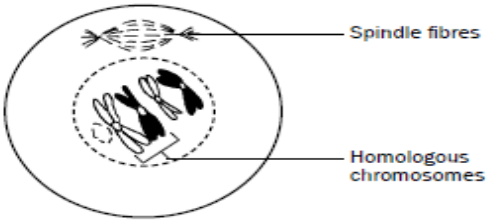
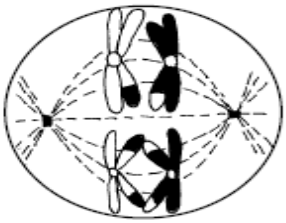
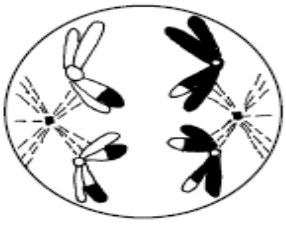
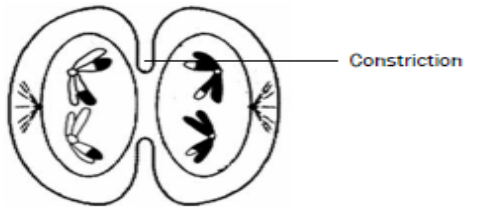
1.1.2 The sequence of nitrogen bases on the DNA molecule will change✓
This would cause a corresponding change on mRNA✓
The amino acid brought in by tRNA will be different✓
A different protein will form✓

1.1.3 Histidine✓, Glycine✓, Methionine✓ **(correct sequence)**

MEIOSIS INCLUDING ABNORMAL MEIOSIS (Wednesday 09 March 2016)

Meiosis is a type of cell division whereby a diploid cell undergoes divisions to form haploid cells. It is a continuous process which is divided into the first meiotic division (Meiosis I) and the second meiotic division (meiosis II).

First meiotic division

 *Figure 2.2 Prophase 1*	*Prophase 1* • Chromosomes shorten and become visible as two chromatids joined by a centromere. • Homologous pairs of chromosomes are now visible. • The nuclear membrane and nucleolus disappear. • The spindle starts to form. • Chromatids from each homologous pair touch. The point where they touch is called a chiasma. • DNA is crossed over (swopped) at the chiasma. • The spindle continues to form.
 *Figure 2.3 Metaphase 1*	*Metaphase 1* • The spindle extends across the whole cell. • The homologous chromosomes line up along the equator of the spindle in their homologous pairs. • One chromosome of each pair lies on either side of the equator. • The centromere of each chromosome attaches to the spindle fibres.
 *Figure 2.4 Anaphase 1*	*Anaphase 1* • The spindle fibres shorten and pull each chromosome of each chromosome pair to opposite poles of the cell.
 *Figure 2.5 Telophase 1*	*Telophase 1* • The chromosomes reach the poles of the cell. • Each pole has half the number of chromosomes present in the original cell. • The cell membrane constricts and divides the cytoplasm in half to form two cells.

Second meiotic division

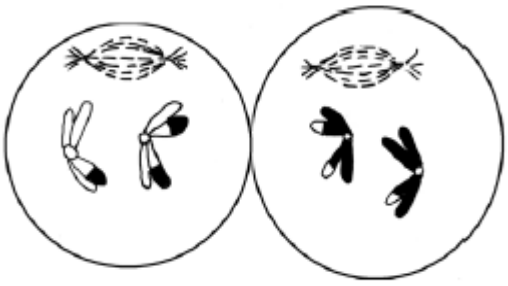


Figure 2.6 Prophase 2

Prophase 2

- Each cell formed during meiosis I now divides again.
- A spindle forms in each of the new cells.

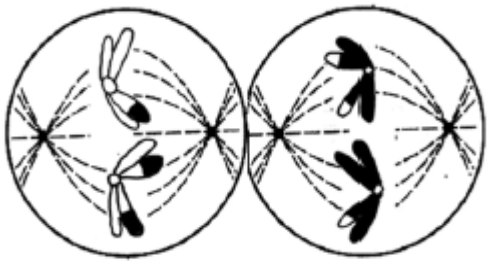


Figure 2.7 Metaphase 2

Metaphase 2

- Individual chromosomes line up at the equator of each cell, with the centromeres attached to the spindle fibres.

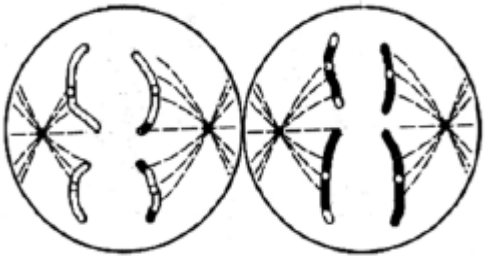


Figure 2.8 Anaphase 2

Anaphase 2

- The spindle fibres start to contract.
- The centromeres split and daughter chromosomes/ chromatids are pulled to the opposite poles of each cell.

Figure 2.9 Telophase 2

Telophase 2

- The daughter chromosomes/chromatids reach the poles and a new nucleus forms.
- The cell membrane of each cell constricts and the cytoplasm divides into two cells.
- Four haploid daughter cells are formed.
- Each daughter cell has half the number of chromosomes of the original cell.
- The daughter cells are genetically different from each other.

Abnormal meiosis:

- Mistakes can occur during meiosis
- During Anaphase I one or more homologous pairs of chromosomes may not separate. Also called non-disjunction
- During Anaphase II sister chromatids of one or more chromosomes may not separate
- If there is non-disjunction of chromosome pair 21 in humans it leads to the formation of an abnormal gamete with an extra copy of chromosome 21
- If a normal gamete fuses with a gamete with an extra copy of chromosome 21 the resulting zygote will have 3 copies of chromosome 21 (47 chromosomes instead of 46)
- This leads to Down syndrome.

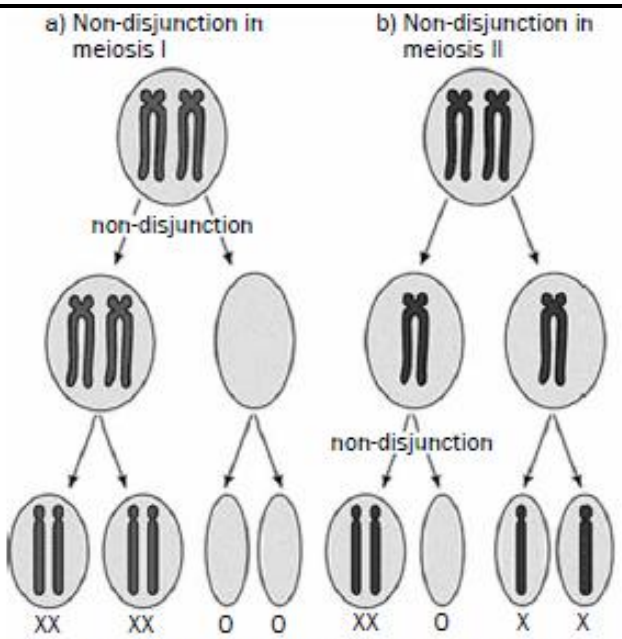


Figure 2.10 Non-disjunction meiosis I and meiosis II
XX : 2 chromosomes X : 1 chromosome O : no chromosomes

Examples of questions on meiosis:

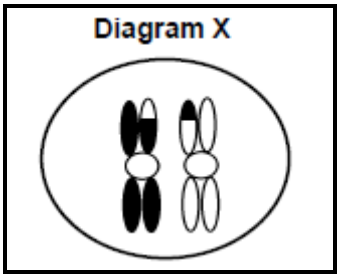
1.1 Describe how meiosis contributes to genetic variation.

Possible answer:

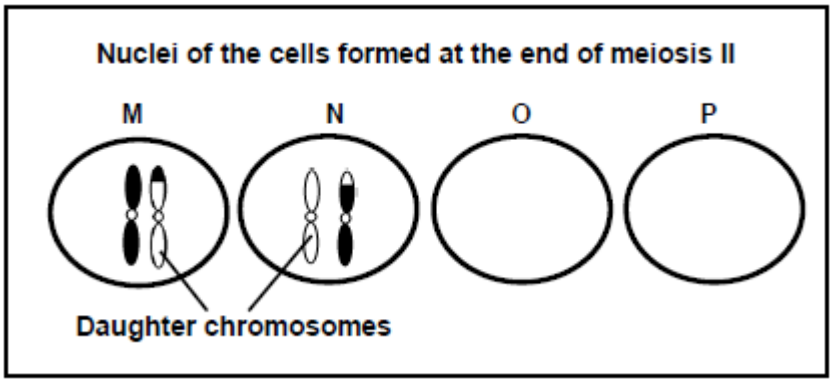
Crossing over✓ occurs during Prophase I✓. Homologous chromosomes/chromatids overlap at points called chiasmata/chiasma✓. Genetic material is exchanged resulting in new combinations of genetic material✓.

Random arrangement of chromosomes✓ occurs during metaphase✓. Chromosomes separate in a random/independent manner resulting in new combinations of genetic material✓.

1.2 The diagram below shows chromosome pair 21 in the nucleus of a cell of the ovary of a woman.



The diagram below shows the nuclei of four cells that resulted from meiosis involving the chromosomes in diagram X above.



1.2.1 Explain why nuclei O and P do NOT have chromosomes.
1.2.2 Name and explain the disorder that will result if diagram M represents an egg cell that fuses with a normal sperm cell.

Possible answers:

1.2.1 During meiosis the chromosome pair 21 does not separate✓/there is non-disjunction. Two gametes (M and N) will have an extra copy of chromosome number 21✓ and therefore the other gametes (O and P) do not have a copy of chromosome 21✓.

1.2.2 Down syndrome✓. If this gamete fuses with a normal sperm having 1 copy of chromosome 21✓ the resulting zygote will have 3 copies of chromosome number 21/47 chromosomes✓.

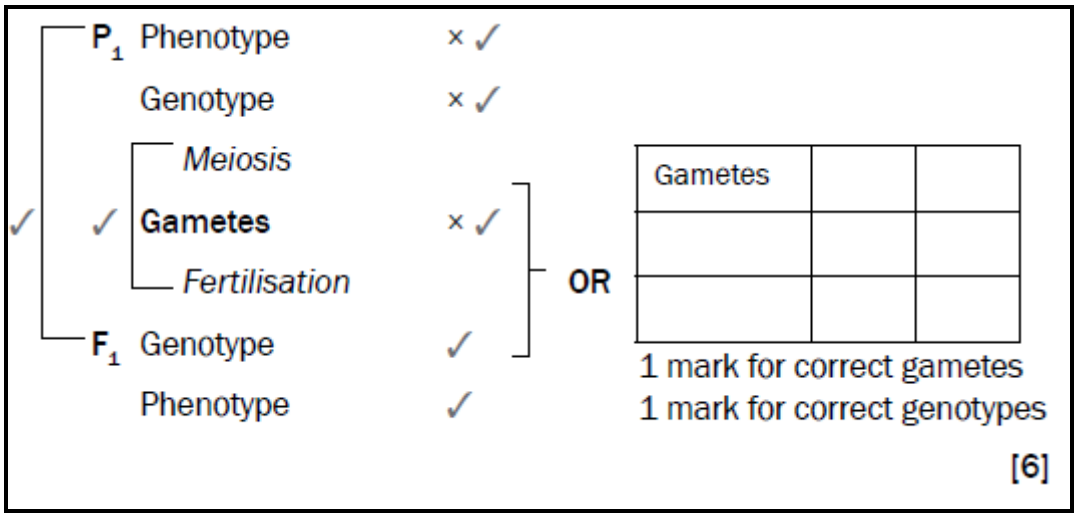
GENETICS (Tuesday 05 April 2016)

Genetic crosses (Monohybrid crosses)

A monohybrid cross involves the inheritance of **one characteristic.**

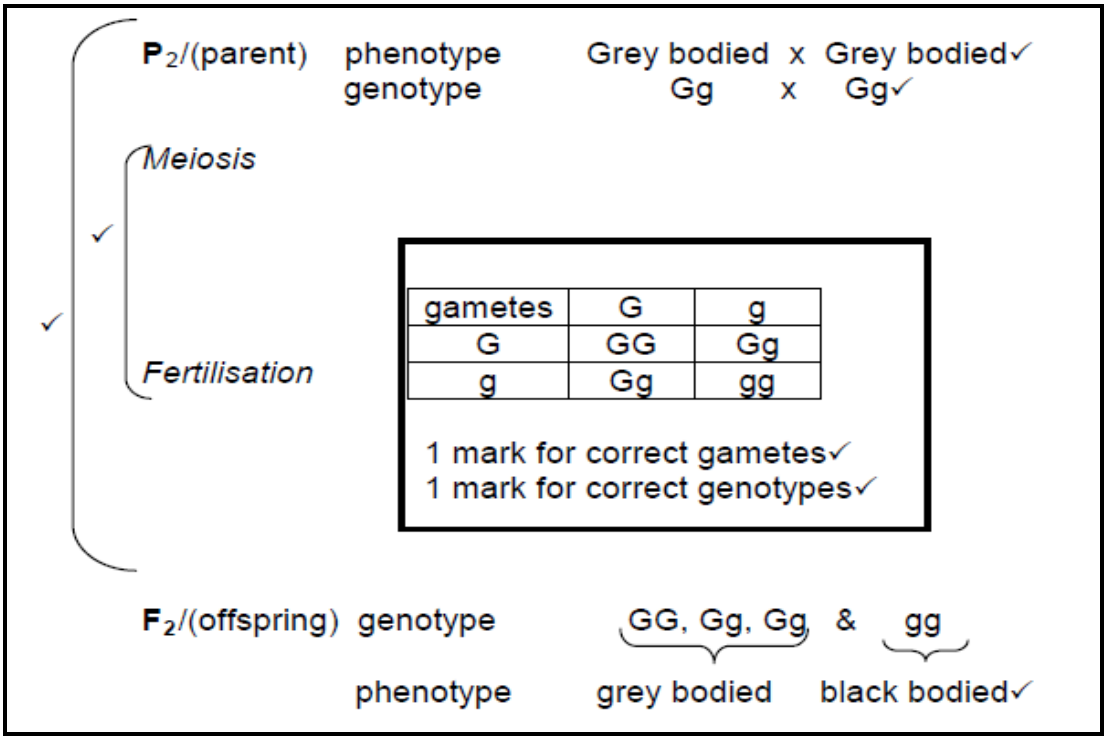
You need to be able to solve genetic cross problems involving **complete dominance, incomplete dominance, co-dominance, inheritance of sex, inheritance of blood groups, sex-linked characteristics.**

Use the following genetic problem format to solve genetic problems:



Example of questions on genetic crosses:

1.1 When flies with grey bodies were crossed with flies with black bodies all the offspring in the F_1 had grey bodies. Use the letters G and g to represent a genetic cross to show the F_2 genotypes and phenotypes if the F_1 were interbred.



1.2 Haemophilia is a **sex-linked disease** caused by the presence of a recessive allele (X^h). A normal father and heterozygous mother have children. Represent a genetic cross to determine the possible genotypes and phenotypes of the children of the parents.

		Father		Mother
P_1/parent	phenotype	Normal	x	Normal✓
	genotype	X^HY	x	X^HX^h ✓

Meiosis

G/gametes X^H , Y x X^H , X^h✓

Fertilisation **OR**

F_1/offspring $X^H X^H$, $X^H X^h$, $X^H Y$, $X^h Y$ ✓

Gametes	X^H	X^h
X^H	$X^H X^H$	$X^H X^h$
Y	X^HY	$X^h Y$

1 mark for correct gametes
1 mark for correct genotypes

2 normal daughters, 1 normal son, 1 son with haemophilia✓

P_1 and F_1/Parents and offspring✓

Meiosis and fertilisation✓

1.3 A man with **blood type** A married a woman with blood type B. They had three children with blood types O, B and AB. Show with a representation of a genetic cross the genotypes and phenotypes of the parents and children.

P_1 phenotype A group x B group✓
genotype $I^A i$ x $I^B i$✓

Meiosis

G I^A, i x I^B, i ✓

Fertilisation

F_1 genotype $I^A I^B$, I^B **i, ii,** (I^A i)✓

phenotype AB, B, O ✓ (A)

Parents and offspring✓/P_1 & F_1
Meiosis and fertilisation✓

Dyhibrid crosses

- 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.

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

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.

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**

Question on a dyhibrid cross:

In tomato plants the allele for red fruit **(R)** is dominant over the allele for yellow fruit **(r)**. The allele for tallness **(T)** is dominant over the allele for shortness **(t)**.

1.1 Plant **A**, which is heterozygous for red fruit and homozygous tall, was crossed with Plant **B**, which has yellow fruit and is short.

1.1.1 Write down the genotype of:

(a) Plant **A**

(b) Plant **B**

1.1.2 Write down ALL the possible genotypes of the gametes of plant **A**.

1.1.3 Name the phenotype of an offspring having the genotype:

(a) Rrtt

(b) RrTt

1.1.4 Plant **B** was then crossed with another plant (Plant **C**) and all the offspring had red fruit and were tall. Use this information to write down the genotype of Plant **C**.

Possible answer:

1.1.1
(a) RrTT✓

(b) rrtt✓

1.1.2 RT✓ rT✓

1.1.3
(a) Red fruit, short✓
(b) Red fruit, tall✓

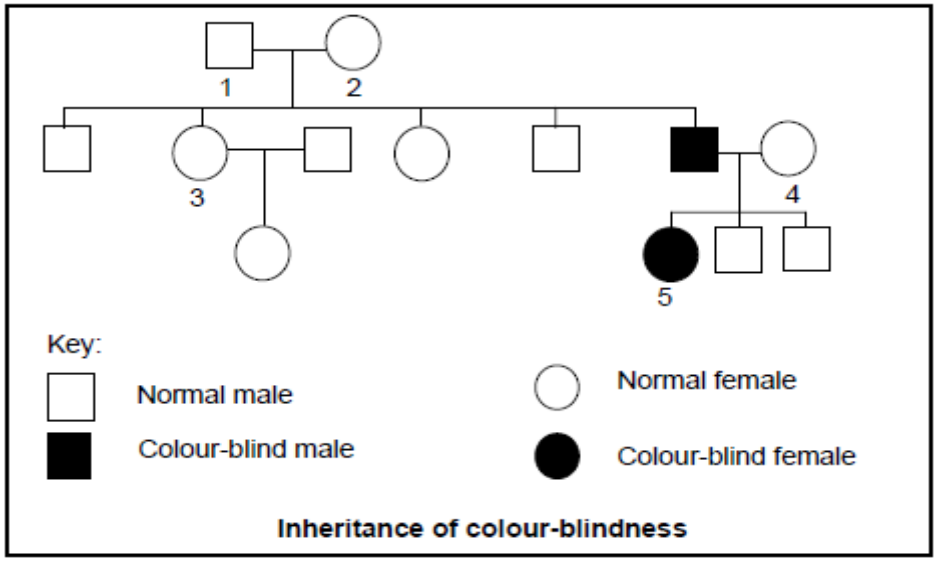
1.1.4 RRTT✓✓

Pedigree diagrams:

Remember the following steps when interpreting pedigree diagrams:

- Study any key and opening statement/s and look for dominant and recessive characteristics and phenotypes
- Write in the phenotypes of all the individuals as given in the problem
- Fill in the genotype of all the individuals with the recessive condition – it must have two recessive alleles e.g. ff
- For every individual that has the recessive condition it means that each allele was obtained from each of the parents. Work backwards and fill in one recessive allele for each parent
- If the parent showed the dominant characteristic, fill in the second letter which represents the dominant allele e.g. F
- Any other individual showing the dominant characteristic will most likely be homozygous dominant (FF) or heterozygous dominant (Ff)

1.1 The pedigree diagram below shows the inheritance of colour-blindness in a family. Colour-blindness is sex-linked and is caused by a recessive allele (d). The ability to see colour normally is caused by a dominant allele (D).



Inheritance of colour-blindness

1.1.1 How many of the male offspring of parents 1 and 2 were normal?

1.1.2 State the genotype of:
(a) Individual 2
(b) Individual 5

1.1.3 If individual 5 marries a normal male, what percentage of their daughters will have an allele for colour –blindness, but will not be colour-blind?

Possible answers:

1.1.1 2✓
1.1.2 (a) X^DX^d✓✓ (b) X^dX^d✓✓
1.1.3 100%✓

EVOLUTION (Wednesday 11 May 2016)

All organisms have descended or evolved from a simple common ancestor that lived several billions of years ago. All organisms are genetically related to one another. The genetic changes take place over time and ultimately lead to new species. Evolution is a continuous process and takes place as a result of changes in the environment.

A BRIEF HISTORY OF THE DEVELOPMENT OF THE THEORY OF EVOLUTION

LAMARCK, DARWIN, ELDREDGE AND GOULD

Jean–Baptista Lamarck (1744-1829)

Lamarck used two 'laws' to explain evolution

- **'Law' of use and disuse** – the more an organism uses a muscle or an organ the stronger the muscle or organ will developed
  Muscle and organ that were not used would simply disappear after several generations.
- **'Law' of the inheritance of acquired characteristics** – the stronger muscle acquired in the organism's life time will be passed on to the next generation.

Lamarck's approach using the giraffe as an example

- All giraffes had short necks originally
- Giraffes frequently stretched/used their necks to reach for leaves of tall trees
- causing their necks to become longer
- The characteristics of long necks acquired in this way
- was then passed on to the next generation
- forming offspring with longer necks than the generation before

Why is Lamarck's theory not acceptable?

Acquired characteristics cannot be passed from one generation to the next

OR

Organisms did not evolve because they wanted to evolve/Lamarck's theory is deterministic

Charles Darwin (1809 – 1882)

Is considered as the father of evolution.
Published his ideas in '*On the origin of species by means of natural selection'*
His research was based on observations made during his long voyage on the HMS Beagle, between 1831 and 1836.
This made him realise that the Earth is very old and that major changes have taken place over long periods of time.

Darwin' approach using the giraffe as an example

- As a result of genetic variation in the giraffe population
- some giraffes have longer necks than others
- Environmental change/competition for resources occurred
- causing those with shorter necks to die
- and those with longer necks to survive
- since they could reach the leaves of tall trees
- This is termed natural selection
- The genotype for longer necks
- was passed on to subsequent generations
- In this way each subsequent generation had necks longer than the generation before

Gradualism

Charles Darwin, described evolution as a gradual process driven by natural selection. This process is slow since it requires many generations for these small changes to be realized in a speciation event. This led Darwin to believe that evolution happens gradually with the accumulation of small changes over long periods of time.

NILES ELDREDGE AND STEPHEN JAY GOULD (1972 -)

Niles Eldredge of the American Museum of Natural History and Stephen Jay Gould of Harvard University described **Punctuated Equilibrium** in 1972.

Punctuated Equilibrium and **gradualism** are concerned with evolutionary rate. Niles Edridge and Stephen Jay Gould (1972) contended that some species are stable (show stasis) throughout much of their evolutionary history, and that when a small daughter population becomes geographically isolated from its parent species, they can evolve quite rapidly into a new species (punctuated equilibrium).

Eldredge and Gould claim that there were **long periods of stasis** (4-10 million years) involving **little evolutionary change** and then occasional **rapid** (as short as 5,000 - 50,000 years) **formation of new species** by means of natural selection**.** This is supported by the absence of transitional fossils indicating the period of rapid change.

Examples of questions:

1.1 **Compare Darwin's ideas to the ideas of punctuated equilibrium.**

- Darwin believed that evolution takes place through an accumulation of small✓
- gradual changes that occur over a long period of time✓
- supported by transitional forms in fossil record✓
- Punctuated equilibrium suggested that evolution sometimes involves long periods of time where species do not change✓/very little change occurs
- This alternates with short periods of time where rapid changes occur✓
- New species are formed in a short period of time✓/relative to the long period of no/little change
- supported by the absence of transitional forms✓

1.2 **Describe how the different types of mutations contribute to genetic variation and the role of this variation in natural selection**

Mutations:

- A gene mutation occurs as a result of a change in sequence of nitrogen bases in the DNA molecule✓
- A chromosome mutation occurs as a result of a change in the structure of a chromosome/number of chromosomes during meiosis✓
- Mutations that occur in sex cells are passed on to the new generations creating new characteristics✓

Role of variation in natural selection:

- Organisms of a particular species shows great deal of variation✓
- Some individuals may have characteristics that are favourable✓
- Others may have characteristics that are unfavourable✓
- If there is competition✓/changing environmental conditions/selective pressure by the environment
- Organisms with favourable characteristics survive and reproduce✓
- And pass the favourable characteristic to their offspring✓
- While organisms with unfavourable characteristics will die✓ out
- Over time the whole population will have the favourable trait✓.

Speciation

What is a species?

A group of similar organisms that is able to interbreed to produce fertile offspring. Each species has its own unique gene pool. Gene flow takes place between these organisms during fertilisation.

What is a population?

A group of organisms of the same species that can interbreed to produce fertile offspring.

Process of speciation due to geographic isolation

Speciation can occur when the original population is physically separated (called a barrier) into two or more populations.
The examples of physically barriers and examples that the curriculum prescribe are the following

1. Galapagos islands – separated by the sea / oceans. These volcanic islands appeared in the Pacific Ocean about 5 million years ago.

1.1 The examples on these islands mentioned in the curriculum that illustrate speciation are the Galapagos finches and the Galapagos tortoises

2 Gondwana split up and separated from each other by continental drift to form the southern continents such as South America, South Africa, Australia and New Zealand and the large island Madagascar.

2.1 The examples are the *Protea* genera and the different Baobab trees

The curriculum requires only **ONE** to be studied. But you have to familiarise yourself with all four, because any of the four or any other example can be asked during the examination.

Describe how a single species can form new species.

Answer - **generic example – remember the key words**

- A population of species shows a great deal of **variation** √
- If a population becomes **separated** √ into two or more populations by means of a **physical barrier**√.
- There is now **no gene flow** √ between the two populations.
- Since each population may be exposed to **different environmental conditions**√,
- **Natural selection** √ occurs **independently** √ in each of the two populations
- The **desired traits** √ that **survive** √ are different for the two or populations
- Over many generations √ the individuals of the two populations become **very different** √ from each other
- **genotypically and phenotypically** √.
- Even if the two populations were **to mix again**√,
- they will not be able **to interbreed** √ with each other, thus becoming **different species**√ / one or both of the populations becomes a new species

1. **Describe how the Proteus species in South Africa and Australia evolved in different species.**

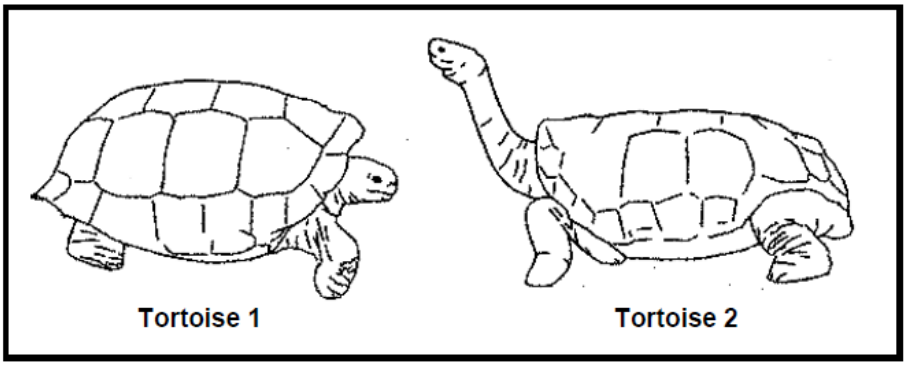
- There was genetic variation✓ within the original *proteus* species population on Gondwana land✓
- because of continental drift✓ the proteus population from the main land separates ✓ into two groups
- each of the proteus groups live on two different continents /South Africa and Australia✓
- living under different environmental conditions✓
- The proteus species underwent natural selection✓ independently✓ on each continent
- Only those proteus species with the favourable characteristic✓ that was better suited✓/ on each specific continent survived✓
- Continued natural selection over many generations ✓
- resulted in each continent having species that were very different ✓ genotypically and phenotypically ✓ from species of the other continent
- These differences prevented them from interbreeding✓ leading to the formation of new species ✓ on each continent

2. **Describe how the Baobabs trees in South Africa and Madagascar evolved in different species.**



- There was genetic variation✓ within the original Baobab tree population on Gondwana land✓
- because of continental drift✓ the Baobabs trees population from the main land separates ✓ into two groups
- each of the Baobabs trees groups live on two different continents /South Africa and Madagascar✓
- living under different environmental conditions✓
- The Baobabs trees underwent natural selection✓ independently✓ on each continent
- Only those Baobabs trees species with the favourable characteristic on each specific continent survived✓
- Continued natural selection over many generations ✓
- resulted in each continent having species that were very different ✓
- genotypically and phenotypically ✓ from species of the other continent
- These differences prevented them from interbreeding✓ leading to the formation of new species ✓ on each continent

3. **Study the diagram below and answer the questions that follow.**

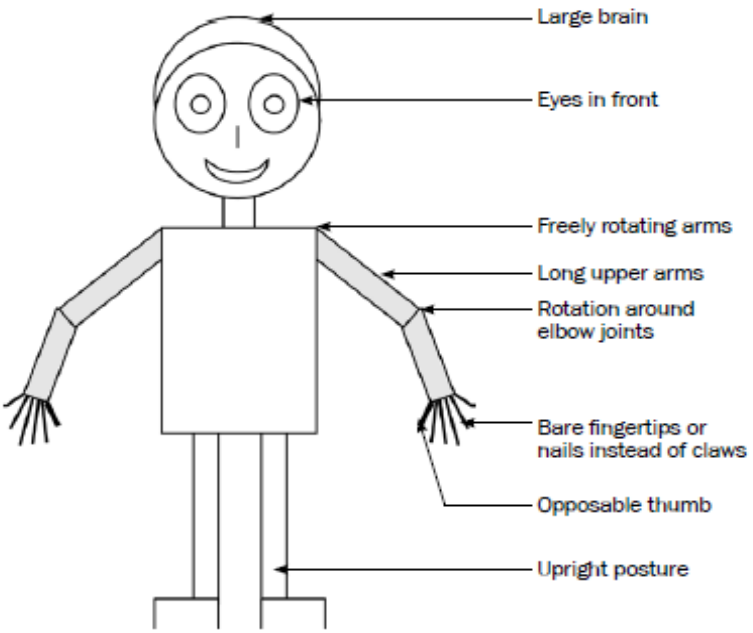


Darwin noticed different species of tortoises on the Galapagos Islands. Two of these tortoises, which are drawn to scale, are shown above. The two species of tortoises shown above lived on different islands. Darwin suggested that they might have evolved from a common ancestor. Explain how this could have occurred.

- On each island there was variation (long and short necks) ✓ in the population of tortoises
- They lived under different environmental conditions / different sources of food ✓
- After a period of time each group of tortoises underwent natural selection✓ independently ✓
- On each island only those tortoises with the characteristics✓ (long or short neck) favourable for its own conditions survived✓
- Continued natural selection resulted✓ in each island having tortoises that are very different from each other✓ they differed genotypically and phenotypically ✓
- Reproductive isolating mechanisms prevented them from interbreeding✓ even if they are
- allowed to mix i.e. each is a separate species ✓

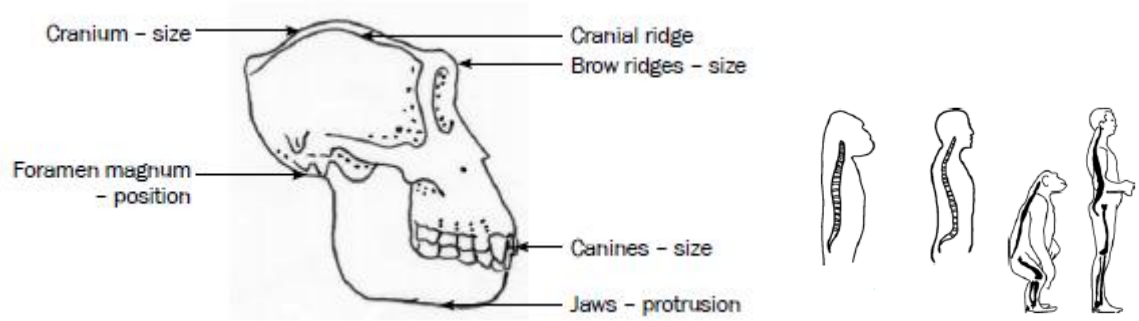
HUMAN EVOLUTION (Thursday 21 July 2016)

The 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.

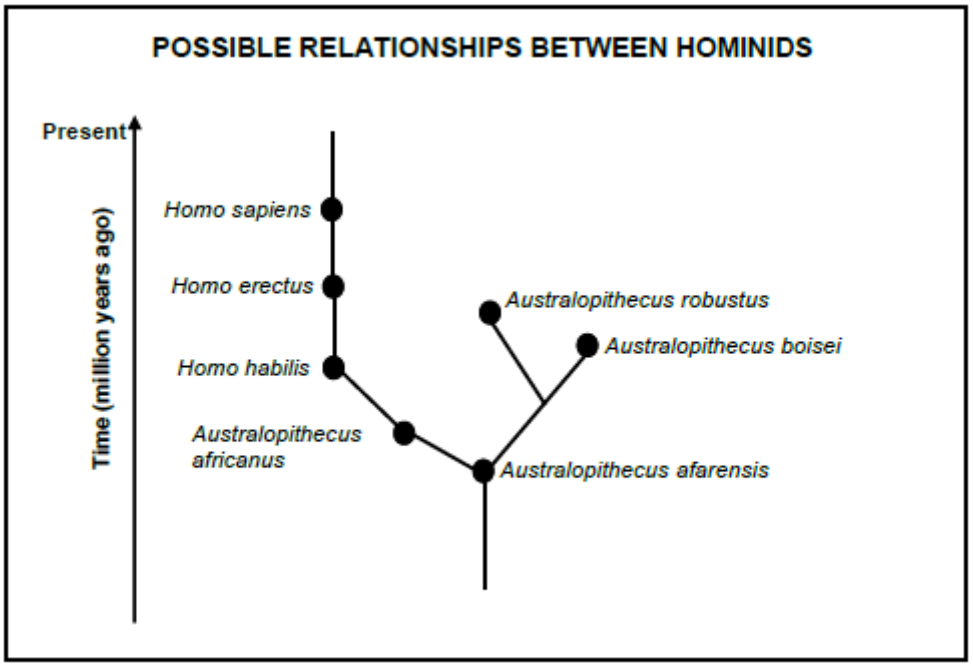
The following **lines of evidence** have been used to support the 'Out of Africa' hypothesis:

- 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.

1.1 The diagram below shows possible relationships between members of the family *Hominidae.*



[Adapted from http://www.ideacentre.org]

1.1.1 What is the name given to the type of diagram above?

1.1.2 How many of each of the following are represented in the diagram?

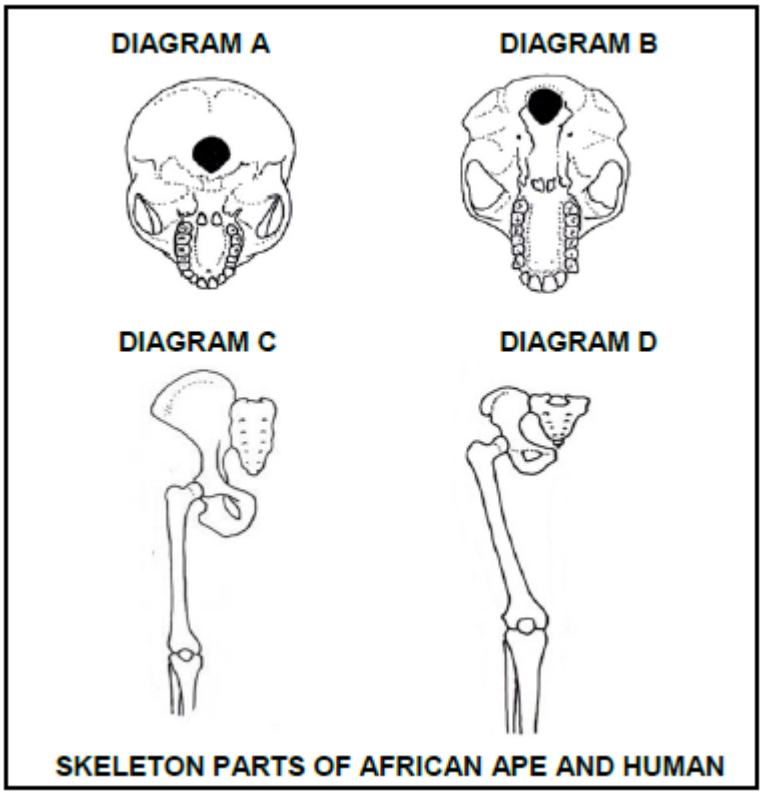
(a) Genera
(b) Species

1.1.3 Explain why *A. robustus* and *A. boisei* are more closely related than *A. boisei* and *A. afarensis*.

Possible answers:

1.1.1 Phylogenetic tree✓
1.1.2 (a) 2✓ (b) 7✓
1.1.3 *A.bosei* and *A. robustus* share a more recent common ancestor✓.

1.2 The diagrams below represent parts of the skeletons of an African ape and a human. Diagrams **A** and **B** are drawn to scale.



1.2.1 Write down the LETTERS only of the diagrams (**A**–**D**) that represent bipedal organisms.

1.2.2 Explain how the shape of the pelvis contributes to bipedalism.

1.2.3 Explain the significance of the position of the foramen magnum in the skulls in diagram **A** and in diagram **B**.

Possible answers:

1.2.1 A✓ and D✓

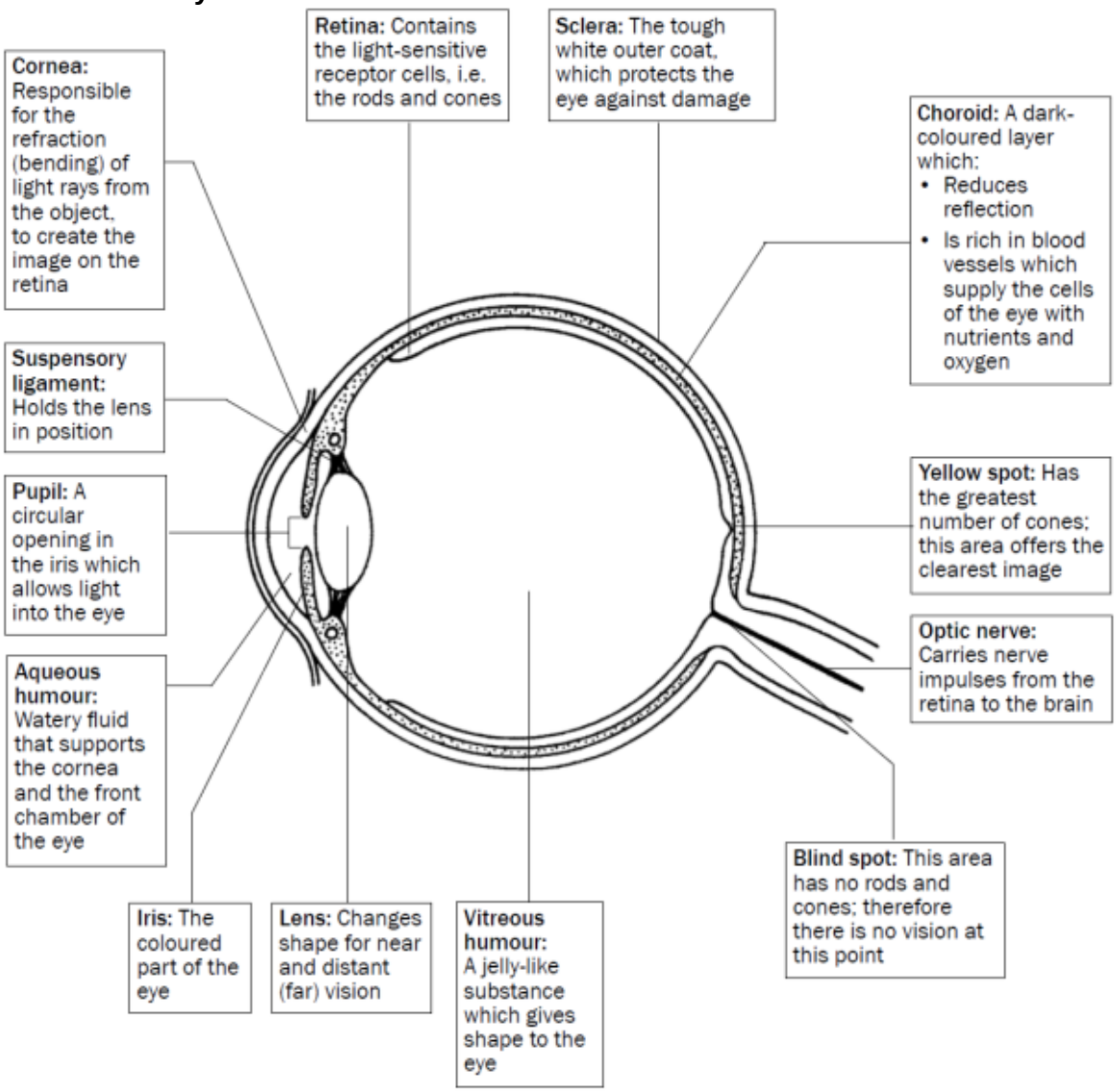
1.2.2 The pelvis is wide✓/cup-shaped
to support the weight✓ of an organism walking upright

1.2.3 <u>Diagram A</u>
The foramen magnum is located centrally✓/more forward position below the skull so that the vertebral column arises from beneath the skull✓ for bipedalism✓

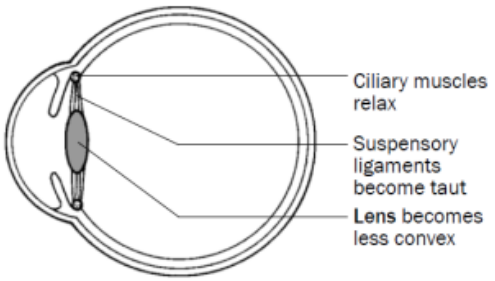
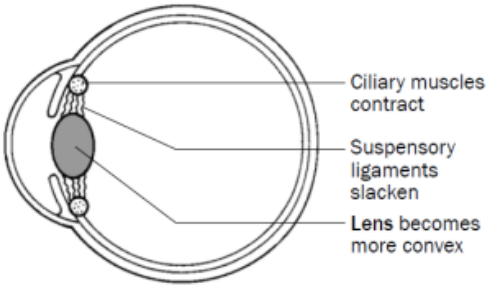
<u>Diagram B</u>
The foramen magnum is located towards the back✓ of the skull
so that the vertebral column arises from the back of the skull✓ for quadrupedal locomotion✓

SENSE ORGANS (Tuesday 06 September 2016)

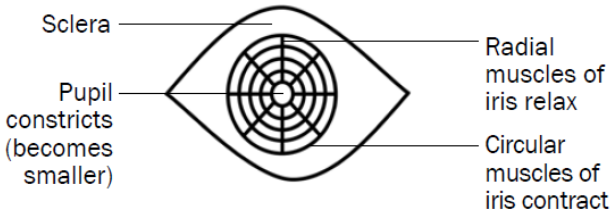
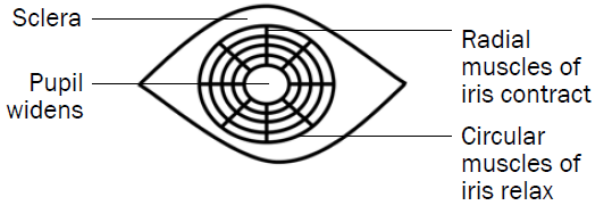
Structure of the eye



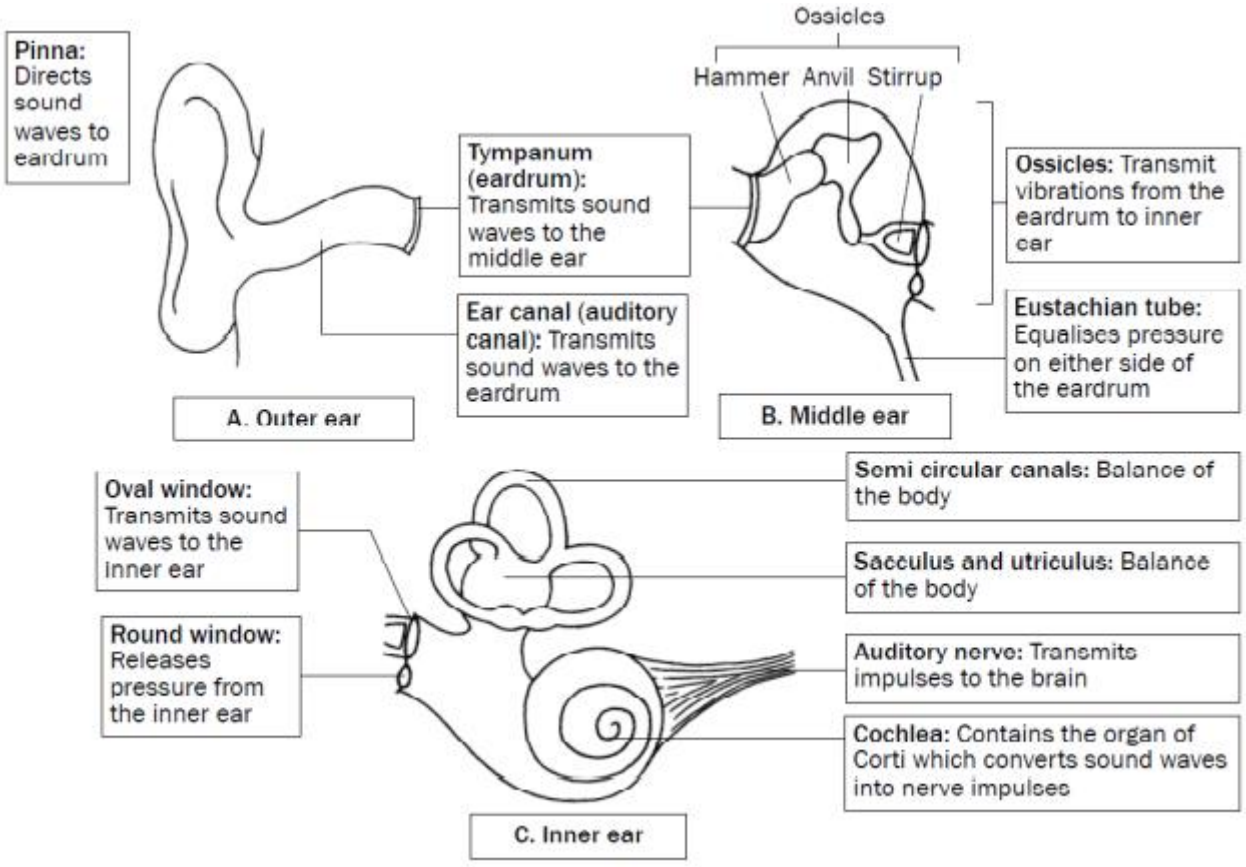
Eye accommodation

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*

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



How hearing takes place:

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.

HOMEOSTASIS THROUGH NEGATIVE FEEDBACK (Tuesday 06 September 2016)

The regulation of glucose levels:

When the glucose level in the blood increases above normal levels:	
Step 1	Glucose levels in the blood increase above normal levels
Step 2	The pancreas is stimulated
Step 3	to secrete insulin into the blood
Step 4	insulin travels in the blood to the liver
Step 5	where it stimulates the conversion of excess glucose to glycogen which is then stored
Step 6	The glucose level in the blood now decreases
Step 7	and returns to normal
When the glucose level in the blood decreases below normal levels:	
Step 1	Glucose levels in the blood decrease below normal levels
Step 2	The pancreas is stimulated
Step 3	to secrete glucagon into the blood
Step 4	Glucagon travels in the blood to the liver
Step 5	where it stimulates the conversion of stored glycogen to glucose
Step 6	The glucose level in the blood now increases
Step 7	and returns to normal

The regulation of carbon dioxide levels:

When the CO_2 level in the blood increases above normal levels:	
Step 1	CO_2 levels in the blood increase above normal levels
Step 2	Receptor cells in the carotid artery in the neck are stimulated
Step 3	To send impulses to the medulla oblongata in the brain
Step 4	Medulla oblongata stimulates breathing muscles (intercostal muscles and diaphragm)
Step 5	Breathing muscles contract more actively – increases the rate and depth of breathing. The heart beats faster.
Step 6	More CO_2 is taken to and exhaled from the lungs
Step 7	The CO_2 level in the blood returns to normal

The regulation of the water balance:

When the blood has less water than normal:	
Step 1	Blood has less water than normal
Step 2	The hypothalamus is stimulated
Step 3	and sends impulses to the pituitary gland to secrete more ADH
Step 4	ADH travels in the blood to the kidneys
Step 5	ADH increases the permeability of the collecting ducts and the distal convoluted tubules of
Step 6	More water is re-absorbed and passed to the surrounding blood vessels
Step 7	The water level in the blood returns to normal

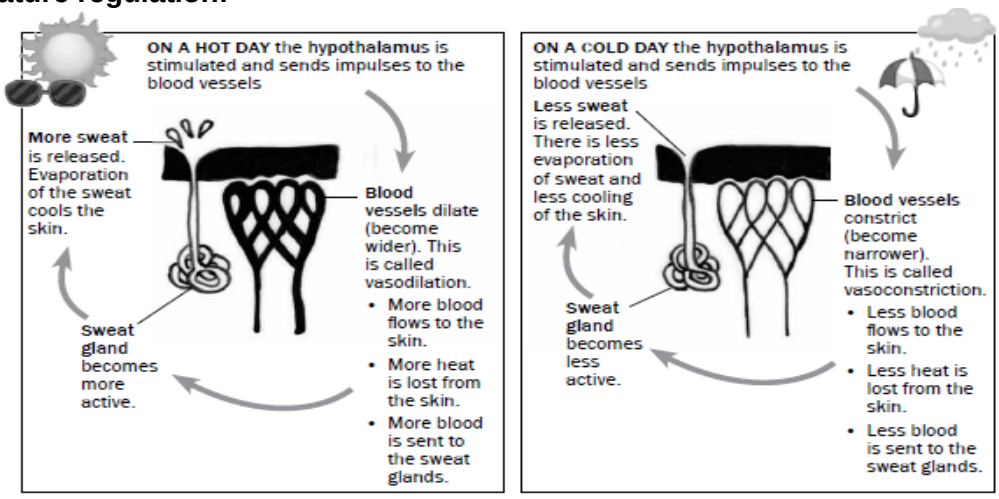
When the blood has more water than normal:	
Step 1	Blood has more water than normal
Step 2	The hypothalamus is stimulated
Step 3	and sends impulses to the pituitary gland to stop secreting ADH/to secrete less
Step 4	No ADH/less ADH travels in the blood to the kidneys
Step 5	The collecting ducts and the distal convoluted tubules of the kidney become less
Step 6	Less water is re-absorbed and passed to the surrounding blood vessels. More
Step 7	The water level in the blood returns to normal

The regulation of the salt balance:

When the salt level in the blood decreases:	
Step 1	The salt level in the blood decreases
Step 2	Receptor cells in the afferent and efferent arterioles of the kidney detect the low salt
Step 3	The adrenal gland is stimulated
Step 4	into secreting more aldosterone
Step 5	Aldosterone increases the re-absorption of sodium ions from the renal tubules in the kidney into the surrounding blood vessels
Step 6	The salt level in the blood vessels increases
Step 7	and returns to normal

When the salt level in the blood increases:	
Step 1	The salt level in the blood increases
Step 2	Receptor cells in the afferent and efferent arterioles of the kidney detect the high salt
Step 3	The adrenal gland is stimulated
Step 4	to stop secreting aldosterone/to secrete less aldosterone
Step 5	This decreases the re-absorption of sodium ions from the renal tubules in the kidney into the surrounding blood vessels
Step 6	The salt level in the blood vessels decreases
Step 7	and returns to normal

Temperature regulation:



1.1 The table below shows how the body temperature is regulated by the hypothalamus by influencing heat production and heat loss.

BODY TEMPERATURE (°C)	HEAT PRODUCTION (JOULES PER SECOND)	HEAT LOSS (JOULES PER SECOND)
36,4	320	5
36,6	260	5
36,8	150	35
36,9	90	90
37,0	90	100
37,2	90	180
37,4	90	310

[Adapted from *Cambridge Biology*, 2002]

1.1.1 Are the blood vessels that supply blood to the skin constricted or dilated when the body temperature is 36,4 °C ?
1.1.2 Explain the advantage of the diameter of the blood vessels mentioned in your answer to QUESTION 1.1.1
1.1.3 Heat loss is the greatest at 37,4 °C. Explain how the body is able to increase heat loss.

Possible answers:

1.1.1 Constricted✓

1.1.2 Less blood flows ✓to the skin so less heat is lost to the environment ✓by radidation. Less sweat is formed✓ because less blood flows to the sweat glands. Less evaporation✓ of sweat and hence less cooling of the skin. Body heat is conserved✓.

1.1.3 Hypothalamus is stimulated ✓and sends message to the blood vessels of the skin to dilate✓/vasodilation occurs. More blood flows✓ to the surface of the skin. More heat is lost by radiation✓ from the skin surface. More sweat is formed✓ because more blood flows to the sweat glands and therefore more heat is lost by increased evaporation ✓of sweat.

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