LIFE SCIENCES GRADE 12 - PAPER 2
(Answers from past Assessment Guidelines)

MEIOSIS

STRUCTURE AND ARRANGEMENT OF CHROMOSOMES IN A NORMAL HUMAN KARYOTYPE

- Each chromosome comprises two chromatids✓
- held together by a centromere✓
- There are 23 pairs✓/46 chromosomes in
- human somatic cells✓/body cells
- which are arranged into homologous pairs✓
- that are similar in length✓
- carry genes for the same characteristics✓
- have alleles of a particular gene at the same loci✓and
- have the same centromere position✓
- Each somatic cell has 22 pairs/44 autosomes✓and
- a pair/2 gonosomes✓/sex chromosomes/X and Y chromosomes
- Autosomes are arranged in pairs from largest to smallest✓ in a karyotype
- Males have XY chromosomes✓
- Females have XX chromosomes✓
- The X chromosome is larger than the Y chromosome✓

BEHAVIOUR OF THE CHROMOSOMES DURING THE DIFFERENT PHASES OF MEIOSIS I

- During prophase✓ I
- chromosomes pair✓up/homologous pairs /bivalents form
- Crossing over✓exchange of genetic material occurs
- between chromatids✓/adjacent chromosome pairs
- During metaphase✓ I of meiosis
- homologous chromosomes✓/chromosome pairs are arranged
- at the equator✓of the cell
- in a random✓ way
- with the chromosome attached to the spindle fibre✓
- During anaphase ✓ I
- chromosome pairs separate✓/chromosomes move to opposite poles
- During telophase ✓ I
- the chromosomes reach the poles of the cell✓

EVENTS THAT LEAD TO DOWN SYNDROME

- Non-disjunction occurred✓/A homologous pair of chromosomes
- at position 21✓
- failed to separate✓
- during anaphase✓
- resulting in one gamete with 24 chromosomes✓ / an extra chromosome / chromosomes at position 21
- The fertilisation of this gamete with a normal gamete✓/gamete with 23 chromosomes /1 chromosome at position 21
- results in a zygote with 47 chromosomes✓

- There are 3 chromosomes✓/an extra chromosome at position 21/ this is Trisomy 21

HOW MEIOSIS CONTRIBUTES TO GENETIC VARIATION

 Crossing over✓

- Occurs during prophase I✓
- Chromatids of homologous chromosomes overlap✓
- at points called chiasma✓/ chiasmata
- Genetic material is exchanged✓
- resulting in new combinations of genetic material ✓from both parents

 Random arrangement of chromosomes

- Occurs during metaphase I ✓/ II
- Each pair of homologous chromosomes ✓ /each chromosome
- may line up in different ways✓ on the equator of the spindle
- allowing the gametes to have different combinations of maternal and paternal chromosomes ✓
- so that they separate in a random✓/ independent manner
- resulting in new combinations of genetic material✓

HOW MUTATIONS CONTRIBUTE TO GENETIC VARIATION

Two types of mutations:

 gene mutation and

 chromosome mutations

- A **gene**✓ **mutation** occurs
- as a result of a change in sequence of nitrogenous bases✓ in the DNA molecule
- A **chromosome**✓**mutation** occurs as a
- result of a change in the structure of a chromosome✓OR
- a change in the number of chromosomes during meiosis✓

- **Mutations that occur in sex cells**✓
- are passed on to the new generations✓
- creating new characteristics✓

DNA: CODE OF LIFE & PROTEIN SYNTHESIS

THE LOCATION, STRUCTURE AND FUNCTIONS OF A DNA MOLECULE

- The DNA is located in the nucleus✓/chromosome/genes/mitochondria
- DNA is a nucleic acid✓
- It is double stranded✓ molecule
- and arranged in the form of a helix✓
- consisting of building blocks called nucleotides✓ The three components of a nucleotide are as follows:
- Nitrogenous bases✓
- Phosphate portion✓
- Deoxyribose sugar portion✓ (in DNA)
- 4 nitrogenous bases ✓are A,T,C,G✓
- adenine (A) binds with thymine (T) ✓ and cytosine (C) binds with guanine (G)✓
- by weak hydrogen bonds✓
- Sections of DNA carry hereditary✓information
- DNA contains coded information for protein synthesis✓

STRUCTURAL DIFFERENCES BETWEEN DNA AND RNA.

DNA	RNA
Double stranded✓ molecule	Single stranded✓molecule
Has a helix✓shape	Is a straight molecule✓
One of the nitrogen bases is thymine✓	The nitrogen base uracil✓in place of thymine
Contains deoxyribose✓ sugar	Contains ribose✓sugar
A longer✓molecule	A shorter✓molecule
Paired bases✓	Unpaired bases✓

DNA REPLICATION

- The DNA- double helix molecule unwinds✓ within the nucleus
- Weak✓ hydrogen bonds between the two strands break✓/ the molecule unzips
- Each strand serves as a template✓ to form a new strand
- Free DNA nucleotides✓ attach to the individual strands
- with complementary nitrogenous bases✓ pairing/ (A to T and C to G)
- Two genetically identical DNA molecules✓ are formed
- Process is controlled by enzymes✓

EXTRACTING DNA (practical work)

SUBSTANCE	FUNCTION
Onion, strawberry, wheat germ etc.	Source of DNA
Dishwashing liquid	Breaks down cell membranes
Salt	Combines with nucleic acid to form visible crystals, since DNA is not visible

Meat tenderizer, pineapple juice, contact lens solution	Contains enzyme to break down the histone proteins
Alcohol/ methylated spirits	DNA is NOT soluble in these solvents and will therefore appear as a stringy or cloudy mass

- Grating the onion, increases the surface area for the dishwashing liquid, salt and tenderizer to act on.
- Placing the beaker in hot water allows for the cell breakdown to occur faster

TRANSCRIPTION IN PROTEIN SYNTHESIS

- Occurs within the nucleus✓
- Double-stranded DNA unwinds✓
- and unzips✓/2 DNA strands separate/the weak hydrogen bonds break
- One strand is used as a template✓
- to form mRNA✓
- using free RNA nucleotides from the nucleoplasm✓
- The mRNA is complementary to the DNA✓/ A-U, C-G
- This process is controlled by enzymes✓
- The coded message for protein synthesis is thus copied onto mRNA✓
- Each base triplet is called a codon✓

TRANSLATION IN PROTEIN SYNTHESIS

- mRNA moves from the nucleus✓/to the ribosome within the cytoplasm
- The anticodon on the tRNA matches the codon on the mRNA✓
- tRNA brings the required amino acid✓
- to the ribosome✓
- Amino acids are joined by peptide bonds✓
- to form the required protein✓/ polypeptide chain.

HOW A GENE MUTATION INFLUENCES THE STRUCTURE OF A PROTEIN

- A mutation is a change in the nucleotide/nitrogenous base sequence✓
- of a DNA molecule✓/a gene
- since mRNA is copied from the DNA molecule✓
- during transcription✓
- This will result in a change in the codons✓
- As a result, different tRNA✓ molecules
- carrying different amino acids✓ will be required
- The sequence of amino acids changes✓
- resulting in the formation of a different protein✓
- If the same amino acid ✓ is coded for
- there will be no change✓ in the protein structure

USES OF DNA PROFILING / ANALYSIS

- To investigate crimes ✓/ resolve disputes
- To identify organisms from their remains✓
- To identify family relationships other than paternity✓ e.g. siblings or cousins
- To test for the presence of specific alleles✓ / genes that cause a genetic disorder - To establish matching tissues for organ transplants✓

GENETICS

MENDEL'S LAW OF DOMINANCE

- When two organisms with pure breeding✓ contrasting characteristics ✓are crossed
- All the individuals of the F_1 generation will display the dominant trait✓
  OR
- If an organism is heterozygous✓ the
- dominant allele✓ will
- determine the phenotype✓

MENDEL'S LAW OF INDEPENDENT ASSORTMENT

- The various genes are separate✓ entities and do not influence each other in any way
- They sort themselves out independently✓
- during gamete formation✓
- since homologous chromosomes arrange themselves randomly✓ along the equator
- during metaphase I✓

MENDEL'S LAW OF SEGREGATION

- Each characteristic is controlled by two genes situated on homologous chromosomes✓
- During meiosis✓ /anaphase/ when gametes form,
- the two genes are separated or segregated✓
- enabling a gamete to contain one of the two alleles✓ from each parent

SUMMARY OF GENETIC CROSSES

TYPE	DEFINITION	EXAMPLE
1) Complete dominance	Only one characteristic is expressed in the phenotype of a hybrid	TT x tt = Tt (100% tall offspring)
2) Incomplete dominance	Neither allele is completely dominant over the other and both genes have equal influence in expressing the phenotype in the F_1 generation	RR x WW = RW (100% pink offspring)

3) Co-dominance	Different alleles of a hybrid are equally dominant over each other	RR x WW = RW (100% roan offspring)
4) Sex linked inheritance	Genes which are carried on gonosomes , are referred to as sex linked genes or alleles	X^HX^h x X^HY (haemophilia) = X^HX^H; X^HX^h; X^HY; X^hY
5) Dihybrid cross	A cross involving 2 characteristics at a time	RRYY x rryy = RrYy (All round, yellow seeds)

WHY THE SEX OF A CHILD IS DETERMINED BY THE MALE GAMETE

- Normal males have one X and one Y✓
- Normal females have two X✓ chromosomes
- The female always provides the X- chromosome in the ovum✓
- If an ovum is fertilized by an X bearing sperm✓ a female/girl✓ is formed
- If an ovum is fertilized by a Y bearing sperm✓
- a male/boy✓ is formed

WHY ARE THERE MORE MALES THAN FEMALES WITH COLOUR-BLINDNESS

- Males only have one X-chromosome✓
- If this chromosome carries the recessive allele✓/X^b
- the male will be colour-blind✓
- the Y-chromosome in males, does not carry any allele to mask the effect of the colour-blind allele✓
- Females have 2 X-chromosomes✓
- They need to have two recessive alleles✓/X^b X^b to be affected
- A dominant allele on the other X-chromosome will mask the effect✓ of the recessive trait.

A HAEMOPHILIAC FEMALE MARRIES A MALE WITHOUT HAEMOPHILIA EXPLAIN WHY ALL THEIR SONS WILL BE HAEMOPHILIAC

- An individual inherits one allele from each parent✓
- The Y chromosome was inherited from the father✓
- and the recessive allele / X^h was inherited from the mother✓
- since the mother has two recessive alleles✓/X^h X^h
- A son only needs to get one recessive allele to be haemophiliac✓ since the
- Y-chromosome does not carry any allele to mask the effect of haemophilia allele✓

WHY FEMALES HAVE A SMALLER CHANCE OF SUFFERING FROM HAEMOPHILIA

- Haemophilia is caused by a recessive allele✓
- Carried on the X chromosome✓
- Females have two X chromosomes✓/ Males only have one X chromosome
- Females must inherit two copies of the recessive allele✓
  females who inherit only one of the recessive alleles are still non-haemophiliac✓

GENETIC MODIFICATION

- Removing a useful gene from one organism✓ and
- inserting it into another organism✓
- to produce beneficial characteristics✓

ADVANTAGES OF GENETIC ENGINEERING

- Production of medication✓/ resources cheaply

- Control pests with specific genes inserted into a crop✓
- Using specific genes to increases crop yields✓ / food security - Selecting genes to increase shelf-life of plant products✓

WHY SOME PEOPLE MAY BE AGAINST THE USE OF GENETIC ENGINEERING

- The long-term effects on health are unknown✓ which
- could lead to health problems in the future✓
- The long-term effects on biodiversity✓/ damaging ecosystems/nature
- People are morally opposed✓ as
- humans are interfering with nature✓/playing God/interfering with the rights of every species
- Initially it is an expensive process✓ and
- many people/countries may not afford it /research money could be used for other needs

CLONING

- A somatic diploid cell from tissue is used✓ - The nucleus is removed from this cell✓ - and is placed inside an "empty" ovum✓
- This is stimulated to divide to form an embryo✓
- The embryo is placed in the uterus of another adult✓
- Embryo develops normally✓
- A genetically identical baby will be born✓

STEM CELLS

- Undifferentiated cells✓
- that can be developed into any tissue type✓

➢ Used for therapeutic purposes, like regenerating spinal tissue (for paralysis) or pancreatic cells (for diabetes mellitus)

SOURCES OF STEM CELLS

➢ Umbilical cord
➢ Embryos
➢ Bone marrow

EVOLUTION

DIFFERENCES BETWEEN LAMARCKISM AND DARWINISM

LAMARCKISM	DARWINISM
Variation of the offspring occurs when individuals in the population change✓	Variation in the offspring is inherited✓
Change occurs because of adaptation to the environment✓/ Law of use and disuse	Natural selection – individuals best suited to the environment survive✓
Individuals in the population change✓	The population as a whole changes✓
Acquired characteristics are inherited by offspring✓	Characteristics are passed on from generation to generation to enable individuals to survive in the environment✓

DIFFERENCES BETWEEN NATURAL SELECTION AND ARTIFICIAL SELECTION

NATURAL SELECTION	ARTIFICIAL SELECTION
The environment ✓or nature is the selective force	Humans✓represent the selective force
Selection is in response to suitability to the environment✓	Selection is in response to satisfying human needs✓
Occurs within a species✓	May involve one or more species ✓ (as in cross breeding)

HOW LAMARCK AND DARWIN EXPLAINED EVOLUTION (IN GENERAL)

*Evolution according to Lamarck

Lamarck explained evolution using the following two 'laws':
The law of use and disuse: ✓
- As an organism uses a structure or organ more regularly✓, it becomes better developed or enlarged in that organism✓.
- If an organism does not use a structure or organ frequently✓, it becomes

less developed or reduced in size and may disappear altogether in that organism✓

The law of inheritance of acquired characteristics: ✓
- Characteristics developed during the life of an individual✓- (Acquired characteristics) can be passed on to their offspring✓

***Evolution according to Darwin**
- Organisms produce a large number of offspring✓
- There is a great deal of variation✓ amongst the offspring
- Some have favourable characteristics✓and some do not
- When there is a change in the environmental conditions✓/or there is competition
- then organisms with characteristics which are more favourable survive✓
- whilst organisms with less favourable characteristics die✓
- This is called natural selection✓
- The organisms that survive reproduce✓
- and thus pass on the favourable characteristics to their offspring✓
- The next generation will therefore have a higher proportion of individuals with the favourable characteristics✓

HOW LAMARCK AND DARWIN EXPLAINED EVOLUTION (SPECIFIC EXAMPLE)

An ancestor of the elephant, *Phiomia*, had a long nose-like structure called a proboscis which evolved into the trunk of the modern elephant. The proboscis was used to gather leaves as food.

Explain the evolution of the elephant's trunk in terms of Lamarckism and Darwinism as well as the way in which an increase in the length of the trunk of the elephant could be achieved through artificial selection.

Lamarckism:
- The ancestral elephant stretched its proboscis✓
- to get leaves✓ in trees/further from the body
- The more it used the proboscis✓
- the longer it became✓ **- law of use and disuse.**
- The offspring then inherited the acquired longer proboscis ✓- **law of inheritance of acquired characteristics**

- Over many generations the length of the proboscis increased✓- until it became a trunk✓ as in the modern elephant

Darwinism:
- There was a great deal of genetic variation✓ amongst the offspring of the ancestral elephant
- Some had a long proboscis✓and some had a short proboscis
- There was a change in environmental conditions✓/competition amongst the animals for food
- They had to reach higher in the trees to get leaves✓
- The animals with shorter proboscis died✓ as they could not reach the leaves
- They did not possess the favourable characteristics for that environment - Those individuals with the longer proboscis survived✓ as they possessed the favourable characteristics for the environment. - The elephants with the longer trunks then reproduced✓
- and passed on this favourable characteristic to their offspring✓
- The next generation of animals had a greater proportion✓ of longer trunks
- Gradually over time the gene pool of the elephants with short trunks are eradicated✓

Artificial selection:
- Humans✓select the elephants with
- desirable characteristics✓/long trunk
- and mate them to produce offspring with longer trunks✓
- Those that are pure breeding✓ for long trunks
- are further selected to mate to produce offspring with further longer trunks✓

DARWIN'S IDEAS ABOUT GRADUALISM COMPARED TO 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✓

THE ROLE OF VARIATION IN NATURAL SELECTION
- Organisms of a particular species shows a great deal of variation✓
- Some individuals may have characteristics that are favourable✓ /any example
- Others may have characteristics that are unfavourable✓ /any example
- If there is competition✓/changing environmental conditions/ selective pressure by the environment
- organisms with favourable characteristics survive✓
- and reproduce✓
- and pass this favourable characteristics to their offspring✓
- while organisms with unfavourable characteristics will die out✓
- Over time the whole population will have this favourable trait✓

DIFFERENCES BETWEEN A POPULATION AND A SPECIES
- **A species** is a group of organisms with similar characteristics✓
- that are able to interbreed✓

- to produce fertile offspring✓
- **A population** is a group of organisms of the same species✓
- found in the same habitat ✓
- at the same time✓

SPECIATION BY GEOGRAPHIC ISOLATION (IN GENERAL)

- If a population splits into two populations ✓ by a geographical 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✓
- such that 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 reproduce with each other✓ thus becoming different / new species

SPECIATION BY GEOGRAPHIC ISOLATION (SPECIFIC EXAMPLE)

Use the example of the anole lizard of the Caribbean Islands to describe how natural selection led to the process of s**peciation** that gave rise to different species of lizards.

- The original species of anole lizards was separated✓
- into different populations✓
- by a geographical barrier ✓
- which is the sea ✓
- There was no gene flow✓
- between the separated populations✓
- Each population was exposed to different environmental conditions✓/ different environmental temperatures and food availability on each island
- Because there is variation✓ amongst the lizards
- natural selection occurred independently ✓ in each population
- Each population became different from the other ✓ over time
- genotypically✓
- and phenotypically✓
- Even if the populations were to mix again✓
- they would not be able to reproduce/interbreed with each other✓

MECHANISMS FOR REPRODUCTIVE ISOLATION

Geographic isolation causes speciation. Reproductive isolation isolates the gene pool of a species.

Examples of reproductive isolation:

• Breeding at different times of the year
• Species-specific courtship behaviour
• Adaptation to different pollinators
• Infertile offspring
• Prevention of fertilisation

THE ROLE OF MUTATIONS AND EVOLUTION IN PRESENT TIMES (IN GENERAL)

- In a population of insects✓ /bacteria/HI viruses/Galápagos' finches
- mutations are a source of variation
- which may make some organisms more resistant ✓ /better suited
- to insecticides✓ /antibiotics/antiretroviral medication/ drought
- Those individuals that are not resistant /suited will die✓ whereas
- those that are resistant/ well suited, will survive✓
- to pass the resistant allele/resistance on to their offspring✓
- This is known as natural selection✓
- As a result, individuals of the future generations will be resistant to the insecticides✓/antibiotics/antiretroviral medication/adapted to drought

HOW MOSQUITOES DEVELOP RESISTANCE TO DDT (SPECIFIC EXAMPLE)

− More mosquitoes are produced than can survive✓
− There is genetic variation✓ amongst the mosquitoes
− Some mosquitoes may be naturally resistant to DDT✓
− When DDT is applied✓
− those that are resistant survive✓
− and they then reproduce✓
− passing the allele for resistance to the offspring✓
− Those that are not resistant, die✓
− and their alleles are lost from the population. ✓
− The number of DDT-resistant mosquitoes therefore increases over the generations✓

EVIDENCE FOR EVOLUTION, HUMAN EVOLUTION AND OUT OF AFRICA HYPOTHESIS

EVOLUTION	HUMAN EVOLUTION	OUT OF AFRICA HYPOTHESIS
Fossil evidence	Fossil evidence	Fossil evidence
Genetics	Genetics, mtDNA	Genetics, mtDNA
Comparative anatomy (modification by descent)	Cultural evidence (tool making)	Cultural evidence (tool making)
Biogeography	Biogeography	Biogeography

HUMAN EVOLUTION

CHARACTERISTICS THAT HUMANS SHARE WITH AFRICAN APES.

- Large brains✓ / skulls compared to their body mass
- Bipedal✓ / upright posture / foramen magnum in a more forward position
- Olfactory brain centres reduced✓/ reduced sense of smell
- Eyes in front✓/ binocular vision / stereoscopic vision
- Eyes with cones✓ / colour vision

- Freely rotating arms✓
- Long upper arms✓
- Five digits per limb✓
- Flat nails instead of claws✓/ bare, sensitive finger tips
- Opposable thumbs✓/precision grip
- Sexual dimorphism✓ / distinct differences between males and females

ANATOMICAL DIFFERENCES BETWEEN HUMANS (*Homo sapiens*) 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 are well ✓developed
Spine	More curved (S-shaped) ✓spine	Less curved (C-shaped) ✓ spine
Pelvic girdle	Short, wide pelvis✓	Long, narrow pelvis✓
Canines	Small canines✓	Large canines✓
Palate shape	Small and rounded palate✓	Long and rectangular palate✓
Jaws	Small jaws✓ less protruding / less prognathous	Large jaws✓ more protruding / more prognathous
Cranial ridges	No cranial ridge✓	Cranial ridge at the top of the cranium✓
Foramen magnum	In a forward position✓	In a backward position✓ below the skull

GENERAL TREND IN HUMAN EVOLUTION HAS BEEN TOWARDS BIPEDALISM AND A CHANGE IN DIET FROM RAW FOOD TO COOKED FOOD

The development of bipedalism:
• The backward position of the foramen magnum on the skull✓
• the narrow pelvis✓
• and the less-curved spine✓
• indicates that the ape-like beings were quadrupedal✓
• The forward position of the foramen magnum on the skull✓
• the wider / shorter pelvis✓
• and the curved S- spine✓
• indicates that modern humans are bipedal✓

Change in the diet from raw food to cooked food:
• The large teeth, especially the canines✓
• as well as the large and long jaws✓
• which makes the skull prognathous✓

• as well as cranial/brow ridges associated with large muscles that operate the jaws✓ • indicate that the ape-like beings ate raw food that required a great amount of processing✓ /tearing, biting and chewing. • The smaller teeth, including the canines✓
• as well as the smaller jaw size✓
• which makes the skull less prognathous✓
• as well as the absence of cranial/brow ridges due to the presence of smaller muscles for chewing✓
• indicate that modern humans rely on a diet of cooked food that does not require the same amount of processing✓ /tearing, biting and chewing.

ADVANTAGES OF BIPEDALISM
- Frees the arms✓ so that they could carry offspring✓/ tools / food / manipulate things
- Allows ability to see further✓to spot danger✓/ food
- Exposes a large surface area✓ for thermoregulation✓ - Reduces the surface area exposed to the sun✓ so less heat is absorbed✓/ less heat lost/thermoregulation
- Expose the genitals✓to attract opposite sex✓
- Efficient locomotion✓allows traveling over longer distances

ADVANTAGES OF LARGER CRANIUM
- Allows for a bigger brain✓
- Development of speech✓/ communication
- Higher intelligence✓
- Complex behaviour✓
- Quick processing of information✓
- Process large amounts of information

OUT OF AFRICA HYPOTHESIS
- All modern humans✓ /*Homo sapiens*
- originated in Africa✓
- and migrated to other parts✓ of the world

EVIDENCE THAT SUPPORTS THE OUT OF AFRICA HYPOTHESIS:

FOSSIL EVIDENCE✓
- The OLDEST Fossils of *Ardipithecus* were found ONLY in Africa✓ /Rift Valley/Ethiopia/South Africa
- The OLDEST Fossils of *Australopithecus* were found ONLY in Africa✓/Rift Valley/Ethiopia/South Africa
- The OLDEST fossils of *Homo habilis* were ONLY found in Africa✓
- The OLDEST fossils of *Homo erectus* were found in Africa✓
- The OLDEST fossils of *Homo sapiens* were found in Africa✓

GENETIC EVIDENCE✓
- Mitochondrial DNA✓
- is passed down from mother to child✓ / is inherited only from the maternal line
- Analysis of mutations✓ on this mitochondrial DNA
- were traced to an ancestral female that existed in Africa✓
- and shows that all humans descended from her✓/mitochondrial Eve
- The Y chromosome shows the paternal line✓

CULTURAL EVIDENCE✓
- The OLDEST/most primitive artefacts (tools, cutlery, art etc.)
- were ONLY found in Africa✓