LIFE SCIENCES

GRADE 12

Instructions:

By now you should all be on a Whatsapp class group with your individual teachers.

If you are not please contact someone in your group so that we can add you to your class.

All the explanations, resources, links and answers will be passed on to you through your teacher.

Pages 80-82 of your notes are revision of Grade 10 and 11 work.

Complete those notes using your textbook.

In the event of needing to email, please use the following addresses:

Mrs. Leat : aleat@northcliffhigh.co.za

Mr. Bailey: mbailey@northcliffhigh.co.za

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The notes that were forwarded to you will take you to the end of next week, i.e.24th April.

Keep on keeping strong…

GENETICS and INHERITANCE

Gregor Mendel (1822 – 1884) is the '**father of genetics**'. He was an Austrian monk that conducted many experiments on the mechanism of inheritance of **traits** (characteristics), by selectively breeding peas. During this time, he looked particularly at seven different traits.

Seed		Flower	Pod		Stem	
Form	Cotyledon	Color	Form	Color	Place	Size
						
Round	Yellow	White	Full	Green	Axial pods	Tall
						
Wrinkled	Green	Violet	Constricted	Yellow	Terminal pods	Short
1	2	3	4	5	6	7

From the data Mendel collected he made his conclusions about the mechanisms of genetic inheritance. Mendel formulated three Law's from these conclusions.

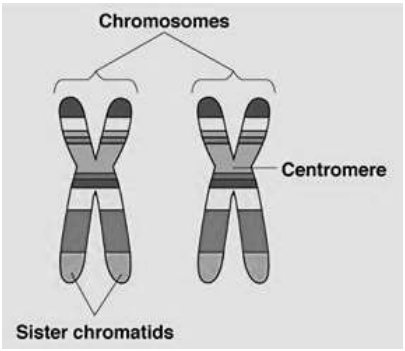
<u>So what do we know so far</u>?

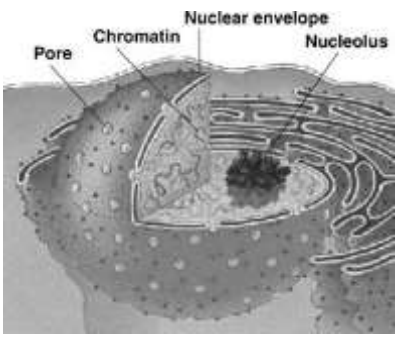
chrom-

-osome
A thread-like structure of nucleic acids and proteins found in the nucleus of most living cells, carrying genetic information in the forms of genes.

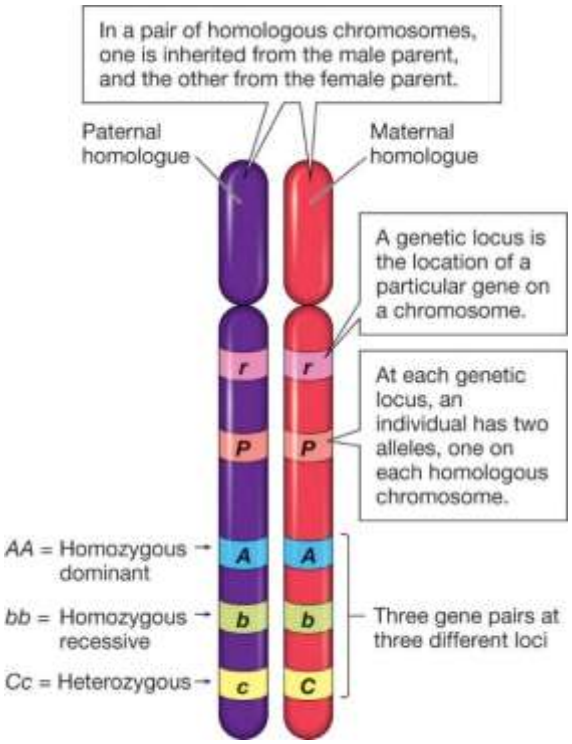
-atid
Each of the two thread-like strands into which a chromosome divides longitudinally during cell division. Each contains a double-helix of DNA.

-atin
The material of which the chromosomes of organisms other than bacteria (i.e. eukaryotes) are composed, consisting of proteins, RNA and DNA





And…what's new?



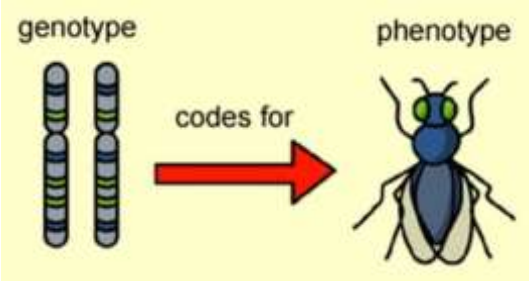
Allele: One of two or more forms (variants) of a gene.

Dominant: An allele whose expression overpowers the effect of a second form of that same gene.

Recessive: An allele whose effects are concealed in offspring by the dominant allele in the pair.

Homozygous: (Pure-breeding) A condition in which two alleles for a given gene are the same.

Heterozygous: **(hybrid/mixed-breeding)** A condition in which two alleles for a given gene are different from each other.



Genotype: The genetic makeup of a person.

Phenotype: The physical characteristics of a person which are determined by the interaction of the person's genotype with the environment.

Mendel's Laws

1. **Law of Segregation**
   During meiosis **alleles separate** and are randomly arranged between the **gametes** that are produced, i.e. one allele from each gene pair is present in a gamete.

2. **Law of Dominance**
   If two alleles are different (heterozygous) the dominant allele will be expressed over the recessive allele.

3. **Law of Independent Assortment**
   The alleles of genes are passed on to the offspring independently of one another.
   (Therefore the combination of alleles will not match the parents' alleles)

Video: https://youtu.be/Mehz7CxjSE

Monohybrid Crosses

A **monohybrid** cross is a **genetic cross** between two individuals each of which has different alleles for a **single trait.**

Format to work out a genetic cross:

E.g.	A **pure-bred** (homozygous) **tall** pea plant was cross-pollinated with a **pure-bred** (homozygous) **short** pea plant. (These plants will be the **P_1** generation) Tall is dominant over short. Use a **genetic drawing / genetic cross/ Punnett square** to determine the **F_1** generation (first filial generation).

P_1: **Phenotype** Tall x short

Genotype TT x tt

Meiosis

Gametes: T T x t t

Fertilisation

F_1:

	T	**T**
t	**Tt**	**Tt**
t	**Tt**	**Tt**

Genotype: 4 Tt

Phenotype: 4 Tall plants

NB: **1.** **Make sure you have answered all the questions asked.**

I.e. The above question may also have asked – What is the percentage of short plants in the F_1 generation?
You would have to make sure you answer this as well.

2. **The F_1 generation may then become the P_2 giving rise to the F_2 generation.**

Types of Dominance

1. Complete Dominance

This is where **one allele is dominant over the other**. The other allele is recessive.
In a heterozygous condition, the recessive allele will be masked by the dominant allele.

2. Incomplete Dominance

This is where **neither of the two alleles of a gene are dominant over one another.**
This results in an **intermediate** (blend) phenotype in a heterozygous condition.

3. Co-dominance

This is where **both alleles of a gene are equally dominant and both alleles are expressed in the phenotype** in a heterozygous condition.

Complete Dominance

- Complete the following examples:

1. In certain rabbits' black fur is dominant over white fur.
   a. A homozygous black male breeds with a homozygous black female.
      Determine the genotype and phenotype of the F_1 generation by using a Punnet square.
   b. A homozygous white male breeds with a homozygous white female.
      Determine the genotype and phenotype of the F_1 generation using a Punnet square.

Note:	When both parents are homozygous for either the dominant or recessive condition **ALL** the offspring will be homozygous for that condition.

2. A brown-eyed male, heterozygous to the condition has four children with a blue eyed female.
   In a genetic diagram, determine how many of the children will have blue eyes.
   Brown eye colour is dominant over blue eye colour.

Note:	When one parent is heterozygous for a condition and the other parent is homozygous for the recessive condition the genotype and phenotype will be a ratio of 2:2 = 1:1.

3. A widow's peak hairline is dominant over a smooth hairline in humans.
   Determine the phenotypic ratio of the F_1 generation if the male and female parents are both heterozygous for the condition.
   Show all your workings.

Note:	When both parents are heterozygous for a condition the resulting genotype will be a ratio of 1:2:1 and a phenotype ratio of 3:1

The above ratios can be used backwards to determine the genotypes of the parents.

4. A pure-breeding pea plant that produces green pods was crossed with a pure-breeding pea plant that produces yellow pods. 600 seeds of the F_1 generation were collected and planted.
When fully grown, two of these plants were crossed and 1000 seeds of the F_2 generation were collected and planted.
Green pods are dominant.

   a. What are the genotypes of the original parent plants (P_1 generation)?

   b. How many of the F_1 plants would you expect to:
      (i) produce yellow pods?
      (ii) produce green pods?
      (iii) be heterozygous?

   c. How many of the F_2 plants would you expect to:
      (i) produce yellow pods?
      (ii) produce green pods?
      (iii) be heterozygous?

5. In certain rats black fur is dominant over white fur. The offspring from a number of crosses between the same parents were counted. There were 20 white rats and 66 black rats.

   a. Determine the ratio of black rats to white rats.

   b. What simple genetic ratio do these numbers represent?

   c. Give a reason to explain why the ratios in 'a' and 'b' differ.

   d. Use the ratios to predict the genotypes of the parents.

6. Complete Activity 1 page 129 TB

Sex Determination

The first 22 pairs of chromosomes in humans are autosomes.
The 23rd pair of chromosomes is the sex chromosomes/gonosomes.
The gonosomes of the female are XX and the male is Xy.

- Complete the genetic cross **and** draw a conclusion from your results:

P1:	Phenotype	male	x	female
	Genotype	Xy	x	XX

Sex-linked (X-linked) Inheritance

Certain human disorders, like **haemophilia** and **colour blindness**, are caused by **sex-linked genes**.
Sex-linked genes are genes on the sex chromosomes (gonosomes).
The y-chromosome is shorter than the X-chromosome, therefore the **X-chromosome carries the genes** for the different **disorders**.

Haemophilia:
H represents the dominant allele for normal, fast blood-clotting time.
h represents the recessive allele for slowed blood-clotting time.

Genotypes	Phenotypes
X^HY	Male; does not have haemophilia (unaffected)
X^hY	Male; has haemophilia (affected)
X^HX^H	Female; does not have haemophilia (unaffected)
X^HX^h	Female; does not have haemophilia but is a carrier of the recessive allele. (unaffected)
X^hX^h	Female; has haemophilia (affected)

This is the same for the sex-linked colour-blindness disorder.

Video: https://youtu.be/3CtM4AaOxQ0

Examples:

1. In fruit flies, eye colour is a sex linked trait. Red is dominant to white.

1. 1 What are the sexes and eye colours of flies with the following genotypes?

X^RX^r _____ X^RY _____ X^rX^r _____

X^RX^R _____ X^rY _____

1.2. What are the genotypes of these flies?

white eyed, male _____ red eyed female (heterozygous) _____

white eyed, female _____ red eyed, male _____

1.3. Using a Punnett square show the cross of a white eyed female X^rX^r and a red-eyed male X^RY . How many are:

a. white eyed, male
b. white eyed, female
c. red eyed, male
d. red eyed, female

2. a. Why is haemophilia never passed from father to son, even though haemophilia is most common in males?
b. Can a mother pass on a sex-linked gene to her daughter?

Incomplete Dominance

NB: Remember that incomplete dominance results in an intermediate phenotype.

1. A snapdragon flower has red and white colour alleles. Neither allele is dominant.

   a. Determine the genotype and phenotype of the F1 generation, if a red snapdragon was crossed with a white snapdragon plant.

   b. Determine the genotype and phenotype of the F2 generation, if the F1 generation were to self-pollinate.

Note:	The F1 generation will ALL be an intermediate of the parents. The F2 generation will have a genotypic and phenotypic ratio of 1:2:1

   c. If the F2 generation gave rise to 36 plants, how many of them would be pink?

2. A child with wavy hair, has one parent with straight hair and one parent with curly hair.

   a. Supply the genotypes of both parents.

   b. If the wavy hair child married a homozygous straight hair person, what is the chance of their children having curly hair?
   Show all your workings.

Co-dominance

NB: Remember that this is where both alleles of a gene are equally dominant and both alleles are expressed in the phenotype in a heterozygous condition.

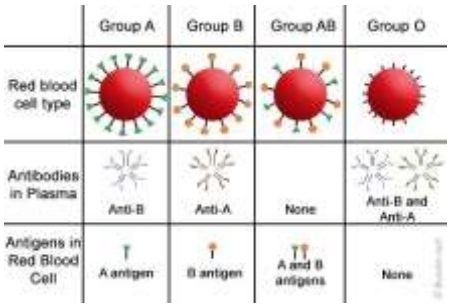
1. When a chicken with white feathers breeds with a chicken with black feathers, the result is an offspring chicken that grows up to have both black and white feathers.
   Show this using a genetic drawing.

2. In the case of rhododendrons, the crossing of a red and white flower may yield a flower that has both red and white patches.
   In a genetic cross show the F1 generation if a red flowered plant is crossed with a white flowered plant.

Blood Type

This is an example of **co-dominance** that occurs in humans.
It is also an example of **multiple alleles**.

There are **three different variants** of the gene for proteins that appear on the outside of our blood cells and help our body to identify the cells as their own.



These alleles are I^A, I^B, and i^O.
Alleles I^A and I^B, and i^O is recessive.

Genotype	Phenotype
I^AI^A or I^Ai^o	**A** blood type
I^BI^B or I^Bi^o	**B** blood type
i^oi^o	**O** blood type
I^AI^B	**AB** blood type

Video: https://youtu.be/yDTYjS1WB-k

3. A man with I^AI^B blood is married to a woman with I^AI^B blood.
   What blood types will their children be and in what proportion?

4. A man who is homozygous for type B blood is married to a woman with type O blood.
   What blood type will their children have?

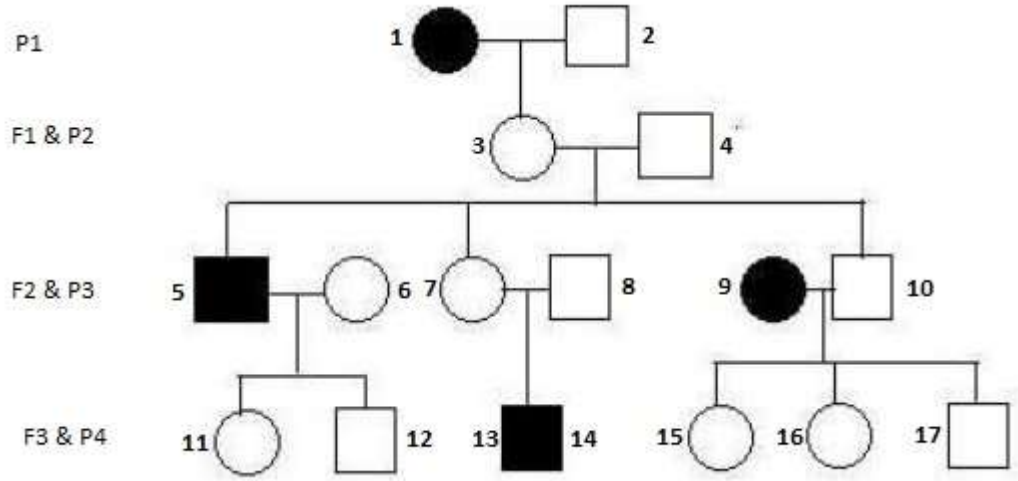
5. A woman with type A blood is claiming that a man with type AB blood is the father of her child, who is also type AB. Could this man be the father?
   Show all the possible crosses.

6. A man with type AB blood is married to a woman with type O blood.
   They have two natural children, and one adopted child. The children's blood types are: A, B, and O.
   Which child was adopted?

Genetic Lineage/ Pedigree

A genetic lineage or pedigree traces the inheritance of traits (characteristics) over many generations. It allows us to work out how genes are inherited.

1. The following pedigree shows the inheritance of cystic fibrosis in humans. Cystic fibrosis is caused by a recessive gene.



Key:

Unaffected/normal male

Unaffected/normal female

Affected male

Affected female

Use C for the dominant allele and c for the recessive allele.

1.1 Give two phenotypes of:

1. _____
2. _____
5. _____
11. _____

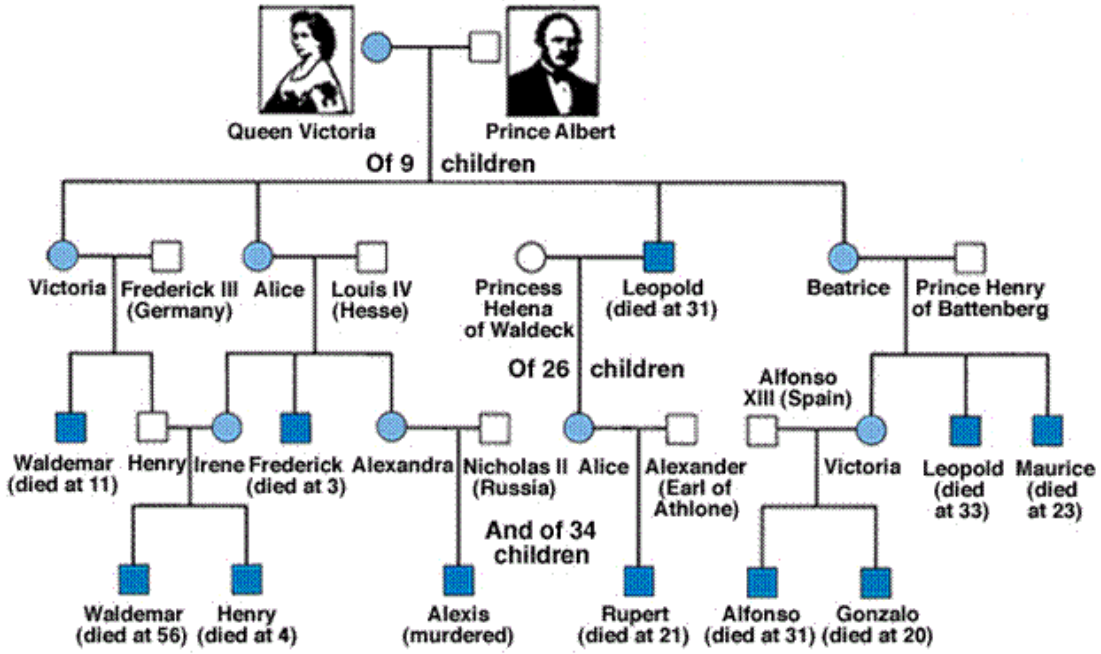
1.2 Give the genotype of:

2. _____
3. _____
5. _____
16. _____

1.3 How many grand children do 1 and 2 have? _____

NB: If you are given the particular disorder, then disorder must be given in your answer. i.e. a male with haemophilia.

2. Queen Victoria was the world's most famous carrier of haemophilia. Her son Leopold, and two carrier daughters, Alice and Beatrice, spread the gene fairly widely through the royal families of Europe, Prussia and Russia.
Fortunately, no modern monarchs have inherited the gene.
Indicate the possible genotype of each of the people below.
Remember: Haemophilia is an X-linked gene.



2.1 Queen Victoria was the first person that haemophilia could be traced back to, although she did not show it herself. What must her genotype have been?

2.2 Leopold was Victoria's only son affected by haemophilia. What must his genotype have been?

2.3 Interestingly, even though haemophilia in the royal families began in England, they were actually the only one of these four families to NOT be affected by it. If Alice's daughter Alex had accepted a marriage proposal from George V (who was unaffected), this may have changed history greatly. If we were to rewrite history, pairing Alex and George V together, what is the probability any of their offspring would have haemophilia? Use a Punnett square to justify your answer.

2.4 Instead, Alex accepted a proposal from Tsar Nikolas II of Russia. Looking at the Russian royalty, there are a number of unknown issues. Both Alex and Nikolas II, along with all five of their children, were assassinated during the Russian Revolution. It is known that their only son, Alexis, was a sufferer of haemophilia. None of their daughters were affected by the disease, but they were too young to have had children, so we do not know if they were carriers. What is the probability any of their daughters would have been a carrier for haemophilia?

2.5 Queen Victoria was the first person within the English royal family to have an allele for haemophilia. How did this allele appear in Queen Victoria?

Dihybrid crosses

A **dihybrid** cross is a **genetic cross** between two individuals each of which has different alleles for a **two traits.**

Example:

1. In a pea plant round seed shapes are dominant over wrinkled and yellow seeds colour is dominant over green seed colour.
   A pea plant that is heterozygous for round, yellow seeds is self-fertilised.
   What are the phenotypic ratios of the resulting offspring?

Note: When both parents are heterozygous for both traits the resulting phenotype will be a ratio of 9:3:3:1.

2. Complete Exercise 5 on page 141 T/B.

Mutations

A **mutation** is any change in the genetic code, which occur during **DNA replication,** of **Interphase.** The frequency of mutations is low as the cell has ways to "check" the copied DNA.
These mutations can be **inherited** from a parent or **acquired** during DNA replication in a person's lifetime.
The mutations can occur in a gene (**genetic mutation**) or when there is a change or break in a chromosome (**chromosomal mutation**).

Mutations lead to variations in genes (alleles) which increase genetic variation within a species, which increases the chances of survival in changing environments.

There are different **effects** of mutations:

1. **Harmful mutations**:
   E.g.: the gene for cystic fibrosis, haemophilia or colour-blindness or a chromosomal mutation.
   I.e. In the DNA of the **gene** that codes for each of the disorders has a **single incorrect nucleotide**.
   This results in an **incorrect amino acid**, which results in a **changed protein**, which therefore **cannot carry out its function.**
   This change in the **gene** or **chromosome** is caused by a **point shift mutation** or a **frameshift mutation**.

2. **Harmless mutations**:
   These mutations have **little or no effect on the survival or reproductive** ability of an organism.
   These mutations may be **useful** in the future, in adapting to changing environment.
   The **single incorrect nucleotide** will **not cause a change in the amino acid**, as each amino acid is coded from two or more different nucleotides.
   I.e. if TCT (code for arginine) is mutated to TCC (code for arginine) the resulting protein is the same.
   This change in the **gene** is caused by a **point shift mutation**.

These harmless mutations can be used as **genetic trace markers** in the **Y-chromosome**, tracing male heredity and **mtDNA**, tracing female heredity.

3. **Lethal mutations**:
These mutations in developing embryos lead to a **natural abortion/miscarriage**.
This change in the **gene** or **chromosome** is caused by a **point shift mutation** or a **frameshift mutation.**

Video: https://youtu.be/xYOK-yzUWSI

Point mutation vs Frameshift mutation

A **point mutation** is a **change** in a **single nucleotide**, causing a change in the respective amino acid resulting in a possible change in the protein.

I.e.

Original DNA:	TAC	GGG	ACA	CCC
Changed DNA:	TAC	GGG	AGA	CCC
Original mRNA:	AUG	CCC	UGU	GGG
Changed mRNA:	AUG	CCC	UCU	GGG

Original amino acids: Met – Pro – Cys – Gly

Changed amino acids: Met – Pro – Ser – Gly

Result: A change in one of the nucleotides of the resulting protein.

A **frameshift mutation** is a **change** in the DNA due to an **addition** of a nucleotide or a **deletion** of a nucleotide.

I.e.

Original DNA:	TAC	GGG	ACA	CCC	
Changed DNA:	TAA	CGG	GAG	ACC	C
Original mRNA:	AUG	CCC	UGU	GGG	
Changed mRNA:	AUU	GCC	CUC	UGG	G

Original amino acids: Met – Pro – Cys – Gly

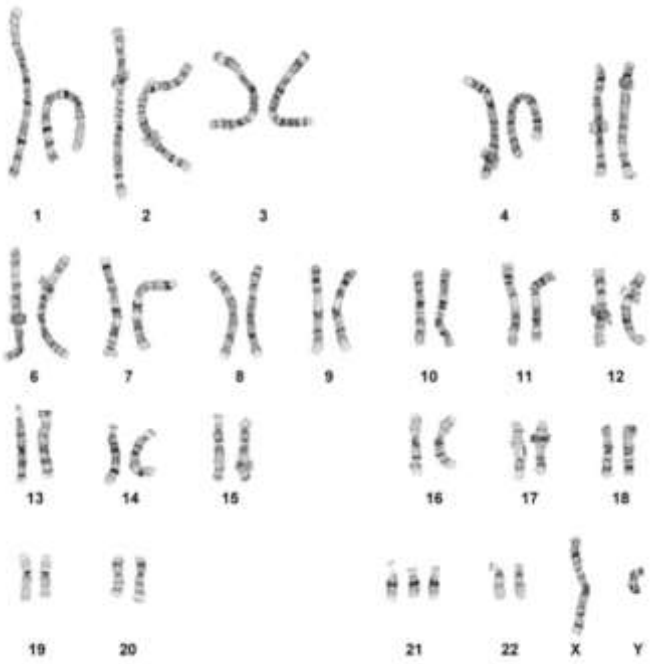
Changed amino acids: Met – Ala – Leu – Trp

Result: A complete change in the resulting protein.

Examples of Mutations:

- Haemophilia: Caused by the absence of blood clotting factors.
- Colour blindness: Caused by the absence of proteins in the retina of the eye that make up the red or green cones (photoreceptors).
- Down Syndrome**:** Caused by non-disjunction during meiosis resulting in an extra copy of chromosome 21 in the gamete.

A karyotype of a Down's syndrome male



Genetic Engineering (Genetic Modification)

Genetic engineering uses **biotechnology** to satisfy human needs.
This is where technology changes the genetic makeup of organisms.

Stem cell research

Stem cells are **undifferentiated** and **unspecialised cells**, whose **genomes are not fixed** in a specific developmental pathway.

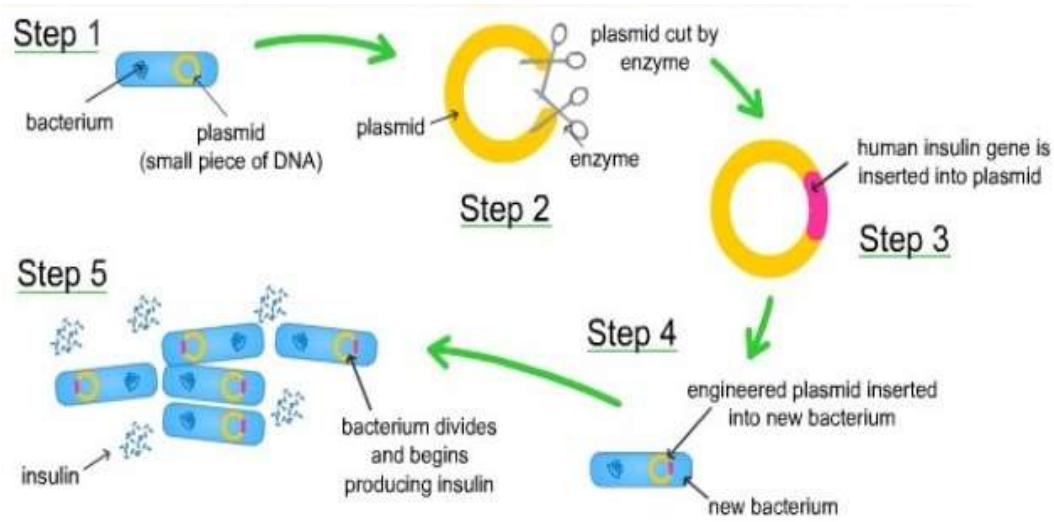
Adult organisms develop from **embryonic stem cells**.
Bone marrow, cells from the placenta and umbilical cord and buds and meristem cells in plants are all places where stem cells are found in an organism.

Stem cells can be used to treat certain cancers, sickle-cell anaemia and brain disparities such as Parkinson's and Alzheimer's disease.

Genetically modified organisms

Recombinant DNA technology: When genes are combined from different organisms.
E.g. human insulin gene and plasmid of a bacterium.
The result of this is said to be genetically modified or genetically engineered or transgenic.

Process:



Benefits:

- Improve nutritional content of food.
- Increase resistance to herbivores.
- Improve resistance to pesticides.
- Increase the life span/shelf life of food.
- Increase the resistance to harsh environmental conditions. E.g. increase the ability of plants to survive in nitrogen-poor soils or areas of little rainfall.
- Decrease costs of products.

Controversies:

- Environmental safety.
- Labelling so that people can make a decision about what they are eating.
- Ethics.
- Intellectual property rights.
- Food security.

Genetically modified products include vaccines, foods, medicines, animal feeds etc.

Cloning

Cloning occurs naturally when plants and animals reproduce **asexually**. The offspring are **identical** to the parents i.e. **clones**.

During this process cells and tissues from a single cell are grown by stimulating mitosis of stem cells, using a medium which contains growth substances.
Organisms such as bacteria, fungi, plants and simpler animals go through this process of cloning.

In more complex organisms, such as Futhi the cow, a somatic cell is removed. The nucleus is removed from the somatic cell. This nucleus is then inserted into an empty fertilised egg. The embryo is then implanted into a surrogate female. The embryo then grows, develops and specialises as normal.

- Complete the following**:**

Benefits:

- Creating the desired traits (characteristics) for human needs.
-
-
-

Controversies:

- Ethics.
-
-
-

Paternity Test

This process uses biotechnology to determine the possible father of a child.
DNA is extracted from a blood sample of the possible father and the child.
A DNA profile is produced and each of the child's genetic variants are traced back to the possible parent.

Past Paper Examples

1.1.1 The genotype for an individual with blood group A is …

A. I^AI^A only.
B. I^AI^A or ii.
C. I^Ai only.
D. I^AI^A or I^Ai.

1.1.2 Study the statements about alleles below:

(i) Alternate forms of a gene are called alleles.
(ii) There is always only two alleles for a given characteristic.
(iii) The alleles for a particular characteristic are given in a genotype.
(iv) Alleles are found at corresponding positions on homologous chromosomes.

Which combination of statements is CORRECT?

A. (i), (ii), (iii) and (iv)
B. (i), (iii) and (iv) only
C. (i), (ii) and (iv) only
D. (ii) and (iv) only

1.1.3 A pedigree diagram shows …

A. how organisms evolve.
B. the inheritance of characteristics over many generations.
C. sex-linked characteristics only.
D. the number of children in a family only.

1.1.4 A red flowering plant is crossed with a white flowering plant.
All the offspring have pink flowers.
When the two pink flowering plants are crossed, the next generation of flowering plants will have flowers that are …

A. pink only.
B. red only.
C. white only.
D. pink, red and white

DBE/Feb-Mar 2017

1.2 Supply the correct term for each of the following:

a. A pair of homologous chromosomes.
b. A sequence of nucleotides that codes for the amino acid sequence of a protein.
c. An organism's entire hereditary information.
d. The direct manipulation of an organism's genome.

2. Coat colour in mice is controlled by two alleles, black (B) and grey (b). Tail length is controlled by two alleles, long (T) and short (t).

The Punnett square below shows a part of the cross between two mice.
Genotype (i) has been left out.

Parent 1 / Parent 2	**BT**	**Bt**	**bT**	**bt**
Bt	BBTt	BBtt	BbTt	Bbtt
Bt	BBTt	BBtt	BbTt	Bbtt
Bt	BBTt	BBtt	(i)	Bbtt
Bt	BBTt	BBtt	BbTt	Bbtt

2.1 Give the:

a. Genotype of parent 1 (2)

b. Phenotype of parent 2 (2)

c. Genotype of offspring (i) (1)

2.2 What percentage of the offspring above is grey with short tails? (1)

2.3 State the genotypes of TWO gametes from the table above that will result in offspring that are heterozygous for both traits, if fertilisation occurs. (2)

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