ABDUR REHMAN BIOLOGY

17 Inheritance

17.1 Variation

Describe variation as differences between individuals of the same species.
Understand that continuous variation results in a range of phenotypes between two extremes, including body length and body mass.

Variation

It is the difference between individuals of the same species.

It refers to the range of differences among individuals of the same species. This can include differences in traits such as appearance, behavior, physiology, and genetic makeup. These variations can be influenced by genetic factors, environmental factors, or a combination of both. All domestic cats belong to the same species, i.e they can all interbreed, but there are many variations of size, coat colour, eye colour, fur length, etc.

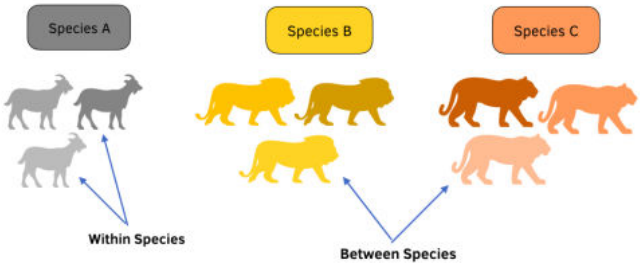


Fig 1. Types of Variation. Variation can occur both within and between species.

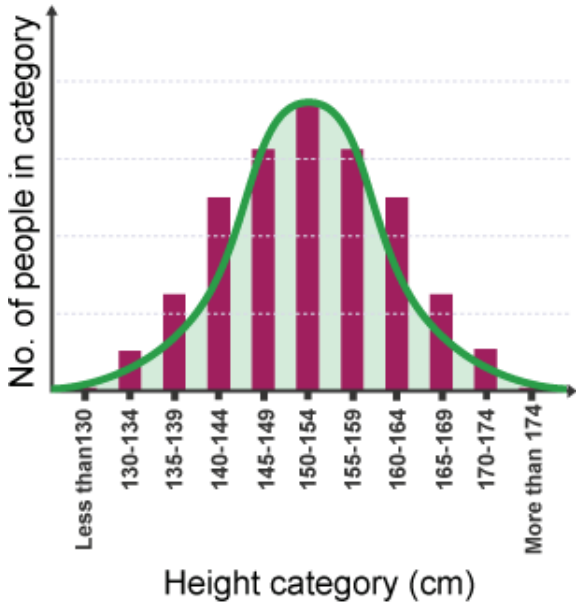
Phenotype

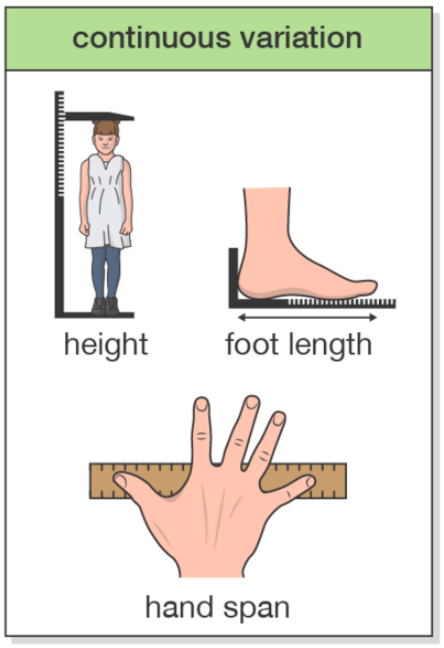
A phenotype refers to the observable characteristics or traits of an organism, resulting from the interaction of its genotype with the environment. These characteristics can include physical traits such as height, color, and shape, as well as behavioral and physiological traits.

Continuous Variation.

Continuous variation refers to the range of phenotypic differences within a population that fall along a continuous spectrum, with no distinct categories or classes.

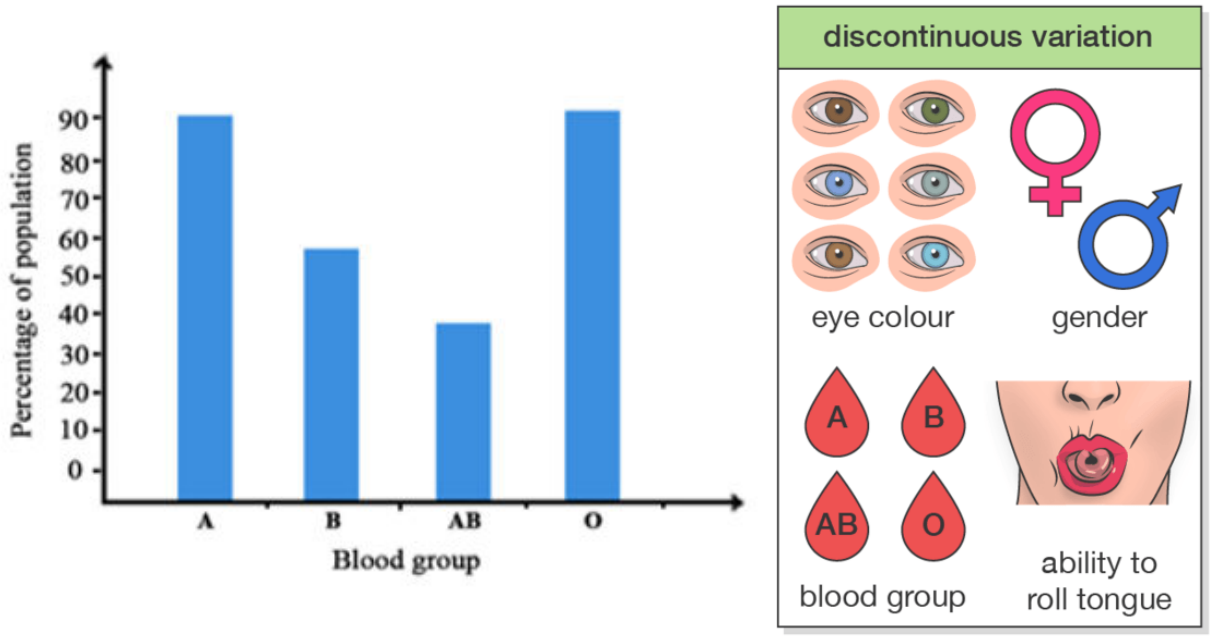
Continuously variable characteristics are strongly influenced by the environment. A person may inherit genes for tallness but they may not get enough food to grow tall. A plant may have the genes for large fruits but not get enough water, mineral ions or sunlight to produce large fruits. Continuous variations in human populations, like height, physique and intelligence, are always the result of contributions from both the genotype and the environment.





Understand that discontinuous variation results in a limited number of phenotypes with no intermediates, including ABO blood groups, seed shape and seed colour in peas.
Understand that discontinuous variation is usually caused by genes only and continuous variation is caused by genes and the environment.

Discontinuous variation refers to the distinct categories or classes that traits fall into within a population, with little to no intermediate forms. Discontinuous variation is under the control of a single pair of alleles or a small number of genes. manifests as a limited number of distinct phenotypes without intermediates within a population. Examples, such as ABO blood groups in humans, seed shape, and seed color in peas, showcase clear-cut categories with no gradual transition between them.



Discontinuous variation is caused entirely by genes, with the environment having no effect. These traits are often controlled by specific alleles, with each allele producing a distinct phenotype. For example, in ABO blood groups, the presence of specific alleles determines whether an individual has blood type A, B, AB, or O. On the other hand, continuous variation arises from the interaction of both genetic and environmental factors. While genes play a significant role in determining the range of phenotypic variation, environmental influences also contribute. Traits subject to continuous variation, such as height or body mass, result from the combined effects of genetic predispositions and environmental conditions. Factors like nutrition, climate, and lifestyle can impact the expression of these traits, leading to a spectrum of phenotypes with no clear boundaries between them.

Investigate and describe examples of continuous and discontinuous variation.

Create a table to collect on variation among a group of people. This could be members of your class or people you live or work with. You will need a ruler and a tape measure. Set up headings for table such as:

Name	Eye Colour	Tongue Roller	Hand Span/cm	Shoe size	Height/cm

When you have collected the data each characteristic needs to be grouped and tallied. For example, for eye colour, count how many people have blue, brown, hazel or green eyes. Variation in height is more difficult when organising the data. You will need to look at the range of data you have collected then choose categories between the smallest and largest height. For example, if your range is 156-193 cm. the categories could be:

- 155-159
- 160-164
- 165-169
- 170-174
- 175-179
- 180-184
- 185-189
- 190-194.

It is tempting to make the categories simpler for example, 5s, so 155-160, 160-165 and so on. However, if you did this, in which category would you place a person who is 160 cm tall? After organising the data it needs to be plotted on a graph. The data for tongue rolling and eye colour is in distinct categories (categoric). Each data set needs to be plotted as a bar chart. In a bar chart the columns do not touch each other.

The data for hand span, shoe size and height is continuous (numerical). The frequencies for the different values should be plotted as a histogram, where each of the blocks touches the next.

Results

Some frequencies for each set of data will be larger than others. For characteristics like shoe size, there may be a normal distribution, where a few individuals have small or large feet and the majority are clustered around the middle of the range. However, this is the ideal and will depend on the data size: a large set of data is more likely to show a normal distribution.

Interpretation

Some of the data collected (tongue rolling and eye colour) will represent examples of discontinuous variation. However, hand span, shoe size and height are examples of continuous variation.

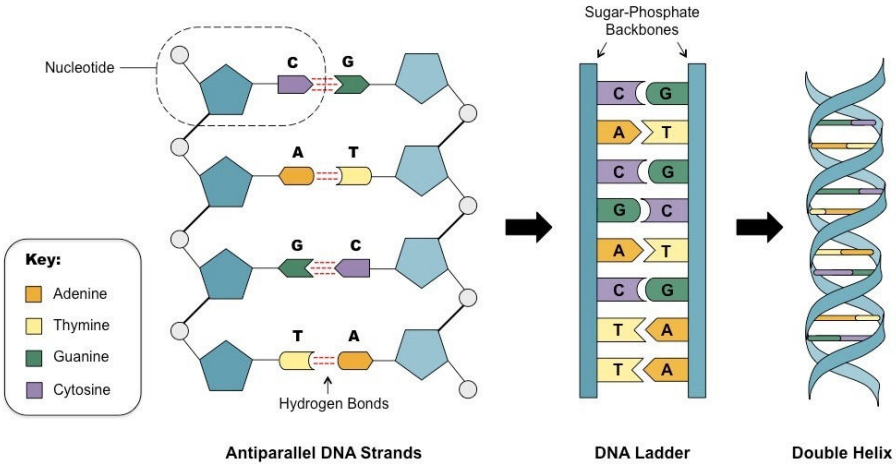
17.2 DNA

Describe the structure of a DNA molecule:

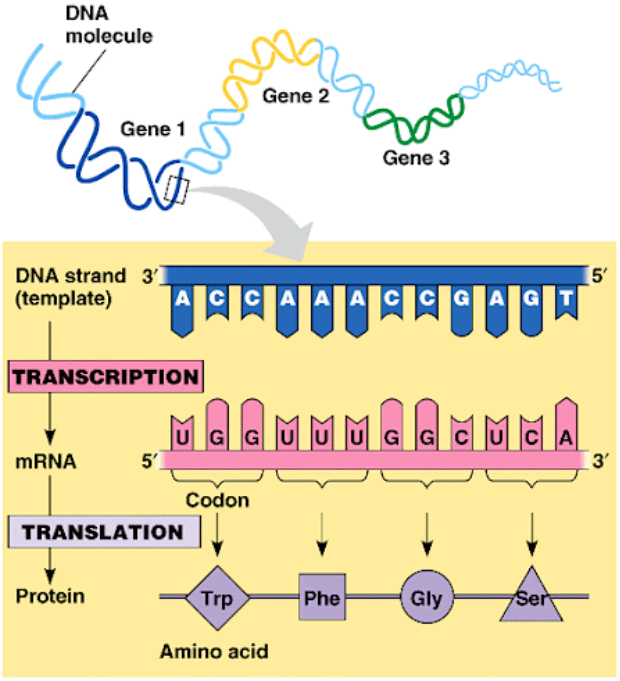
(a) two strands coiled together to form a double helix (b) each strand is made up of a chain of nucleotides (c) each nucleotide contains a base (A, T, C, G; full names are not required) (d) bonds between pairs of bases hold the strands together (e) the bases always pair up in the same way: A with T, and C with G.

Define a gene as a length of DNA that codes for a protein.

The structure of the DNA molecule is explained through Watson and Crick model presented by James D. Watson and Francis Crick in 1953. According to the Watson-Crick model, a DNA molecule consists of two polynucleotide strands. These strands are coiled around each other in the form of a double helix. There is a phosphate- sugar backbone on the outside of double helix, and the nitrogenous bases are on the inside. In double helix, the nitrogenous bases of opposite nucleotides form pairs through hydrogen bonds. This pairing is very specific. The nitrogenous base adenine of one nucleotide forms pair with the thymine of opposing nucleotide, while cytosine forms pair with guanine. There are two hydrogen bonds between adenine and thymine while there are three hydrogen bonds between cytosine and guanine.



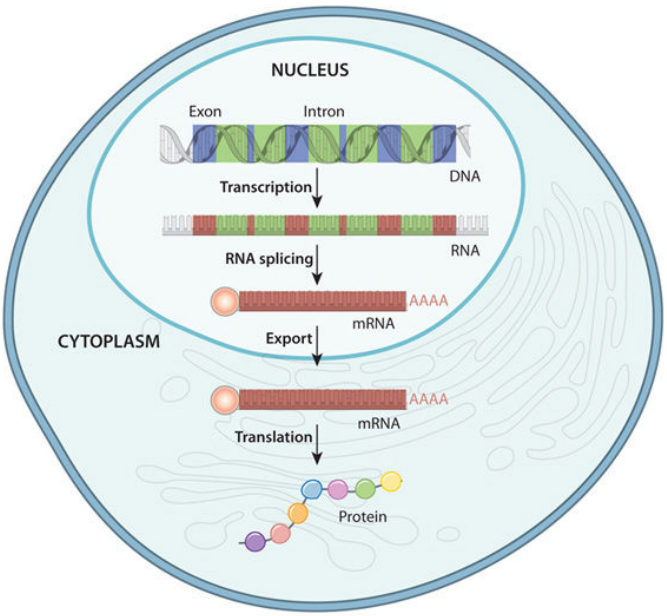
A gene is a length of DNA. The contain specific instructions for protein synthesis. These instructions are transcribed into RNA and then translated into a protein molecule through a process called gene expression. Genes play a fundamental role in determining the traits and characteristics of an organism.



Explain that DNA controls cell function by controlling the production of proteins, including enzymes.

State that the sequence of bases in a gene determines the sequence of amino acids needed to make a specific protein (knowledge of the details of nucleotide structure is not required).

DNA controls cell function by serving as the blueprint for the synthesis of proteins, which are essential for various cellular processes. This control occurs through a process called gene expression. Proteins have diverse roles in the cell, including acting as enzymes. Enzymes are catalysts that facilitate biochemical reactions within the cell, such as metabolism, DNA replication, and protein synthesis itself.



DNA controls the sequence of a amino acids through its base sequence. This sequence forms a code, which instructs the cell to make specific proteins. Proteins are made from amino acids a link together. The type and sequence of a Mino acids are joined together will determine the kind of protein formed. Each set of three nucleotides on the mRNA, known as a codon, corresponds to a specific amino acid, ultimately determining the structure and function of the protein being synthesized. For example, one protein molecule may start with the sequence methionine-glycine-glycine... A different protein may start methionine -serine-alanine-...

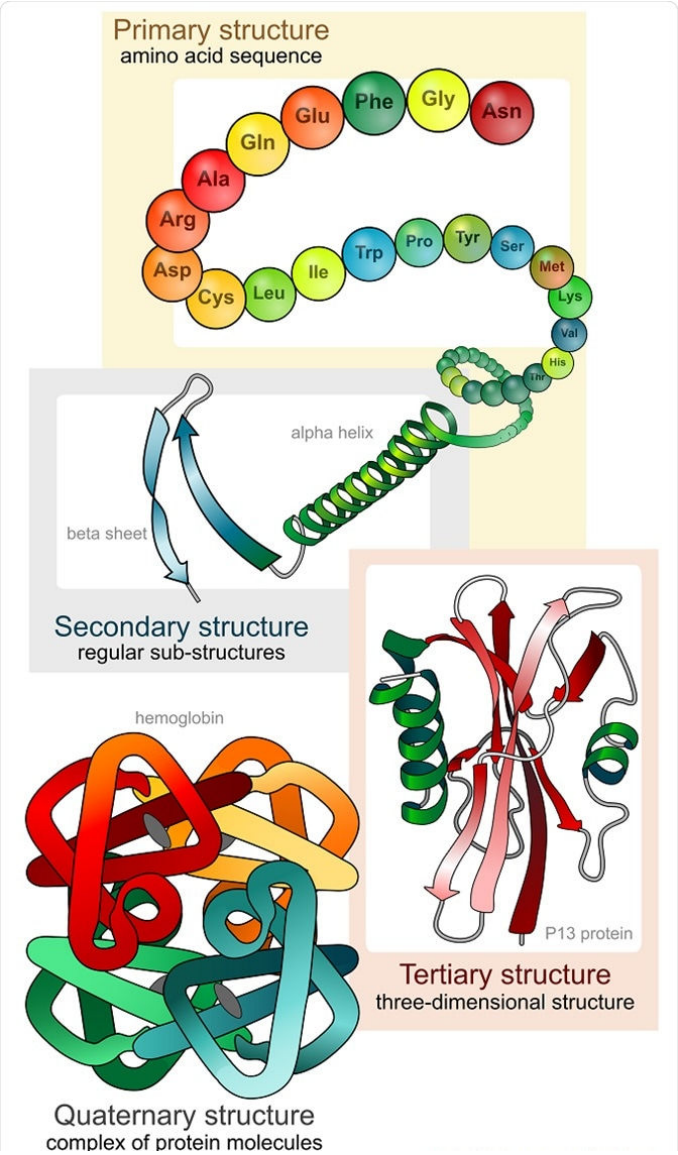
The sequence of basis in the DNA molecule controls which amino acids are used and in which order are they joined. Each group of three bases stands for one amino acid, for example, the triplet of basis CGA course for the amino acid alanine, the base triplet AUG codes for methionine, and the triplet AAG codes for lysine. The triplet peptide alanine-methionine-lysine is codes by CGA-AUG-AAG. So, the sequence of bases in a gene determines the sequence of amino acids needed to make a specific protein through the processes of transcription and translation. This sequence of amino acids ultimately determines the structure and function of the protein.

SECOND LETTER

FIRST LETTER	U	C	A	G	THIRD LETTER
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA Stop UAG Stop	UGU Cys UGC Cys UGA Stop UGG Trp	U C A G
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Ile AUC Ile AUA Ile AUG Met	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

Understand that different sequences of amino acids give different shapes to protein molecules.

The sequence of amino acids in a protein is crucial because it determines the final three-dimensional structure of the protein. This three-dimensional structure is essential for the protein's function. The sequence of amino acids influences how the protein folds and interacts with other molecules in its environment. Proteins can fold into intricate shapes, such as helices, sheets, and loops, driven by various chemical interactions between amino acids, including hydrogen bonds, disulfide bonds, hydrophobic interactions, and electrostatic interactions. The specific shape of a protein molecule is crucial for its function because it determines how the protein interacts with other molecules, such as substrates, enzymes, or other proteins. For example, enzymes have active sites with specific shapes that allow them to bind to substrates and catalyze chemical reactions. Even small changes in the amino acid sequence can lead to significant alterations in the protein's structure and function. Mutations, which are changes in the DNA sequence, can result in changes in the corresponding amino acid sequence and, consequently, in the protein's structure and function. These changes can have important implications for an organism's health and physiology.



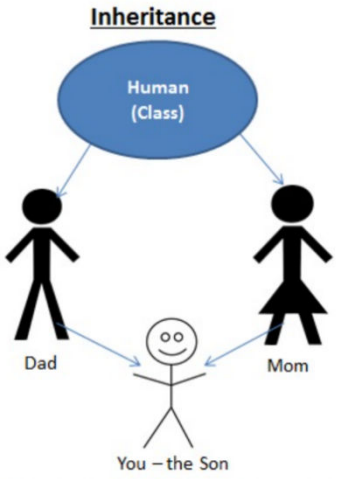
17.3 Inheritance

Describe inheritance as the transmission of genetic information from generation to generation.

Inheritance

Inheritance is the transmission of genetic information from generation to generation.

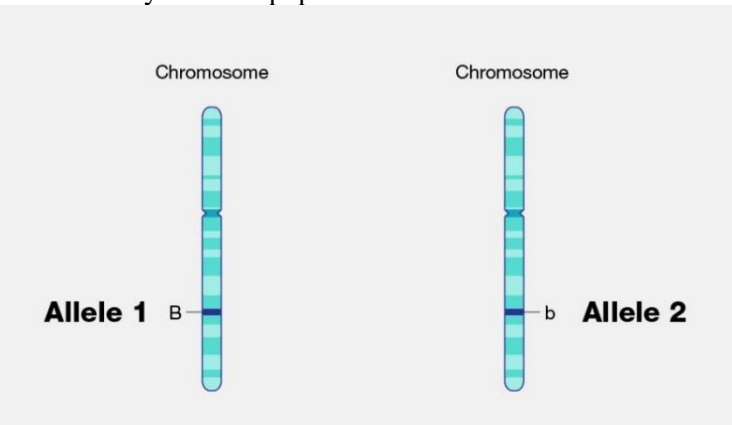
During reproduction, genetic material in the form of chromosomes is passed from parent organisms to their offspring. The allele in a mother's body cells that causes her to have brown eyes may be present on one of the chromosomes in each egg cell she produces. If the father's sperm cell contains an allele for brown eyes on the corresponding chromosome, the zygote will receive an allele for brown eyes from each parent. These alleles will be reproduced by cell division in all the embryo's body cells. When the embryo's eyes develop, the alleles will make the cells of the iris produce brown pigment (melanin) and the child will have brown eyes. In a similar way, the child may receive alleles for curly hair.



Define an allele as an alternative form of a gene.
Understand and use the terms: dominant, recessive, phenotype, genotype, homozygous and heterozygous.

Allele

An allele is one of two or more alternative forms of a gene that occupy the same position, or locus, on a chromosome. These alternative forms arise from mutations or variations in the DNA sequence of a gene. Alleles can produce different phenotypic traits, such as eye color or blood type, and they contribute to genetic diversity within a population.



Genotype

Genotype refers to the genetic makeup of an organism.

Phenotype

Phenotype refers to the observable traits or characteristics of an organism, such as its physical appearance, behavior, or biochemical properties.

Genotype	Phenotype
BB Homozygous dominant	
Bb Heterozygous	
bb Homozygous recessive	

Homozygous

Homozygous individuals have two identical alleles at a particular gene locus. For example, if an organism carries two dominant alleles (AA) or two recessive alleles (aa) for a given trait, it is homozygous for that trait.

Heterozygous

Heterozygous individuals have two different alleles at a particular gene locus. For example, if an organism carries one dominant allele and one recessive allele (Aa) for a given trait, it is heterozygous for that trait.

Dominant

Dominant describes an allele that is expressed if it is present in the genotype. It masks the presence of other allele.

Recessive

Recessive describe an allele that is only expressed when there is no dominant allele of the gene present in the genotype.

Use genetic diagrams, including Punnett squares, to predict the results of monohybrid crosses and calculate phenotypic ratios, limited to 1:1 and 3:1 ratios.

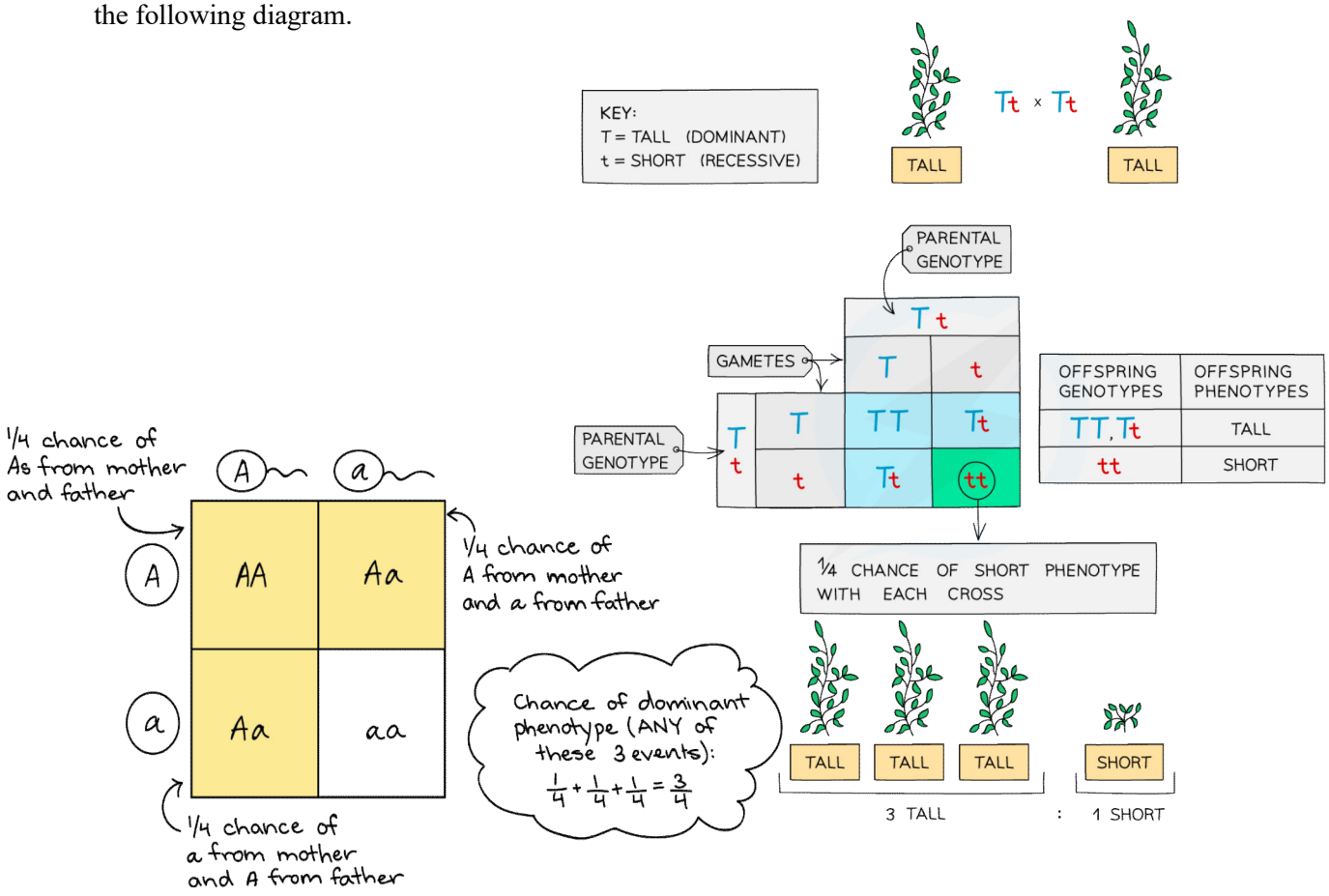
Punnett square

A Punnett square diagram is a simple graphical tool used to predict the possible combinations of alleles in offspring from the mating of two individuals. It is named after the geneticist Reginald Punnett, who developed the concept.

Monohybrid cross

A monohybrid cross is a genetic cross involving the study of a single trait or characteristic controlled by a single gene with two different alleles.

Let's consider an example of a monohybrid cross of among plants. In this example one of the parents has the phenotype tallness and the other is dwarf. The genotype of both the parents is homozygous. The first parent is homozygous dominant (TT), the second parent is homozygous recessive (tt). The dominant allele is expressed by "T" and the recessive allele is expressed by "t". When both the parents cross the results of the first filial generation is a heterozygous individual having genotype Tt. When the first filial generation interbreed these produce the ratio of 3:1 phenotype. This is also expressed in the following diagram.



Explain why observed ratios often differ from expected ratios, especially when there are small numbers of Offspring.

Observed ratios in genetic crosses often differ from expected ratios, especially when there are small numbers of offspring, due to chance variation and sampling error. This phenomenon is known as genetic drift.

Genetic drift occurs because the actual outcome of genetic crosses may not perfectly reflect the predicted ratios due to random segregation of alleles during gamete formation and chance events during fertilization. When the number of offspring is small, chance plays a more significant role in determining the observed ratios, leading to greater deviation from the expected ratios.

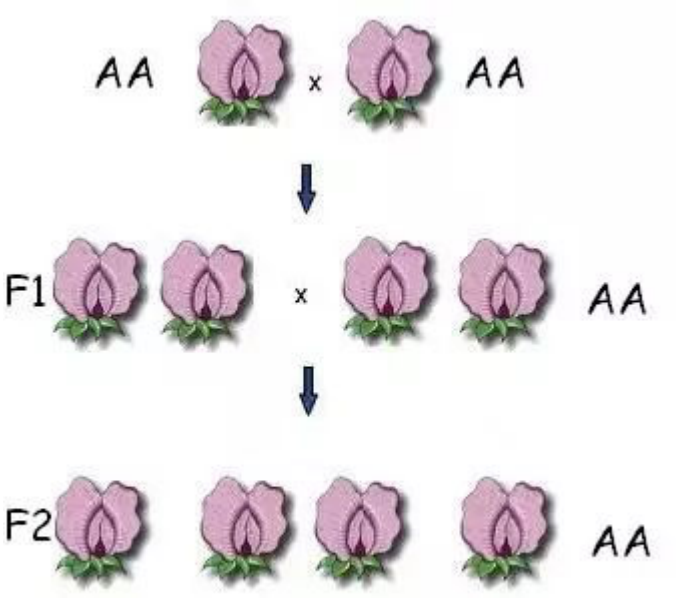
For example, let's consider a monohybrid cross involving the tallness of pea plants, where tallness (T) is dominant over shortness (t). If we perform a genetic cross between two heterozygous tall plants (Tt), the expected phenotypic ratio based on Mendelian principles would be 3 tall (TT or Tt) : 1 short (tt).

However, if we were to conduct this cross with only a small number of offspring, let's say four plants, the observed ratios might deviate significantly from the expected ratios due to chance events during gamete formation and fertilization. For instance, we might end up with 2 tall plants and 2 short plants instead of the expected 3:1 ratio.

This discrepancy between observed and expected ratios is more pronounced with smaller sample sizes. With a larger number of offspring, the observed ratios tend to converge toward the expected ratios, as chance variation is minimized. Therefore, to accurately predict genetic ratios and ensure reliable results, it's essential to conduct genetic crosses with a sufficiently large sample size.

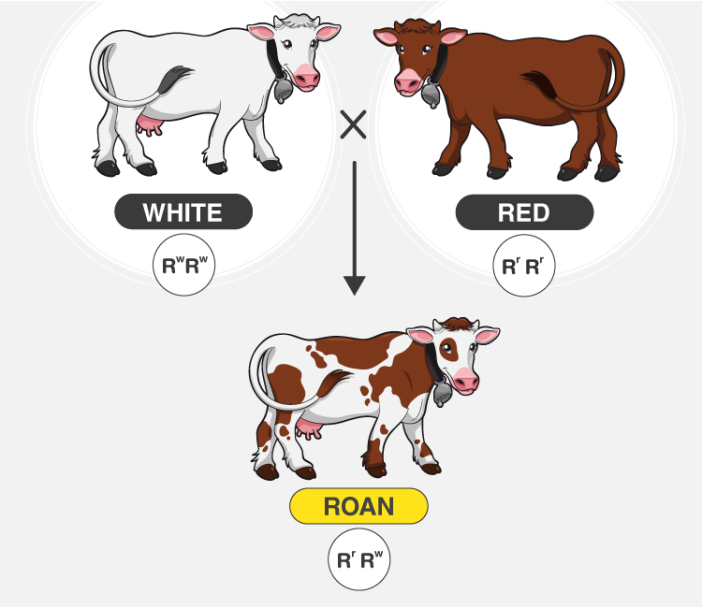
State that two identical homozygous individuals that breed together will be pure-breeding.

When two identical homozygous individuals breed together, they will produce offspring that are also homozygous for the same trait, resulting in a generation of pure-breeding individuals for that trait.
For example, if two homozygous purple-colored plants (AA) are bred together, all of their offspring will inherit two copies of the purple allele (A) and will therefore also be homozygous for purple color. These offspring will consistently produce purple-colored offspring when bred with each other or with other homozygous purple plants. This is because each parent contributes one identical allele for the same trait, ensuring that all offspring inherit the same allele combination. As a result, the offspring from such a breeding pair will be genetically uniform and display the same trait as the parents, making them pure-breeding for that particular trait.

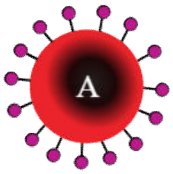
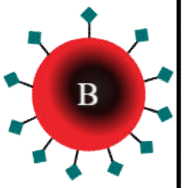
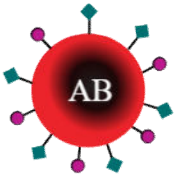
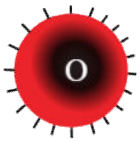
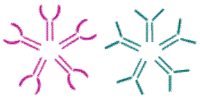


Explain codominance by reference to the inheritance of the ABO blood groups (phenotypes A, B, AB, O, gene alleles IA, IB and Io).

Codominance is a genetic phenomenon where both alleles of a gene are fully expressed in the heterozygous condition, resulting in a combined phenotype that exhibits characteristics of both alleles. In other words, neither allele is dominant over the other, and both are simultaneously expressed in the phenotype.



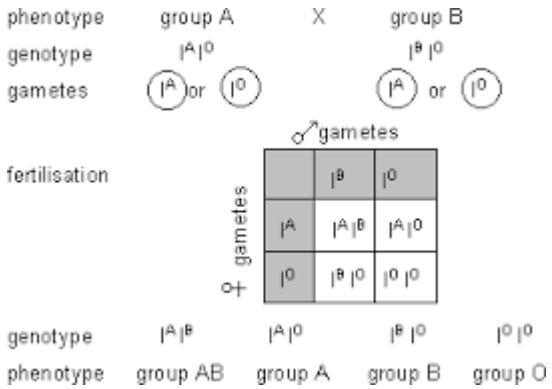
The inheritance of the human ABO blood groups is an example of codominance. In the ABO system, there are four phenotypic blood groups, A, B, AB and 0. The alleles for groups A and B are codominant. If a person inherits alleles for group A and group B, his or her red blood cells will carry both antigen A and antigen B.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in red blood cell	 A antigen	 B antigen	 A and B antigens	None

However, the alleles for groups A and B are both completely dominant to the allele for group 0. (Group O people have neither A nor B antigens on their red blood cells.)

Phenotype	Genotype
O	ii
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^AI^B

Above table shows the genotypes and phenotypes for the ABO blood groups. (Note: The allele for group O is sometimes represented as I^o and sometimes as i.) Since the alleles for groups A and B are dominant to that for group 0, a group A person could have the genotype I^AI^A or I^AI°. Similarly, a group B person could be I^BI^B or I^BI°. There are no alternative genotypes for groups AB and 0. Blood group O can be inherited even though neither parent shows this phenotype. Two parents have the groups A and B. The father is I^AI^0 and the mother is I^BI°.



Describe the determination of sex in humans (XX and XY chromosomes).

Humans have 46 chromosomes in the form of 23 pairs, 22 pairs are of autosomes and one pair is of sex chromosomes. Autosome pairs are common in both the sexes but the 23rd sex chromosome pair is it different in males and females. Females have two X chromosomes (XX) as their sex chromosome pair. The presence of two X chromosomes typically results in the development of female reproductive anatomy and secondary sexual characteristics. Males have one X chromosome and one Y chromosome (XY) as their sex chromosome pair. The presence of one X and one Y chromosome typically results in the development of male reproductive anatomy and secondary sexual characteristics.

During fertilization, the father's sperm determines the sex of the offspring by contributing either an X or a Y chromosome. If an X-carrying sperm fertilizes the egg, the resulting zygote will have an XX chromosome pair and develop into a female. If a Y-carrying sperm fertilizes the egg, the resulting zygote will have an XY chromosome pair and develop into a male.

This XY system of sex determination is a characteristic feature of mammals, including humans. It is a relatively simple genetic mechanism that governs the development of sexual characteristics in males and females.

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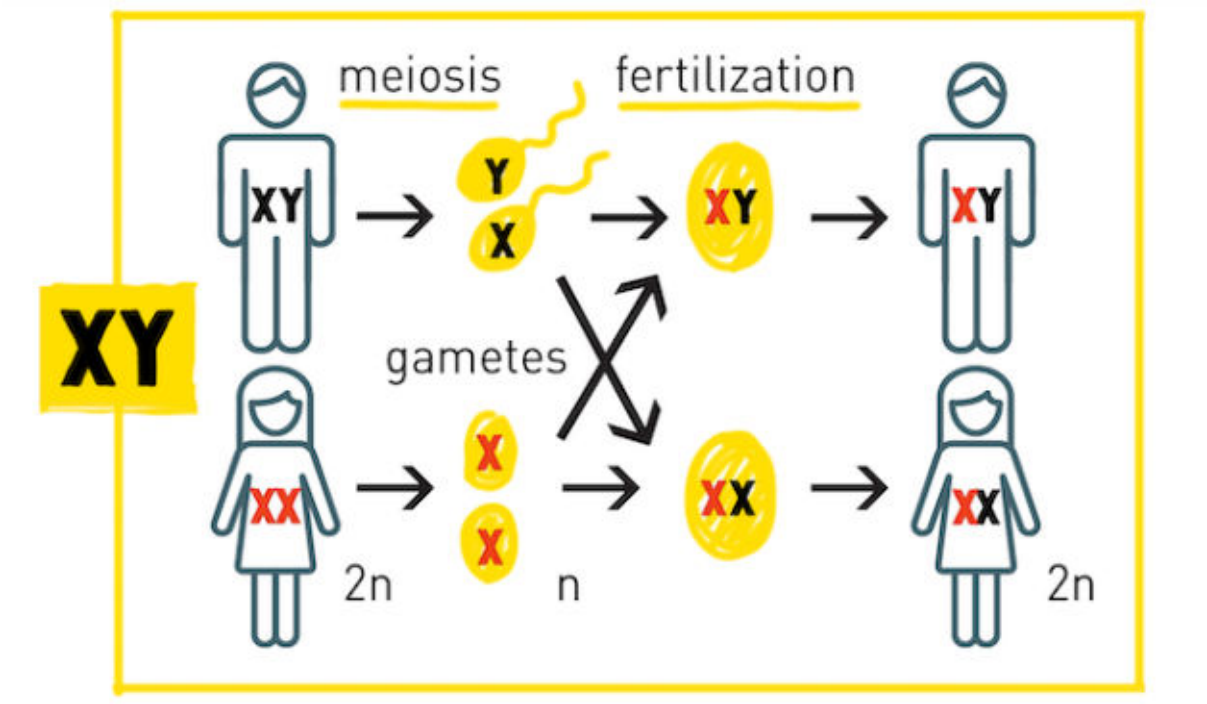


Describe a gene mutation as a random change in the base sequence of DNA, using sickle cell anaemia as an example.

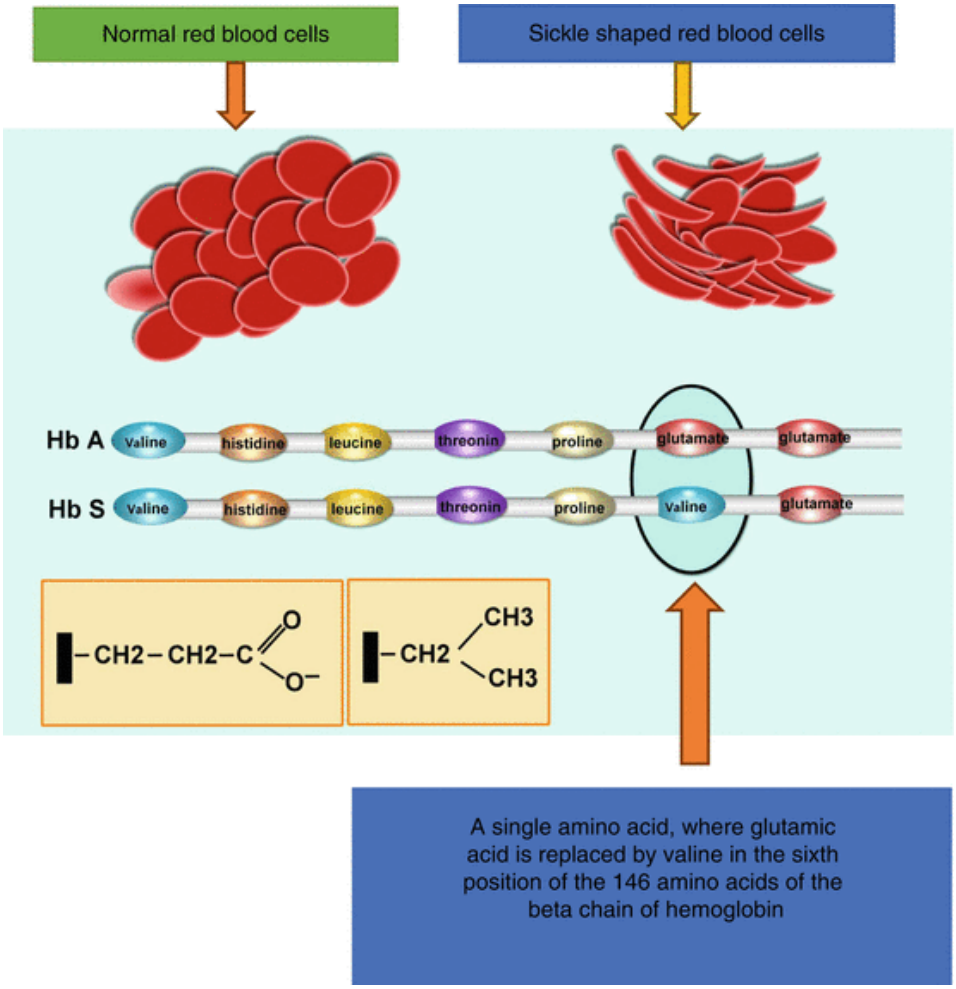
A gene mutation is a permanent and a random change in the DNA sequence of a gene. These changes can occur spontaneously during DNA replication. One example of a gene mutation is seen in sickle cell anemia. Haemoglobin is the red pigment in red blood cells. It carries oxygen around the body. A haemoglobin molecule is made up of four polypeptide chains. Each chain has one iron-containing haem group in the centre. Two of the polypeptide chains are called α (alpha) chains, and the other two β (beta) chains. The gene which codes for the amino acid sequence in the β chains is not the same in everyone. In most people, the β chains begin with the amino acid sequence:

Val–His–Leu–Thr–Pro–Glu–Glu–Lys–

But in people with sickle cell anaemia, the base sequence CTT is replaced by CAT, and the amino acid sequence becomes:

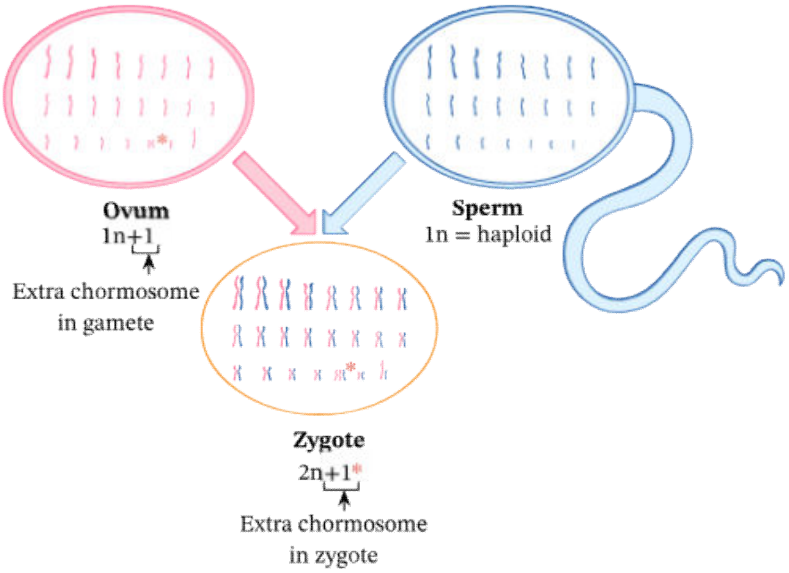
Val–His–Leu–Thr–Pro–Val–Glu–Lys–

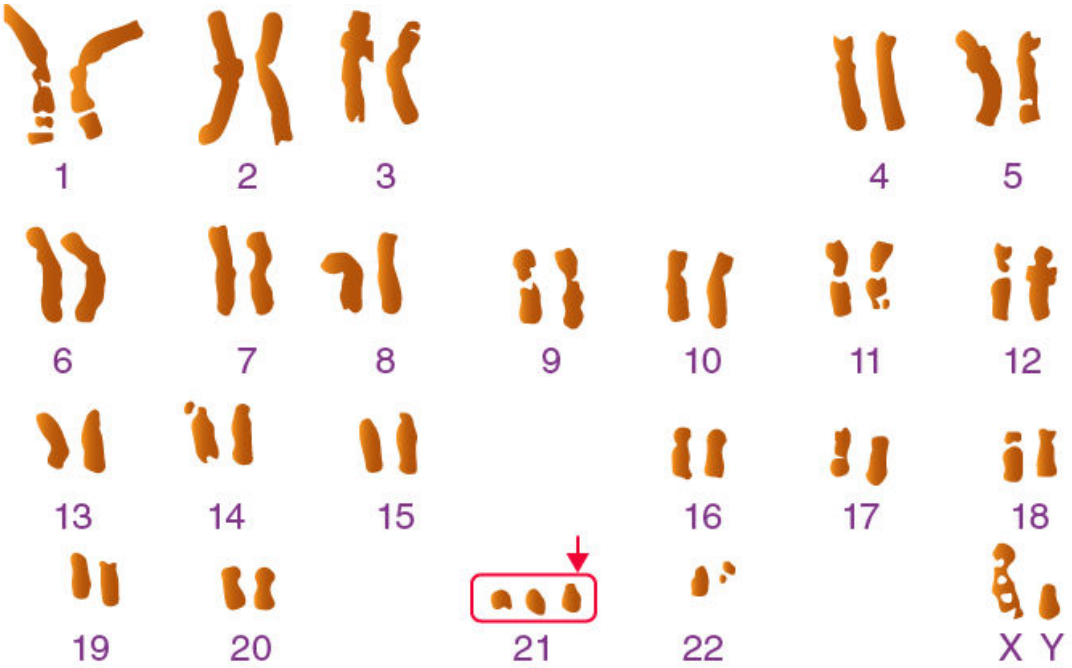
The mutation responsible is a substitution: the first T in the triplet has been substituted by A. In this case, the small difference in the amino acid sequence results in sickle cell anaemia and cell become sickle shaped. These cells lose their ability to carry oxygen efficiently and may also block narrow capillaries.



Describe a chromosome mutation as a change in the chromosome number or structure, using Down's syndrome as an example (47 chromosomes instead of 46).

It is one of the consequences of autosomal non-disjunction in man, during which 21st pair of chromosome fails to segregate, resulting in gamete with 24 chromosomes. When this gamete, fertilizes normal gamete the new individual will have 47 (2n + 1) chromosomes. Non-disjunction appears to occur in the ova and is related to the age of mother. The chances of teenage mother having Down's syndrome child is one in many thousands, of forty years old mother, one in hundred chances and by forty-five the risk is three times greater. The affected individuals have flat, broad face, squint eyes with the skin fold in the inner corner, and protruding tongue, mental retardation, and defective development of central nervous system.

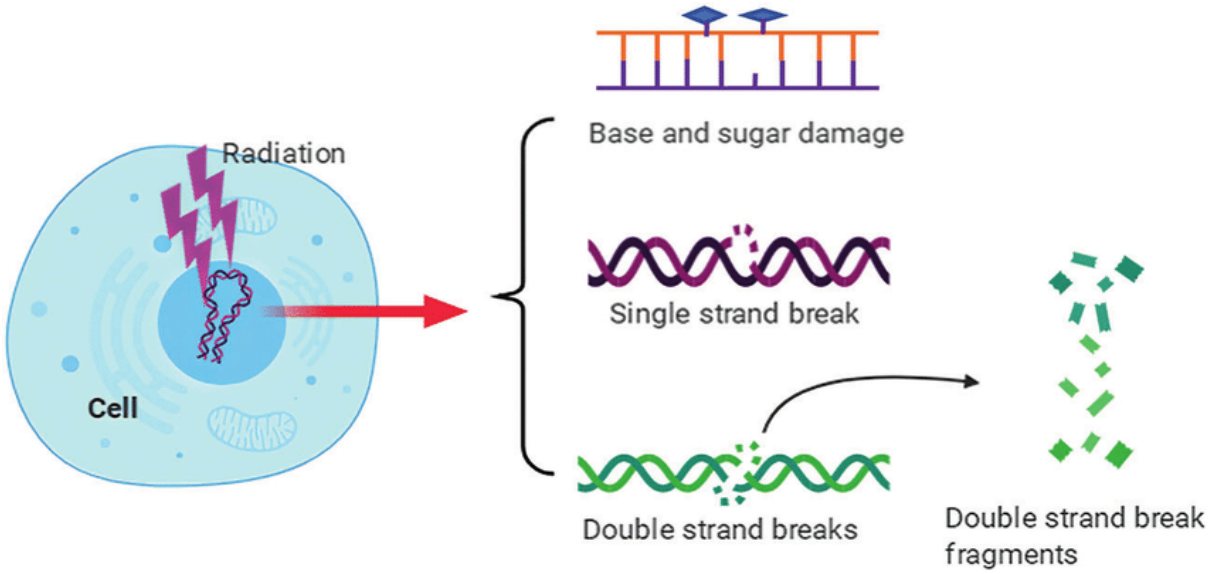




State that mutation, meiosis, random mating and random fertilisation are sources of genetic variation in Populations.
Understand that ionising radiation and some chemicals increase the rate of mutation.

Genetic variation may be the result of mutations. For example, a mutation in a gene encoding for eye color may result in a new allele that produces a different eye color than what was previously present in the population. In addition, meiosis, random mating and new combinations of genes in the zygote through random fertilization are all sources of genetic variation in populations. For example, in humans, each gamete produced by meiosis carries a random assortment of maternal and paternal chromosomes, contributing to genetic variation in offspring.
New combination of genes may also happen in some cases. If a grey cat with long fur is mated with a black cat with short fur, the kittens will all be black with short fur. If these offspring are mated together, eventually the litters of kittens may include four varieties: black- short, black-long, grey-short and grey-long. Two of these are different from either of the parents.

ionizing radiation and certain chemicals are known to increase the rate of mutation. These mutagens can cause changes in the DNA sequence by directly damaging the DNA molecule or by interfering with the processes of DNA replication and repair. Ionizing radiation, such as X-rays, gamma rays, and certain types of ultraviolet (UV) radiation, has enough energy to remove tightly bound electrons from atoms, creating ions. These ions can then interact with DNA molecules, causing breaks in the DNA strands or other types of damage. This damage can lead to mutations if not repaired correctly. For example, prolonged exposure to UV radiation from the sun can increase the risk of skin cancer by inducing mutations in the skin cells' DNA. Certain chemicals, such as some pesticides, industrial chemicals, and components of cigarette smoke, can also increase the rate of mutation. These chemicals may directly modify DNA bases, leading to mismatches during DNA replication, or they may interfere with DNA repair mechanisms. For example, polycyclic aromatic hydrocarbons (PAHs) found in tobacco smoke can form DNA adducts that can cause mutations and increase the risk of cancer.



17.4 Selection

Describe natural selection with reference to:

(a) variation within populations.

(b) production of many offspring.

(c) struggle for survival, including competition for resources.

(d) reproduction by individuals that are better adapted to the environment than others.

(e) passing on of their alleles to the next generation.

Natural selection is a fundamental mechanism of evolution proposed by Charles Darwin, which describes the process by which organisms with advantageous traits are more likely to survive and reproduce in a given environment, while those with less advantageous traits are less likely to survive and reproduce.

The theory of evolution by natural selection states that:

- Most characteristics in the population must be inherited.
- More offspring must be produced than can survive.
- The fittest offspring must be more likely to survive and reproduce.
- There must be genetic variation that allows for the best traits to be selected.
- There must be sufficient time for reproduction to occur and evolution to take place.

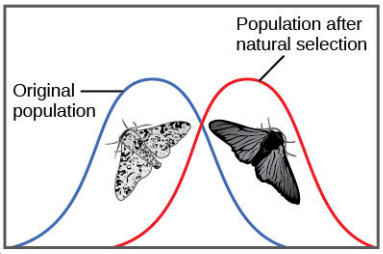
As a result of natural selection, the allele that gives more fitness of characteristics (favourable variations) than other alleles become more common within population. So, the individuals with favourable variations become a major part of population while the individuals with harmful or unfavourable variations become rarer. This is sometimes called the survival of the fittest.

In England, the moths had two variations i.e. dark and white coloured moths. The moths used to rest on light coloured tree trunks (on which white lichens had grown). In the 19th century when industries were established in England, the lichens on tree trunks died (due to polluted air) and the naked tree trunks turned dark. Now the white moth variation became harmful because a white moth resting on a dark tree trunk was easily visible to the predatory birds. The natural selection selected dark moths to reproduce. In this way dark coloured moth became more common and at last the white moths disappeared from population. In this case, the dark colour variation in moth may be considered an adaptation to environment.

Thomas Malthus, in 1798, suggested that the increase in the size of the human population would overtake the rate of food production. He predicted that the number of people would eventually be regulated by famine, disease and war. When Darwin read the Malthus essay, he applied its principles to other populations of living organisms. He observed that animals and plants produce far more offspring than can possibly survive to maturity and he concluded that there must be a struggle for survival. For example, if a pair of rabbits had eight offspring that grew up. They formed four pairs and eventually had eight offspring per pair. In four generations the number of rabbits stemming from the original pair would be 512 (i.e. 2-8-32-128-512). The population of rabbits, however, remains roughly constant. So, many of the offspring in each generation must have died before they reached reproductive age.

Describe how the inherited features of a population can evolve over time as a result of natural selection.

Describe the development of strains of antibiotic-resistant bacteria, including MRSA, as an example of natural selection.



Light-colored peppered moths are better camouflaged against a pristine environment; likewise, dark-colored peppered moths are better camouflaged against a sooty environment. Thus, as the Industrial Revolution progressed in nineteenth-century England, the color of the moth population shifted from light to dark.

Variations that are not heritable are of no value in natural selection. In a competitive environment where resources such as food shelter, and potential mates are limited, natural selection favour the survival and reproduction of individuals with advantageous traits. These traits may include heightened health, vigour, fertility and adaptability to environmental challenges. Rather than direct conflict, competition manifests through differential reproductive success, wherein individuals possessing traits such as greater speed, efficient digestion, prolific reproduction, or effective camouflage are more likely to survive and pass on their advantageous traits to offspring.

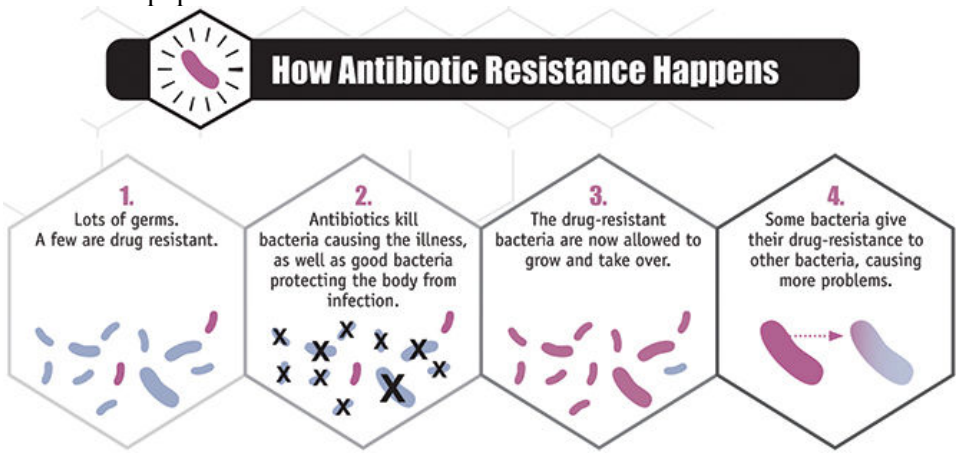
Over time, the accumulation of advantageous traits in successive generations leads to the emergence of new variations within the rabbit population. These variations, characterized by features such as enhanced speed, diverse coloration, thicker fur, and increased fertility, confer a survival advantage and gradually replace less well-adapted individuals. This process, known as natural selection, operates as a fundamental mechanism driving evolutionary change, whereby the fittest individuals are selected by environmental pressures to perpetuate their genetic traits within the population.

Adaptation.

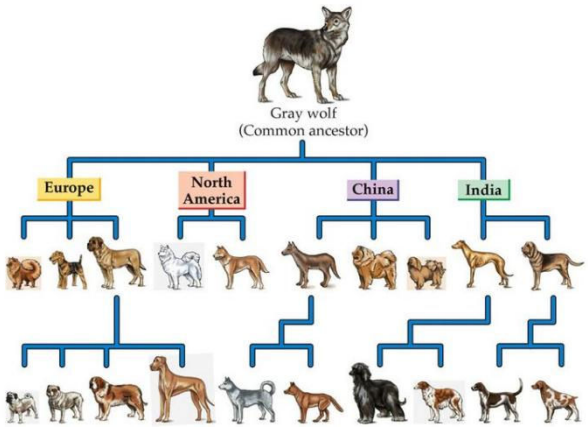
Adaptation refers to the evolutionary process by which organisms develop traits or characteristics that enable them to better survive and reproduce in their specific environment.

An illustrative example of this phenomenon can be observed in the development of antibiotic resistance in bacterial populations. When a patient is prescribed a course of antibiotics to combat a bacterial infection, incomplete adherence to the treatment regimen can lead to the survival of a subset of bacteria that have been exposed to the antibiotic. Among these survivors, spontaneous mutations may occur, resulting in the emergence of drug-resistant strains.

For instance, Methicillin-resistant Staphylococcus aureus (MRSA) is a notable example of bacterial resistance to multiple antibiotics. This resistance poses a significant challenge in clinical settings, earning such bacteria the moniker "superbugs." Staphylococcus aureus commonly colonizes the skin, nasal passages, and throat without causing harm; however, it can become pathogenic if it gains entry into the bloodstream, leading to severe infections and potentially life-threatening conditions such as sepsis. Within a bacterial population exposed to antibiotics, natural selection operates to favor the survival and proliferation of drug-resistant mutants. Consequently, the offspring of these mutants inherit the resistance traits, perpetuating the cycle of antibiotic resistance. This phenomenon underscores the dynamic interplay between selective pressures and genetic variation in shaping the evolution of microbial populations.



Describe artificial selection (selective breeding) with reference to: (a) selection by humans of animals or plants with desirable features (b) crossing these to produce the next generation (c) selection of offspring showing the desirable features (d) repetition over many generations. Describe the role of artificial selection in the production of economically important plants and animals.



Artificial selection, also known as selective breeding or directed evolution, is a process whereby humans intentionally select and breed individuals with desirable traits to perpetuate those traits in subsequent generations. This process mimics the natural selection mechanism observed in nature but is directed by human intervention rather than environmental pressures. This method has been instrumental in the development of diverse breeds and varieties in both plants and animals. Here's how it works, along with examples:

(a) Selection by humans of animals or plants with desirable features:

For example, in agriculture, farmers may select crops with high yields, disease resistance, or desirable taste traits. Similarly, breeders of livestock may choose animals with traits such as meat quality, milk production, or docile temperament for further breeding.

(b) Crossing these to produce the next generation:

Selected individuals are bred together to create offspring with a combination of the desired traits. For instance, if farmers want to develop a crop with both high yield and disease resistance, they may cross two parent plants with these traits to produce hybrid offspring.

(c) Selection of offspring showing the desirable features:

After breeding, offspring are evaluated for the presence of the desired traits. Those that exhibit the traits most prominently are chosen as the parents for the next generation. For example, in dog breeding, individuals with desired traits like size, coat colour, or temperament are selected to produce future generations with those traits.

(d) Repetition over many generations:

This process is repeated over multiple generations, with each generation building upon the improvements made in the previous ones. Over time, the frequency and expression of the desired traits become more pronounced within the population. For instance, through successive generations of selective breeding, modern dairy cows have been developed to produce significantly higher milk yields compared to their ancestors.

Artificial selection, a cornerstone of breeding programs in agriculture, involves the deliberate selection and propagation of individuals with desired traits to enhance those traits in successive generations. In crop plants, such as tomatoes, breeders selectively choose seeds from plants with the largest fruits for planting in the next season. Through repeated cycles of selection and propagation, plants with increasingly large fruits are bred, ultimately resulting in the development of true-breeding varieties characterized by consistently large fruit size.

Similarly, in farm animals like dairy cows, artificial selection is employed to amplify desirable traits such as high milk yield and disease resistance. Farmers select calves from cows with superior milk production to serve as breeding stock. Over time, this selective breeding process leads to the development of herds with uniformly high milk yields. In both plants and animals, artificial selection involves the intentional retention of genes associated with desired traits while discarding those associated with less desirable characteristics. This process highlights the power of human intervention in driving genetic change and improving the performance of agricultural species to meet the needs of modern agriculture

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