Inheritance

20

20.1 Diversity among organisms

You know that there are large numbers of plant or animal species in the biosphere. One species can be identified separately from another species by observing their external features. We get this ability as these species possess inherited features. Inherited characters are the features that transmit from generation to generation.

Although there are common characteristics for a species all the organisms belong to a single species are not similar.

The body features of every human is not similar. There are many differences among them. (Fig - 20.1)

Figure 20.1 - Diversity of human living in different areas in the world

You can identify differences within species like cats and parrots.

Figure 20.2 - Diversity of cats and parrots

- Rose and Orchid plants that grow in your home garden also produce flowers with different colours and sizes. (Fig-20.3)

Figure 20.3 - Roses and Orchids of different colours & sizes

You can observe Tomato and Brinjal plants that grow in your home garden with fruits of different shapes. (Fig-20.4)

Figure 20.4 - Different varieties of Tomatoes and Brinjals

We will consider few common inherited characteristics of human species.

• Common inherited characteristics in human population

We will identify different common inherited characteristics observed in human in the pictures below.

Figure 20.5 - Skin colour (Complexion) -white, fair, dark

Figure 20.6 - Curly and straight hair

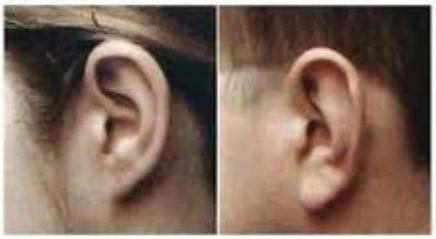


Figure 20.7 - Fused or free earlobes

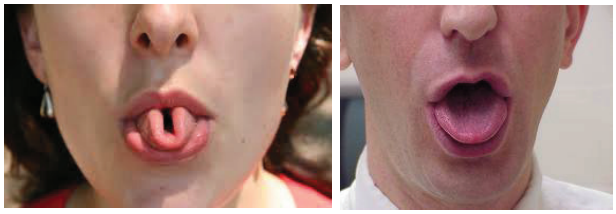


Figure 20.8 - Ability to fold the tongue

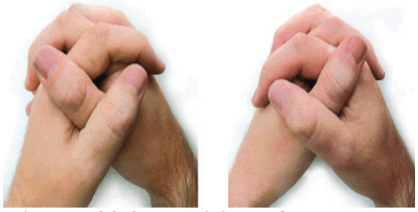


Figure 20.9 - Position of the thumb when the fingers are crossed

Figure 20.10 - Dimpled and normal cheeks

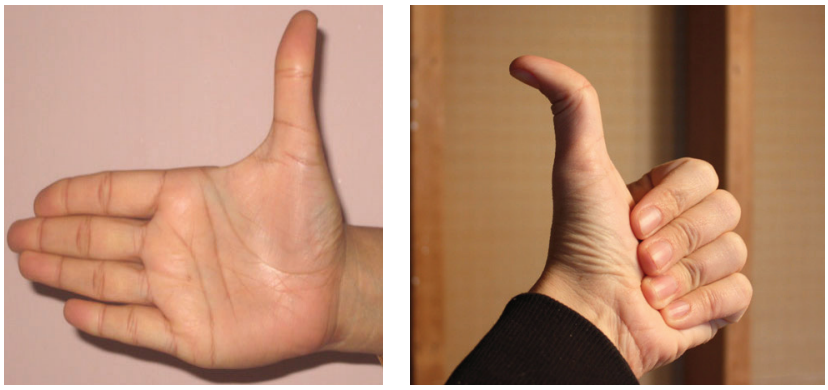


Figure 20.11- Straight and curved thumb

Figure 20.12 - Widow's peack on forehead

Activity 20.1

- Prepare a table using above inherited characteristics of your mother's and father's relatives.
- Using above information identify characteristics and skills that have transmitted from generation to generation.
- Study whether you or your brother, sister or any other relative has got a new characteristic which was not found in any relative of the generation.

According to the observation of the above activity it is revealed that most of the mother's and father's characteristics have passed to the next generations. But you may have found new characteristics in your brother, sister or any other relative which is not found in any relative. If you further study previous generations you may find that particular characteristic in them. It is clear that inherited characteristics may pass evading from one generation to the next.

There are some rare inherited characteristics. Identify them using the pictures bellow.

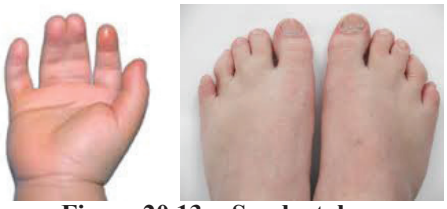


Figure 20.13 - Syndactyly

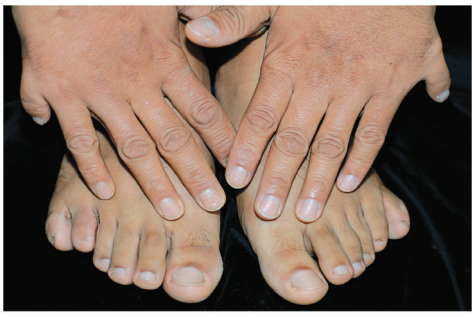


Figure 20.14 - Polydactyly

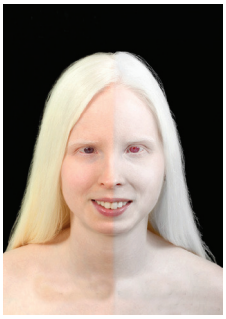


Figure 20.15 - Albinism

Figure 20.16 - Brown or blue eyes

Transmission of inherited characteristics is common to all organisms. Other than human other plants and animals possess inherited characteristics. Do the assignment 20.1 to determine those characteristics.

Assignment 20.1

- Select few plants or animals found in your home garden.
- Record few characteristics of them which have not changed for the past time period.

It is clear that according to the collected information the nature of complexion, ears, teeth, foot, wings, skin pattern, beak are inherited characteristics. Taste of fruits, colour of flowers, nature of pods and seeds and height of the plant are also inherited characteristics.

For extra knowledge

Non inherited characteristics

The characteristics which appear due to the changes of the environment, nutrition, exercises and activities are not inherited.

Example :- Growth of muscles by exercises, corns in toes and scars on skin

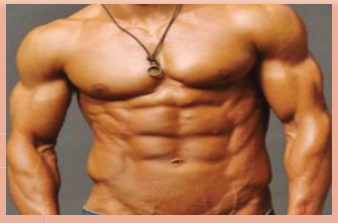


Figure 20.17 - Growth of muscles due to exercises

Figure 20.18 - Gregor Mendel

The first person to study about the transmission of inherited characteristics is an Austrian priest, and a science graduate Gregor Mendel. He is honoured as the father of genetics.

20.2 Mendel's experiments about inheritance

He used the garden pea (*Pisum sativum*) plant for his experiments in 1865. He has used that partcular plant for his experiment because of its special features.

The reasons to select the garden pea plant for his experiment are as follows.

- Can be easily grown
- Can obtain the yield within a short time period
- Can obtain pure breeding plants. (The selected characteristics are not changed for many generations)
- Naturally self pollinating. When necessary cross pollination is also possible
- Ability to obtain off springs by breeding and can continue the generations
- He observed 7 contrasting characters and tested one character at a time

The procedure he followed for the tall and short character was as follows,

- Cultivation of pure breeding tall and short plants. These parental generation was known as P
- Pollens of tall plants were deposited on stigma of short plants, and vice versa
- Obtain new seeds by cross-pollination and plant them to obtain the next generation. All plants were tall and they are referred to as F_1 generation
- Allow self-pollination to take place within F_1 generation
- The resultant seeds were planted to obtain the F_2 generation. The tall to short plant ratio was 3 : 1.

- It was a question to Mendel, that what has happened to short character in F_1 generation. According to Mendel's opinion, the tall character was dominant and short was recessive.

Assignment 20.2

Mendel has used large number of samples and repeatedly done the experiments to confirm his conclusions. Analyse how Mendel has carried out his experiment according to scientific method.

The feature which was recessive in F_1 generation reappear in F_2 generation. It was an important observation. As Mendel used a single pair of contrasting characters at a time, it was known as **Monohybrid cross**.

• The inherited pattern of a Monohybrid cross

The results obtained from the Mendel monohybrid cross using 7 different contrasting characters are given in the below table.

Table 20.1- The results of the experements of Mendel

Character	Cross	F_1 generation	F_2 generation		Closest ratio
			Dominant	Recessive	
Colour of the flower	Purple x white	Purple	Purple 705	White 224	3 : 1
Colour of the seed	Yellow x Green	Yellow	Yellow 6022	Green 2001	3 : 1
Shape of the seed	Round x Wrinkled	Round	Round 5474	Wrinkled 1850	3 : 1
Shape of the Pod	Inflated x Constricted	Inflated	Inflated 882	Constricted 299	3 : 1
Colour of the Pod	Green x Yellow	Green	Green 428	Yellow 152	3 : 1
Position of flower	Axial x terminal	Axial	Axial 652	Terminal 207	3 : 1
Height of the plant	Tall x Short	Tall	Tall 787	Short 277	3 : 1

It is clear that all above characters, are inherited in the same manner. One feature is completely hidden in F_1 generation and it reappears in F_2 generation. This is the recessive feature. In both generations all the plants were with the features of P generation. No pea plants were with intermediate characters. Mendel assumed that it was because two different factors determine a single characteristic. In genetics, symbols are used to denote those factors. The standard is that the dominant factor is denoted by a capital letter and the recessive by a simple letter.

Accordingly,

» For tall feature T,

» For Short feature t is used

For each inherited feature 2 factors are involved.

- Pure breeding Tall plants TT
- Pure breeding short plants tt.
- The tall plants with recessive short feature Tt.

When two factors are similar, they are known as homozygous, (TT, tt) when the factors are not similar they are known as heterozygous (Tt).The monohybrid cross of pea plant, considering tall and short character can be expressed using symbols as below. (Fig - 20.19 (a))

Punnett square (Fig - 20.19 (b))which was introduced by a scientist called Punnett can be used to show the occurrence of F_2 generation.

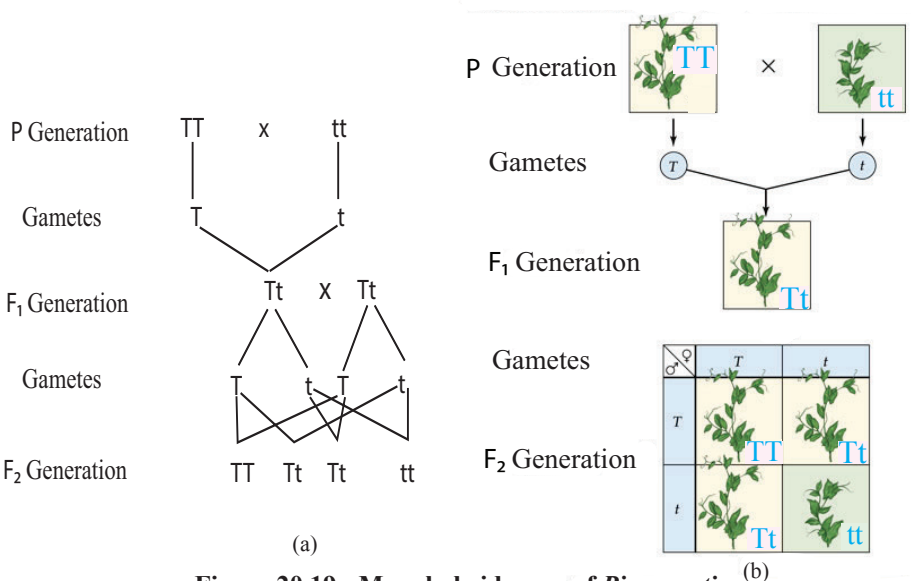


Figure 20.19 - Monohybrid cross of *Pisum sativum*

Assignment 20.3

- Select another pair of contrasting feature of pea plant using 20.1 table.
- State pure breeding dominant character or pure breeding recessive character using symbols.
- Build up a punnett square to show the inheritance of this monohybrid character.

• Explanation of patterns of inheritance using probability

When any two different objects combine randomly, the result will take place according to a particular pattern.

As an example consider random combination of X & Y objects.

$(x + y)\ (x + y)$

$xx + xy + xy + yy$

Two characters present in parents inherit into off springs randomly. Carryout below activity to identify the probability (Probability means the ability of an incident to happen.)

Do you know ?

The probability of getting the head or the tail when tossing a coin is 1/2

The bead experiment is similar to relationships of probabilities using two coins at a time. To find out Head – Head, Head – Tail, Tail – Head, Tail – Tail probabilities, the probabilities obtained from each coin has to be multiplied.

Then the probability is $1/2 \times 1/2 = 1/4$

When the same incident takes place in two ways (Eg. getting Head – Tail and Tail – Head) is the total of separately taken probabilities.

That is $1/4 + 1/4 = 1/2$

Activity 20.2

Identification of probability patterns obtained by a bead experiment

- Divide the class into 4 to 5 groups.
- Provide 2 vessels with mixture of 50 white beads (W) & 50 red beads (R) to each group (instead of beads, can use buttons or seeds with two different colour can be used)
- Take out a bead from two vessels at a time & note the colour of two beads with tally marks in the relevant column and return them into the same vessels.
- Likewise continue it for 50 times & tabulate results.
- Present the results to the class.

	RR	RW	WR	WW
1 st Group	𝍸 𝍸 ///	𝍸 𝍸 //	𝍸 ///	𝍸 𝍸 /
2 st Group	...	...	...	...
Total	...	...	...	...

Fill the above table using results obtained by the above practical using tally marks

Calculate,

I. Times of Red - Red beads & probability of getting Red - Red.

ii. Times of Red – White & Probability of getting Red – White.

iii. Times of White – Red & Probability of getting White – Red.

iv. Times of White – White and probability of getting White – White beads.

Using those probability values, find out the ratio of RR: RW: WR:WW.

Let's analyse the Mendel's results using the probability results obtained by the bead experiment.

From 1st & 2nd vessels.

i) The probability of getting Red – Red = 1/4

ii) The probability of getting White - White = 1/4

iii) The probability of getting Red – White = 1/4

iv) The probability of getting White – Red = 1/4

In (iii)rd & (iv)th instances, both show the same incidence, both vessels,

i) The probability of getting Red – Red =1/4

ii) The probability of getting White – White = 1/4

iii) The probability of getting Red – White = 1/4 + 1/4 = 2/4

The ratio between probability is = 1/4 : 2/4 : 1/4

1 : 2 : 1

According to Mendel's monohybrid cross, the ratio of F_2 genotypes, TT, Tt, tt is

1 : 2 : 1

Similarly the probability ratio of bead experiment compatible with the genotypes of F_2 generation.

20.3 Basic concepts of genetics

• Gene concepts about inheritance

Mendel said that the features of an organism is determined by a special particular factors. The identified particular factor is named as genes later.

In gene concept, as a standard the dominant feature is denoted by a capital letter and the recessive by a simple letter. We have already used these letters in Mendel monohybrid cross.

If two genes are similar for a given feature of an organism, it is said that this organism is homozygous for that feature, or else that organism possess homozygous genes.

If two genes are not similar then that organism is heterozygous, or else that organism possesses heterozygous genes.

Example :-

Gene for round seed is R, Gene for wrinkled seed is r

- Homozygous situations, RR or rr
- Heterozygous situations Rr

• Gene expression

The combination of a gene pair for a particular character is known as gene expression of that organism.

Example :- Rr, rr, Rr

• Phenotype & Genotype

The feature that externally appears is known as phenotype. The gene composition to determine that feature is known as genotype.

Examples :-

- The phenotype of round seed heterozygote is round. The genotype is Rr
- The phenotype of round seed homozygote is round. The genotype is RR
- The phenotype of wrinkled seed homozygote is wrinkled. The genotype is rr

• Nature of genetic material & genes

Scientists have identified that the Deoxy ribo Nucleic Acid (DNA) present in chromosomes acts as the genetic material that transmits features of organisms from generation to generation.

The double helical structure of DNA was first discovered by two scientists named Watson & Crick in 1953.

According to the sequence of base pairs in DNA strand, different genetic information are stored.

The features of organisms are determined by the sequence of base pairs. Accordingly a gene is a specific base sequence in a DNA molecule responsible for a particular character. In other way, gene is a specific segment of DNA for a particular character.

The genes that determine large number of features in an organism and transmit them from generation to the next are present in chromosomes. Each gene has a particular location in a chromosome.

For extra kowledge

A DNA molecule is a clockwise twined double helical structure of two strands that run anti parallel to each other. The two strands are joined by Adenine, Thymine Cytosine & Guanine nitrogenous base pairs. These combinations in DNA are denoted as A – T, C – G (Fig - 20.20) A for Adenine, T for Thymine, C for Cytosine & G for Guanine.

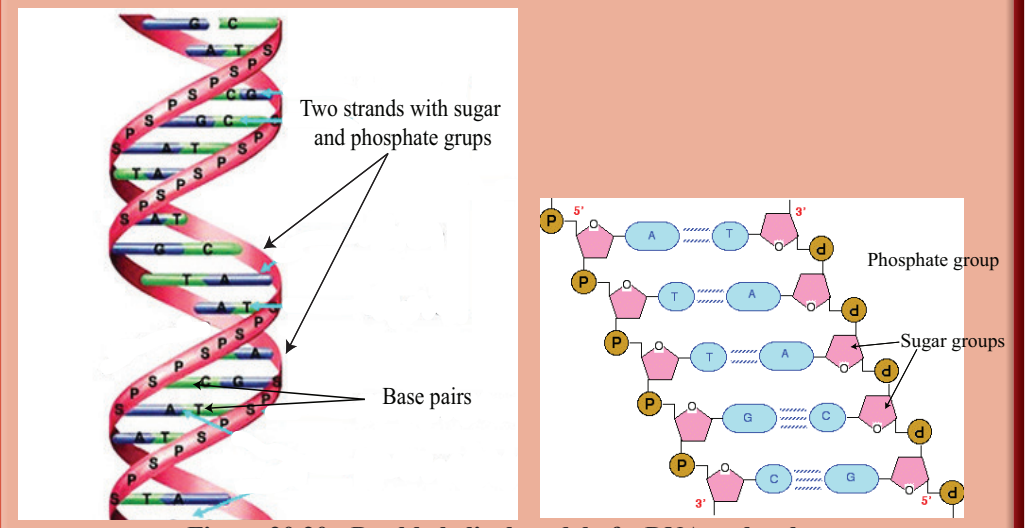


Figure 20.20 - Double helical model of a DNA molecule

• Gene linkage

A pair of chromosomes that are arranged to the same sequence of characters are known as homologous chromosomes. They are same in length, width and the location of centromere. An organism receives this homologous chromosomes from its parents, one from mother and the other from father. A pair of genes that determine a particular character are present in complementary locations of homologous chromosomes. It is clear in Mendel's experiment that during gamete formation, these genes, independently segregate.

A scientist called Morgon also did experiments about genetics. He got unexpected phenotypic ratios, and found out that, the genes do not segregate always independently. The genes that present in the same chromosome which are not segregated independently are known as **linked genes**. **Morgon** discovered the gene linkage.

20.4 Heredity of human

Transmission of inherited characters to next generation is known as heredity. The process by which those characters transmit is known as inheritance. You have already learnt that the characters of organisms pass to the next generations by the genes of chromosomes. The behaviour of genes & chromosomes during inheritance has mentioned above in gene linkage & meiosis.

The behaviour of chromosomes during sex determination of human is discussed under inheritance.

Even though the chromosomes in a nucleus of a cell are different in shape & size, the number of them is constant for a species. It is a unique feature of a species. Below are the number of chromosomes present in nuclei of different organisms.

Table - 20.2

Organism	Number of chromosomes	Organism	Number of chromosomes
E. Coli Bacteria	1	Paddy	24
Garden Pea	14	Tomato	24
Onion	16	Horse	33
Maize	20	Mouse	40
		Human	46
		Chimpanzee	48
		Carp	104

20.5 Sex determination of human

You may prefer to know how your gender is determined. This incidence is known as sex determination. We will look at how the sex is determined.

There are 46 chromosomes, or 23 pairs of chromosomes, in a human cell. Out of those 23 pairs, 22 pairs are autosomal chromosomes and the remaining pair is the sex chromosomes.

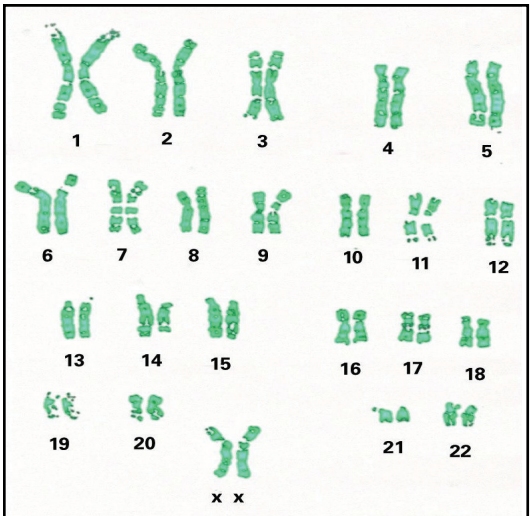


Figure 20.21 - 22 pairs of Autosomal chromosomes and sex chromosome pair of a female

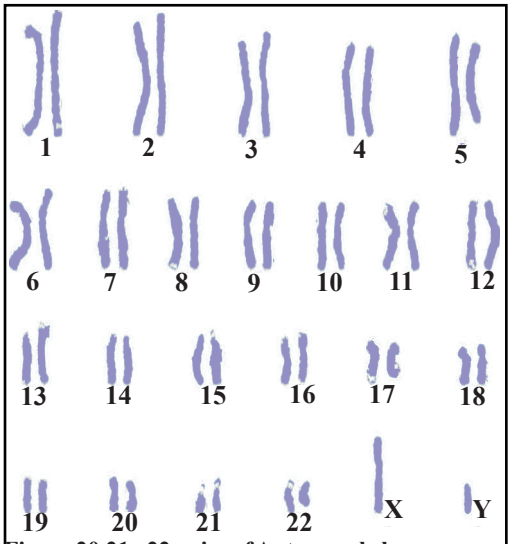


Figure 20.21 - 22 pairs of Autosomal chromosomes and sex chromosome pair of a male

Two sex chromosomes of a female are similar in structure & shape. They are known as X chromosomes. The sex chromosomes of a male are different from each other. They are known as X & Y chromosomes. The Y chromosome is smaller than X. The X chromosome of males is similar to the X chromosome of females.

During formation of an egg from an egg mother cell and sperms from sperm mother cell the pair of sex chromosomes separate. A sperm contains 22 autosomal chromosomes & only a single sex chromosome. An egg possesses only a X chromosome & a sperm contains a X or a Y chromosome.

When an egg gets fertilized with a sperm, there may be two X chromosomes or X & a Y chromosomes in the zygote.

A zygote with two X chromosomes produces a girl & X & Y chromosomes produces a boy, Accordingly the factor that needs to determine a boy is received from the father and not the mother. The sex determination is shown in the diagram 20.23. The probability of getting a girl or a boy is 50% .

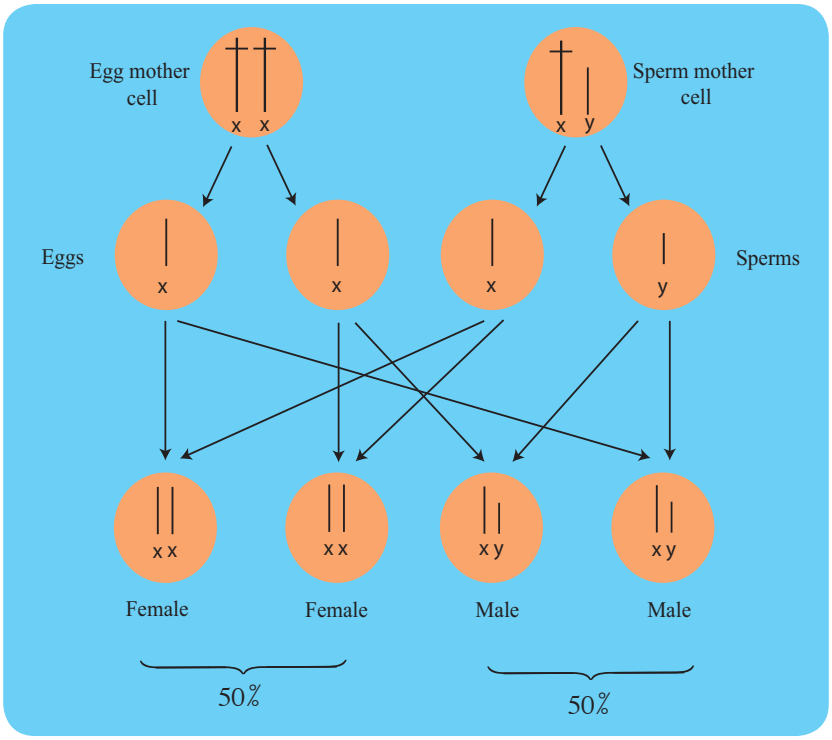


Figure 20.23 -Sex determination of human

Assignment 20.3

How the females to males ratio will affect the composition of population in a country ? Discuss with your teacher using data of past census.

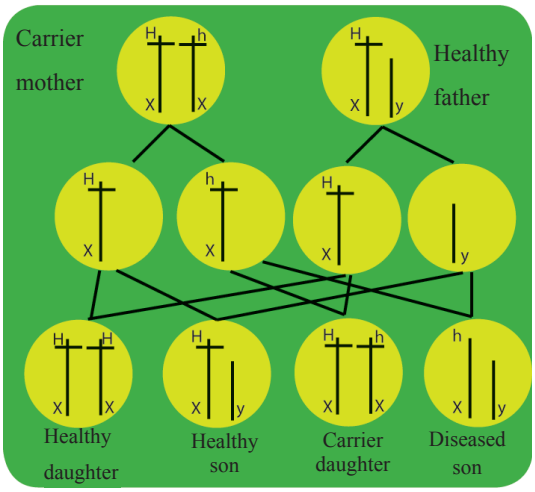
20.6 Human inherited disorders

- Genetic disorders due to sex linked inheritance

Even though X & Y chromosomes determine the human sex, all the genes present on those sex chromosomes, are not used in determination of sex. Most of the genes on X & Y chromosomes, determine other features as autosomal chromosomes. As Y chromosomes is shorter than X chromosome, most of the genes complementary for X are absent in Y. Accordingly, in males for most of the X linked genes, there are no complementary genes in Y.

Therefore most of the genes in X, whether they are dominant or recessive, they are phenotypically expressed in males. But as females possess a pair of X chromosomes, X linked genes are paired. They phenotypically express a recessive character only when they are present as double recessive genes . We will consider several genetic disorders, occur due to sex linked recessive genes.

• Haemophilia



h - Recessive gene for Haemophilia

H - Dominant gene of the recessive gene for Haemophilia

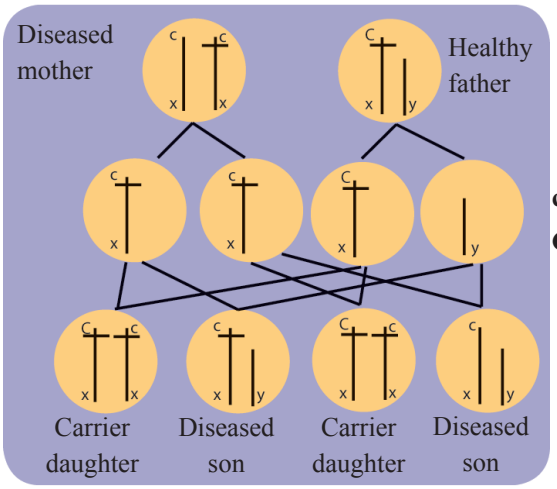
Figure 20.24 - Inheritance of Haemophilia

Haemophilia which occurs due to a X linked recessive gene only present in males in the population. When a wound or cut occurs, it is essential to clot blood. At that time when a blood clot is formed, it stops excessive bleeding. Haemophilic patients, blood does not clot. Therefore they die because of bleeding. Females act as carriers for this disease.

• Colour blindness (Red – Green colour blindness)

This is the most common sex linked inherited disease. The reason for this disease is, a recessive gene in X chromosome. The sufferer cannot distinguish red colour from green colour. This is common among males rarely occur in females. When a colour blind female is married to a healthy male the inheritance of colour blindness is given in the below diagram.

The chance to show the sex linked inherited diseases in females is low, the chance of getting those diseases in female children is high if they are married to blood relatives. The reason for that is the female that joined the family is most probably a carrier.



c - Recessive gene for colour blindness

C - Dominant gene of the recessive gene for colour blindness

Figure 20.25 - Inheritence of colour blindness

• Gene mutations & related inherited disorders

Due to a change in DNA of a chromosome, the mutations occur in a single gene, are known as gene mutation. When a naturally active gene is mutated, it gets inherited, we will look at few genetic disorders that occur due to a mutated gene.

Do you know ?

Occurence of gene mutations takes place due to several reasons. They are

- Spontaneous without any external effects
- Due to radiations
- Due to chemicals

• Albinism

Natural complexion is due to a pigment called Melanin. This disorder occurred due to a mutation of the gene is responsible for the production of the above pigment present in an autosomal chromosome.

The features of this disorder are the abnormal white colour of skin, hair and eye lashes. Albinism occurs when gene is present as recessive homozygous condition. Not only human but also animals become albino. (Fig - 20.26)

Figure 20.26 - Albone child & Albone peacock

• Thalassemia

This is a condition that occurs due to a mutation in a gene responsible for the production of haemoglobin. Haemoglobin is a protein that acts as a carrier for O_2 transportation in blood. Due to reduction of haemoglobin production in thalassemic patients, the main symptom is anaemia. Homozygous recessive tt, condition is diseased. Heterozygous Tt condition is the carrier. There are several areas in Sri Lanka with higher number of thalassemic patients. The reason for that may be the marriages between blood relatives.

For extra knowledge

Mutations can Occur due to changes in the number of chromosomes

- Due to the presence of a single X chromosome, a mutated condition called Turner's syndrome occurs. They are females lacking sexual maturity and mental retardation.
- Due to presence of XXY as sex chromosomes, this mutated condition called kleinfelter's syndrome occurs. Though they are males, they are feminised, sterile individuals.
- Down's syndrome is a mutated condition due to the presence of three copies of 21st autosomal chromosome. They are short & mentally retarded.

• Application of knowledge of inheritance

Since long time man has understood that by selecting animals and plants with better qualities, can produce quality hybrid plants and animal varieties. Cows that can produce higher volume of milk, hens that produce large number of eggs, chicken with higher growth rate, crops with high yield or pest resistant, fleshy seedless

fruits (Fig-20.27) are examples of genetic applications to improve quality of animal or plant products.

Figure 20.27 - Improved seedless oranges

When principles of genetics were identified, production of hybrid plants and animals becomes a technology. It was first applied among some wheat cultivators in America. The economy was developed as they have used improved wheat varieties. Now in Sri Lanka, crop research centres and breeding centres have achieved a considerable development in gene technology.

Large sized fruits or vegetables, improved grains and livestock have been used to fulfilling the needs of the greatly increasing population. If we have not used genetically modified high quality products, we would not be able to fulfill the high demand of food.

Figure 20.28 - Improved vegetables & fruits

20.7 Genetic engineering

New technology is being used to produce a recombinant DNA molecule, which is formed by combining DNA fragments of different sources. This field is known as

Recombinant DNA technology.

This field is highly popularized as genetic engineering or gene technology.

The genotype of an organism can be altered by removing or adding extra DNA fragments into genome.

We will look at the application of gene technology in food and agriculture, medical and industrial fields.

• Food and Agricultural field

01. Production of high productive plants and animals

Examples for plants and animals with better qualities that has produced using recombinant DNA technology.

- Weedicide resistant crops - By inserting a gene obtained from a bacterium.
- Pest resistant crops - By inserting a gene obtained from a soil bacterium.
- Rice enriched with vitamin A (Golden rice) A gene that produces vitamin A in carrot is obtained and inserted into paddy.
- A tomato resistant to cold weather - By inserting a gene obtained from a fish living in mud of cold countries.
- High productive (flesh and milk) cattle and milk with high nutritious value. Food produced by genetically modified organism (Genetically modified food).

02. Industrial field

Below are some instances where bacteria produced by gene technology are being used in industrial field.

- Production of enzymes such as Amylase.
- Production of some amino acids. (To produce MSG - Monosodium Glutamate.)
- Production of vitamins by (Cyanobacteria Eg :- vitamin B_{12} and E)

- As a remedy to the pollution by fossil fuel combustion and other waste material.

03 Medical field

Gene technology is used in different sections of medical field.

- Production of Insulin - Human gene related to Insulin production is inserted into *E coli* bacteria.
- Production of proteins including growth hormones – By inserting relevant gene into a bacterium.
- Use of developed bacteria and fungi in production of antibiotics.
- Insertion of genes that is responsible for the formation of arteries in the embryo into patients with artery blockages (patients to carryout bypass surgery) to induce growth of new arteries.
- Replacement of the diseased gene by a healthy gene. (gene therapy)
- Use of DNA technology to confirm the identity of a person in forensic medicine. For the identification of a criminal blood sample, semen, hair or DNA of any other part of the body obtained from a site of crime are used. Identification of the criminal by checking the compatibility of the DNA of those samples with the suspects, DNA.

Summary

- The diversity among organisms in the biosphere is because of the inherited features of each species.
- Inherited features are the characters that transmit from generation to generation.
- Within the same species too the organisms possess differences.
- There are common and rare inherited characters in human populations.
- The field that study about the way that the inherited characters are transmitted is known as genetics.
- Gregor Mendel was the first person to carryout experiments regarding inherited characters of plants.
- Mendel concluded that two factors, different to each other which are responsible for determining, a character of the pea plant.
- These factors that determine characters, later identified as genes. One of these is a dominant gene and the other is a recessive gene.
- The pattern of inheritance of a monohybrid cross can be expressed in a chart.
- The pair of genes, responsible for a particular feature can be shown in a gene expression.

- The externally expressed feature of an organism is phenotype.
- The gene composition that determines a particular phenotype is the genotype.
- The material that transmits features from generation to generation is the DNA in chromosomes.
- A specific nitrogenous base sequence of DNA is known as a gene.
- The number of chromosomes in nucleus is constant for a species.
- The pair of chromosomes that are similar in length, width and location of centromere is known as the homologous chromosome.
- The pair of genes responsible for a particular character present in complementary locations of the homologous chromosomes.
- The genes that are present in the same chromosome and that cannot be segregated independently are known as linked genes.
- The sex of human is determined by the way of association of sex chromosomes during fertilization.
- A zygote with two X chromosomes gives rise to a girl and a zygote with X and a Y chromosome gives rise to a boy.

Exerices

1. Red – green colour blindness is an inherited disease. Select the correct genotype of a carrier female.

   1) X^oX^o 2) X^cX^o 3) X^cY 4) X^cX^c

2. What is the percentage of parental genotypes received to the progeny if BB x bb cross is done ?

   1) 100% 2) 75% 3) 50% 4) 0%

3. Parents with normal complexion, got a child with white skin.

   i) Is it possible to happen?

   ii) Explain your answer with the knowledge of genetics.

4. An improved organism by recombinant DNA technology has,

i) Changed its genotype only

ii) Changed its phenotype only

iii) Changed its genotype and phenotype both

iv) No effect on genotype and phenotype both

5. If you are given with a homozygous yellow seed plant where the green colour (G) is dominant and yellow colour (g) is recessive. How do you find out the genotype of the green coloured seed plant? Explain your answer.

6. Sum of the genes in an organism is known as "genome". Under human genome project, it has started to arrange the base sequence of genes (map) in chromosomes. Which is the statement that shows the harmful effect of the above to human?

1. Use of gene technology as a remedy for genetic disorders.
2. Ability to produce human with special features.
3. Ability of the life insurance firms to identify the applicants, health conditions easily.
4. As a remedy for food problem using improved plants and animals by gene technology.

Technical terms

Inhertance	-	ප්‍රවේණිය	-	பிறப்புரிமையியல்
Heredity	-	ආවේණිය	-	நிறமூர்த்தம்
Genetics	-	ප්‍රවේණි විද්‍යාව	-	பரம்பரையலகு
Chromosome	-	වර්ණදේහය	-	பரம்பரை வெளிப்பாடு
Gene	-	ජානය	-	பரம்பரைத் தொடர்பு
Gene expression	-	ජාන ප්‍රකාශනය	-	பிறப்புரிமையியலுக்குரிய பாதிப்பு
Gene linkage	-	ජාන ප්‍රතිබද්ධය	-	இலிங்க நிர்ணயம்
Sex determination	-	ලිංග නිර්ණය	-	மரபுரிமை
Genetical disorders	-	ජානමය ආබාධ	-	மரபு வழித்தொடர்பு