8. Cell Biology and Biotechnology

- Cell Biology (Cytology)
- Biotechnology and Its Applications
- Stem Cells
- Important Stages in Development of Agriculture

Can you Recall

1. What is cell?
2. What is tissue? Which are the functions of tissue?
3. Which technique in relation to tissues have you studied in earlier classes?
4. Which are the various processes in tissue culture?

We have studied the plant production by technique of tissue culture in the last class. Stem cells are used for that purpose. Whether such stem cells are present in animals?

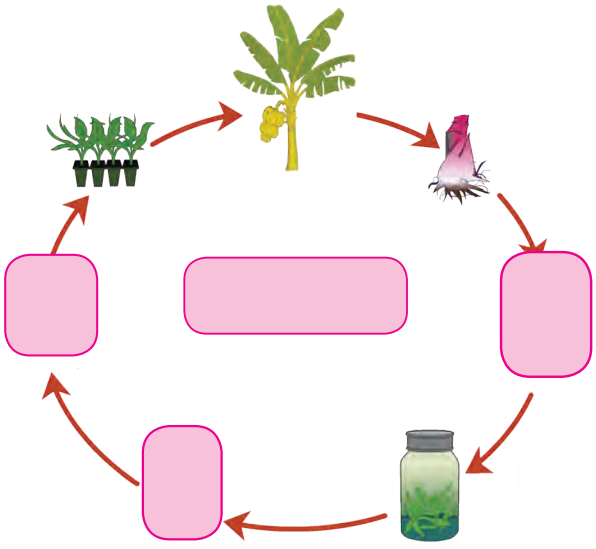
Observe

Assign names in the figure given below. Explain the various stages those are kept blank.

Cytology

Earlier, we have studied the structure, types and organelles of the cell. This is called as cell biology / cytology. Besides above mentioned points, it includes the study of cell division and many other aspects of the cell.

There are revolutionary changes in the field of human health due to cell biology. Research institutes specially dedicated for research on cells are established at Pune and Bengaluru, India. National Center for Cell Science (http://www.nccs.res.in) at Pune and 'Instem' (http://www.instem.res.in) at Bengaluru are involved in valuable research.



8.1 Diagram

Visit both the websites mentioned above and with the help of your teacher, try to understand the research undergoing in those institutes.

Stem Cells

These are special types of cells present in the body of multicellular organisms. These cells give rise to all other types of cells present in the body of multicellular organisms. Similarly, these cells play an important role in wound healing.

We had studied the stem cells of plants in the previous class. Now, we shall study the stem cells in animals, particularly in human beings.

New organism is formed from the zygote that is formed by union of male and female gamete. At the earliest stage of development, organism is in the form of a mass of cells. All the cells in that mass are almost alike. Those cells are called as stem cells.

During further development, these cells form any type of cell, different types of tissues and perform different functions in the body. This is the differentiation of stem cells. However, once the tissues are formed, the cells in those tissues, at the most, can form same types of cells only. This is the case in each part of the body. However, stem cells are present for longer duration in some parts of the body.

Stem cells are present in the umbilical cord by which the foetus is joined to the uterus of the mother. Stem cells are also present in the blastocyst stage of embryonic development. Stem cells are present in red bone marrow and adipose connective tissue of adult human beings. It has become possible to produce different types of tissues and the degenerated part of any organ with the help of these stem cells.

Stem Cell Preservation

For the purpose of preservation, stem cell samples are carefully collected from sources like cord blood, red bone marrow or embryo (blastocyst) and are kept in small, sterile vials. Those vials are kept in liquid nitrogen at -135^{0}C to -190^{0}C.

Use your brain Just like the grafting in plants, is the organ transplantation possible in humans?

Stem cell research

In biotechnology, stem cell research is a revolutionary event after cloning. This technique has the potential of bringing about the fundamental changes in the medical science.

Depending upon source, stem cells are of two types as embryonic stem cells and adult stem cells.

Embryonic stem cells

Division of the zygote starts and thereby it is converted into embryo. Cells of embryo undergo repeated mitotic divisions. Cell differentiation starts from 14th day of conception. Cells of different organs like osteocytes (bone cells), hepatocytes (liver cells), and neurons are formed due to differentiation. Embryonic cells before differentiation are called as embryonic stem cells. 220 different types of cells in human body are formed from single type cells i.e. embryonic stem cells. Thus, stem cells are primary type of undifferentiated cells with self-multiplying ability and they are parent cells of all types of human cells. This property of stem cells is called as pleuripotency. It has been found that if these stem cells are collected well before the beginning of differentiation on 14th day i.e. during 5th – 7th day and cultured with certain biochemical stimulus in laboratory, as per the stimulus, they can transform themselves into desired type of cells, thereby tissues and finally into organs.

Adult stem cells

Stem cells can be obtained from the body of adult person too. There are three main sources of stem cells in the body of adult persons. Stem cells can be obtained from red bone marrow, adipose connective tissue and blood. Besides, stem cells can be obtained from cord blood immediate after birth.

Uses of Stem Cells

1. Regenerative Therapy

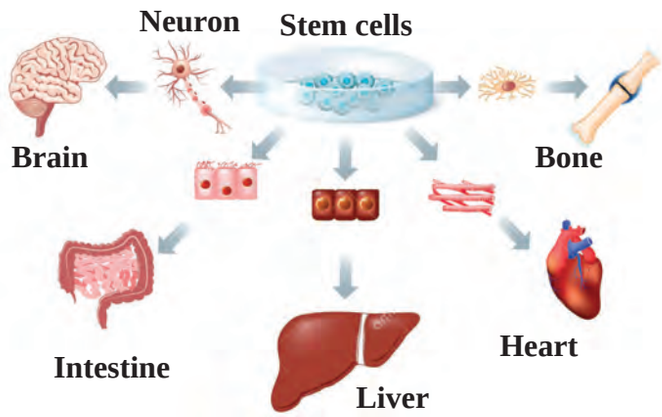
A. Cell Therapy: Stem cells are used to replace the dead cells in case of conditions like diabetes, myocardial infarction, Alzheimer's disease, Parkinson's disease, etc.

B. To produce blood cells required in conditions like anaemia, thalassemia, leukemia, etc.

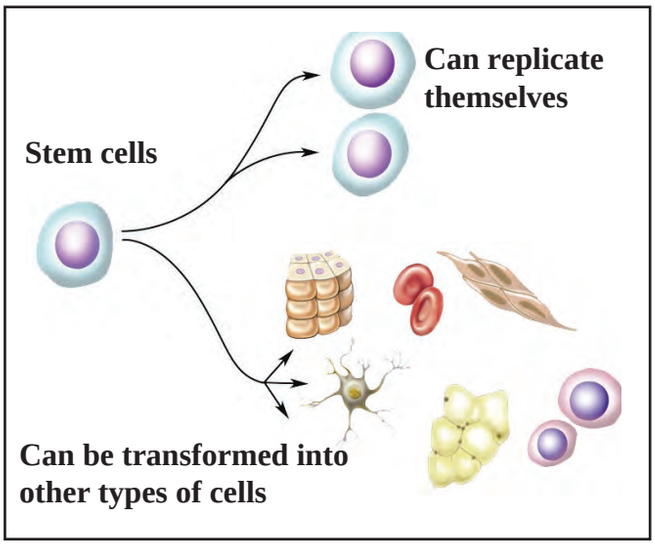
2. Organ Transplantation: In case of failure of organs like kidney and liver, those can be produced with the help of stem cells and transplanted.

Observe

Discuss about stem cells and organ transplantation in the class with the help of figures given below.



8.2 Stem cells and organs



8.3 Stem cells therapy

Organ transplantation

Various organs in the human body either become less efficient or completely functionless due to various reasons like aging, accidents, infections, disorders, etc. Life of such person becomes difficult or even fatality may occur under such conditions. However, if a person gets the necessary organ under such conditions, its life can be saved.

Availability of donor is an important requirement in organ transplantation. Each person has a pair of kidneys. As the process of excretion can occur with the help of single kidney, person can donate another one. Similarly, skin from certain parts of the body can also be donated.

Various factors like blood group, diseases, disorders, age, etc. of the donor and recipient need to be paid attention during transplantation.

However, other organs cannot be donated during life time. Organs like liver, heart, eyes can be donated after death only. This has led to the emergence of concepts like posthumous (after death) donation of body and organs.

Organ and Body Donation: Human bodies are disposed off after death as per traditional customs. However due to progress in science, it has been realized that many organs remain functional for certain period even after death occurs under specific conditions. Concepts like organ donation and body donation have emerged recently after realization that such organs can be used to save the life of other needful persons. A liberal view behind the concept of organ and body donation is that after death, our body should be useful to other needful persons so that their miserable life would become comfortable. Awareness about these concepts is increasing in our country and people are voluntarily donating their bodies.

Life of many people can be saved by organ and body donation. Blinds can regain the vision. Life of many people can be rendered comfortable by donation of organs like liver, kidneys, heart, heart valves, skin, etc. Similarly, body can be made available for research in medical studies. Many government and social organizations are working towards increasing the awareness about body donation.

Internet is my friend

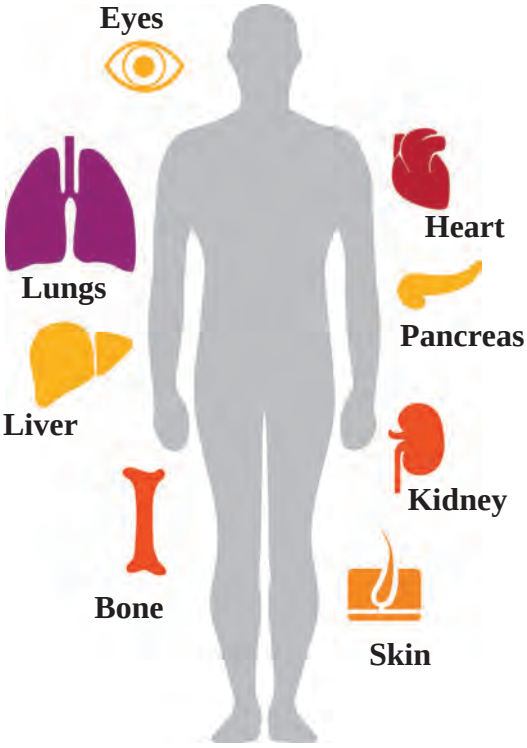
Visit the websites- http://www.who.int/transplantation/organ/en/ & www.organindia.org/approaching-the-transplant/ and collect more information about 'brain dead', organ donation and body donation.

Always Remember

Organ donation and transplantation is under the control of 'Transplantation of Human Organs Act, 1994' and subsequent amendments of 2009, 2011 and 2014 so that overall process would be transparent and any person would not be cheated.

Recall A Little

1. What is biotechnology?
2. In which various fields, the biotechnology has been useful?
3. What is the impact of biotechnology on agriculture and other related fields?



8.4 Organs that can be donated

Biotechnology

We have studied in the earlier class that biotechnology is bringing about artificial genetic changes and hybridization in organisms for human welfare. Various branches of science like cytology, biochemistry, molecular biology, and genetic engineering are included in biotechnology. There is considerable progress mainly in the field of agriculture and pharmacy due to biotechnology. New experiments are being performed for improving the agricultural yield. In pharmacy, experiments for production of antibodies, vitamins, and hormones like insulin have been successful. High-class varieties of crops have been developed through the technique of tissue-culture.

Biotechnology includes following main areas

1. Use of various abilities of microbes like yoghurt production from milk and alcohol from molasses.
2. Use of productivity of the cells. Ex. – Production of antibiotics and vaccines, etc. with the help of specific cells.
3. Use of bio-molecules like DNA and proteins in human welfare.
4. Development of plants, animals and products of desired quality by gene manipulation. Production of human growth hormone with the help of genetically modified bacteria.
5. Use of genetic and non-genetic technique. Non-genetic biotechnology involves use of either cell or tissue. Ex. Tissue culture, production of hybrid seeds, etc.

Benefits of Biotechnology

1. It has become possible to increase the per hectare yield irrespective of the limitations of crop-land area.
2. Expenses on disease control have minimized since development of resistant varieties.
3. Due to development of fast fruit setting varieties, yield per annum has been increased.
4. Development of stress resistant varieties which can withstand variable temperature, water-stress, changing fertility of soil, etc. has become possible.

Development of Biotechnology in India

Government of India had established the National Biotechnology Board in 1982. This board was transformed into department of biotechnology under the ministry of science and technology, in 1986. Various institutes in India are working under the control of this department of biotechnology. It includes National Institute of Immunology, National Facility for Animal Tissue and Cell Culture, National Centre for Cell Science, National Brain Research Centre, Central Institute of Medicinal and Aromatic Plants. There are facilities of higher education and research in these institutes from where thousands of students have pursued Ph.D. degrees and are contributing to the progress of country in the field of biotechnology.

Commercial Applications of Biotechnology:

1. Crop Biotechnology: Biotechnology is used in agricultural field to improve yield and variety.

a. Hybrid Seeds: Genes of two different crops are recombined to form hybrids of various crops. This is especially useful for fruits.

b. Genetically Modified Crops: Crops developed with desired characters by integrating foreign gene with their genome are called as genetically modified crops. High yielding varieties with resistance to diseases, alkalinity, weeds, other stresses like cold and drought.

Bt Cotton: A gene had been isolated from the bacterium *Bacillus thuringiensis* and integrated with the genome of cotton. Due to this, the toxin which is fatal for bollworm was produced in leaves and bolls of cotton. If bollworm feeds on leaves, the toxin destroys its alimentary canal and the bollworm dies.

Bt Brinjal: BT Brinjal variety is developed by using the gene isolated from *Bacillus thuringiensis*. This improved variety of brinjal kills the pest in same way as the Bt cotton does.

Golden Rice: A gene synthesizing the vitamin A (Beta carotene) has been introduced in this variety of rice. As compared to the normal variety, this variety which has been developed in 2005 contains 23 times more amount of beta carotene.

Herbicide tolerant plants: Weeds always affect the growth of main crop. If herbicides are used to destroy the weeds, it affects the main crop too. Due to this, Herbicide tolerant plants varieties of crops are being developed. Due to this, it has become possible to selectively destroy the weeds.

8.5 Some crops

c. Biofertilizers

Due to use of biofertilizers instead of chemical fertilizers, nitrogen fixation and phosphate solubilization abilities of the plants are improved. Mainly the bacteria like *Rhizobium*, *Azotobacter*, *Nostoc*, *Anabaena* and plants like *Azolla* are used as biofertilizers.

In the last year, we have studied the tissue culture. Genetic improvement of the plants has become possible due to tissue culture and besides, those characters inherited to next generation.

8.6 Azolla

Make a list and discuss

Give five examples of each of the fruiting and flowering plants developed through tissue culture and mention their benefits.

2. Animal Husbandry

Two main methods as artificial insemination and embryo transfer are used in animal husbandry. It helps to improve both, the quantity and quality of animal products. Ex. Milk, meat, wool, etc. Similarly, animals with more strength have been developed for hard work.

USE OF ICT

Collect information about various hybrid varieties of animals. What are their benefits? Make a presentation of various pictures and videos.

3. Human Health

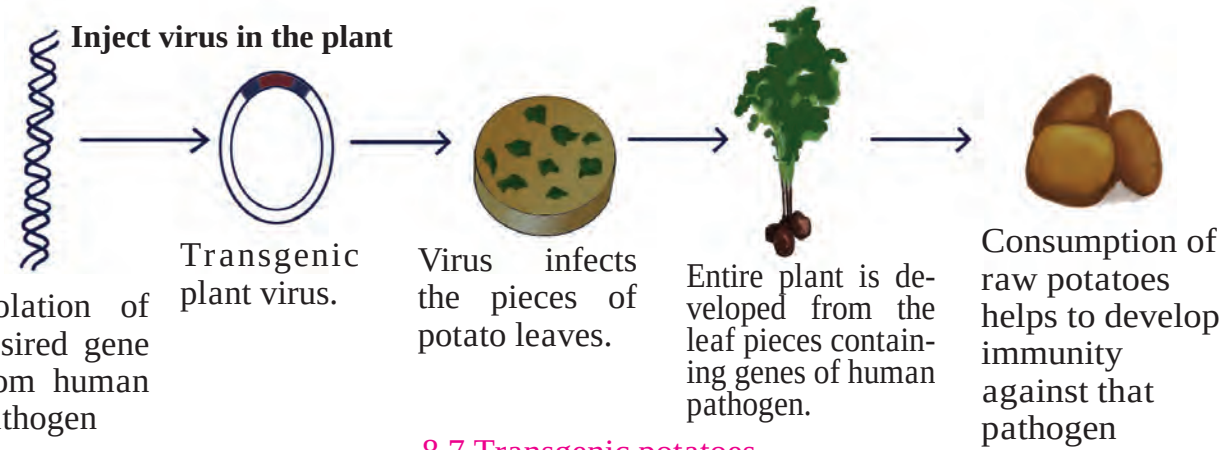
Diagnosis and treatment of the diseases are two important aspects of the human health management. Biotechnology helps to identify the role of gene, if any, in disease of a person. Diagnosis of diabetes and heart diseases has become possible even before the onset of symptoms, with the help of biotechnology. Diagnosis of the diseases like AIDS, dengue can be done within few minutes. Hence, treatment can be done at the earliest.

Various medicines are used for the treatment of diseases. Ex. The hormone insulin is used in treatment of diabetes. Earlier, insulin was being collected from the pancreas of horses. However, nowadays, due to biotechnology, insulin can be prepared with the help of bacteria. For this purpose, human insulin gene has been inserted into the genome of bacteria. Various vaccines and antibiotics are also produced in the same way.

a. Vaccines and Vaccination: Vaccine is the 'antigen' containing material given to acquire either permanent or temporary immunity against a specific pathogen or disease. Traditionally, vaccines were prepared with the help of pathogens. Completely or partially killed pathogens were used as vaccines. However, due to this, there were chances of contracting the disease in case of some persons. Hence, as an alternative, scientists tried to artificially produce vaccines with the help of biotechnology. For this purpose, scientists produced the antigen in laboratory with the help of gene isolated from the pathogen and used it as vaccine. Thus, safer vaccines are being produced.

Now, proteins which act as antigen are injected in pure form instead of injecting the killed or semi-killed pathogens. These proteins keep the persons away from the diseases by keeping the immune system active. Thus, injecting the antigens is safest way in vaccination. Vaccines produced with the help of biotechnology are more thermo-stable and remain active for longer duration. Ex. Vaccines of polio, hepatitis,

Edible Vaccines: Work on production of edible vaccines is in progress and presently, potatoes are being produced with the help of biotechnology. These potatoes are called as transgenic potatoes. These potatoes will act against bacteria like *Vibrio cholerae, Escherichia coli.* Consumption of these raw potatoes generates the immunity against cholera and the disease caused due to *E. coli.* What will happen if these potatoes are cooked for consumption?



8.7 Transgenic potatoes

b. Treatment: Biotechnology is useful for production of hormones like insulin, somatotropin and blood clotting factors.

c. Interferon: This is a group of small sized protein molecule used in treatment of viral diseases. These are produced in blood. However, nowadays, with the help of biotechnology, transgenic E. coli are used for production of interferon.

d. Gene therapy: Gene therapy to treat genetic disorders in somatic cells has become possible due to biotechnology. Ex. Phenylketonuria (PKU) arises due to genetic changes in hepatocytes (liver cells). It has become possible to treat it with gene therapy. This method is called as somatic cell gene therapy. All the cells except sperms and ova in the body are called as somatic cells

Do you know ?

Indian Institute of Science has developed a transgenic variety of tobacco. If cattles feed upon leaves of this plant, they do not contract a viral disease- rinderpest.

e. Cloning: Production of replica of any cell or organ or entire organism is called cloning.

i. Reproductive cloning: A clone can be produced by fusion of a nucleus of somatic cell with the enucleated ovum of anybody. Thus, there is no need of sperm to produce the new organism.

Internet My Friend

Collect more information about the Human Genome Project, one of the important projects in the world

ii. Therapeutic cloning

Stem cells can be derived from the cell formed in laboratory by the union of somatic cell nucleus with the enucleated egg cell. Various diseases can be treated with the help of these stem cells.

* Similar to cells, genes can also be cloned and millions of copies of same gene can be produced. Those can be used for gene therapy and other purposes.
* Controlling the inheritance of hereditary diseases, continuation of generations, enhancing the specific tendency may become possible due to cloning technique. However, there is world-wide opposition to human cloning on various issues.

4. Industrial Products / White Biotechnology

Various industrial chemicals can be produced through less expensive processes. Example: Alcohol production from sugar molasses with the help of transgenic yeast.

5. Environment and Biotechnology

It has become possible to solve environment related various problems with the help of biotechnology.

Microbial techniques are already in use for treatment on sewage and solid waste. Sewage is rich in organic matter. If such sewage is released in natural water bodies like rivers, the organic matter in it gets oxidized with the help of dissolved oxygen. Due to this, level of dissolved oxygen in water decreases, adversely affecting the aquatic life. As a remedy on this, sewage should be released in to rivers only after oxidation with the help of microbial technique.

See the proteins produced by biotechnology and the names of diseases they are used against-

1.	Insulin	Diabetes
2.	Somatostatin	Dwarfism
3.	Erythropoietin	Anaemia
4.	Factor VIII	Haemophilia
5.	Interleukin	Cancer
6.	Interferon	Viral infection

Peeking into History

A sheep 'Dolly' was born in Scotland by cloning technique on 5th July 1996. Nucleus from the udder cell of sheep of 'Finn Dorset' variety had been introduced into enucleated ovum of Scottish sheep. Then, the ovum was allowed to develop in the uterus of Scottish sheep and thereby the 'Dolly' had been born. It was showing the characters as per the chromosomes in nucleus and any character of Scottish sheep was not visible.

Dolly (Clone)

i. Microbes are useful on large scale while production of compost by treatment on solid organic waste material.
ii. Bio-remediation, biopesticides, biofertilizers, biosensors, etc, are some new concepts in biotechnological methods.

Bioremediation means either absorption or destruction of toxic chemicals and harmful pollutants with the help of plants and microorganisms. If plants are used for this purpose, it called as 'phyto-remediation'. Some examples of bioremediation are as follows-

* The *Pseudomonas* bacteria are useful for cleaning the hydrocarbon and oil pollutants from soil and water.
* The fern *Pteris vitata* can absorb the arsenic from the soil.
* Genetically modified variety of Indian mustard can absorb selenium from soil.
* Sunflower can absorb uranium and arsenic.
* The bacterium *Deinococcus radiodurans* is highly radiation resistant organism. It has been genetically modified and used to absorb the radiations from radioactive debris.
* Grasses like alfalfa, clover and rye are used in phyto-remediation.

5. **Food Biotechnology:** Food items like bread, cheese, wine, beer, yoghurt, vinegar are produced with the help of microorganisms. These food items are probably the oldest ones produced with the help of biotechnology.
6. **DNA fingerprinting:** DNA sequence of each person is unique as that of the fingerprints. Due to this, identity of any person can be established with the help of its available DNA. This is called as DNA fingerprinting. It is mainly useful in forensic sciences. Identity of the criminal can be established with the help of any part of its body found at the site of crime. Similarly, identity of father of any child can be established. This research is performed in Center for DNA fingerprinting and Diagnostics, Hyderabad.

Cleaning of Oil Spillage in Oceans: If oil spillage occurs, it adversely affects the marine life. Now, cleaning the ocean without any harm to environment in cheaper way has become possible with the help of oil-digesting and fast multiplying bacteria. India born American citizen and scientist Dr. Anand Mohan Chakravarti had for the first time suggested the use of such microbes. Naturally, the credit for this discovery goes to him.

Important stages in agricultural development

Green revolution

Problems of population explosion were started to appear at the beginning of 20th century. Almost all the countries, especially underdeveloped and developing countries had been badly affected by the effects of poor quality and quantity of food. Various methods applied for harvesting maximum yield from minimum land are collectively called as green revolution.


Dr.M.S Swaminathan


Dr. Norman Borloug

Improvised dwarf varieties of wheat and rice, proper use of fertilizers and pesticides and water management has led to the increased production of food grains and thereby large population had been saved from hunger. Dr. Norman Borlaug (USA) and Dr. M. S. Swaminathan (India) have valuable contribution in green revolution.

Various research institutes and laboratories are engaged in development of new varieties of various crops through research. Ex. Indian Agricultural Research Institute (IARI), New Delhi, National Citrus Research Institute, Nagpur and allied branches, Indian Institute of Sciences, National Pomegranate Research Institute, Solapur.

Collect Information

Which new species of the rice have been developed in India?

Internet is My Friend

Collect the information and make the chart about the work of various state and national-level institutes related with biotechnology.

White revolution

Various parts of India were rich in milk and milk products. However, those products were not sufficient to meet the needs of far-flung regions. Dr. Verghese Kurien proved through the cooperative movement and use of biotechnology that Dairy cannot be allied but it will be a mainstream business. He put the cooperative dairy movement of Anand, Gujarat at all time high status.

While achieving the self-sufficiency in dairy business, various experiments were performed for quality control, newer dairy products and their preservation. Why people from all over the world are again preferring the local wild varieties?

8.8 Milk processing and milk products

Blue revolution

Production of various useful aquatic organisms with the help of water is called as blue revolution. Farm ponds and the fishes are very common in East Asian countries. However, people are not only thinking of cultivating the fishes and shrimps but other aquatic plants and animals too. Government of India has vowed to increase the production by encouraging the people for pisciculture by launching the program 'Nil-Kranti Mission-2016' (NKM-16). 50% to 100% subsidies are offered in this case.

Marine and fresh water fishery is possible on large scale. Fresh water fishes like rohu, catla and other fishery products like shrimp and lobsters are being cultured on large scale

8.9 Pisciculture : Prawns

Fertilizers

Two types of fertilizers are used in agriculture. One of those is organic manure and others are chemical fertilizers. Water holding capacity of the soil improves with soil conservation due to use of manures.

Upper layer of the soil essential in agriculture is formed due to humus formation. Various essential elements like N, P, K can be available to crops due to earthworms and fungi. In soil-less farming i.e. hydroponics, liquid chemical fertilizers are used. However, there are more harmful effects of liberal use of chemical fertilizers. It includes decrease in fertility of soil.

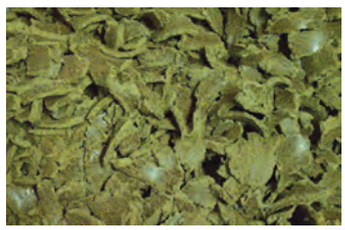
8.10 Fertilizers and Insecticides

Insecticides

Though the natural immunity of plants can prevent the infections, use of insecticides is not under control. Irrespective of the natural friends of farmers like frogs and insectivorous birds, pesticides are used on large scale for increase in yield. Pesticides are in fact a type of poison. This poison enters the food-web through water and food and its bio-magnification occurs. Various pesticides like DDT, malathion, chloropyriphos, etc. have been proved to be dangerous.

Organic farming

Now a days, organic farming and organic products have become buzzwords. Organic products are being available and demand for them is ever-increasing.



Oil cake

Chemical fertilizers and pesticides have been used on large scale. These poisonous chemicals reached the human body through food and water and their adverse harmful effects on human and environment became apparent.

Vermiculture

8.11 Oil cake and Vermiculture

Various problems like soil fertility and pest infestation have become serious. So as to overcome these problems, farmers are opting for organic farming. It includes complete ban on chemical fertilizers and pesticides and use of local, sturdy varieties and thereby maintaining natural balance. Definitely, this is a welcome decision.

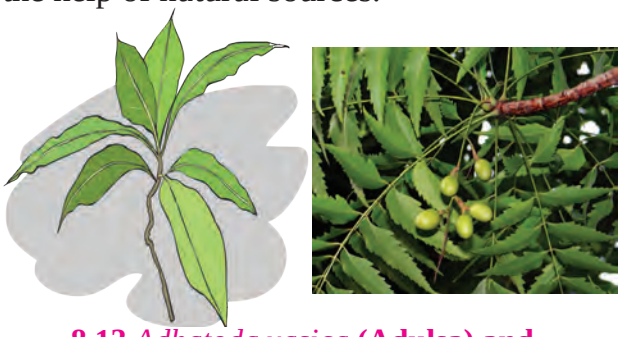
8.12 Apiculture

Apiculture

You must have seen the bee hive. Worst method of harvesting / collecting the honey from these hives is driving away the bees by smoking the hive with burning torch and then cutting the hive into pieces. This method causes the destruction of hive and large scale death of bees. However, it is easy to collect the honey without destroying the hive and bees, if artificial bee boxes are used.

Cultivation of Medicinal Plants

India has been gifted with a great biodiversity. Indian citizens have established the humble and strong relation with the nature. We have a great tradition of ayurveda that cures the diseases with the help of natural sources.



8.13 *Adhatoda vasica* **(Adulsa) and** *Azadirachta Indica* **(Neem)**

Try this

Bring a packet of 'Balghuti' from ayurveda shop. Learn the information about each component in it. Collect information about various other medicines and prepare the chart as shown below.

Local Name of plant	Name of active ingredient	Uses
Adulsa	Vasicine present the leaves	Cough

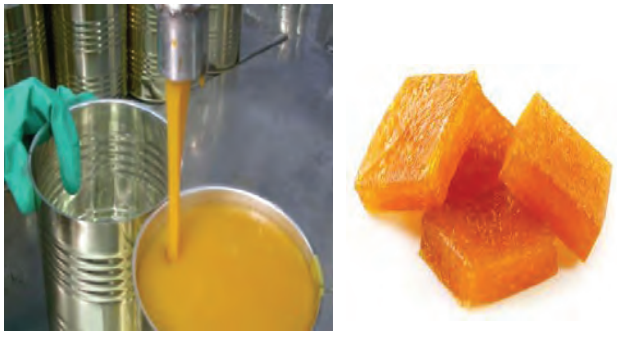
During earlier days, medicinal plants were collected from the forest. However, due to depletion in forest area, medicinal plants are becoming rare. Hence, medicinal plants are being cultivated.

Make a list and discuss

Which fruit processing industries you observe in your surrounding ? What is their effect ?

Fruit Processing

We are daily using various products prepared from fruits. All are consuming the products like chocolates, juices, jams and jellies. All these products can be produced by processing on fruits. Fruits are perishable agro-produce. It needs the processing in such a way that it can be used throughout the year. Fruit processing includes various methods ranging from storage in cold storage to drying, salting, air tight packing, preparing murabba, evaporating, etc.



8.14 Mango processing Unit

Exercise

1. Fill in the blanks and complete the statements.

a. Methods like artificial insemination and embryo transplant are mainly used for --

b. -- -- -- -- is the revolutionary event in biotechnology after cloning.

c. The disease related with the synthesis of insulin is --- --- ---.

d. Government of India has encouraged the -- -- --- -- for improving the productivity by launching NKM-16.

2. Match the pairs.

a. Interferon	1. Diabetes
b. Factor	2. Dwarfness
c. Somatostatin	3. Viral infection
d. Interleukin	4. Cancer
	5. Haemophilia

3. Rewrite the following wrong statements after corrections.

a. Changes in genes of the cells are brought about in non-genetic technique.

b. Gene from *Bacillus thuringiensis* is introduced into soyabean.

4. Write short notes.

a. Biotechnology: Professional uses.

b. Importance of medicinal plants.

5. Answer the following questions in your own words.

a. Which products produced through biotechnology do you use in your daily life?

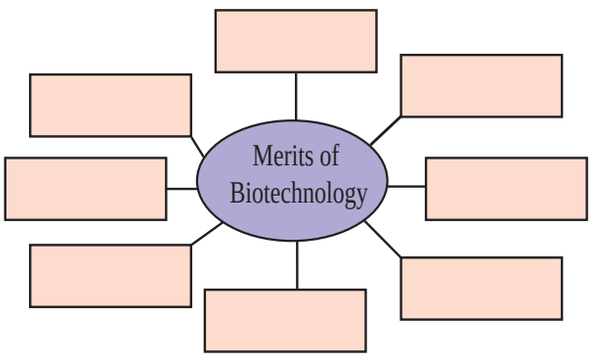
b. Which precautions will you take during spraying of pesticides?

c. Why some of the organs in human body are most valuable?

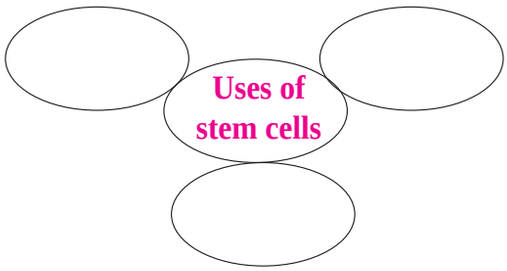
d. Explain the importance of fruit processing in human life?

e. Explain the meaning of vaccination.

6. Complete the following chart.



7. Write the correct answer in blank circles.



8. Identify and complete the following correlations.

a. Insulin : Diabetes :: Interleukin : -- -- --

b. Interferon : -- :: Erythropoietin : Anaemia.

c. ------- : Dwarfness :: Factor VIII : Haemophilia.

d. White revolution : Dairy :: Blue revolution : -- -- -- --.

9. Write a comparative note on usefulness and harmfulness of biotechnology.

Projects:

1. Visit the organic manuring projects nearby your place and collect more information.
2. What will you do to increase public awareness about organ donation in your area?
3. Collect information about 'green corridor'. Make a news-collection about it.

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