# BIOTECHNOLOGY

**DEFINITION –**

**"Biotechnology** may be defined as use of micro-organism, animals, or plant cells or their products to generate different products at industrial scale and services useful to human beings."

A powerful industry based on microbes has been developed in recent time. A careful selection of microbial strains, improved method of extraction and purification of the product, have resulted in enormous yields.

The use of living organisms in systems or process for the manufacturer of useful products, It may in volve algae, bacteria, fungi, yeast, cells og higher plants & animals or subsystems of any of these or Isolated components from living matter.

**Old biotechnology are based on the natural capabilities of micro organisms.**

e.g. formation of citricacid, production of penicillin by Penicillium Notatum

**New biotechnology ios based on Recombinant DNA technology.**

e.g. Human gene producing Insulin.

has been transferred and expressed in bacteria like E.coli.

In, **modern biotechnology,** different type of valuable products are produced with help of microbiology, biochemistry, tissue culture, chemical gngineering and Genetic engineering, molecular biology and immunology.

**MICROBES IN HOUSEHOLD PRODUCTS**

A common example is the production of curd from milk. Micro-organism such as Lactobacillus and others commonly called **lactic acid bacteria (LAB)** grow in milk and convert it to curd. During growth, the LAB produce acids that coagulate and partially digest the milk proteins. A small amout of curd added to the fresh milk as inoculum or starter contain millions of LAB, which at suitable temperatures multiply, thus converting milk to curd, which also improves its nutritional quality by increasing vitamin $B_{12}$. In our stomach too, the LAB play very beneficial role in checking disease causing microbes. The dough, which is used for making foods such as dosa and idli is also fermented by bacteria. The puffed-up appearance of dough is due to the production of $CO_2$ gas. Similarly the dough, which is used for making bread, is fermented using baker's yeast (Saccharomyces cerevisiae). A number of traditional drinks (e.g. "Todi prepared from sap of palms) and foods are also made by fermentation by the microbes. Microbes. Microbes are also used to ferment fish, soyabean and bamboo shoots to make foods. Cheese, is one of the oldest food items in which microbes were used. Different varieties of cheese are known by their characteristic textur flavour and tate, the specificity coming from the microbes used. For example, th large holes in 'Swiss cheese' are due production of a large amount of $CO_2$ by a bacterium named propionibacterium **sharmanii.** The 'Roquefort cheese' are ripened by growing a specific fungi on them, which gives them a particular flavour.

## YEAST

**Louis Pasteur** showed in the middle of nineteenth centuary that **beer** and **butter milk** are product of fermentation brought about by **"yeast"** .It is a microscopic single celled organism **- Saccharomyces cerevisiae.** Presenty however yeast product for human and animal consumption are produced on commercial scale.

**"Alcohol** was the first product of ancient biotechnology"

There are basically two types of yeasts (i) Baker's yeast (ii) Alcohol yeast of Brewer's yeast

Baker's yeast generally utilize during the preparation of food materials to increase the taste of food, flavour in food and nutrients in food. It is also utilized as **"Leavening agent".**

By the incomplete degradation of complex organic compounds [sucrose] by yeast fermentation, alcohol is formed.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow[\text{invertase}]{\text{yeast}} C_6H_{12}O_6 + C_6H_{12}O_6$$

**[Sucrose]** **[Glucose]** **[Fructose]**

$$C_6H_{12}O_6 \xrightarrow[\text{zymase}]{\text{yeast}} 2C_2H_5OH + 2CO_2$$

**[Ethyl alcohol]**

**Some other common products of yeast fermentation are –**

**[i]** **Beer -** It is produced from **Hordeum Vulgare** [Barely] ,alt and alcohol content is 4-8%

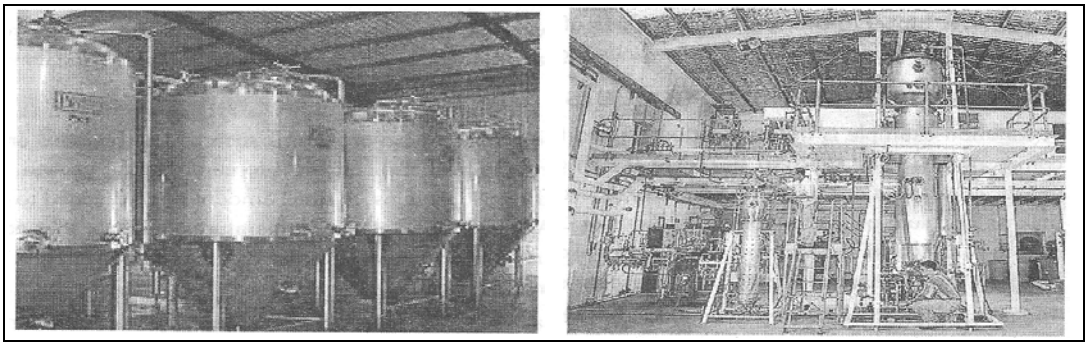
**[ii]** **Wine –** Produced from **grapes,** alcohol content is 10-20%.

**[iii]** **Brandy –** Produced by distillation of wine and alcohol content is 43-57%

**[iv]** **Gin –** Produced from **Europen Rye-Scale cereal.**

**[v]** **Rum -** Produsd from **Molasses** of Sugarcane and alcohol contents is 40%

**Note –** Another yeast which supplies nutrirional rich food for Man and animals is **Torulopsis utilis.**



**Industrial utilization of biotechnology involve three steps –**

[i] Laboratory scale process

[ii] Pilot plant scale

[iii] Manufacturing unit

The development from laboratory scale to manufacturing unit is "Scaling up to in dustrial production"

**[i] Laboratory Scale -**

In this process for the production of desirable product, proper micro organism searched and then suitable atrain is selected and multiplied. Proper medium also find out on which selected strain, produce best and more amount of product.

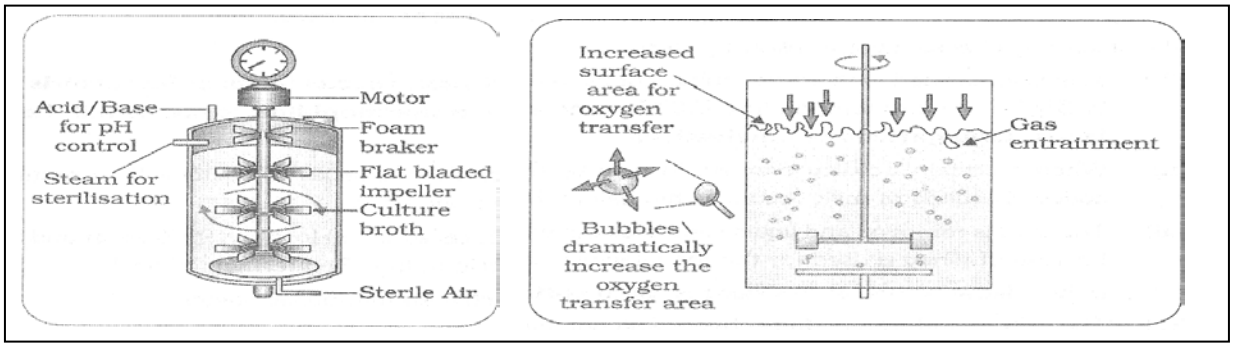
Many number of experiments performed in lab for the analysis and selection of strains and medium. All the equipment are utilized in lab i.e., glass apparatus. All the parameters of the process worked out and precaution are also not down for the smooth running of process such as – proper sterilization of nutrient and microbesstrain, required – pH, suitable aerator, disposal of $CO_2$ if evolved, temperature, by product or product inhibition or stimulation, time of optimum production, separation of product and its purification etc. Ultimately, the laboratory scale process finalized and transfer at pilot plant scale.

**[ii] Pilot plant Scale –**

It is the intermediate stage where working of laboratory scale process is tested. At this stage **cost** and **quality** of product thoroughly checked. Glass apparatus are replaced by stainless steel equipment/containers is called **"bio reactor".**

To produce in large quantities, the development of **bioreactors.** where large volumes (100-1000 litres) of culture can be processed, was required. Thus, bioreactors can be through of as vessels in which raw materials are biologically converted into specific products, individual enzymes, etc., using microbial plant, animal or human cells. A bioreactor provides the optimal conditions for achieving the desired product by providing optimum growth conditions (temperature, pH, substrate, salts, vitamins, oxygen).

The most commonly used bioreacters are of stirring type




A stirred-tank reactor is usually cylindrical or with a curved base to facilitate the mixing of the reactor contents. The stirrer facilitates even mixing and oxygen availability throughout the bioreactor. Alternatively air can be bubbled through the reactor. The bioreactor has an agitator system, an oxygen delivery system and a foam control system, a temperature control system, pH control system and sampling parts so that small volumes of the cukture can be withdrawn periodically.

Micro organism can be grown in bioreactors in two ways :

**(b) Support growth system –** In this method microorganisms are growing as a thin layer or film in the **solid medium.**

**(b) Suspended growth system –** By suspending cells or mycelia in the **liquid** medium is called suspended growth system.

**[iii] Manufacturing unit –**

During the designing of bioreactor for the process often very large size so that it accommodate huge amount of medium.

**Downstream Processing –**

After completion of the biosynthetic stage, the product has to be subjected through a series of processes before it is ready for mareting as a finished product. The processes include separation and purification, which are collectively referred to as downstream processing. The product has to be formulated with suitable preservatives. Such formulation has to undergo through clinical trials as in case of drugs. Strict quality control testing for each product is also required. The downstream processing quality control testing vary from product to product.

**Some important biotechnological products which are produced with the help of organisms as follows –**

## 1. ENZYME

Total known enzymes 2,200 and only 1-1.5% are used

**(i)** **Rennet –** manufacturing **"Cheese"**

Old days cheese had been prepared either using the layer of stomach of Goat or Sheep OR the sap of **Fig. tree,** containing special enzyme-**Ficin.** In 1874 a Danish Chemist - **Christian Hansen** extracted pure rennet enzyme from **Calf's stomach** for industrial production of cheese. First of all diastase enzyme was identify by payen and persoz (1933)

Cheese is mainly two different types.

**I. Unripened cheese –** Ripened from out side-soft

**II. Ripened cheese –** It is hard and ripened externally as well as internally.

Manufacturing cheese involve following steps.

**(i)** Milk is inoculated with starter cure terai **- Streptococcus lactis** or **S. cremoris** and warmed at 38$^{o}$ C. If higher temperature [50$^{o}$C or more] then **S.thermophilus** combined with **Lactobaccilus lactis , L. bulgaricus L.helveticus.**

**(ii)** When a certain **acidity** reached in milk by the activity of species of bacteria then rennet enzyme is added. Curdling of milk occurs within half an hour to one hour.

**(iii)** The curd is removed and liquid separates out which is called **whey** [contain 93% water and 5% Lactose]. Lactose of whey is used for the manufacture of **Lactic acid –** First fermented acid.

If the cheese is used at this stage is called **cottage cheese** (unripened stage).

**(iv)** The salts mixed with cottage cheese and put into the frames and pressed so as to allow removal of whey. Salts hastens the removal moisture and prevent the growth of undesirable microbes. The frames are removed as soon as the cheese has set sufficiently to maintin its shape.

The ripening period varies from 1-16 months but which is very tasty and nutritions. This is hard and ripened cheese contains about 20-30% fats, 20-35% proteins and small amount of minerals and vitamins. [Cheese which prepared at homes with the help of lemon juice is called **Raw cheese]**

Nearly 400 varieties of cheese available which can be classified into following type –

| | Type of Cheese | Micro Organisms used | Reaction |
|---|---|---|---|
| 1. | Soft<br>(A) Camembert<br><br>(B) Limburger | <br>Penicillium camemberti<br>Brevibacterium<br>Streptococcus liquifaciens<br>Brevibacterium | <br>Ripend by action of<br>Microorganisms on<br>The surface of curd |
| 2. | Semi-hard<br>(A) Roquefort<br>(B) Blue | Penicillium roqueforti | Combination of<br>Surface and interior<br>Growths |
| 3. | Hard<br>(A) Swiss<br>(B) Cheddar | <br>Propionibacterium sp<br>Geotrichum | Inoculating the<br>Organisms throughout<br>The curd |

**(ii)** **Proteases –** This enzyme obtained from **Aspergillus orizae** and **Bacillus subtilis, Bacillus licheniformis** and utilized from the formation of **detergents** in detergent industry [For removing proteinous strains on clothes]. The bottlejuices are clarified by the use of pectinases and protease.

**(iii)** **Amylases –** It works on starch and used in Beer, Bread and Textiles industries.

**(iv)** **Amylase, Gluco amylase and Gluco isomerase –** By the action of all these enzymes **corn** (maize) **starch** transformed into **fructose corn syrup.** This syrup is more seeter than sucrose and used in beverage industry to flavour **soft drinks** and in baking industry to sweeten biscuits and cakes.

**(5)** **Tissue Plasminogen Activator [TPA] or Streptokinase –** This enzyme utilized in medicinal field. Streptokinase produced by the bacterium Streptococcus and modified by genetic engineering is used as a clot buster for removing clots from the blood vessels of patients who have undergone myocardial infraction leading to heart attack.

**Uses Of Enzymes**

**(1) Detergents**
- (i) **Proteases**
- (ii) **α – Amylase**
- (iii) **Cellulases**
- (iv) **Lipases**

**(2) Leather Industry**
**(3) Wool Industries**
**(4) Glucose from cellulose**
**(5) Food, Dairy, Juice and Beverages Industries**
**(6) Production Of Glucose Syrup**

Bioactive molecule, **cyclosporineA,** that is used as an immunosuppressive agent in organ-transplant patients, is produced by the fungus **Trichoderma polysporum. Statins** produced by the yeast Monascus purpureus have been commercialized as blood-cholesterol lowering agents. It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

## "YOGHURT" [CURDS]

For production of curds or yoghurt pasteurized milk is inoculated with a mixture of **Streptococcus thermophilus** and **Lactobacillus bulgaricus** and its lactose is fermented by keeping it at 40°C. The peculiar or characteristic taste and flavour of curds are due to presence of lactic acid and acetaldehyde. Curdling or coagulation of milk is also caused by lactic acid which is formed. In India, curds are not generally commercially produced but in developed countries large scale manufacture of yoghurt is done. In U.S.A. alone about 75 lakh kilogram of yoghurt is manufactured every year.

## 2. VITAMINS

**Definition :-**

"Vitamins are complex organic substances found in various food and required for specific metabolic reaction in cells.

"The term vitamin first of all used by **Funk** and first of all **Vit-$B_1$** also isolated by him.**Vit-C** isolated by **A.S.Gyorgy.** The **first vitamin** to be produced by fermentation was **vit-C** by A.S. Gyorgy also **Vit-A** was isolated by **Mc Collum** and **Vit-D** by **Millanby.**

Micorbes are important commercial sources of several vitamins. Some examples are given here :-

1. **Riboflavin (vitamin $B_2$) :-** This found in cereals, vegetables and Brewer's yeast was first produced in 1938. It is a crystalline, odourless, yellowish brown chemical and is essential for growth and reproduction in animals. The main sources of Riboflavin are **fungi- Ashbya gossypii** and the yeast like **Eremothecium ashybyii.** By the use of original wild strain of mould Ashbya gossypi production of Vit $B_2$ increase 100-300 time more.

2. **Cobalamin or Vitamin $B_{12}$ :-** First isolated from **liver extract** in 1948. It is a compound which contains cobalt, and is now obtained in a cobalt rich substrate (eg. corn sugarcane molasses or starch) by microbes such as **Propionibacterium frendenreichii, Bacillus megatherium.**
Vitamin $B_{12}$ is used to supplement animal feed, and in man for increasing appetite and for treating Anaemia. By the use of Mutant strains of **Pseudomonas denitrificans** Production of Vit-$B_{12}$ increase 50,000 times more.

3. **Ascorbic Acid (Vitamin C) :-** It is manufactured from L.Sorbose which is commercially produced from D-Sorbitol by Biological dehydrogenation brought about by different species of **Acetobacter.**

## 3. ANTIBIOTICS

The term was coined by **Selman Waksman** (1942).

**Definition :-**

"An antibiotic is a substance produced by a microorganism which in low concentration inhibits the growth and metabolic activity of pathogenic organism without harming the host".

**Alexander Flemming** was first to produce and antibiotic named **penicillin** from **Penicillium notatum.**
**Waksman** and **Albert** discovered **Streptomycin** and **Actinomycin.**
**Burkholder** isolated **Chloromycetin.**
Antibiotics are of two types :-

1. **Broad spectrum Antibiotic :-** It is and antibiotic which can kill or destroy a number of pathogens that belong to different groups with different structure and wall composition.
2. **Limited spectrum (Specefic) antibiotic :-** It is an antibiotic which is effective only against one type of pathogens.

**Action of Antibiotics :-** An antibiotic acts on pathogen by
(1) disruption of wall synthesis
(2) Disruption of plasmalemma repair and synthesis
(3) inhibition of DNA/RNA/Protein synthesis.

**Good Antibiotic :-**
A. Harmless to host with no side effect.
B. Harmless to normal micro-flora of Alimentary canal
C. Ability to destroy pathogen as well as broad spectrum.
D. Effective against all strains of pathogen
E. Quick Action

**Resistance to Antibiotics :-**

Pathogens often develop resistance to existing antibiotics so that newer antibiotics are required to be produced.
The resistance is produced due to :-
i. Development of copious mucilage
ii. Alteration of cell membrane so that antibiotic cannot recognise the pathogen.

iii. Change to L-form by pathogen
iv. Mutation in pathogen.

**Main sources of Antibiotic :-**

The main sources of Antibiotics production are three types -

**(i)** **Eubacterials –** Most of this type of antibiotic is obtaind from **Bacillus sps** 70%. Bacillus subtilis produced more than 60 Antibiotics and from **Pseudomonas species** 30%

**(ii)** **Actinomycetales [Ramified] –** Streptomyces, Micromonospora and streptosporangium. From single species **Streptomyces griseus** more than 40 antibiotics have been obtained.

**(iii)** **Fungi –** Penicillium.

## 4. STEROIDS

They are complex crystallisable lipids having a tetracyclic hydrocarbon core (one 5-carbon and three 6 carbon rings) and a long side chain. They are constituents of hormones and some important biochemical like cholesterol, progesterone, oestrogen, testosterone, cortisterone, and cortisone. Compounds of steroids are found in both animals and plants. The main important steroid which is found in animals i.e. **Cholestrol.** It is the main constituent of animal cell membrane and main point for the initiation of steroid in hormone inside the body. Steroids are used medicinally in correcting hormonal imbalance, Anabolic stimulants, Birth control pills, antifertility drugs, Anti-inflammatories, relieving pain and suppressing immune responses various steroids differ from one another in radicals like – OH = O, - $CO\text{-}CH_3$, -$COCH_2OH$.
**Murray** and **Peterson** (1950) found that **Rhizopus stolonifer** could bring about hydroxylation required for steroid synthesis including removal removal of hydrogen [dehydrogenation] from specific carbons.
Different microorganism produce different steroids from progesterone like pregnane, cortexolone, Androsterone etc. The commercial conversion of **Cortixolone** to **Predinisolone** which is used as **Antiflammatory drugs** which involve first hydroxylation then dehydrogenation.

## 5.ORGANIC ACIDS

Some organic acids are manufactured by employing fermentation activities of Fungi and others of Bacteria.

**For example :-**

**1.** **Citric Acid :-** It is obtained by the aerobic fermentation of sucrose by the fungus **Aspergillus niger.** This acid is used in medicine, flavouring extracts, food and candies; the manufacture of ink, dyeing. It is also produced by yeast.

**2.** **Acetic acid or Vinegar :-** Vinegar production is a two step fermentation process :-
**A. First step :-** Alcoholic fermentation of a carbohydrate in to alcohol by yeast.
**B. Secound step :-** Aerobic oxidation of alcohol into acetic acid by the Bacterium **Acetobactoer aceti.**
Venegar is a French word, meaning - **sour wine,** and was known to man thousands of years ago.
The Vinegar is the product of microbial fermentation, was recognised by **Kutzing** in 1837. In 1868 **Pasteur** discovered it to be a result of Biological Activity.
Vinegar is used in various ways in homes. It is used as a condiment and for preserving pickles, canned vegetables and fruits.
Medicinally, it has an important role in promoting digestion and in overcoming constipation.

**3.** **Lactic Acid :-** Produced by fermentation of corn starch, Molasses potatoes and whey by **Lactobacillus bulgaris** and **Streptococcus lactis.**

4. **Gluconic acid :-** Produced from glucose by fungus like **Aspergillus, Penicillium** and **Mucor.**

5. **Fumaric acid :-** Produced from Sugar by activity of **Rhizopus nigricans** [Bread mould]

6. **Butyricacid –** Obtained by clostridium butylicum.

## 6. INTERFERON

First of **all lssac** and **Linderman** observed that immunity due to the formation of special soluble substances, produced by viral infected cells. This small group pf protein is named - **Interferons.**These are the proteins released by the cells in response to a viral infection which they help to combat. These interferon do not inactivate the virus, but they make the unattacked cells, less susceptible so they are prevented from the attack of virus. They also prevent the viruses from taking over the cellular machinery. Interferon proteins have proved to be effective in treating influenza and hepatitis, but their role in cancer treatment is doubtful. Interferon produced by **Charlse Weisman** through the **E.coli** strain produced by Recombinent DNA technology.

There are three major types of interferons :

(1) Interferon-α (INF - α, produced by leucocytes or white blood cells,)

(2) Interferon-β (INF - β, produced by fibroblasts), and

(3) Interferon-γ(INF- γ produced by stimulated T-lymphocyte cells, hence also called immune interferon.

## 7. DEXTRINS

It is a **plasma expander** having 6-10% solution of dextrins which is given in case of haemorrhge, shock and dehydration and plasma transfusion.

Dextrins are soluble **polyglycans** or polymers of D-glucose. They are prepared either through partial hydrolysis of starch or partial polymerization of simple sugars through microorganism **Leuconostoc mesenteroids** Or Enzyme dextran sucrase. The enzyme is more usefull as dextran or dextrin of suitable molecular weight can be obtained more easily.

## 8. INSULIN

It is a proteinaceous hormone having 51 Amino acids arranged in two polypeptides A and B having 21 and 30 Amino Acids, respectively and joined by S-S disulphidges.

**Sir Edward sharpy-Shafer** (1916) was the first to not that diabetes of some persons was because of failure of some islands of pancreas to produce a substance which he called insulin (Derived from the latin, insula, menning island).

**Banting** and **best** (1921) were the first to isolate insulin from dog's pancreas and used it to cure diabetes in man.

The source of insulin used for curing diabetes these days, is the pancreas of slaughtered **cattle** and **pigs.** Through this insulin is effective in controlling diabetes, it results in certain undesirable effects.

The first genetically engineered insulin obtained by **recombinant DNA technique** with the help of **E-Coli** was produced by the American firms,**Eli-Lilly** on July 5, 1983. It has been given te trade name **humulin** and has been approved for clinical use.

## 9. VACCINES

Production of **antibodies** against of antigens inside the body is the basis of **immunity.** Process of inoculation of vaccines is called **vaccination.** Scientific base of vaccination established by **Louis Pasteur.** First vaccine discovered by **Edward Jenner** for small pox.

A vaccine contains either **weakened** or even **killed-attenuation pathogens** [serum suspension with virulence] which have still antigens to induce antibody production. All these vaccines are called **First generation vaccines.**

They are produced by **conventional technique.**

Recently new vaccines are produced called **second generation vaccines.** These are produced by **Recombinent DNA technology** [Genetic Engineering] e.g. **Herpese Virus and Hepatitis-B.**

Latest vaccines produced synthetically or **synthesized vaccines** are called **third generation vaccines.**

**AN IDEAL VACCINE**

1. It should not be tumerogenic or toxic or pathogenic, i.e., it should be safe.
2. It should have very low levels of side effects in normal individuals.
3. It should not cause problems in individuals with impaired immune system.
4. It should not spread either within the vaccinated individual or to other individuals (live vaccines.)
5. It should not contaminate the environment.
6. It should be effective in producing long lasting humoral and cellular immunities.
7. The technique of vaccination should be simple.
8. The vaccine should be cheap so that it is generally affordable. So far, such an ideal vaccine has not been developed.

## 10. PLANT TISSUE CULTURE

Now a days plant tissue culture technique utilized for the production of important compounds, such as **Red dye-** is called **Shikonin** which is obtained from **Lithospermum erythrorhizon.**

It is utilized for the formation of cosmetic materials.

**Note : (i)** **Antirabies** vaccine obtained from culture of **chick embryo** cells [Rabipur]

**(ii)** **Probiotics :** These are dietary nutritional supplements containing micro-organisms (eg. Sporlac tablet containing lactobacillus)

### Some special Techniques Utilized in Biotechnology –

**Rcombinant DNA technology –**

**recombinant DNA molecule** is produced by joining together two or more DNA segments usually originating from different organisms. More specifically, a recombinant DNA, molecule is a vector (e.g., a plasmid, phage or virus) into which the desired DNA fragment has been inserted to enable its cloning in an appropriate host.

Recombinant DNA molecules are produced with one of the following three objectives :

(1) To obtain a large number of copies of specific DNA fragments,

(2) To recover large quantities of the protein produced by the concerned gene.

(3) To integrate the gene in question of the chromosome of a target organism where it expresses it self.

This technique developed by Genetic engineering. In this techniques first of all isolation of desired gene from any organisms and its transfer and expression into any organism of choice. They are known as **transgenic**

**micro-organisms.** Transgenic micro organisms are produced with view to obtain novel pharmaceutical proteins.
For example **- Human Insulin** is being produced commercially from **Transgenic E.coli strain.**
Many valuable recombinant recombinant proteins are also being produced, using transgenic animal cells lines and transgenic plants.
At the same time, a number of these proteins of great medicinal value could not be produced on a commercial scale using the non-transgenic cells or organisms.
Proteins produced by transgens are called **"recombinant proteins".** Such type of recombinant genes are utilized for the formation of different products.
Plants, bacterial, fungi and animals whose genes have been altered by manipulation are called **Genetically**
**Modified Organisms (GMO).**
**Genetically modified crops –** A **transgenic crop** is a crop that contains and expresses a **transgene.** This crop is known as genetically modified crops or **GM crops.**
**(i) Two unique advantages :-** Any gene (from any organism or a gene synthesized chemically) can be used for transfer, and (ii) the change in genotype can be precisely controlled since only the transgene is added into the crop genome. For example **– Hirudin** is a protein that prevents blood clotting. The gene incoding hirudin was chemically synthesized and transferred into **Brassica napus.** Where hirudin accumulates in seeds. The hirudin is purified and used in medicine.
A soil bacterium **Bacillus thuringiensis,** produces **crystal** [Cry] **protein.** This Cry protein is toxic to Larvae of certain insects. Each Cry protein is toxic to a different group of insects. The gene encoding cry protein is called **"cry gene".** This Cry protein isolated and transferred into several crops. A crop expressing a cry gene is usually resistant to the group of insects for which the concerned Cry protein is toxic. There are a number of them, for example, the proteins encoded by the genes cryIAc and cryllAb control the cotton bollworms, that of crylAb controls corn borer.
However, gene symbol italics, e.g., cry. The first letter or the protein symbol, on the other hand , is always capital and the symbol is always written in roman letters, e.g., Cry.
**Bt Cotton :** Some strains of Bacillus thuringiensis produce proteins that kill certain insects such as lepidopterans (tobacco budworm, armyworm), coleopterans (beetles) and dipterans (flies, mosquitoes) .
B. thuringiensis forms protein crystals during a particular phase of their growth. These crystals contain a toxic **insecticidal protein**
The Bt toxin protein exist as inactive protoxins but once an insect ingest the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilise the crystals. The activated toxin binds to the surface of midgut epithelial cells and create pores that cause cell swelling and lysis and eventually cause death of the insect.
Transgenic variety of **Tomato – Flavr Savr** due to the inhibition of **polygalacturonase enzyme** which degrades pectin. So that tomato variety remains fresh and retain flavour much longer.
GM crops are already in cultivation in U.S.A., Europe and several other countries. In India, some insect resistant cotton varieties expressing cry genes have reached the farmers, fields. It has been argued that transgenic crops may be harmful to the environment. The three points.**Firstly, the transgene may be transferred through pollen** from **these crops to their wild relatives.**
Secondary, the transgenic crops **may themselves become persisten weeds.** Thirdly. GM **crops** may pollute the enviorment.

**APPLICATIONS OF TRANSGENIC PLANTS**

1. They have proved to be extremely **valuable tools** in studies on plant molecular biology, regulation of gene action, identification of regulatory promotary sequences etc.

2. Specific genes have been transferred into plants to **improve their agronomic** abd other features.

3. Genes for **resistance to various biotic stresses** have been engineerd to generate transgenic plants resistant to **insects viruses etc.**
4. Several gene transfers have been aimed at improving the **produce quality e.g. protein or lipid** quality etc. of transgenic plants ;
5. Transgenic plants are aimed to produce novel biochemicals like interferon, insulin, immunoglobulins etc.
6. Transgenic plants have been produced that express a gene encoding an antigenic protein from a pathogen.
7. Made crops more tolereant to Abiotic stresses (cold, drought, salt, heat).
8. Reduced reliance on chemical pesticides (pest-resistant crops).
9. Helped to reduce post harvest losses.
10. Increased efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).
11. Enhanced nutritional value of food e.g., Vitamin 'A' enriched rice.

**Genetic modified food –** The food is prepared from genetically modified crop[transgenic] is called genetically modified food or **G.M. Food.**
GM food difers from the food prepared from the produce of conventionally developed varieties mainly in the following aspects. **Firstly,** it contains **the protein** produced by the trangene in question, e.g., Cry protein in the case of insect resistant varieties. Secondly, **it contains the enzyme** produced by the **antibiotic resistance gene** that was used **during gene transfer by genetic engineering.** Finally, it contains the antibiotic resistance gene itself.
GM foods could lead to the following problems when they are consumed. Firstly, the **transgene product** may **toxicity and or produce allergies.** Secondly, the enzyme produced by the antibiotic resistance gene could cause allergies, since it is a foreign protein. **Finally,** the bacteria present in the alimentary canal of the humans could take up the antibiotic resistance gene that is present in the GM food.

**Biochemical Production**
Plants are the chioef source carbohydrates, e.g., starch, sugar etc., lipids, proteins, and a variety of unique biochemicals. Transgenes have been shown to introduce novel branches in the biosynthetic pathways of plants and, thereby, to generate valuable products or to produce new, valuavle new, valuavle proteins virtually all the cases are promising and in developmental stages, **except for the thrombin inhibitor protein hirudin, which is the first commercial example - Hirudin.**

**TRANSGENIC ANIMALS**
Animals that have had their DNA manipulated to possess and express an extra (foreign) gene are known as **transgenic animals.** Transgenic rats, rabbits, pigs, sheep, cows and fish have been produced, although over 95 percent of all existing transgenic animals are mice.

(i) **Normal physiology and development :** Transgenic animals can be specifically designed to allow the study of how genes are regulated, and how they affect the normal functions of the body and its development, e.g., study of complex factors involved in growth such as **insulin-like growth factor.** By introducing genes from other species that alter the formation of this factor and studying the biological effects that result, information is obtained about the biological role of the factor in the body.

(ii) **Study of disease :** Many transgenic animals are designed to increase our understanding of how genes contribute to the development of disease.These are specially made to serve as models for human diseases so that investigation of new treatments for diseases is made possible. Today transgenic models exist for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's

(iii) **Biological products :** Medicines required to treat certain human diseases can contain biological products, but such products are often expensive to make. Transgenic animals that produce useful biological products can be created by the introduction of the portion of DNA (or genes) which codes for a particular product such as human protein (α-1-antitrypsin) used to treat emphysema. Similar attempts are being made for treatment of phenylketonuria (PKU) and cystic fibrosis. In 1997, the transgenic cow, Rosie, produced human protein-enriched milk (2.4 grams per litre). The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies that natural cow-milk.

(iv) **Vaccine safety :** Transgenic mice are being developed for use in testing the safety of vaccines before they are used on humans. Transgenic mice are being used to test the safety of the polio vaccine. If successful and found to be reliable, they could replace the use of monkeys to test the safety of batches of the vaccine.

(v) **Chemical safety testing :** This is known as toxicity/safety testing. The procedure is the same as that used for testing toxicity of drugs. Transgenic animals are made that carry genes which make them more sensitive to toxic substances than non-transgenic animals. They are then exposed to the toxic substances and the effects studied. Toxicity testing in such animals will allow us to obtain results in less time.

**Sustainable Agriculture –** Sustainable agriculture primarily use renewable resources, would cause **minimum pollution and maintain the optimum** yield level. Any development that reduce the use of non renewable resources and level of pollution, would enhance the sustainability of agriculture. Biotechnology play significant role in sustainable agriculture by the use of **biofertilizer,** bio **pesticides, disease and insect resistant varieties etc.**

**Biopatent -** A patent is a right granted by a government to an **inventor** to prevent others from commercial use of his invention. A patent is granted for –

(A) An invention [including product]
(B) An improvement in an earlier invention
(C) The process of generating products and
(D) A concept or design.

These products are called biopatents because they are granted for biological entities.
Biopatents are awarded for the following :
(i) strains of microorganism, (ii) cell lines, (iii) genetically modified strains of plants and animals, (iv) DNA sequences, (v) the proteins encoded by DNA sequences, (vi) various biotechnological procedures, (vii) production processes, (viii) products, and (ix) product applications.
For example, one patent covers **'all transgenic plants of Brassica family'.** Such broad patents are considered morally unacceptable and fundamentally inequitable.

**Biopiracy –** Many organisations and multinational companies exploit or patent biological resources or bioresources of other nations without proper authorization from the countries concerned is known as **biopiracy.**
The industrialized nations are rich in technology and financial resources but poor in biodiversity and traditional knowledge related to the utilisation of the bioresources. In contrast, developing nations are poor in technology and financial resources, but are rich in biodiversity and traditional knowledge related to bioresources.

**Biological resources** or **bioresources** include all those organisms that can be used to derive commercial benefits.**Traditional knowledge related to bioresources** is the knowledge developed by various communities over long periods of history, regarding the utilisation of the bioresources, e.g., use of herbs, etc, as drugs.
Institutions and companies of industrialized nations are collecting and exploiting the bioresources, as follows.

(i) The are collection and patenting the genetic resources themselves. For example, a patent granted in U.S.A. covers the entire 'basmati' rice germplasm indigenous to our country.
(ii) The bioresources are being analysed for identification of valuable biomolecules. A **biomolecules** is a compound produced by a living organism. The biomolecules are then patented and used for commercial activites.
(iii) Useful genes are isolated from the bioresources and patented. These genes are then used to generate commercial products.

A west African plant **Pentadiplandra brazzena** produces a protein called **Brazzein** which is approximately 2000 times more sweeter than sugar. It is proposed to transfer the brazzein gene into maize and express it in maize Kernels.

But the protein brazzein was patented in U.S.A. subsequently, the gene encoding brazzein was isolated and patenmted in U.S.A.

**Biowar –** Biowar or biological war is the use of biological weapens against humans or their crops and animals. Bioweapens are a device that carries and delivers to the target organism in the form of **pathological biological agents toxins "bioweapen agent".**

**Bioweapen agent** is kept in a suitable container so that it remains active and virulent during delivery. This container could be delivered in various ways, including missiles and aircraft. The use of biological agents in war may date back to 5$^{th}$ century B.C.

Some of the potential pathogen for bioweapons are those that causes **Anthrax, Small pox** and **Botulinum toxin.** These bio weapens sent either through letters (envelopes) as power or in the form of spray.

The possible defences against bioweapons include the use of respirator or gas mask, vaccination, administration of appropriate antibiotics, and decontamination. In addition, sensitive detection systems should be developed to control and minmimise damage.

| **Bio Weapon** | ⇒ | **Bio War** | ⇐ | **Bio Weapon Agent** |
|---|---|---|---|---|
| A bio weapon agent + A container for this agent + A suitable delivery syse | | Use of biological agents to kill humans, crops, or domesticated animals | | A virus, bacteria or toxin produced by it and used to kill human crops, or domesticated animals |

**Benefits of Biological Weapons over Conventional Weapons –**

i. Biological weapons or agents for biological warfare are not costly and can be produced with ease.
ii. Detection is almost impossible.
iii. Use is likely to increase.
iv. They are more danger that conventional weapons.

**Potential Biological Weapon Agents –**

i. Anthrax → Bacillus anthracis.
ii. Botulinum toxin (Botulin) → Clostridium botulinum.
iii. Plague → Yersinia pestis.
iv. Viral Encephalitides → Alpha virus.

**Ethics**

**Includes a set of standards by** which a community regulates its behaviour and decides as to which activity is **legitimate and which is not.** Therefore **bioethics** may be viewed as a set of standards that may be issued to regulated our activities in relation to the biological world.

Therefore, the Indian Government has set up organisations such as **GEAC** (Genetic Engineering Approval Committee) , which will make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.

The major bioethical concerns pertaining to biotechnology are summarized below.

(i) **Use of animals biotechnology** causes great suffering to them.

(ii) When animals are used for production of **pharmaceutical proteins,** they are irtual;ly reduced to the status of a 'factory'.

(iii) Introduction of a transgene **from one species another species violates** the **'integrity of species'.**

(iv) Transfer of **human genes into animals** (and vice-versa) dilutes the concept of 'humanness'.

(v) Biotechnology **is disrespectful** to living being, and only exploits them for the benefit of huiman beings.

(vi) Biotechnology may pose unforeseen risks to the environment, including risk to biodiversity.

**Bioethics in Plant Genetic Engineering**

The GM crops are fast becoming a part of agriculature throughout the world because of their contribution to the increased crop productivity and to global food, feed and fiber security, besides their use in health-care and industry. However, the constraints associated with public acceptance of transgenic crops continue to be important challenges facing the global community.The following are the major concerns about GM crops and GM food :

- ☞ The safety of GM food human and animal consumption (e.g. GM food may cause allergenicity).
- ☞ The effect of GM crops on biodiversity and environment.
- ☞ The effect of GM crops on non-target and beneficial insects/microbes.
- ☞ Transgenes may escape through pollen to related plant species (gene pollution) and may lead to the development of supper weeds.
- ☞ The GM crops may change the fundamental vegetable nature of plants as the genes from animals (e.g. fish or mouse) ar being introduced into crop plants.
- ☞ The antibiotic resistance marker genes used to produce transenic crops may horizontally transfer into microbes and thus exacerbate probles of antibiotic resistance in human and animal pathogens (i.g. transgenes may move from plants to gut microflora of humans and animals)
- ☞ The GM crops may lead to the change in the evolutionary pattern.

**Biopesticides**

Biopesticides are those biological agents that are used for control of weeds, insects and pathogens. The microorganisms used as biopesticides include viruses, bacteria, fungi, protozoa and mites.

One example is the soil bacterium, Bacillus thuringiensis. Spores of ths bacterium produce the insecticidal Cry protein. Therefore, spores of this bacterium kill larvae of certain insects. The commercial preparations of B. thuringiensis contain a mixture of spores, Cry protein and an inert carrier. This bacterium was the first biopesticide to be used on a commercial scale in the world.

The very familiar beetle with red and black markings-the Ladybird, and Dragonflies are useful to get rid of aphids and mosquitoes, respectively. An example of microbial biocontrol agents that can be introduced in order to control butterfly caterpillars is the bacteria Bacillus thuringiensis (often written as Bt). These are available in sachets as dried spores which are mixed with water and sprayed onto vulnerable plants such as brassicas and

fruit trees, where these are eaten by the insect larvae. In the gut of the larvae, the toxin is released and the larvae get killed. The bacterial disease will kill the caterpillars. but leave other insects unharmed.

**Fungal pathogens** are attractive biocontrol agents for weed control in view of their host specificity and ease in production and inoculation in the field where,

A biological control being developed for use in the treatment of plant disease is the fungus **Trichoderma.** Trichoderma species are free-living fungi that are very common in the root ecosystems. They are effective biocontrol agents of several plant pathogens.

Baculoviruses are pathogens that attack insects and other arthropods. The majority of **baculoviruses** used as biological control agents are in the genus Nucleopolyhedrovirus.

These viruses are excellent candidates for species-spcific, narrow spectrum insecticidal application. They have been shown to have no negative impacts on plants, mammals, birds, fish or even on non-target insects. This is especially desirable when beneficial insects are being conserved to aid in an overall **integrated pest management (IPM) programme,** or when an ecologically sensitive area is being treated.

**Between bio-pesticides and chemical pesticides**

| | **Biopesticides** | **Chemical pesticides** |
|---|---|---|
| 1. | These do not harm nontarget species. | Nontarget species are also harmed. |
| 2. | They do not pollute the environment. | Cause pollution by organic farming; Sometimes serious. |
| 3. | No harmful residues remain in food, Fodder and fibers | Harmful residues may ofthn remain in food, Fodder and fibers. |
| 4. | Relatively Cheaper. | Relatively costlier |
| 5. | Insects are expected not to develop resistance To Biopesticides. | Insects may become resistant, e.g., Heliothis Has become resistant to most insecticides. |
| 6. | Since they are highly specific, correct Identification o the pest is essential. | It is of ten not critical. |
| 7. | High specificity may often make the use of Two or more biopesticides necessary. | Often not required |
| 8. | Performance may be variable due to the Influence of biotic and Abiotic factors of the Environment. | This is not often the case. |

**Biofertilisers**

Micro-organisms (bacteria, fungi and cyano bacteria) employed to enhance the availability of nutrients like nitrogen (N), and phosphorus (P) to crops are called **biofertilisers.** You know that several micro-organisms fix atmospheric nitrogen and make them available to plants.

Examples of nitrogen-fixing micro-organisams are bacteria and Cyanobacteria (blue-green algae); some of these are free-living, while others form symbiotic association with plant roots. **Rhizobia** form root nodules in legume crops and some Cyanobacteria (blue-green algae) from symbiotic association with the fern Azolla.

The fungus and plant root association is called **Mycorrhiza.** Some of these fungi are present on root surface only, whereas others enter into the roots as well. These fungi solubilise phosphorus, produce plant growth promoting substances and protect host plants from soil pathogens.

Biofertilisers are a low-cost input and they do not pollute the environment. They also reduce the depebdence on chemical fertilisers and also help to use **organic farming.**

**SINGLE CELL PROTEIN :-** It is a microbial biomass. This biomass is obtained from both mono and multicellular microorganism.

**Single cell protein can be produced using algae, fungi, yeast and bacteria.** Commercial production of S.C.P. is mostly based on yeasts and some other fungi e.g. **fusarium graminearum.**

(i) SCP may be used directly as human food supplement, or else

(ii) It may be used animal feed to at least partially replace the currently used protein-rich soyabean meal and fish proteins, and even cereals, which can be diverted for human consumption

**ADVANTAGES OF SCP**

The SCP processes and processes and products offer several advantages aslisted below :

1. They SCP is rich in high quality protein and is rather poor in fats, which is rather desirable.
2. They can be produced all the year round and are not dependent of the climate (except the algal processes).
3. The microbes are very fast growing and produce large quantities of SCP from relatively small area of land.
4. They use low cost substrates and, in some cases, such substrates which are being wasted and causing pollution to the environment.
5. When the substrate used for SCP process is a source of pollution, SCP productioe helps reduce pollution.
6. Strains having high biomass yields and a desirable amino acid composition can be easily selected or ptoduced by genetic enginnering.
7. Some SCPs are good sources of vitamins, particularly B-group of vitamins, as well, e.g., yeasts and mushrooms.
8. Mushrooms are considered as delicacy in the human diet.
9. At present, SCP appears to be the only feasible approach to bridge the gap between requirement and supply of proteins.

   Production of SCP reguire carbon source and other nitrogen, phosphorus and other nutrients needed to support optimal growth of the selected microorganism. SCP process are highly aerobic (except thjose using algae). Therefore aeration must be provided.

# BIOENERGY

## INTRODUCTION :

Only about 0.2 percent of the solar energy that reaches the earth's surface is converted into biomass. Yet this energy trapped annually in the biomass is about ten times the non-biomass energy from other sources (conventional) used by the people the world over. "Bioenergy is the energy obtained from biological sources", broadaly classified into **Animal energy** and **Biofules.** Coal, petroleum and natural gas also of biological origin, but are classified as fossil fuels. Bioenergy is widely used in the developing countries especially in the rural areas.

## ANIMAL ENERGY :

Animal energy is available in two forms- **Human Muscle Power** (HMP) and **Draught** (pronounced draft) **Animal Power** (DAP). HMP is widely used by women in their domestic chores and by marginal farmers, artisans and non-agricultural labourers HMP forms a sizable part of the energy utilised. It is approximately equivalent to **one-fifth** of the total electricity generated per year in india.

## BIOFULES :

Biofules or fules of biological origin have been used by man since the discovery fo fire. In spite of the improved methods of btaining energy, biofules continue to be a major resource. Biofules are **renewable,** and if used properly and efficiently they can help overcome energy problems of developing countries. With improvements in technology it is becoming possible to substantially replace fossil fules by biofules. Biomass can be used to generate producer gas to run irrigation pumps, to obtain alcohol, to replace petrol, ot generate biogas for cooking and lighting, or merely to generate electricity.

Biofules are obtained from wood and agricultural, agro-industrial and animal wastes, and from plants that produce alcohol, oil and petroleum.

## WOOD :

Wood has been used by man from the time he discovered fire. Over half global population still depends on wood for cooking and heating. Wood is also used as fuel in many industries. The consumption of fuelwood in the world was estimated at 1.7 billion m3 in 1984. Two-thirds of this was utilised by the developing countries in Africa and Asia. Such massive use of fuelwood has resulted in extensive deforestation and consequent environmental degradation.

A major quantity of wood is used as firewood. The principal advantages of firewood are :

1. It is a widely distributed source of renewable energy.
2. It can be harvested by unskilled labor, using simple equipment
3. When perfectly dry, 99 percent of it is combustible.
4. It is a fuel which produces flame and is well-adapted to heating large surfaces.
5. As all wood is composed essentially of the same substances, wood from most species can be used as fuel.

Plantation of trees for fire wood is called **energy plantation.**

**What determines the value o particular wood as fuel.**

There are hundred types of wood in a vast country like India. Of these only a few are selected as suitable fuel. Good firewool must

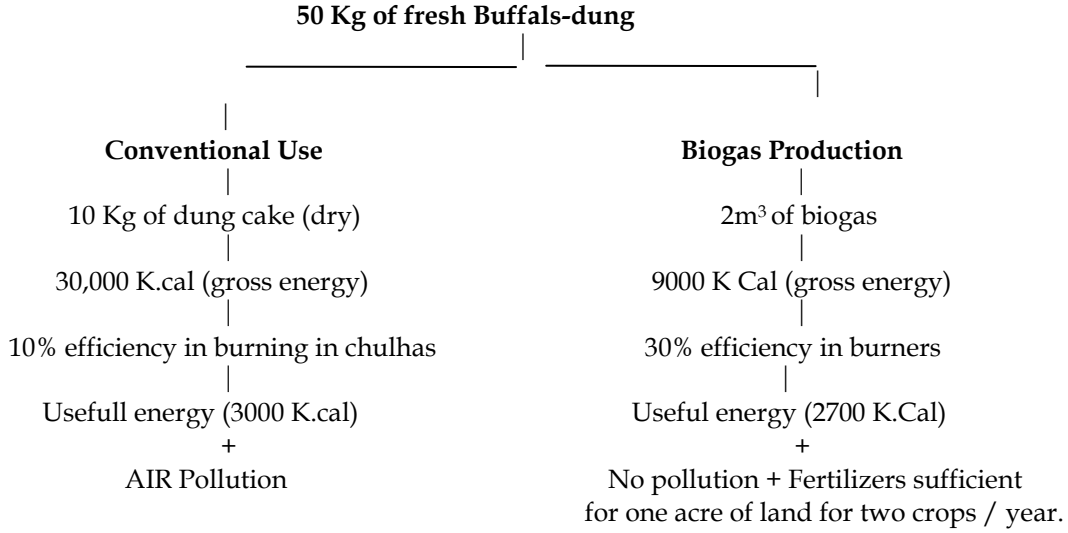
(i) be highly combustible, (ii) have a high calorific value,
(iii) be easy to dry, (iv) not split when ignited,
(v) be non-resinous and non-smoky and (vi) be free from offensive odours.

Generally speaking hardwood (dicotyledonous) is better than soft wood (gymnospermous) as fuel. The former produces uniform heat over a long period of time. Soft woof burns rapidly to produce intense heat but only for a short period.

**Cow Dung Cakes :-**

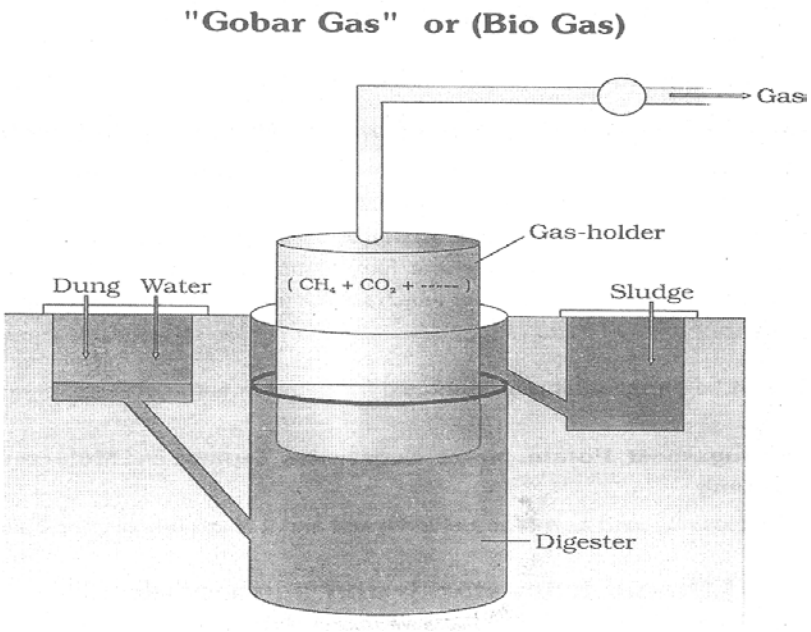
In rural areas of developing countries, it is a common practice to use animal dung for making dung cakes which are used for fuel. Thus a potential fertiliser of the agricultural fields is wasted in Burning.

The dung Can be put to a better use if it used to generate Bio gas (Gobar Gas) and side by side a stabilized residue to serve as the fertiliser.




The energy yield of Biogas is lower than that of dung cakes but the efficiency of Biogas burners is very high. Thus over all result indicates that production of biogas is more cost effective.

The biogas plant consists of a concrete tank (10-15 feet deep) in which bio-wastes are collected and a slurry of during is fed. A floating cover is placed over the slurry, which keeps on rising as the gas is produced in the tank due to the microbial activity. The biogas plan has an outlet, which is connected to a pipe to supply biogas to nearby houses. The spent slurry is removed through another outlet and may be used as fertiliser. Cattle dung is available in large quantities in rural areas wher cattle are used for a variety of purposes. So biogas plants are more after build in rural areas. The biogas thus produced is used for cooking and lighting. The technology of biogas production was developed in India mainly due to the efforts of **Indian Agricultural Research Institute (IARI)** and **Khadi and Village Industries Commission (KVIC)**




The organic wastes from the farmhouse cow dung, wastes, urine, faeces etc. can be used economically for producing of **Gobar gas** (Bio gas). It consists of **methane** (50-70%), **$CO_2$** (30-40%) and traces of hydrogen, nitrogen and hydrogen sulphides.
Biogas produced by anaerobic fermentation of waste biomass.
Anaerobic fermentation of waste biomass can be visualized in three stages :-

1. The **facultative anaerobic microbes** degrade the complex **polymers** to simple **monomers** by enzymatic action.
   The Polymers like cellulose, hemicellulose, proteins and lipids get degraded into monomers but **lignins** and inorganic salts are left as residue because they do not degraded.

2. In second stage, monomers are converted in to **organic acids** by microbial action under partially aerobic conditions which are finally converted to **acetic acid.**

3. In third stage acetic acid is oxidized in to **methane** by the activity of anaerobic methanogenic bacteria. These bacteria are commonly found in the anaerobic sludge during sewage treatment. These bacteria are also present in the rumen (a part of stomach) of cattle. A lot of cellulosic material present in the food of cattle is also present in the rumen. In rumen, these bacteria help in the breakdown of cellulose and play an important role in the nutrition of cattle. In this whole process digestion of **cellulose** takes place at very slow rate so that so that it is the **"rate limiting factor in biogas production".**

**Advantage :**

1. Biogas can be easily stored to provide more efficient source of energy.

2. It can be used for various purposes in addition to its use for cooking.

3. One bye product of this process is a stabilized residue which serves as a good fertilizer.

4. It reduces the overgrowth of faecal pathogens because of non availability of exposed waste. Thus it is significant in improving sanitation.

5. It also reduces the chances of spreading of pathogens in the field condition, minimizing the incidence of diseases in a crop year after year.

6. Its calorific value is about **23-28** $MJ/m^3$.

**Plants as Sources of hydrocarbons for Producing Petroleum**

**Melvin Calvin** has identified certain plants which produce hydrocarbons. The plants of **Euphorbiaceae, Asclepiadaceae** and **Apocyanaceae** produce **latex miecretion which contains hydrocarbons.**

The liquid hydrocarbon of the latex can serve as the liquid fuel which can replace the fuel requirement of automobiles either with petrol or as entire fuel. Plantation os such type of plants are called **Petro Plantation.** This is the such type of method in which source is available only through the demand.

**Alcohol as fuel :-**

1. Ethanol ($C_2H_5OH$) can be partly or wholly substituted for petrol in automobiles after suitable modifications in Engines.
2. Raising of crops like **Sugarbeet, Potato, Maize, Sugarcane, Tapioca** and **Molasses** for producing ethanol is called **energy cropping.**
3. Alcohol has been successfully used as motor fuel in **Brazil** and it is the first leading country in the world.

**"Ethanol from starch and lignocellulose"**

Ethanol or Ethyl Alcohol obtained from starch sources.
Ex. Potato, Molasses, waste sulphate liquor and wood sugars (lignocellulose)
**Method :-** The starch is hydrolysed into sugars which is then fermented in to alcohol.

$$C_6H_{12}O_6 \xrightarrow[\text{Zymase}]{\text{yeast}} 2C_2H_5OH + 2CO_2$$

glucose Ethanol Carbondioxide

**1.** Humuline is the term used for
(1) A new antibiotic (2) A sex hormone
(3) Human insulin (4) A vaccine

**2.** Conversion of sugar into alcohol during fermentation is due to the direst action of
(1) Temperature
(2) Microorganisms
(3) Zymase
(4) Concentration of sugar solution

**3.** The term antibiotic was coined by
(1) Alexander Fleming (2) S. WAksman
(3) Louis Pasteur (4) Edward Jenner

**4.** Rennin used in cheese industry is
(1) Antibiotic (9) Enzyme
(3) Alkalodi (4) Inhibitor

**5.** A compound which is produced by an organism and inhibits the growth of other organism is called –
(1) Antibody (2) Antigen
(3) Antiallergic (4) Antibiotic

**6.** Genetically engineered bacteria have been used in commercial production of
(1) Thyroxine (2) Testosterone
(3) Human insulin (4) Melatonium

**7.** Which one of the following is not true about antibiotics –
(1) First antiobiotic was discovered by Alexander Fleming
(2) The term 'antibiotic' was coined by S. Waksman in 1942.
(3) Some persons can be allergic to a particular antibiotic
(4) Each antibiotic is effective only against one particular kind of germ.

**8.** Antibiotics are mostly obtained from
(1) Fungi (2) Actionmycetes (3) Cyanobacteria (4) (1) & (2)

**9.** Which one of the microorganism is used for production of citric acid in industries ?
(1) Lactobacillus bulgaricus
(2) Penicillium citrinum
(3) Aspergillus niger
(4) Rhizopus nigricans

**10.** Important objective of biotechnology in riculture section is
(1) To produce pest resistant varieties of plants
(2) To increase the nitrogen contant
(3) To decrease the seed number
(4) To increase the plant weight

**11.** The new strain of bacteria produced by biotechnology in alcohol industry is
(1) Escherichia coli
(2) Saccharomyces cerevisiae
(3) Bacillus subtills
(4) Pseudomonas putida

**12.** Which one of the following is used in the manufacture of alcohol ?
(1) Bacteria (2) Water molds
(3) Yeasts (4) Slime molds

**13.** The name of drug used in cancer treatment produced by biotechnology is
(1) Interferon
(2) [HGH] Human growth hormone
(3) TSH (4) Insulin

**14.** The prerequisites for biotechnological production of antibiotics is
(1) To search an antibiotic producing microorganism
(2) To isolate an antibiotic gene
(3) To join antibiotic gene with E.coli plasmid
(4) All of the above

**15.** Propionic-bacteria is an important source of
(1) Vitamin-C (2) Cobalamin
(3) Sugars (4) Proteins

**16.** The microorganism grown on molasses and sold as a food flavouring substance is
(1) Saccharomyces (2) Rhizopus
(3) Acetobacter (4) Lactobacillus

**17.** Formation of vinegar from alcohol is caused by
(1) Bacillus subtilis (2) Clostridium
(3) Acetobacter aceti (4) Azotobacter

**18.** Which one of the following is used in industrial preparation of ethanol ?
(1) Lactobacillius (2) Azotobacter
(3) Penicillium (4) Saccharomyces

**19.** Biogas consists of
(1) Carbon monoxide, methane and hydrogen
(2) Carbon dioxide, methane and hydrogen
(3) Carbon monoxide, ethane and hydrogen
(4) Carbon dioxide, ethane and hydrogen

**20.** Bioenergy is the energy obtained from
(1) Biological sources (2) Coal
(3) Petroleum (4) Natural gases

**21.** The example of non-renewable source of energy is
(1) Alcohol fuel (2) Petroleum
(3) Biogas (4) Fuel wood

**22.** An example of petroleum plant is
(1) Zea mays (2) Beta vulgaris
(3) Euphorbia lathyrism
(4) Solanum tuberosum

**23.** The pioneer country in the production of 'Fuel alcohol' is
(1) Japan (2) Brazil
(3) Saudi Arabia (4) India

**24.** For biogas production besides dung an extensive use of which weed is recommended in our country
(1) Mangifera indica (2) Hydrilla
(3) Eichhornia crassipes (4) Solanum

**25.** For biogas production, besides dung, which of the following is used as manure
(1) Eichhornia (2) Parthenium
(3) Glycine (4) Arachis

**26.** Gobar gas contains mainly
(1) $CH_4 + CO_2$ (2) $CH_4 + O_2$
(3) $CO_2 + H_2$ (4) $CO_2 + SO_2$

**27.** Domestic cooking gas cylinder is filled with
(1) Alcohol (2) Diesel oil
(3) Liquid petroleum gas (4) Coal gas

**28.** Most of the petrocrops belong to family
(1) Leguminoase (2) Euphorbiaseae
(3) Rutaceae (4) Malvaceae

**29.** Who is credited with identifying petrocrops ?
(1) M.S. Swaminathan (2) M.Calvin
(3) Rutaceae (4) N. Borlaug

**30.** Biogas is produced by anaerobic breakdown of biomass of agricultural waste by methanogenic bacteria. It is a
(1) One step process (2)Two step process
(3) Three step process (4) Multistepprocess

**31.** One of the following is not the renewable source of Bioenergy :
(1) Wood (2) Alcohol
(3) Biogas (4) Coal

**32.** Beer is obtained from :
(1) Molasses (2) Grapes
(3) Barley (4) Rye

**33.** Maximum percentage of alcohol present in the product of yeast termentation :
(1) Brandy (2) Gin (3) Rum (4) Wine

**34.** Modern biotechnology consist :
(1) Genetic engineering(2) tissue culture
(3) Microbiology (4) All the above

**35.** First fermented acid is :
(1) Gluconic acid (2) Lactic acid
(3) Fumaric acid(4) All the above

**36.** Which of the following Microorganisms use for swisss cheese :
(1) Protrionibacterium (2) Geotrichum
(3) Penicillium (4) Streptococcus

**37.** Mechanism of action of antibiotics are :
(1) Disruption of cell wall
(2) Inhibition of DNA/RNA synthesis
(3) Disruption of plama lemma
(4) All the above

**38.** Which is not a charater of good antibiotic :
(1) No side effect for host
(2) Destroy microflora of alimentary canal of host
(3) Broad spectrum antibiotics
(4) Immediate reaction

**39.** What is mode of bacterial resistance against antibiotics :
(1) Development of thick mucilagrens layer
(2) Alteration of cell membrane
(3) Mutation in bacteria
(4) All the above

**40.** After Viral infection some substances are released by injected cells, these substances called as :
(1) Antigen (2) antibody
(3) Interferon (4) None of the above

**41.** First artificially synthesysed hormone is :
(1) Secretin (2) Insulin
(3) Glucagen (4) Renin

**42.** Recombinant DNA Tecnology prepared vaccine is called :
(1) First generation vaccine
(2) Second generation vaccine
(3) Third generation vaccine
(4) Synthesized vaccine

**43.** Which of the following vaccine related with tissue culture :
(1) Chicken pox (2) Hepatities –B
(3) Antirabies (4) Measles

**44.** Dextrin is :
(1) Polymer of glucose
(2) Plasa expander
(3) Use in dehydration condition
(4) All the above

**45.** Which type of transgenic microorganism :
(1) Escherichia coli (2) Entamoba coli
(3) Prendomona (4) Clostridium

**46.** Cry protein is obtained from :
(1) Bacillus thuringiensis
(2) Baccilus subtilis
(3) Clostridium welchi
(4) E.Coli

**47.** Which of following is not related with bio weapons :
(1) Bacillus anthracis
(2) Clostridium botulinum
(3) E. Coli (4) Yersinia pestis

**48.** Rate limiting step inbiogas production is :
(1) Methane (2) Cellulose
(3) Starch (4) Acetic acid

**49.** Which group is not related with petroplantation :
(1) Euphorbiaceae (2) Asclepiadiaceae
(3) Apocyanaceae (4) Leguminaceae

**50.** Which country has been successfully used alcohol as a motor fuel :
(1) India (2) U.S.A.
(3) Brazil (4) Canada

**51.** What are the advantage of gobar gas over convential utilization :
(1) More efficient soiurce of energy
(2) Used as good fertilizer
(3) Reduces the changes of spreading of pathogens
(4) All the above

**52.** Which is not a character of good fire wood
(1) Highly combustible
(2) Soft wood
(3) Non resinoces and non smoky
(4) High caloric value

**53.** Fuel wood requid per person perday is :
(1) 10 Kg (2) 3 Kg
(3) 1 Kg (4) 30 Kg

**54.** Biogas consists of
(1) $CO_2, C_2H_5OH, H_2$ (2) $CH_4, CO_2, H_2$
(3) $CH_4, SO_2, H_2$ (4) $C_2H_3, CO, H_2$

**55.** Biogas production gram waste Biomass with the help of methanogenic bacteria is -
(1) one step process (2) two step process
(3) three step process (4) multi step process

**56.** Citric acid is produced by –
(1) Asper gillus higher
(2) Streptococcus lactis
(3) Aceto bacter syboxidans
(4) Candida utilis

**57.** Transgenic animal has
(1) Foreign DNA is all its cells
(2) Foreign RNA is all its cells
(3) Foreign DNA is some of the cells
(4) Both 2 and 3

**58.** Vitamin $B_{12}$ is formed during fermentation-
(1) Ashloya gassipii
(2) Rhizopus stalonifer
(3) Propionibacteria
(4) Saccharomyces cervisieve

**59.** Cheese and yoghurt are prducts of -
(1) Pasteurisation (2) Distillation
(3) Dehydration (4) Fermentation

**60.** Milk is changed into curd by -
(1) Bacillus Megatherium
(2) Aceto bactor aceti
(3) Xanthomonas citri
(4) None of the above

**61.** Which of the following is ionic detergent :-
(1) RPM (2) HAT
(3) PEG (4) SDS
Sodium para dode ceyl benzene sulphonate

**62.** Which of the following yields citric acid:- **[CBSE-1998]**
(1) Penicillium citricum (2) Aspergillus niuger
(3) Saccharomyces (4) Azospiriliu

**63.** Saccharomyces cerevissae is used in the formation of :- **[CBSE-1998]**
(1) Ethanol (2) Methanol
(3) Acetic acid (4) Antibiotics

**64.** Indicator of water pollution :- **[CBSE-1998]**
(1) E. Coli (2) Chlorella
(3) Beggiatoa (4) Ulothrix

**65.** Modern farmer's can increase the yield of Paddy upto 50% by the use of : **[CBSE-1998]**
(1) Cyanobacteria
(2) Rhizobium
(3) Cyanobacteria in Azolla pinnata
(4) Farm yard manure

**66.** Sewage purification by :- **[CBSE-1998]**
(1) Microbes (2) Fertilisers
(3) Antibiotics (4) Antiseptics

**67.** Most stable pesticides :- **[CBSE-1999]**
(1) Organophosphates (2) Organochlorines
(3) Bordeaux mix. (4) Azederectin

**68.** Best economic method to harvest the solar energy :- **[CBSE-1999]**
(1) Solar cell
(2) Energy plantation
(3) Cultivation of sugar cane then obtain by burning it.
(4) Solar cooker.

**69.** First transgenic plant :- **[CBSE-1999]**
(1) Potato (2) Tomato
(3) Tobacco (4) Maize

**70.** Which one produce gas by decomposing the gobar (Dung) in gobar gas :- **[CBSE-1999]**
(1) Fungus (2) Virus
(3) Methanogenic bacteria (4) Algae

**71.** E. coli are used in production of :- **[CBSE-1999]**
(1) Rifampicin (2) LH
(3) Ecdyson (4) Interferon

**72.** What is vaccine :- **[CBSE-1999]**
(1) Treated bacteria, virus & protein
(2) Treated algae
(3) Treated fungi
(4) Treated plasmodium

**73.** The bacteria generally used for genetic engineering is - **[CBSE-2000]**
(1) Agro bacterium (2) Bacillus
(3) Pseudomonas (4) Clostridium

**74.** Which of the following is used to manufacture ethanol from starch :- **[CBSE-2000]**
(1) Penicilline (2) Saccharomyces
(3) Azotobactor (4) Lactobacillus

**75.** Which of the following is the pair of biofertilizers :- **[CBSE-2000]**
(1) Azolla and BGA (2) Nostoc and legume
(3) Rhizobium and grasses
(4) Salmonella & E. Coli

**76.** Interferons are synthesized in response to :- **[CBSE-2001]**
(1) Mycoplasma (2) Bacteria
(3) Viruses (4) Fungi

**77.** Which bacteria is utilized in Gober gas plant :- **[CBSE-2002]**
(1) Methanogens (2) Nitrifying bacteria
(3) Ammonifying bacteria
(4) Denitrifying bacteria

**78.** During the formation of bread it becomes porous due to release of $CO_2$ by the action of :- **[CBSE-2002]**
(1) Yeast (2) Bacteria
(3) Virus (4) Protozoans

**79.** Maximum application of animal cell culture technology today is in the production of **[CBSE-2003]**
(1) Insulin (2) Interfereons
(3) Vaccines (4) Edible proteins

**80.** **Escherichia coli** is used as an indicator organism to determine pollution of water with **[CBSE-2003]**
(1) Heavy metals (2) Faecal matter
(3) Industrial effluents
(4) Pollen of aquatic plants

**81.** During anaerobic digestion of organic waste, such as in producing biogas, which one of the following is left undergraded :- **[CBSE-2003]**
(1) Lipids (2) Lignin
(3) Hemi-cellulose (4) Cellulose

**82.** The term "antibiotic" was coined by :- **[CBSE-2003]**
(1) Edward Jenner (2) Louis Pasteur
(3) Selman waksman (4) Alexander Fleming

**83.** Recently Govt of India has allowed mixing of alcohol in petrol. What is the amount of alcohol permitted for mixing in petrol. ? **[CBSE-2004]**
(1) 5% (2) 2.5% (3) 10-15% (4) 10%

**84.** A major component of gobar gas is **[CBSE-2004]**
(1) Butane (2) Ammonia
(3) Methane (4) Ethane

**85.** A free living nitrogen-fixing cyanobacterium which can also form symbiotic association with the water form Azolla is :- **[CBSE-2004]**

(1) Anabaena (2) Tolypothrix
(3) Chlorella (4) Nostoc

**86.** Bacillus thuringiensis (Bt) strans have been used for designing novel : **[CBSE-2005]**

(1) Bio-metallorgical techniques
(2) Bio-insecticidal plants
(3) Bio-mineralization processes
(4) Bio-fertilizers

**87.** Which one of the following is a correct statement ? **[AIIMS-2005]**

(1) "Bt" in "Bt-cotton" indicates that it is a genetically modified organismproduced through biotechnology
(2) Somatic hybridization involves fusion of two complete plant cells carrying desired genes.
(3) The acticoagulant hirudin is being produced from transgenic Brassica napus seeds.
(4) "Flavr Savr" variety of tomato has enhanced the production of ethylene which improves its taste

**88.** Cry 1 endotoxins obtained from Bacillus thuringiensis are effective against :- **[CBSE-2008]**

(1) Flies (2) Nematodes
(3) Boll worms (4) Mosquitose

**89.** Humna insulin is being commercially produced from a transgenic specis of **[CBSE-2008]**

(1) Mycobacterium (2) Rhizobium
(3) Saccharomyces (4) Escherichia

**90.** Moder detergents contain enzyme preparations of **[CBSE-2008]**

(1) Alkaliphiles (2) Thermoacdiophiles
(3) Thermophiles (4) Acidophiles

**91.** Main objective of production/use of herbicide resistant GM crops is to:- **[CBSE-2008]**

(1) Eliminate weeds from the field without the use of herbicides
(2) Encourage eco-friendly herbicides
(3) Reduce herbicide accumulation in food articles for health safety
(4) Eliminate weeds from the field without the use of manual labor

**92.** Which one of the following is being tried in India as a biofuel substitute for fossil fueles ? **[CBSE-2008]**

(1) Jatropha (2) Musa
(3) Aegilops (4) Azadirachta

**93.** A transgenic food crop which may help in solving the problem of night blindness in developing countries is :- **[CBSE-2008]**

(1) Starlink maize (2) Bt Soybean
(3) Golden rice (4) Flavr Savr tomatoes

**BIOTECHNOLOGY & BIOENERGY** **ANSWER KEY**

| Q. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A.** | **3** | **3** | **2** | **2** | **4** | **3** | **4** | **4** | **3** | **1** | **4** | **3** | **1** | **4** | **2** |
| Q. | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| **A.** | **1** | **3** | **4** | **2** | **1** | **2** | **3** | **2** | **3** | **1** | **1** | **3** | **2** | **2** | **3** |
| Q. | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| **A.** | **4** | **3** | **1** | **4** | **2** | **1** | **4** | **2** | **4** | **3** | **2** | **2** | **3** | **4** | **1** |
| Q. | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| **A.** | **1** | **3** | **2** | **4** | **3** | **4** | **2** | **2** | **2** | **3** | **1** | **1** | **3** | **4** | **4** |
| Q. | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 |
| **A.** | **4** | **2** | **1** | **1** | **3** | **1** | **2** | **2** | **3** | **3** | **4** | **1** | **1** | **2** | **1** |
| Q. | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| **A.** | **3** | **1** | **1** | **3** | **2** | **2** | **3** | **1** | **3** | **1** | **2** | **3** | **3** | **4** | **1** |
| Q. | 91 | 92 | 93 | | | | | | | | | | | | |
| **A.** | **4** | **1** | **3** | | | | | | | | | | | | |

**BIOTECHNOLOGY & BIO-ENERGY STATE PMT EXAMS EXERCISE**

**1.** Find the odd one out :
**[UTTARANCHAL PMT - 2006]**
(1) Vaccines-immunology
(2) Eco degradation –pesticides
(3) Solar energy converter –pest control
(4) Recombinant DNA – biotechnology

**2.** The technology of biogas roduction was developed in India mainly due to efforts of
**[WEST BENGAL JEE - 2007]**
(1) IARI
(2) KVIC
(3) both (1) and (2)
(4) WHO

**3.** Yeast is used in the formation of :
**[C.G. PMT 2004]**
(1) Ammonia
(2) Alcohol
(3) Curd
(4) Petrol

**4.** Humulin is :
**[C.G. MPT - 2005]**
(1) Antibiotic
(2) Insulin
(3) Hemoglobin
(4) Pepsin

**5.** Bio gas production from waste bio mass with the help of methanogenic bacteria is :
**[ JHARKHAND - 2004]**
(1) Multi step process
(2) one step process
(3) two step process
(4) Three step process

**6.** IPM (Integrated Pest Management) involves : **[BIHAR - 2003]**
(1) tissue culture
(2) biological
(3) bio-fertilizers
(4) confusion technique

**7.** Biogas produced by anaerobic fermentation of waste biomass consists of : **[UP-CPMT 2005]**
(1) methane
(2) tracces of $H_2$, $H_2S$ and $N_2$
(3) $CO_2$
(4) all of these

**8.** Which one is not used in the production of yoghurt :
(1) Streptococcus lactis
**[MP-PMT 2002]**
(2) Streptococcus thermophilous
(3) Lactobacillus bulgaris
(4) Acetobacter aceti

**9.** Vitamin $B_{12}$ is produced by :
**[MP – MPT 20002]**
(1) Propionibacterium
(2) Ashbya gossypii
(3) Saccharomyces
(4) Rhizopus

**10.** Rennet is used in :
**[MP – CPMT 2002]**
(1) Bread making
(2) Fermentation
(3) Cheese making
(4) Synthesis of antibiotics

**11.** Which one of the following is used is used in the making of bread :
**[MP-CPMT 2004]**
(1) Rhizopus stolonifer
(2) Saccharomyces cerevisiae
(3) Zygasaccharoumyces
(4) Saccharomyces ludwigi

| Q . | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A . | 3 | 3 | 2 | 2 | 4 | 2 | 4 | 4 | 1 | 3 | 2 |