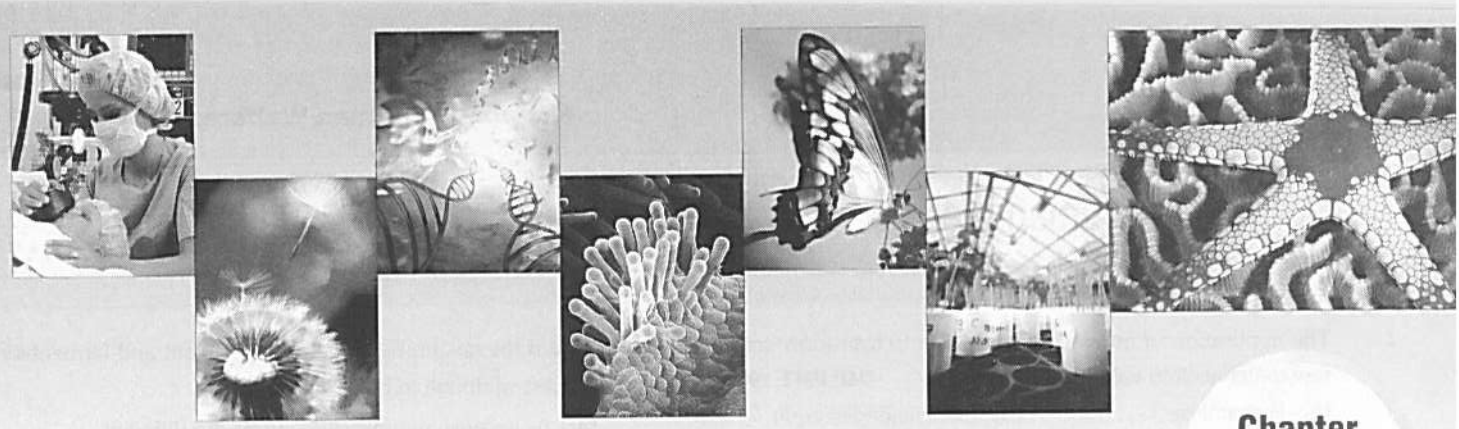


Chapter

8.7

Bioenergy, Biofertilizer and Biological Pest Control

The energy obtained from biological sources is called bioenergy. Bioenergy is the use of biomass (organic matter) to produce electricity, transportation fuels or chemicals. Bioenergy sources include agriculture and forestry residues and the organic components of municipal and industrial wastes. Fossil fuels (coal, petroleum and natural gas) are not included under bioenergy.

Only 0.2% of solar radiations reaching the earth is converted into biomass. This amount is about-10 times the energy produced from nonbiomass sources. Being a tropical country, India receives more solar radiations and therefore has high potential for biomass synthesis to meet the requirement of energy.

Bioenergy is obtained from following types of biological sources:

Animal energy : Animal energy is basically of two forms :

(1) **Human muscle power (HMP) :** It is the form of animal energy, which is used throughout the world in the form of physical work by human race like farmers in the field, women in house work and non agricultural labourers like artisans in wood work, gardeners, etc. A major part of the energy utilized today belongs to this type and it constitutes about $1/5^{th}$ of the total generated electricity in India. Thus, it constitutes the significant part of energy used.

(2) **Draught animal power (DAP) :** Animals are domesticated not only for providing us with food, hides and bones but they are also used in agriculture and transport. These animals play an important role in villages. India has about 84 million of work animals; 70 million bullocks; 8 million buffaloes and one million each of horses and camels. In addition mules, donkeys, elephants and yaks are also used. 50 percent of the Indian farmers have holdings less than two acres each, as a result they cannot use tractors. More than 15 million animal-drawn carts are used in India. Carts have the advantage that they can be used on all types of roads in all terrains. The energy potential of DAP is enormous. Suppose if each animal generates 0.5 horsepower then the

installed capacity of animals comes about 42 million horsepower or 30,500 MW. This value is almost equal to total electric power generation in India. Because of poor quality of animals and outdated designs of carts and agricultural machinery, full potential of DAP has not been realised in India. Methods recommended to achieve this are :

(i) Improved breeds of draught animals.

(ii) Use of better carts.

(iii) Proper management of grazing lands and pastures.

(iv) Supply of nutritious fodder.

Biofuels and Biomass : They are fuels of biological origin. Biofuels are major source of energy. They are renewable and if used properly and efficiently they can solve the energy problems of developing countries.

Biomass is the term applied to all materials whose origin can be traced to photosynthesis. Biomass can be used to generate producer gas, to run water pumps for irrigation, to obtain alcohol, to replace petrol, to generate biogas for cooking and lighting and to generate electricity.

Table : 8.7-1 Ways of utilising biomass as fuel

Biomass	Process	Form / Source of energy produced
Wood	Direct burning, Gasification, Carbonisation, Pyrolysis, Hydrolysis, Fermentation and Synthesis.	Heat, Producer gas, Charcoal gas, Oil and Charcoal, Methanol, Ethanol.
Agro-industrial residues.	Fermentation/Distillation, Anaerobic digestion.	Ethanol, Biogas.
Petroleum and Oil producing plants	Cracking and direct use.	Petroleum products, Heating, Running engines.
Energy cropping	Fermentation/ Distillations.	Ethanol.

Wood : It is the renewable and most common source of energy in use since time immemorial. Wood which is used as source of energy is called fuel wood and about 2 billion people in world are dependent upon wood as source of fuel. Excessive use of wood as fuel has led to deforestation, soil erosion, loss in fertility of soil and hence deterioration of environment.

The consumption of fuel wood was estimated at 1.7 billion m^3 in 1984 of which more than two third was consumed in Asia and Africa.

Characteristics of good fire wood

(1) It should be highly combustible and catch fire easily.

(2) It should have high calorific value and should be free of disagreeable odour.

(3) The fuel wood plants should be present every where.

(4) These should be easy to dry and should not split when burnt.

(5) Should be non-resinous in nature and smokeless.

Table : 8.7-2 Good fire woods and bad fire woods

Good fire-woods	Bad fire-woods
Acacia senegal (Gum Arabic)	*Pinus roxburghii* (Chir Pine)
Acacia nilotica (Kikar) (Black wood tree)	*Mangifera indica* (Mango)
Albizzia (Siris)	*Madhuca indica* (Mahua)
Azadirachta indica (Neem)	*Bauhinia racemosa* (Kachnar)
Quercus (Oak)	*Bombax* (Red silk cotton)
Casuarina equisetifolia (Jhau)	*Michelia excelsa* (Champak)
Adina cordifolia (yellow teak)	
Hopea (Dammar tree)	
Dalbergia sisso (Shisham)	
Prosopis (Jand)	
Anogeissus latifolia (Axle wood, Dhawra)	
Ceripos tagal (Goran)	
Gmelina arborea (Gumhar)	
Terminalia tomentosa (Asna)	
Syzygium cumini (Jambolana Jamun)	

The angiospermic wood (hard wood) is generally better than gymnospermic wood (soft wood). Soft wood produces intense heat but for shorter periods and hard wood gives uniform heat for longer periods. Bad fuel wood does not catch fire quickly, has low flame, low calorific value, gets burnt quickly, is full of smoke with offensive odour.

Due to increase in population, the demand of fuel wood is increasing day by day and this has led to fuel wood crisis. In order to overcome fuel wood crisis, following methods have been suggested :

(1) To grow more fuel wood trees, *i.e.*, energy plantations.

(2) Proper designing of wood stoves or chullahs in order to increase efficiency of these and hence to save energy loss.

(3) Electric cremation should be enhanced.

(4) Energy production from woods by different processes like carbonisation (Change of wood into carbon/charcoal by heating), gasification (change of wood into producer gas by passing steam over incandescent coke), pyrolysis (thermochemical conversion of wood into charcoal, pyroligneous acid (10% acetic acid), wood gas, wood tar, wood alcohol, etc.).

Energy plantations : Energy plantations mean to grow more trees for fuelwood. The uses of energy plantations are :

(1) Solar energy can be stored continuously.

(2) Minimum technology is required for raising the trees.

(3) They are ecologically safe, economical, renewable and sufficient manpower is available to raise them.

Mobilisation of land resources : To minimise the danger of loss of agricultural land for growing fuelwood, trees should be grown for fuelwood on :

(1) On farmer's own land where cultivation is not done.

(2) Village common lands

(3) Along both sides of road, canals and railway tracks

(4) On degraded forests and

(5) On wastelands

Over 30 million hectares of land is available in India for energy plantations, without affecting land under agricultural and industrial use.

Selection of suitable species : While selecting suitable species following criteria can be considered :

(1) The saplings should establish quickly and rapidly.

(2) The species should be preferably local and well adapted to local climatic and soil conditions.

(3) It should have high coppicing ability or regenerative potential. Coppicing means thick growth of branches from the stump after the aerial branches have been removed. Coppiced growth is faster as compared to the growth of new saplings because they have already established root system.

(4) The plant should be able to grow with minimum water and fertilizer requirement.

(5) The plant should draw minimum quantity of nutrients from soil.

(6) Plants should be able to improve the soil quality like sterilization, correction of alkalinity or acidity etc.

(7) Plants should have the xerophytic character when grown under xeric conditions.

(8) Plants should be resistant to pests and diseases.

(9) Plants grown along both the sides of roads and railway tracks should be able to tolerate water logging.

Development of suitable agro-technology : Techniques of growing particular species in particular habitat must be carried out to get maximum yield. Cultivating grasses and fodder crops along with fuel wood species brings out maximum land use.

Producer gas : It is mixture of mainly CO, H_2, O_2. Producer gas is produced due to incomplete combusion of coal and wood. With restricted supply of air, coal and wood is burnt. Mixture gas thus produced is passed through filter to remove shoot and ashes. Now the gas is passed through coolers to condense other waste residue. Now the gas is released for industrial use. This gas is free from pollution. Raw material for producer gas is easily available and can be produced at normal temperature. The gas produced is inflammable but otherwise costly and generates less power.

Agro-industrial residues : Some methods have been devised for bioconversion of agricultural residues, industrial waste materials and animal wastes into energy. This is very important in solving the environmental pollution problems. About 28 percent of population in the developing countries uses dung and crop residues as fuel for cooking food. Thus potential fertilizer of the agricultural fields is wasted in burning. The problem can be solved by using dung to produce gobar gas (biogas) and residue can be used as manure. The aerobic fermentation of dung yields fuel as well as fertilizer.

Biogas (Gobar gas) : Biogas is methane rich fuel gas produced by anaerobic breakdown and fermentation of biomass. Biogas consists of 50- 70% CH_4 (methane), 30- 40% CO_2, 1% H_2S and traces of H_2, N_2, O_2 and CO. Calorific value of biogas is 4,429 $kcal/m^3$ (23-28 MJ/m^3), and its CH_4 content is 50%.

Table : 8.7-3 Composition of biogas

S.No.	Name of gas	Chemical formula	Percentage
(1)	Methane	CH_4	50-68%
(2)	Carbon dioxide	CO_2	25–35%
(3)	Hydrogen	H_2	1–5%
(4)	Nitrogen	N_2	2–7%
(5)	Oxygen	O_2	0–0.1%
(6)	Hydrogen sulphide	H_2S	Rare

Biogas generation is a three stage anaerobic digestion of animal and other organic wastes.

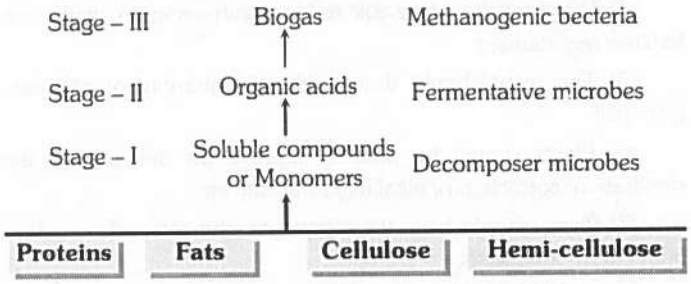


Fig : 8.7-1 Possible stages in anaerobic digestion during biogas formation

First stage : The facultative anaerobic micro-organisms breakdown the polymers into soluble monomers with the help of enzymatic hydrolysis. The complex carbohydrates such as cellulose and hemicellulose are degraded by cellulytic enzymes. Proteins are broken by proteolytic enzymes and lipids by lipolytic enzymes. Lignin cannot be broken down by micro-organisms, so it remains as residue along with inorganic salts.

Second stage : Here the monomers become the substrate for micro-organisms. These are then converted into organic acids.

Third stage : In this stage soluble organic acids (acetic acid) are formed for the substrates of the last stage. Finally methanogenic anaerobic bacteria (*e.g.*, *Methanobacterium, Methanobacillus, Methanosarcina* and *Methanococcus*) produce methane (biogas).

Biogas plants : Biogas (gobar gas) generation has been taken up in India on a large scale. One such plant is already existing at Okhla near New Delhi which generates a total of about 0.6 million cubic feet of gas per day. About 1.95 lakh biogas plants were set up during 1985-86 under the National Biogas Development Programe.

Important substrates in biogas production : Animal wastes like dung of cattle, urine and slaughter house wastes; agroindustrial wastes like oil cakes, sugar industry wastes, wastes from fruits and vegetables processing; agricultural or crop residues; human wastes (night soil); urban solid wastes and also aquatic plants like *Eichhorina* (water hyacinth), *Wolffia, Hydrilla, Salvinia, Azolla* and algae, etc.

In biogas production, water content is maintained at 90% at which most methanogenic bacteria are active.

The biogas so produced can be used for different purposes, can be efficiently used and stored easily. Further pathogens of faecal matter can be reduced (sanitation) and thus disease cycles are broken.

Energy cropping and petroplants : These are renewable resources of energy. Growing of crops from which alcohol and other energy fuels can be produced, constitute energy cropping. Important plants of energy cropping (*i.e.*, energy crops) are :

(a) *Saccharum officinarum* (Sugarcane)

(b) *Beta vulgaris* (Beet root or Chukandar)

(c) *Solanum tuberosum* (Potato)

(d) *Zea mays* (Maize)

(e) *Manihot glaziovii* (Tapioca)

These plants are efficient users of solar energy. These plants can be easily changed into ethanol (ethyl alcohol). The pioneer country in the production of fuel alcohol is Brazil. Pro alcohol programme in Brazil is aimed at completely replacing petrol with alcohol for running automobiles. In Brazil, ethanol fuel is used in automobiles (95% alcohol), where as in USA, 85-90% petrol is mixed with 10- 15% alcohol to form a new fuel called gasohol, which is used as fuel in automobiles. But slight modification is required in conventional engines to use these new fuels, *i.e.*, ethanol and gasohol.

Petroplants or Petrocrops : Latex of some plants containing long chain hydrocarbons is considered to be a good substitute for liquid fuels or petroleum. Such plants having large amount of latex with long chain hydrocarbons are called petroplants. Cultivation of petroplants is also a part of energy-cropping. Cultivation of these petrocrops was first of all done by Italians in Ethiopia about fifty years back, although actual credit for identifying the petrocrops goes to Dr. Melvin Calvin.

Dr. Calvin was first to identify few petroleum plants whose products can be used in place of petrol and oil. Most of such plants belong to families asclepiadaceae, euphorbiaceae and apocynaceae. These plants are able to convert a substantial amount of photosynthates into latex.

Latex contains long chained liquid hydrocarbons. These can be used directly or broken to hydrocarbons of chain length similar to the ones present in petrol.

Their hydrocarbon contents can be increased by genetic manipulations (genetic engineering). But commercial production of petroleum or liquid fuel alternative (through petroplants) is in early stage.

Most common petrocrops are :

(a) *Euphorbia antisyphilitica*

(b) *E. caudicifolia*

(c) *E. lathyris* (Gasoline tree)

(d) *E. royleana*

(e) *Calotropis procera*

(f) *Copaifera langsdorfii* (A Brazilian tree and its sap is a good alternative for diesel. About 3 litres of sap per month is produced per tree, which can be filled directly in fuel tank of diesel engine automobile).

(g) *Cryptostegia grandiflora*

(h) *Pittosporum resiniferum* (Petroleum nut)

The use of these petroplants may reduce the pressure on liquid fuel or petroleum.

Biofertilizers

Fertilizers of biological origin are called biofertilizers. These provide the essential elements to the soil and hence maintain or increase the soil fertility. Use of these biological fertilizers is safe both economically as well as ecologically.

There are two main categories of fertilizers of biological origin:

(1) **Green manures**

These are fast growing herbaceous crops which are ploughed down and mixed with the soil while still green for enrichment of soil. These provide both organic matter and nitrogen to the soil, in which Indian soils are generally poor. The green manure checks soil erosion by forming protective soil cover and also prevents leaching. Increase in yield by 30-50% has been observed by the use of green manures.

Some important green manure crops, which are mostly members of family Leguminosae are as follows:

(i) *Trifolium alexandrianum* (Barseem or Egyptian clover)

(ii) *Melilotus parviflora* (Senji/Sweet clover)

(iii) *Dolichos biflorus* (Horse gram or Kulthi)

(iv) *Lens esculenta* (Lentil or Masure)

(v) *Cyamopsis tetragonoloba* (Guar or Cluster bean)

(vi) *Sesbania sesban* (Dhaincha)

(vii) *Crotalaria juncea* (Sunhemp or Sunn)

(viii) *Vigna sinensis* (Lobiya or Cowpea)

(2) **Biofertilizers**

These are the organisms which bring about nutrient enrichment of the soil. Some of the important biofertilizers are :

Blue-green algae (Cyanobacteria) as biofertilizers

(i) **Symbiotic Nitrogen-fixing blue-green algae**

Anabaena azollae, *Anabaena cycadacae* and *Nostoc punctaeformae* are present symbiotically in leaves of *Azolla* (water fern), *Cycas* roots and *Anthoceros* thallus respectively, which fix atmospheric nitrogen. *Azolla-Anabaena* symbiotic system is the main biofertilizer which is inoculated in rice fields in South-Eastern Asia, which is found to increase yield upto 50%

(ii) **Free living Nitrogen-fixing blue-green algae**

Blue-green algae like *Nostoc*, *Anabaena*, *Aulosira*, *Tolypothrix*, *Plectonema* and *cylindrospermum* are the most common nitrogen fixing organisms, probably with the help of heterocysts. Photosynthesis provides the energy for nitrogen fixation. In the rice fields, *Aulosira* is the most active nitrogen fixing blue green algae. It is estimated that 7-8 lakh tons of nitrogen can be fixed by blue-green algae thus saving 15-17 lakh tons of urea every year.

Bacteria as biofertilizers

(i) **Free-living Nitrogen-fixing bacteria :** Some bacteria like *Azotobacter* (aerobic), *Clostridium* (anaerobic), *Rhodospirillum*, *Chromatium* (photosynthetic bacteria) are free living nitrogen fixing bacteria of soil, which increase fertility of soil and hence yield of crop plants.

(ii) **Symbiotic Nitrogen-fixing bacteria :** *Rhizobium leguminosarium* bacteria live symbiotically in root nodules of legumes and some non-legumes, which fix atmospheric N_2 and hence increase the fertility of soil.

(iii) **Loose association of Nitrogen-fixing bacteria :** A bacterium *Azosprillum lipoferum* forms loose association with roots of maize and some Brazilian grasses (Dobreiner, 1975), which increase the crop yield upto a large extent.

Fungi as biofertilizers

(i) **Mycorrhiza** : Symbiotic association between roots of higher plants and fungal hyphae, is called mycorrhizal association or mycorrhiza. It is of 2 types :

(ii) **Endotrophic or Endophytic mycorrhiza :** Here, fungal hyphae are present inside or between the cells of cortex, *e.g.*, in Coffee, Pepper and Cardamon, etc.

In many grasses and some other crops, the fungal hyphae penetrate to the cortical cells, which swell to form vesicles or arbuscules, called vesicular-arbuscular mycorrhiza (VAM). It has significant role in phosphate nutrition of plants.

(iii) **Ectotrophic or Ectophytic mycorrhiza :** Here, fungal hyphae are present on the surface of roots. It increases water and nutrient absorption, growth, vigour and yield of plants, *e.g.*, in Pinus, Oak, Eucalyptus, Peach, etc.

Biological pest control

Due to harmful effects of pesticides on organisms, some alternative methods of pest control are being used and biological pest control is one of the suitable methods, *i.e.*, use of other organisms to kill the pests constitutes biological pest control and such organisms are called biopesticides.

Bioherbicides/Biological control of weeds

Bioherbicides are organisms or their extracts which destroy weeds without harming useful plants. The first bioherbicide is devine, which is a mycoherbicide, based on fungus *Phytophthora palmivora*. It is being used since 1981 to control *Morrenia odorata* (milkweed vines) in *Citrus* orchards. Similarly Collego is another mycoherbicide from conidia *Colletotrichum gloeosporioides* fungus.

Bioinsecticides : They are living organisms or their products which are able to kill or repel specific insects.

(1) **Use of parasites, predators and pathogens :** *e.g.*, control of **aphids** by use of praying mantis or lady bug, *i.e.*, *Mantis*.

Bacillus thuringiensis : One of the most widely used bioinsecticide is a naturally occurring soil bacterium called *Bacillus thuringiensis* or *Bt.* that produces a protein, poisonous to insects. Insects affecting maize, cotton, cabbage, sunflowers, etc. are controlled by mutant strains of *Bacillus thuringiensis (Bt) bacteria* (sporeine). Often within 15 minutes of being eaten, the poisons begin to create ulcers in the insect's stomach lining. The insect stops eating and eventually dies. Researchers have identified between 500 and 600 strains, or types of *Bacillus thuringiensis*. *Bt* is very selective, it affects only a specific species of insect pest and does not harm humans, birds, fish or beneficial insects.

Prickly pear cactus (*Opuntia*) in Australia and India was effectively controlled by larvae of *Cactoblastis cactorum* (Cochineal insect).

By use of lady bugs or praying mantis, aphids (plant bugs or homopterous insects) can be kept under control. Fluted scale insect (*Icerya purchasi*), a pest on *citrus* can be effectively controlled by lady bird beetles. Similarly mosquito larvae can be easily controlled by fish *Gambusia* and sugar cane scale insects are controlled by coccinellid predators.

(2) **Use of natural insecticides :** The insecticides of plant or micro-organisms origin are called natural insecticides. These have little toxicity for animals, *e.g.*, Rotenone (from roots of *Derris* sps. and *Lonchocarpus* sps.); different alkaloids like Nicotine (from tobacco), Pyrethrum and Cinerin (from *Chrysanthemum*); Azadirachtin (from *Margosa* or Neem) are useful natural insecticides.

Neem or margosa (*Azadirachta indica*) is most useful natural insecticide. It is resistant to about 200 species of insects, nematodes, mites, etc.

(3) **Sterilization technique :** This is a modern method of biological pest control. In this technique, male insects are sterilized by irradiation, these are released at the time of mating and hence their multiplication is checked, *e.g.*, screw worm (*Cochliomyia hominivorax*) and red weavil (a pest on coconut) have been checked by this method.

(4) **Use of insect hormones (Sex attractants) :** The insect hormones called pherohormones (Pheromones) are useful in controlling insects. These pherohormones attract opposite sex insects during breeding season. The natural and synthetic pherohormones are now used to attract the insects towards death traps. The Orient-fruit fly has been eradicated by this method. Similarly, gipsy moth, a pest of conifers can be trapped

(i) Use of insect hormones like juvenile hormone and moulting hormone or ecdysone is also made as bioinsecticides, Juvenile hormone should be present in early stages of growth to prevent early maturation, but if the same is given artificially at later stage of growth, the insect is transformed into giant larva (immature adult) which dies quickly. Similarly, periodic shedding of insect cuticle (moulting) occurs during the process of growth and ecdysone hormone is associated with moulting. Use of this hormone at inappropriate time also results in early death of insect.

(ii) '**Confusion technique**' is a variation of this approach and it involves use of pheromones or sex attractants. In this technique, hydrophobic paper having pheromones or sex attractants is placed over the crop area, due to which characteristic smell is spread over the whole field and thus males are unable to locate the females.

Integrated Pest Management (IPM)

IPM involves use of different pest control methods, which are ecologically sound (*i.e.*, not cause hazard to environment), *e.g.*, biological control methods, better agricultural practices like crop rotation, sanitation, etc. starvation method, *i.e.*, growing of target crop away from major crop, ultra low volume spraying method, *i.e.*, use of very low and most effective concentration of chemicals, which does not cause pollution etc.

Tips & Tricks

- Per hectare potential production of alcohol 4000 litres for Sugarcane, 1800 litres for Sugarbeet, 1650 litres for Potato and 1125 litres for Maize.
- Fuel wood consumption provides 43% of total energy consumed in developing countries and amounts to about 14% of total world's energy production.
- Pyrolysis is heating of wood and waste wood to high temperature. The products are charcoal, pyroligneous acid, tar, oil, wood alcohol and wood gas.
- The energy potential of DAP is enormous.
- Hardwood is better as a fuel than softwood.
- Fuel gas (methane) is obtained by anaerobic fermentation of gobar gas
- Fuel wood is a renewable energy source.
- Gosohol : Brazil is obtaining alcohol from Sugarcane while USA is from Maize.
- Methanogens : Essential for biogas production. Decomposers are required for breaking down organic wastes.
- Sporeine developed in Germany is first commercial bioinsecticide obtained from *Bacillus thuringenesis.*
- Red squill (*Urginea maritima*) produce a raticide harmless to other animals.
- Juvenile Hormone : spray prevents larvae to metamorphose. They die without reproduction.
- Male Sterilisation : The technique was developed by Kiplings (1955). It has been used to eradicate Screw Worm.
- Biological Control of Parthenium : *Zygogramma bicolorata*, a beetle, suppresses *Parthenium hysterophorus* effectively. It, however, also attacks sunflower, shoot and root borer insect *Nupserha lenita* reduces population of the weed. Marigold and *Cassia tora* are two plants that can displace *Parthenium*. The latter is also controlled by spray of *Gliocladium virens* and *Trichoderma viride*.
- Parasitoids : They are organisms which are parasite in early stages (egg and larval) but live freely later on *e.g.*, parasitoid Wasp or Cabbage Butterfly.

Ordinary Thinking

Objective Questions

Bioenergy

1. With the exception of water, which one of the following is possibly the most important accessory chemical substance in industrial processes **[CBSE PMT 1994]**
(a) Petroleum (b) Rubber
(c) Ethanol (d) Liquid nitrogen

2. Non-conventional energy source is
(a) Tidal energy (b) Biogas
(c) Geothermal energy (d) All of these

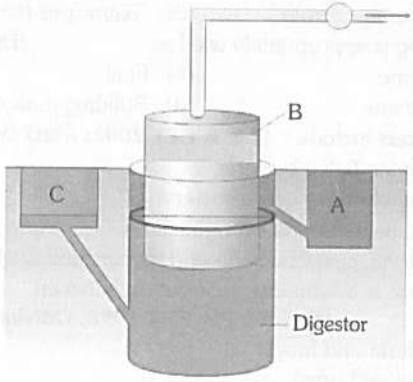
3. Which of the following plant species you would select for the production of bioethanol **[CBSE PMT 2009]**

Or

Which one of the following is being tried in India as a biofuel substitute for fossil fuels **[CBSE PMT 2008; AFMC 2012]**
(a) *Brassica* (b) *Zea mays*
(c) *Pongamia* (d) *Jatropha*

4. During Biogas production acetic acid is transformed into the final product by the enzymes of **[MHCET 2015]**
(a) *Clostridium* (b) *Pseudomonas*
(c) *Penicillium* (d) *Methanobacillus*

5. The following figure shows a typical biogas plant. Select the right option in which products labelled as A, B and C are correctly identified **[NCERT]**



(a) A - Sludge; B - Methane, Carbon dioxide; C - Sewage
(b) A - Sludge; B - Ethylin Carbon dioxide; C - Dung, water
(c) A - Sludge; B - Methane, Carbon dioxide; C - Dung, water
(d) A - Sludge; B - Methane, Oxygen; C - Dung, water

6. Biogas can be a good substitute for **[BHU 2000]**

Or

In developing countries, the heaviest demand on forests is for **[BHU 1996]**
(a) Fuel wood (b) Petroleum and oil
(c) Coal (d) Charcoal

7. The primitive prokaryotes responsible for the production of biogas from the dung of ruminant animals include the **[JIPMER 2000; NEET (Phase-I) 2016]**
(a) Methogens (b) Methanotrophs
(c) Organotrophs (d) Eubacteria

8. Major autotrophic biomass in oceans is contributed by **[CBSE PMT 2000]**
(a) Forests (b) Algae and phytoplanktons
(c) Crops (d) None of these

9. Biogas production from waste biomass with the help of methanogenic bacteria is **[Pb. PMT 1999]**
(a) One step process (b) Two step process
(c) Three step process (d) Multi step process

10. Methane content of biogas is **[BVP 2000]**
(a) 24.6% (b) 55.8%
(c) 8% (d) 4%

11. Energy plantation refers to **[HPMT 1995]**
(a) Setting up new electricity plants
(b) Growth of fuel wood trees
(c) Manufacture of more generators
(d) Erection of more dams

12. Major source of liquid hydrocarbon is
(a) *Calotropis gigantea* (b) *Cocos nucifera*
(c) *Euphorbia antisyphilitica* (d) *Solanum tuberosum*

13. The current consumption on domestic fire wood in India is about **[CBSE PMT 1990]**
(a) 18.6 million tonnes (b) 146.5 million tonnes
(c) 1246 million tonnes (d) 21870 million tonnes

14. Which wood burns for short period of time **[HPMT 1996]**

Or

One of the following plants have contributed to coal formation **[AFMC 2000]**
(a) Gymnosperms (b) Angiosperm
(c) Dicotyledonous (d) Monocotyledonous

15. What type of fuel are coal, petrol and natural gas **[CBSE PMT 1990]**
(a) Biofuels (b) Electrical fuels
(c) Fossil fuels (d) Liquid fuels

16. Cultivation of more fuel wood trees is known as
(a) Afforestation (b) Energy plantations
(c) Energy cropping (d) Deforestation

17. A good fodder **[CBSE PMT 1991]**
(a) Contains high dry matter
(b) Is free from disease and pest
(c) Has nutrient without toxicity
(d) All of these

18. Producer gas differs from biogas in having **[MHCET 2004]**
(a) Methane (b) Carbon monoxide
(c) Carbon dioxide (d) Formed by fermentation

19. In gobar gas, the maximum amount is that of **[NCERT; CBSE PMT 2004; CBSE PMT (Mains) 2012]**

Or

Biogas produced through anaerobic fermentation of organic material is primarily **[AIEEE Pharmacy 2004; BVP 2004]**
(a) Butane (b) Methane
(c) Propane (d) Carbon dioxide

20. Recently government of India has allowed mixing of alcohol in petrol. What is amount of alcohol permitted for mixing in petrol **[CBSE PMT 2004]**
(a) 2.5% (b) 10-15%
(c) 10% (d) 5%

21. The black wood tree of India is **[HPMT 1997]**
(a) *Acacia nilotica* (b) *Dalbergia sissoo*
(c) *Dalbergia latifolia* (d) *Mangifera indica*

22. Which of the followings is mainly produced by the activity of anaerobic bacteria on sewage **[NCERT; CBSE PMT (Pre.) 2011]**
(a) Marsh gas (b) Laughing gas
(c) Propane (d) Mustard gas

23. Biogas is a mixture of **[NCERT; MHCET 2002; DUMET 2010]**
(a) $CO+H_2+CO_2$ (b) $CH_4+CO+CO_2$
(c) $CH_4+CO_2+H_2$ (d) $CO+CO_2+NO_2$

24. The fuel wood crisis can be overcome by **[KCET 1997]**
(a) Efficient forest extractions (b) Afforestation
(c) More efficient heat transfer (d) A combination of these

25. An ideal good fuelwood is obtained from
(a) *Bauhinia racemosa* (b) *Dalbergia sissoo*
(c) *Michelia excelsa* (d) *Mangifera indica*

26. Biogas produced by anaerobic fermentation of water biomass consists of **[CPMT 2005]**
(a) Methane (b) Traces of H_2, H_2S and N_2
(c) CO_2 (d) All of these

27. Select the correct statement from the following **[CBSE PMT (Pre.) 2010]**
(a) Activated sludge-sediment in settlement tanks of sewage treatment plant is a rich source of aerobic bacteria
(b) Biogas is produced by the activity of aerobic bacteria on animal waste
(c) *Methanobacterium* is an aerobic bacterium found in rumen of cattle
(d) Biogas, commonly called gobar gas, is pure methane

28. Certain plants convert a substantial amount of photosynthate into latex. Most of them belong to family **[HP PMT 2001]**
(a) Euphorbiaceae (b) Malvaceae
(c) Asteraceae (d) Sterculiaceae

29. Sap of which plant is considered as a good substitute for diesel oil
(a) *Euphorbia sp* (b) *Copaifera longsdorfii*
(c) *Calotropis procera* (d) *Manihot glaziovii*

30. Non-renewal Energy gas is **[VITEEE 2006]**
(a) Natural gas (b) Geothermal energy
(c) Gobar gas (d) Biogas

31. Fuel wood is
(a) Source of petroleum products
(b) Renewable resource of energy
(c) Source of biogas
(d) Source of alcohol

32. Petroplants were first recognized by **[MP PMT 1999]**
(a) Lamarck (b) Darwin
(c) Hatch and Slack (d) M. Calvin

33. Which one of the following is being utilized as a source of biodiesel in the Indian countryside **[CBSE PMT 2007]**

Or

An example of Petrocrop is **[MP PMT 2012]**
(a) *Euphorbia* (b) Beetroot
(c) Sugarcane (d) *Pongarnia*

Biofertilizer

1. Biofertilizers **[BVP 2000]**
(a) Kill pests (b) Prevent pest growth
(c) Retain soil fertility (d) All the above

2. The common nitrogen-fixer in paddy fields is **[NCERT; CBSE PMT (Pre.) 2010]**
(a) *Frankia* (b) *Rhizobium*
(c) *Azospirillum* (B.G.A.) (d) *Oscillatoria*

3. Some blue green algae can be used as biofertilizer as they are **[KCET 2002]**
(a) Photosynthetic (b) Surrounded by mucilage
(c) Growing every where (d) Capable of fixing nitrogen

4. Which of the following plants are used as green manure in crop fields and in sandy soils **[CBSE PMT 2003]**
(a) *Dicanthium annulatum* and *Azolla pinnata*
(b) *Crotalaria juncea* and *Alhagi camelorum*
(c) *Calotropis procera* and *Pitylanthus niruri*
(d) *Saccharum munja* and *Lantana camara*

5. Agricultural chemicals include **[Pb. PMT 2000]**
(a) Pesticides (b) Fertilizers
(c) Growth regulators (d) All of these

6. Red pigment (Leghaemoglobin) having affinity for oxygen is present in the roots of **[CBSE PMT 2001]**
(a) Mustard (b) Soybean
(c) Carrot (d) Radish

7. A nitrogen fixing bacterium that forms a loose assocation with the roots of crop plants is **[Kerala PMT 2001]**

Or

Which one of the following micro-organisms is used as a bio fertilizer **[WB JEE 2016]**
(a) *Azotobacter* (b) *Bacillus polymyxa*
(c) *Clostridium* (d) *Azospirillum*

8. A legume having symbiotic association with two nitrogen fixing bacteria (*Rhizobium* and *Aerorhizobium*) is
(a) *Crotalaria juncea* (b) *Sesbania aculeata*
(c) *Sesbania rostrata* (d) *Cyamopsis tetragonoloba*

9. Cow dung is appropriately used as **[DPMT 2001]**
(a) Manure (b) Fuel
(c) Medicine (d) Building material

10. Biofertilizers include **[J & K CET 2002; AMU (Med.) 2010]**
(a) Nitrogen fixing bacteria
(b) Nitrogen fixing cyanobacteria
(c) Both bacteria and cyanobacteria
(d) Bacteria, cyanobacteria and mycorrhizal fungi

11. Mycorrhiza is a symbiotic association between **[NCERT; Pb. PMT 1998; Odisha JEE 2008]**
(a) Bacteria and fungi
(b) Algae and fungi
(c) Fungi and roots of higher plants
(d) Blue green algae and roots of higher plants.

12. *Azolla* enriches rice fields with nitrogen due to its association with **[Wardha 2001; Chd. CET 2001; CBSE PMT (Pre.) 2012]**

Or

A free living nitrogen fixing cyanobacterium which can also form symbiotic association with the water fern *Azolla* is **[CBSE PMT 2004]**
(a) *Anabaena* (b) *Nostoc*
(c) *Rhizobium* (d) *Frankia*

13. Rhizosphere is the region where
(a) *Rhizobium* forms root nodules
(b) Algae and root make contact
(c) Soil and root make contact
(d) Bacterial and root nearly make contact

14. An organism used as biofertilizer for raising soyabean crop is **[NCERT; J & K CET 2010; CBSE PMT (Pre.) 2011]**

Or

Most famous nitrogen fixing bacterium/biofertilizer is **[Kerala PMT 2000; JIPMER 2000]**

(a) *Nostoc* (b) *Azotobacter*
(c) *Azospirillum* (d) *Rhizobium*

15. Aquatic fern which is an excellent biofertilizer **[CBSE PMT 1999, 2000,01]**

(a) *Salvinia* (b) *Azolla*
(c) *Marsilea* (d) *Pteridium*

16. *Azolla* is used as biofertilizer as it has **[DPMT 2001; AIIMS 2003]**

(a) *Rhizobium* (b) *Cyanobacteria*
(c) *Mycorrhiza* (d) Large quantity of humus

17. Which is correct **[CBSE PMT 1994; AFMC 1999]**

(a) Legumes fix nitrogen through bacteria in their leaves
(b) Legumes fix nitrogen through bacteria in their roots
(c) Legumes fix nitrogen independent of bacteria
(d) Legumes do not fix nitrogen

18. Which one of the following is not biofertilizer **[NCERT; CBSE PMT (Pre.) 2011]**

(a) *Mycorrhiza* (b) *Agrobacterium*
(c) *Rhizobium* (d) *Nostoc*

19. Farmers have reported 50% higher yield of rice by using biofertilizer **[CBSE PMT 1993, 98, 99; MP PMT 1997; AMU (Med.) 2006; BHU 2006; Odisha JEE 2008]**

(a) *Azolla pinnata*
(b) Legume-*Rhizobium* symbiosis
(c) Cyanobacteria
(d) Mycorrhiza

20. Which one is a biofertilizer **[BVP 2001]**

(a) VAM (b) Sporeine
(c) Devine (d) Agent Orange

21. VAM is important for **[Kerala PMT 2000]**

(a) Breaking of dormancy (b) Phosphate nutrition
(c) Water uptake (d) Retarding flowering
(e) Decrease in yield

22. Leghaemoglobin occurs in **[Bih. PMT 1996]**

(a) Coralloid root (b) BGA
(c) Around bacteriods (d) Mycorrhiza

23. *Azotobacter* and *Bacillus polymyxa* are **[CBSE PMT 1996]**

(a) Decomposers
(b) Nonsymbiotic nitrogen fixers
(c) Symbiotic nitrogen fixers
(d) Pathogenic bacteria

24. Crop rotation is carried out for **[AFMC 1996; BHU 2004]**

(a) Increasing acidity of soil (b) Decreasing fertility of soil
(c) Increasing fertility of soil (d) All the above

25. Which disease is caused in children due to excessive use of nitrate fertilizers **[MP PMT 1996]**

(a) Septicemia (b) Jaundice
(c) Methaemoglobinaemia (d) Mumps

26. Which one is a nonsymbiotic nitrogen fixer **[Pb. PMT 1998]**

(a) *Rhizobium* (b) *Oscillatoria*
(c) *Nostoc* (d) *Lactobacillus*

27. Biofertilizers include **[CBSE PMT 1997, 2001; DPMT 2004; BHU 2008; AIIMS 2013]**

(a) Cowdung manure and farmyard waste
(b) A quick growing crop ploughed back
(c) BGA/*Anabaena* and *Azolla*
(d) All the above

28. Yield of paddy field can be increased by application of **[MP PMT 1997; CBSE PMT 1999; BHU 2012]**

(a) Iron bacteria (b) *Nostoc*/*Anabaena*
(c) Archaebacteria (d) Symbiotic bacteria

29. Green manure plants belong to **[Chd. CET 1997]**

(a) Compositae (b) Solanaceae
(c) Poaceae (d) Leguminosae

30. Which of the following can use molecular nitrogen as nutrient **[MP PMT 1998]**

(a) *Methanomonas* (b) *Mucor*
(c) *Rhizobium* (d) *Spirogyra*

31. Leghaemoglobin takes part in **[Kerala PMT 2000]**

(a) Energy release
(b) Stimulating growth of *Rhizobium*
(c) N_2 absorption
(d) Protecting nitrogenase
(e) Supply of oxygen

32. If wheat field is inoculated with *Rhizobium* **[Pb. PMT 1998; MP PMT 2007]**

(a) Soil will become nitrogen rich
(b) No effect on soil nitrogen
(c) Soil will be depleted of nitrogen
(d) Soil will become rich in calcium

Pest control

1. The bacterium *Bacillus thuringiensis* is widely used in contemporary biology as **[DPMT 2006; WB JEE 2008; CBSE PMT 2009; DUMET 2010; Odisha JEE 2010]**

Or

Thurioside is

(a) Indicator of water pollution
(b) Insecticide
(c) Agent for production of dairy products
(d) Source of industrial enzyme

2. Which one of the following statements are not related to Scirpophaga incertulus **[WB JEE 2008]**

(a) Adult stage never cause any damage to the plant
(b) It is a polyphagous pest
(c) It feeds on inner tissues of the stem
(d) It is inactive during day but active in evening

3. BT cotton is resistant to **[Odisha JEE 2005]**

(a) Insect (b) Herbicides
(c) Salt (d) Drought

4. Find out the pairs, which are correctly matched

A. Cyanobacteria	-	1. Biopesticides
B. Mycorrhiza	-	2. Solubilization of phosphate
C. *Bacillus thuringiensis*	-	3. Cry protein
D. Single cell protein	-	4. Rhizobia

[Kerala PMT 2007]

(a) *A* and 2 (b) *C* and 3
(c) *C* and 4 (d) *A* and 3
(e) *B* and 4

5. Microbe used for biocontrol of pest butterfly caterpillars is **[NEET (Karnataka) 2013]**
(a) *Saccharomyces cerevisiae*
(b) *Bacillus thuringiensis*
(c) *Streptococcus* sp.
(d) *Trichoderma* sp.

6. IPM (Integrated Pest Management) involves **[CPMT 1998]**
Or
Latest trend in plant disease control is **[Pb. PMT 1999]**
(a) Biological control (b) Pesticides
(c) Confusion technique (d) Biofertilizers

7. Third generation pesticides are **[CBSE PMT 1998; AFMC 2000]**
(a) Insect repellents
(b) Pheromones
(c) Pathogens
(d) Insect (juvenile) hormone analogues

8. Which weed has been eradicated by biological control **[DPMT 1997]**
(a) *Parthenium* (b) Cactus
(c) *Eichhornia* (d) *Chrysanthemum*

9. Cochineal insect has been used in checking the wild growth of **[CBSE PMT 1996]**
(a) *Opuntia* (b) *Eichhornia*
(c) Aphids (d) Screw worm

10. Which one of the following is an example of carrying out biological control of pests/diseases using microbes **[NCERT; CBSE PMT (Pre.) 2012]**
(a) *Trichoderma* sp against certain plant pathogens
(b) Nucleopolyhedrovirus against white rust in *Brassica*
(c) *Bt*–cotton to increase cotton yield
(d) Lady bird beetle against aphids in mustard

11. The phenomenon of using a predator for controlling a pest is **[CBSE PMT 1996]**
(a) Biological control (b) Genetic engineering
(c) Artificial control (d) Confusion technique

12. Biological control of pests is **[CBSE PMT 1994; CPMT 2000]**
(a) Polluting (b) Highly expensive
(c) Self perpetuating (d) Toxic

13. Pyrethrin is a common ingredient of
(a) Mosquito coils (b) Fly sprays
(c) Mosquito mats (d) All the above

14. A common biocontrol agent for the control of plant diseases is **[CBSE PMT (Pre.) 2010]**
(a) Trichoderma (b) Baculovirus
(c) *Bacillus thuringiensis* (d) Glomus

15. Antifeedant property occurs in
(a) Nicotine (b) Azadirachtin
(c) Rotenone (d) Cinerin

16. Confusion technique uses **[DPMT 2001]**
(a) Juvenile hormone
(b) Ecdysone
(c) Pheromone
(d) A combination of hormones

17. Which one is an effective plant insecticide
(a) Pyrethrin (b) Cinerin
(c) Nicotine (d) All the above

18. Pyrethrin is extracted from **[CPMT 1999, 2004; BHU 2000, 02; AFMC 2002]**
(a) *Azadirachta indica*
(b) *Helianthus annus*
(c) *Poa indica*
(d) *Chrysanthemum cinerarifolium*

19. *Bacillus thuringiensis* forms protein crystals which contain insecticidal protein. This protein **[CBSE PMT (Mains) 2011]**
(a) Is activated by acid pH of the foregut of the insect pest
(b) Does not kill the carrier bacterium which is itself resistant to this toxin
(c) Binds with epithelial cells of midgut of the insect pest ultimately killing it
(d) Is coded by several genes including the gene cry

20. cry II Ab and cry I Ab produce toxins that control **[Kerala PMT 2010]**
(a) Cotton bollworms and corn borer respectively
(b) Corn borer and cotton bollworms respectively
(c) Tobacco budworms and nematodes respectively
(d) Nematodes and tobacco budworms respectively
(e) Corn borer and tobacco budworms respectively

21. Parathion is a pesticide. In which one of the following categories it belongs **[WB JEE 2016]**
(a) Organochlorine (b) Synthetic pyrethroids
(c) Carbamate (d) Organophosphate

NCERT Exemplar Questions

1. Methanogenic bacteria are not found in **[NCERT]**
(a) Rumen of cattle
(b) Gobar gas plant
(c) Bottom of water-logged paddy fields
(d) Activated sludge

2. The technology of biogas production from cow dung was developed in India largely due to the efforts of **[NCERT]**
(a) Gas Authority of India
(b) Oil and Natural Gas Commission
(c) Indian Agricultural Research Institute and Khadi & Village Industries Commission
(d) India Oil Corporation

3. The free-living fungus *Trichoderma* can be used for **[NCERT]**
(a) Killing insects
(b) Biological control of plant diseases
(c) Controlling butterfly caterpillars
(d) Producing antibiotics

4. Mycorrhiza does not help the host plant in **[NCERT]**
(a) Enhancing its phosphorus uptake capacity
(b) Increasing its tolerance to drought
(c) Enhancing its resistance to root pathogens
(d) Increasing its resistance to insects

5. Which one of the following is not a nitrogen-fixing organism **[NCERT]**
(a) Anabaena (b) Nostoc
(c) Azotobacter (d) Pseudomonas

6. The residue left after methane production from cattle dung is **[NCERT]**
(a) Burnt (b) Burried in land fills
(c) Used as manure (d) Used in civil construction

7. Methanogens do not produce **[NCERT]**
(a) Oxygen (b) Methane
(c) Hydrogen sulfide (d) Carbon dioxide

8. Match the items in Column 'A' and Column 'B' and choose correct answer

Column A	Column B
A. Lady bird	i. Methano bacterium
B. Mycorrhiza	ii. Trichoderma
C. Biological control	iii. Aphids
D. Biogas	iv. Glomus

The correct answer is **[NCERT]**
(a) A-ii, B-iv, C-iii, D-i
(b) A-iii, B-iv, C-ii, D-i
(c) A-iv, B-i, C-ii, D-iii
(d) A-iii, B-ii, C-i, D-iv

CT Critical Thinking

Objective Questions

1. The calorific value of biogas is
(a) 10 – 20 mj/m^3 (b) 23 – 28 mj/m^3
(c) 35 – 40 mj/m^3 (d) 5 – 10 mj/m^3

2. One of the following aquatic weed has been exploited for biogas production **[CPMT 1995]**
(a) *Cryptostegia* (b) *Ceratophyllum*
(c) *Eichhornia* (d) *Vallisneria*

3. Gasohol is **[AFMC 1997]**
(a) 90% alcohol + 10% petrol
(b) 10% alcohol + 90% petrol
(c) 20% alcohol + 80% petrol
(d) 100% ethanol

4. Which one of the following is NOT a mycoherbicide **[MHCET 2015]**
(a) *Phytophthora palmivora* (b) *Xanthomonas sp.*
(c) *Alternaria crassa* (d) *Fusarium sp.*

5. For biogas production besides dung which one of the following weed is recommended in our country **[Kerala PMT 2004]**
(a) *Eichhornia crassipes* (b) *Coffea arabica*
(c) *Mangifera* (d) *Solanum nigrum*

6. Consider the following statements (A-D) about organic farming
(A) Utilizes genetically modified crops like Bt cotton
(B) Uses only naturally produced inputs like compost
(C) Does not use pesticides and urea
(D) Produces vegetables rich in vitamins and minerals
Which of the above statements are correct **[CBSE PMT (Mains) 2011]**
(a) (B) and (C) only (b) (A) and (B) only
(c) (B), (C) and (D) (d) (C) and (D) only

7. A Bioenergy source obtained by fermentation to supplement fossil fuel petrol is **[Chd. CET 1998; Odisha JEE 2011]**
(a) Kerosene (b) Ethanol
(c) Diesel (d) Methane

8. Ladybug is a predator of
(a) Moths (b) Beetles
(c) Bacteria (d) Aphids

9. A major pest eradicated through release of sterile males is
(a) Screw worm (b) Aphids
(c) Ladybug (d) Praying Mantis

10. Which one is green manure/biofertilizer **[Wardha 2002]**
(a) *Sesbania* (b) Maize
(c) Rice (d) Oat

11. Nitrogen content of urea is
(a) 26% (b) 56%
(c) 46% (d) 36%

AR Assertion & Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Bioenergy is the energy available from biological sources.
Reason : Fossil fuels are examples of bioenergy.

2. Assertion : Wood is an excellent fuel.
Reason : The average calorific value of seasoned wood is half to coal.

3. Assertion : Sugar crops and starch crops are valuable as solar energy converters.
Reason : They provide both liquid and solid fuels.

4. Assertion : Charcoal has equal heating power than wood.
Reason : Charcoal burns without producing flame or smoke. **[AIIMS 2009]**

5. Assertion : *Bacillus thuringenesis* is toxic to many insects.
Reason : It inhibits ion transport in the midgut.

6. Assertion : Pyrethrum is collected from the leaves of *Chrysanthemum cinerarifolium.*
Reason : Pyrethrin is prepared from pyrethrum.

7. Assertion : Compost is formed after decay of vegetable matter and organic refuse
Reason : Green manure is prepared by ploughing back any green plants into soil.

8. Assertion : Juvenile hormone inhibits maturation of insects if given artificially in later stages of growth of insects.
Reason : If forms giant larvae.

Answers

Bioenergy

1	a	2	d	3	d	4	d	5	c
6	a	7	a	8	b	9	c	10	b
11	b	12	c	13	b	14	a	15	c
16	b	17	d	18	b	19	b	20	d
21	a	22	a	23	c	24	a	25	b
26	d	27	a	28	a	29	b	30	a
31	a	32	d	33	a				

Biofertilizer

1	c	2	c	3	d	4	b	5	d
6	b	7	d	8	c	9	a	10	d
11	c	12	a	13	c	14	d	15	b
16	b	17	b	18	b	19	a	20	a
21	b	22	c	23	b	24	c	25	c
26	c	27	c	28	b	29	d	30	c
31	d	32	b						

Pest control

1	b	2	b	3	a	4	b	5	b
6	a	7	d	8	b	9	a	10	c
11	a	12	c	13	d	14	a	15	b
16	c	17	d	18	d	19	c	20	a
21	d								

NCERT Exemplar Questions

1	d	2	c	3	b	4	d	5	d
6	c	7	a	8	b				

Critical Thinking Questions

1	b	2	c	3	b	4	b	5	a
6	a	7	b	8	d	9	a	10	a
11	c								

Assertion and Reason

1	c	2	b	3	a	4	d	5	a
6	e	7	c	8	b				

AS Answers and Solutions

Bioenergy

6. (a) Wood which is used as source of energy is called fuel wood and about 2 billion people in world are dependent upon wood as a source of fuel.

7. (a) Conversion of organic acid into CH_4 gas by activity of methanogenic bacteria (anaerobes).

11. (b) Energy plantation mean to grow more trees for fuel wood, solar energy stored, safe ecologically, renewable etc.

12. (c) *Euphorbia antisyphilitica*, yields large amount of latex which contain long chain of hydrocarbons.

14. (a) Woods of dicots serve as better fuel wood than gymnospermous woods, because the former provide uniform heat for a long time.

16. (b) Wood gives a good flame with sufficient heat, whose source is green plants are called energy plantations.

18. (b) Biogas is methane rich fuel gas produced through anaerobic breakdown and fermentation of biomass. It contains CH_4, CO_2 and trace of H_2, H_2S and N_2, where as producer gas mainly contains CO, H_2 and N_2.

19. (b) In gobar gas the maximum amount of methane is produced by methanogenic bacteria.

21. (a) *Acacia nilotica* or kikar or black wood is good fire wood. They are easy to dry and catch fire quickly.

22. (a) It is by the activity of methanogens.

23. (c) Biogas / Gobar gas production by anaerobic respiration & fermentation of animal dung. Which consists 50–70% CH_4 ,30–40% CO_2 ,1% H_2S and trace H_2 , N_2 , O_2 .

25. (b) Good fuel wood are easy to dry, quickly catch fire, having good flame with high calorific value, *e.g.*, *Albizzia*, *Casuarina*, *Hopea*, *Dalbergia sisso* etc.

26. (d) Result of anaerobic fermentation of animal dung produces gobar gas.

29. (b) *Copaifera longsdorfii* / Brazilian tree and its sap is good alternative for diesel. About 3 litres of sap per month produced per tree.

32. (d) Melvin Calvin recognised that certain plant of family Euphorbiaceae convert a substantial amount of photosynthate into latex containing liquid hydrocarbon which are potential substitutes for petroleum.

33. (a) Those plant which are latex containing, long chain of hydrocarbons is called petroplants. e.g. *Euphorbia lathyris*, *E. caudicifolia*, *Calotropis procera*, *Pittosporum resiniferum* etc.

Biofertilizer

1. (c) Biofertilizers provides the essential elements to the soil and hence maintain or increase the soil fertility.

6. (b) Leguminous plants are having root nodules and nodules contains a red coloured pigment called leghaemoglobin. This pigment is the oxygen carrier. It keeps the level of molecular oxygen low inside the bacteriod.

7. (d) A bacterium *Azospirillum lipoferum* forms loose association with roots of maize and some Brazilian grasses which increase the crop yield upto a large extent.

9. (a) Manure is a semi-decayed organic matter which is added to the soil in order to maintain its fertility, crumb structure, aeration and hydration capacities, *e.g.*, dung, farm refuse, rotten vegetable matters etc.

10. (d) Biofertilizers are of three types : nitrogen fixing bacteria, nitrogen fixing cyanobacteria and mycorrhiza.

11. (c) Mycorrhiza is a mutually beneficial relationship between fungus and roots of higher plants.

12. (a) *Azolla pinnata* contains symbiont Anabaena in its leaf cavities. It is often inoculated to rice fields for nitrogen fixation.

14. (d) Soyabean is a legume associated symbiotically with *Rhizobium*.

15. (b) *Azolla pinnata* (aquatic fern) is a symbiotic nitrogen fixing cyanobacteria which is inoculated in rice fields in south-eastern Asia, and found to increase yield upto 50%.

16. (b) *Azolla* is used as a biofertilizer because it has association of cyanobacterial members in their internal tissue. Cyanobacterial members can fix atmospheric nitrogen.

18. (b) *Agrobacterium* is a gene transfer agent.

21. (b) VAM has significant role in phosphate nutrition of plants.

22. (c) A root nodule has a growing point, vascular strand and reddish pigment leghaemoglobin but lacks root cap and root hair. Its central infection zone has large cells with groups of bacteriods covered by membrane lined by leghaemoglobin.

23. (b) *Azotobacter* and *Bacillus polymyxa* are free living or non-symbiotic nitrogen fixing bacteria of soil, which increase fertility of soil and hence yield of crop plants.

26. (c) *Nostoc* is a free living nitrogen-fixing blue green algae probably with the help of heterocysts. Photosynthesis provides the energy for nitrogen fixation.

28. (b) They are the free living nitrogen fixing cyanobacteria and increase nitrogen content of moist soil and water bodies, which can be used in increasing paddy yield.

29. (d) Young leguminous crops are used for green manuring because they increase the nitrogen fertility of soil *e.g.*, *Crotalaria juncea, Sesbania aculeata*, etc.

31. (d) The nodule cells have a pigment called leghaemoglobin. The fixation of nitrogen is brought about by the enzyme nitrogenase are those nodules where leghaemoglobin is not produced cannot fix nitrogen.

32. (b) Because *Rhizobium* bacteria live symbiotically in root nodules of legumes and some non-legumes.

Pest control

6. (a) Biological pest control is one of the suitable methods, *i.e.*, use of other organisms to kill the pests constitutes biological pest control.

9. (a) In India and Australia, prodigious spread of prickly pear (*opuntia*) was controlled by introduction of cochineal insects (*Cactoblastis cactorum*).

11. (a) Predators is example of biological control and lady bug (lady bird beetle) and praying mantis can control scale insect or aphid pests of vegetables.

12. (c) The control organism which parasitises/preys upon/ inhibits the target pest, multiplies itself and is, hence, self-perpetuating.

13. (d) Pyrethrin are obtained from the dry inflorescence of *Chrysanthemum cinerarifolium*. Pyrethrin is also used for sprays, mosquito coils mats and aerosols.

15. (b) Neem extracts contain an antifeedant compound azadirachtin which keeps way the insects.

17. (d) Nicotine, pyrethrin and cinerin are natural insecticides and nicotine obtained from tobacco, pyrethrum and cinerin obtained from *Chrysanthemum cinerarifolium*.

Critical Thinking Questions

1. (b) Calorific value of biogas is 4.429 $K\ cal/m^3$ or 23–28 mj/m^3, when its CH_4 content is 50%.

3. (b) Gasohol programme of U.S.A. uses mixture of alcohol (10 – 15%) and petrol (85 – 90%).

9. (a) A large number of sterile males are released which mate without producing offspring *e.g.*, screw worm (Kiplings 1955).

10. (a) It is ploughed back young leguminous crop like *Sesbania aculeata, S. rostrata, Crotalaria juncea* etc.

Assertion and Reason

1. (c) Bioenergy is the energy available from biological sources, both living and their immediate remains eg. wood, gobar gas. It does not include fossil fuels (coal, petroleum, natural gas) etc.

2. (b) Wood is an excellent fuel since 99% of the over dried wood is combustible, leaving behind about 1%. The average calorific value of seasoned wood is around 4600 *calories/kg*, two kilograms of, which yield approximately the same heating value as produced by one kilogram of good coal.

3. (a) Sugar crops (like sugarcane and sugar beet) and starch crops (like corn) are efficient as solar energy converters. These crop not only give sugar which may be used directly or converted into ethanol (liquid fuel), but also give valuable byproducts such as bagasse, which can be used as solid fuels.

4. (d) Charcoal has twice heating power than wood. The wood is heated and changed to charcoal. Charcoal burns without producing flame or smoke. It is used in medicine, iron and steel industry and for absorbing impurities of air and water.

5. (a) Thurioside is a toxin produced by bacterium *Bacillus thuringenesis*. The toxin is highly effective against different groups of insects like moths, flies, mosquitoes and beetles. It kills the susceptible insects through inhibiting ion transport in the midgut.

6. (e) Pyrethrum is an insecticide which is obtained from the inflorescence of *Chrysanthemum cinerarifolium, C. coccineum* and *C.marshallii*. The active compounds are pyrethrin and cinerin. Pyrethrin is also used in fly sprays, aerosols, mosquito coils etc.

7. (c) Compost is a prepared mixture made of rotted vegetable matter and manure. An enriched composited manure is made by dumping all kinds of plant matter including garbage of vegetable markets and other organic refuse in heaps interspersed by the thin sprinkling of chemical fertilizers like ammonium sulphate, superphosphate, sodium nitrate, lime etc. It requires – 6 months for preparation of manure. Green manure is prepared from young, green crop plants by ploughing them back into soil. Usually young leguminous crops are used for green manuring because they also increase the nitrogen fertility of the soil. The plants are slowly converted into manure through the activity of micro organisms.

8. (b) Juvenile hormone prevents maturation and induces growth. If juvenile hormone is given artificially in later stages of growth of insect, the latter does not undergo maturation but instead forms giant larva which die quickly.

Bioenergy, Biofertilizers and Biological Pest Control

SET Self Evaluation Test

1. The biomass can be used to **[CBSE PMT 1992]**
(a) Obtain alcohol (b) Generate biogas
(c) Generate producer gas (d) All of these

2. The economically friendly measure to conserve solar energy is **[CBSE PMT 1999]**
(a) Sugarcane plantation (b) Energy plantation
(c) Both (a) and (b) (d) None of these

3. Existence of coal and petroleum may be detected with the study of **[Pb. PMT 1998]**
(a) Palaeobotany (b) Ecology
(c) Bacteriology (d) Economic botany

4. Pyrolysis of wood is responsible for yielding **[MP PMT 1999]**
(a) Alcohol (b) Charcoal
(c) Charcoal and gas (d) Charcoal, gas and oil

5. Biofuels are
(a) Renewable (b) Orthodox
(c) Pollution producing (d) Organic wastes

6. HMP is equivalent to ..... total electricity generated/year in India **[Manipal PMT 1998]**
(a) 2/5 (b) 1/3
(c) 1/4 (d) 1/5

7. Which one of the following is used as biological insecticide **[WB JEE 2010]**
(a) Tiger beetle (b) Caterpillar
(c) Silkmoth (d) Mazra poka

8. Producer gas consists of
(a) CH_4, CO_2, H_2 (b) CO_2, H_2, N_2
(c) CO, H_2, N_2 (d) CH_4, H_2, N_2

9. Brown Plant Hopper is **[Kerala PMT 2000]**
(a) *Nilparavata lugens* (b) *Calliphora erythrophala*
(c) *Helizoverpa armigera* (d) *Schistocerea gregaria*
(e) *Carasius morosus*

10. The pioneer country in the production of fuel-alcohol is **[MP PMT 1994; AFMC 1998]**
(a) Saudi Arabia (b) Iran, Iraq
(c) Brazil (d) Japan

11. Types of manures are
(a) Farmyard, composited and green
(b) Green and farmyard
(c) Green and composited
(d) Farmyard and composited

12. BGA is chiefly used as fertilizer in **[NCERT; MP PMT 1995; Pb. PMT 1998]**
(a) Wheat (b) Paddy
(c) Mustard (d) Gram

13. In insect ecdysone takes part in **[RPMT 1998]**
(a) Growth and development
(b) Maturation into adult
(c) Moulting till pupa is formed
(d) Secretion of cuticle

14. Which one is a biofertilizer **[JKCMEE 2000; JIPMER 2000]**
(a) NPK mixture
(b) Rhizobia in legume roots
(c) Rhizobia in farmyard manure
(d) Green manure

15. VAM is
(a) Vesicular-arbuscular mycorrhiza
(b) Variable adenine mutation
(c) Variable associative mutualism
(d) Vitamins and minerals

16. Thurioside is proteinaceous toxin obtained from **[AFMC 1999]**
(a) Biofertilizer (b) Green manure
(c) Bacterial origin (d) Farmyard manure

17. Which of the following is not used as a biopesticide **[CBSE PMT 2009]**
(a) *Bacillus thuringiensis*
(b) *Trichoderma harzianum*
(c) Nuclear Polyhedrosis Virus (NPV)
(d) *Xanthomonas campestris*

18. Cry 1 endotoxins obtained from *Bacillus Thuringiensis* are effective against **[CBSE PMT 2008]**
(a) Nematodes (b) Boll worms
(c) Mosquitoes (d) Flies

AS Answers and Solutions

1	b	2	c	3	a	4	d	5	a
6	d	7	a	8	c	9	a	10	c
11	a	12	b	13	c	14	b	15	a
16	c	17	d	18	b				

1. (b) Biomass is the organic matter present in living organisms, their wastes and residues are used in biogas production.

2. (c) All green plants stores solar energy by photosynthesis.

4. (d) Pyrolysis – Thermochemical conversion of wood into charcoal, pyroligneous acid (10% acetic acid) wood gas, wood tar, oil wood alcohol, etc.

5. (a) Biofuels are biological origin, which is a major source of energy. They are renewable and used properly and efficiently.

6. (d) HMP / human muscle power means physical work by human produces energy which about 1/5th of the total generated electricity in India.

7. (a) Caterpillar- larval stage of insects, silkmoth is used in silk culture in mazara poka is the paddy pest.

8. (c) Producer gas produced by gasification and it consists CO, H_2, N_2.

10. (c) Pioneer work has been done in Brazil. Pro – alcohol programme in Brazil is aimed at completely replacing petrol with alcohol for running automobiles.

11. (a) Farmyard manure, compost and green manure all are bio-fertilizers.

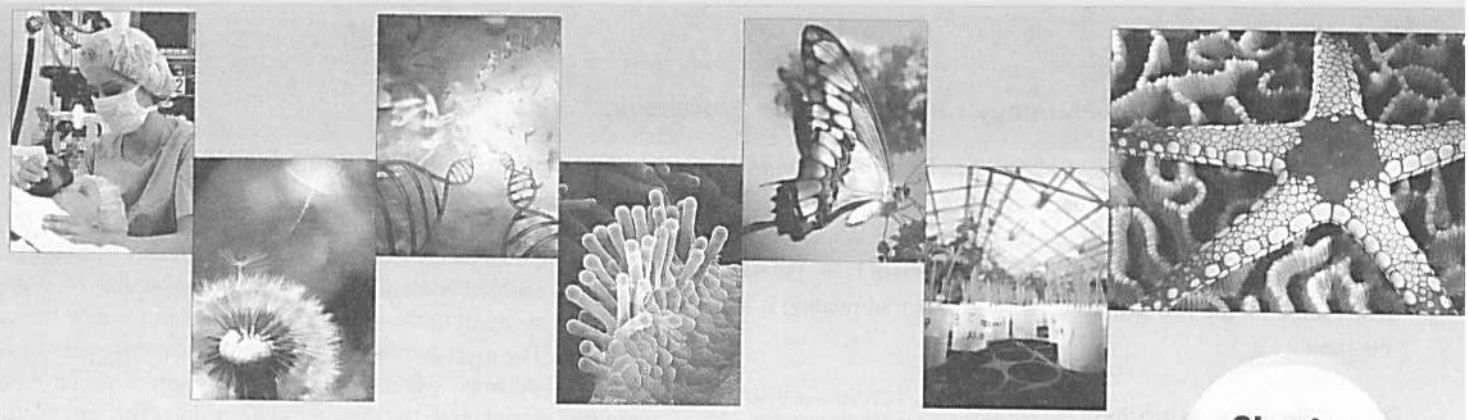
12. (b) BGA (Blue-green algae) for the nitrogen fixing.

14. (b) All cyanophyceae member's are biofertilizers because they has fixing of N_2 e.g. *Nostoc, Rebulla, Rhizobia* etc.

15. (a) Fungal hyphal tips into the host vesicular cell and arbuscules. Hence VAM (Vesicular-arbuscular mycorrhiza).

16. (c) Thurioside from *Bacillus* thuringienesis, is toxic to several insects.

* * *



Chapter

9.1

Biotechnology : Principles and Processes

Recombinant DNA Technology

It is a technology that allows DNA to be produced via artificial means.

It is the joining together of DNA molecules from two different species that are inserted into a host organism to produce new genetic combinations that are of value to science, medicine agriculture and industry.

This technology works by taking DNA from two different sources and combining it into a single molecule. That alone, however will not do much. It only becomes useful when that artificially created DNA is 111 reproduced in a process known as DNA cloning.

There are two main types of cloning that recombinant DNA technology is used for therapeutic cloning & reproductive cloning most people are familiar with reproductive cloning. Which will produce an organism with the exact genetic information of one that already exist. This has already been done with some animals. Dolly a Sheep, was the first mammal to ever be reproduced as an exact genetic copy.

Recombinant DNA technology is not accepted by some people, especially social conservatives who feel the technology is a slippery slope to devaluing the uniqueness of life. Further, because some DNA work involves the use and destruction of embryos. It attracts even more controversy still, proponents of the technology say the ultimate goal is to benefit human life, not destroy it.

Recombinant DNA technology is widely used in biotechnology medicine and research. Today recombinant proteins and other products that result from the use of rDNA technology are found in essentially every western pharmacy, doctor's, medical testing laboratory and biological research laboratory. In addition, organisms that have been manipulated using rDNA technology and products derived from those organisms have found their way into many farms supermarkets, home, medicine cabinets and even pet shops.

Genetic engineering

Recombinant DNA technology : Genetic engineering, a kind of biotechnology, is the latest branch in applied genetics dealing the alteration of the genetic make up of cells by deliberate and artificial means. Genetic engineering involves transfer or replacement of genes, so also known as recombination DNA technology or gene splicing.

Tools of Recombinant DNA Technology : Now we know from the foregoing discussion that genetic engineering or recombinant DNA technology can be accomplished only if we have the key tools, i.e., restriction enzymes, polymerase enzymes, ligases, vectors and the host organism. Let us try to understand some of these in detail.

Restriction Endonucleases : In 1963, two enzymes responsible for restricting the growth of bacteriophage in *Escherichia coli* were isolated. One of these added methyl groups to DNA, while the other cut DNA. The later was called **restriction endonucleases.**

The First Restriction Endonucleases : *Hind II*, whose functioning depended on a specific DNA nucleotide sequence was isolated and characterized five years later. It was found that *Hind II* always cut DNA molecules at a particular point by recognizing a specific sequence of six base pairs. This specific base sequence is known as the recognition sequence for *Hind II*. Besides *Hind II* today we know more than 900 restriction enzymes that have been isolated from over 230 strains of bacteria each of which recognize different recognition sequences. The convention of naming these enzymes is the first letter of the name comes from the genus and the second two letters come from the species of the prokaryotic cell from which they were isolated, *e.g.*, EcoRI comes from *Escherichia coli* RY 13. In EcoRI, the letter 'R' is derived from the name of strain. Roman numbers following the names indicate the order in which the enzymes were isolated from the strain of bacteria.

Palindromes are groups of letters that form the same words when read both forward and backward, *e.g.*, "MALAYALAM". As against a word-palindrome where the same word is read in both directions, the palindrome in DNA is a sequence of basic pairs that reads same on the two strands when orientation of reading is kept the same.

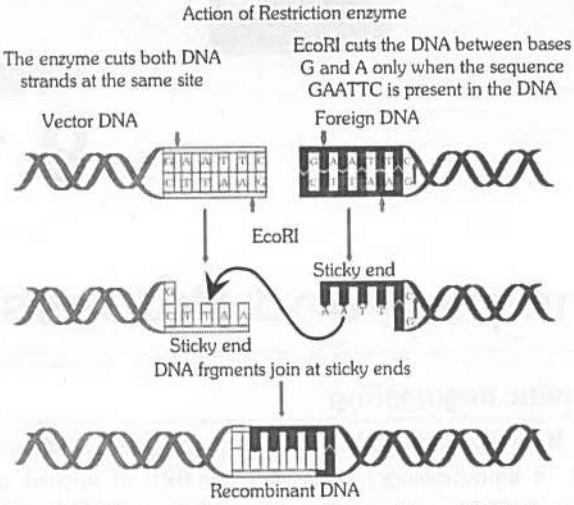


Fig : 9.1-1 Steps in formation of recombinant DNA by action of restriction endonuclesase enzyme - EcoRI

For example, the following sequence reads the same on the two strands in 5'→3' direction. This is also true if read in the 3'→5' direction.

5'——— GAATTC ———3'
3'——— CTTAAG ———5'

Restriction enzymes cut the strand of DNA a little away from the centre of the palindrome sites, but between the same two bases on the opposite strands. This leaves single stranded positions at the ends. There are overhanging stretches called **sticky ends** on each strand. These are named so because they form hydrogen bonds with their complementary cut counterparts. This stickiness of the ends facilitates the action of the enzyme DNA ligase. Such enzymes help in creating recombinant molecules of DNA.

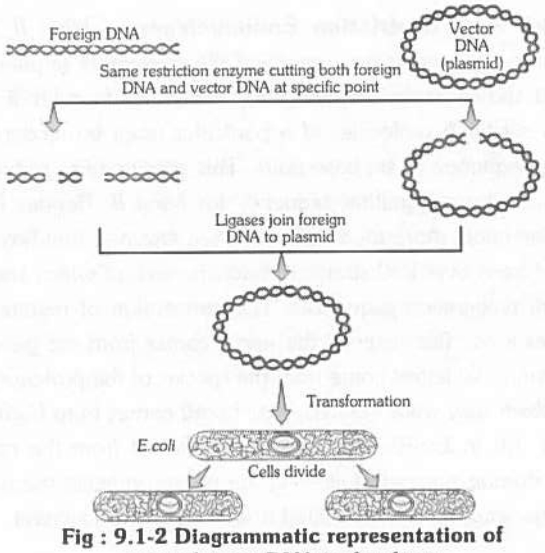


Fig : 9.1-2 Diagrammatic representation of recombinant DNA technology

Separation and Isolation of DNA Fragments : The cutting of DNA by restriction endonucleases results in the fragments of DNA. These fragments can be separated by a technique known as gel electrophoresis. Since DNA fragments are negatively charged molecules they can be separated by forcing them to move apart to the anode through the electric field through a medium. The most commonly used matrix is agarose gel which is a natural polymer extracted from sea weed. The DNA are separated according to their size through sieving effect provided by the agarose gel. The smaller the fragment the farther it moves. The separated DNA can be visualized only after staining the DNA with a compound known as ethidium bromide followed by exposer to UV radiations Bright orange coloured bands of DNA in a ethidium bromide stained gel exposed to UV light. The separated bands of DNA are cut out from the agarose gel and extracted from the gel piece. This is called **elution**. The DNA fragment is purified and used in constructing DNA recombinant.

Cloning Vectors : Once an alien DNA has been added to the host DNA, then the right vector is needed which can pass this DNA to a host cell for multiplication of the alien DNA. The choice can be of a bacteriophage or a plasmid. A bacteriophage makes many copies per cell. Some plasmids may have only one or two copies per cell whereas others may have 15 – 100 copies per cell. Vectors used at present are engineered in such a way that they help easy linking of foreign DNA and selection of recombinants from non-recombinants. The following are the features required to facilitate cloning into a vector.

(i) **Origin of replication (ori) :** This is a sequence from where replication starts and any piece of DNA when linked to this sequence can be made to replicate within the host cells. This sequence is also responsible for controlling the copy number of the linked DNA. So, if one wants to recover many copies of the target DNA it should be cloned in a vector whose origin support high copy number.

(ii) **Selectable marker :** In addition to 'ori', the vector requires a selectable marker, which helps in identifying and eliminating non-transformants and selectively permitting the growth of the transformants. **Transformation** is a procedure through which a piece of DNA is introduced in a host bacterium (you will study the process in subsequent section). Normally, the genes encoding resistance to antibiotics such as ampicillin, chloramphenicol, tetracycline or kanamycin etc., are considered useful selectable markers for *E. coli*. The normal *E. coli* cells do not carry resistance against any of these antibiotics.

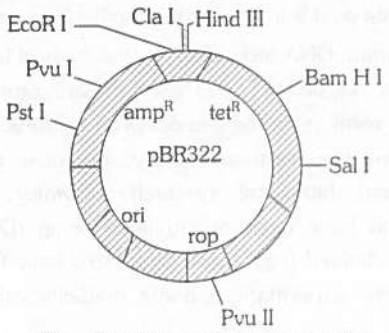


Fig : 9.1-3 E. coli cloning vector pBR322 showing restriction sites