

# MICROBES IN HUMAN WELFARE

- Beside plant & animals, microbes are major components of biological system on earth.
- All microbes are not pathogenic.
- Microbes are included in Kingdom Monera & Protista. Fungi are also considered.
- Microbes are cosmopolitan in distribution & present at sites. Where no other life form can survive, as thermal vents (geysers), deep in soil under layers of snow & highly acidic environment.
- Microbes like bacteria & many fungi can be grown on nutritive media to form colonies for their study.
- Several microbes are useful to human in many ways.

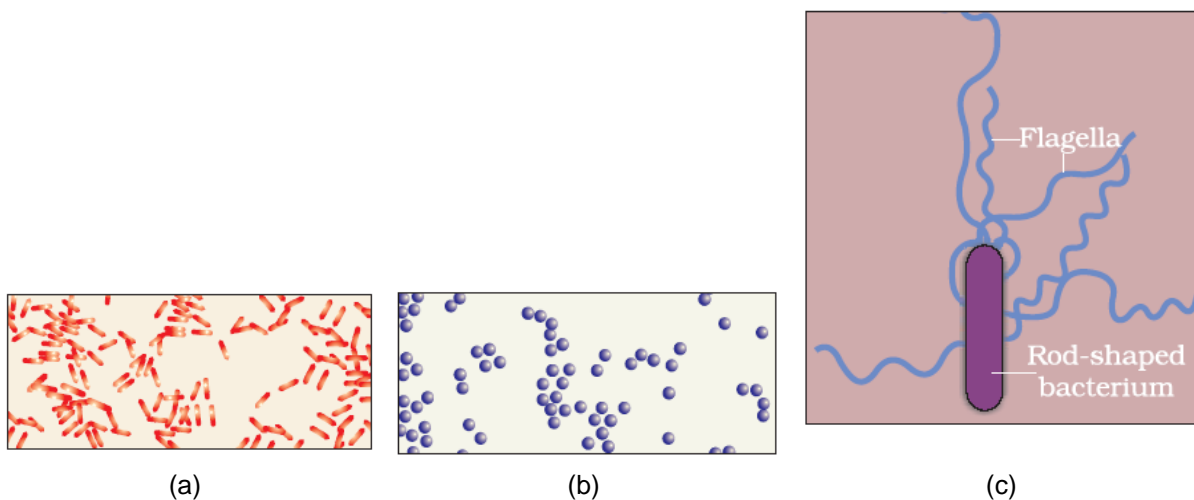
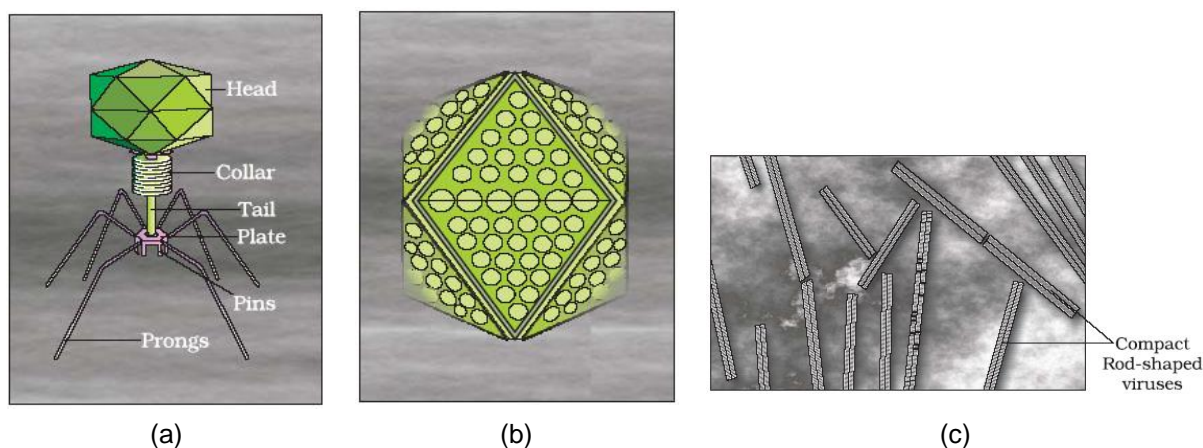
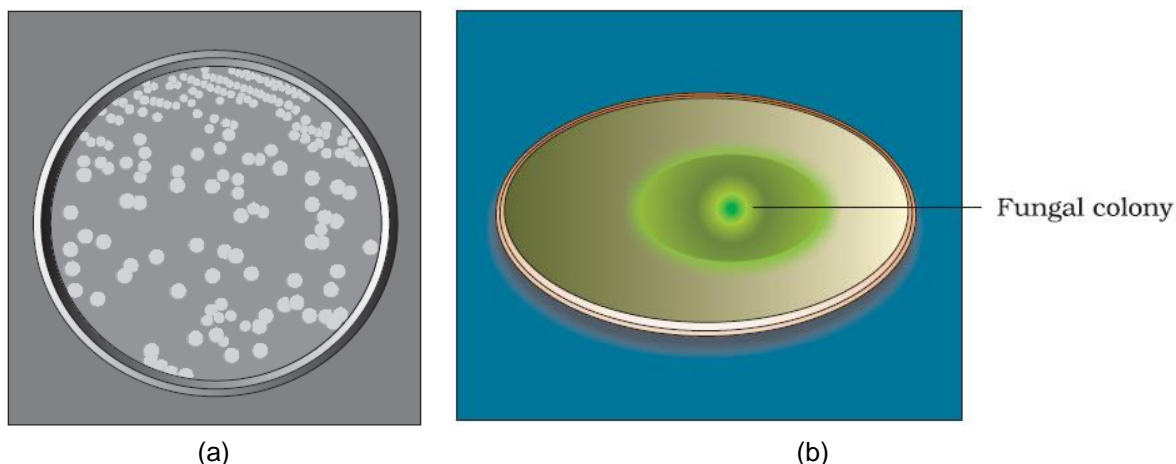


Figure : Bacteria: (a) Rod-shaped, magnified 1500X; (b) Spherical shaped, magnified 1500X; (c) A rodshaped bacterium showing flagella, magnified 50,000X



**Figure** : Viruses: (a) A bacteriophage; (b) Adenovirus which causes respiratory infections; (c) Rod-shaped Tobacco Mosaic Virus (TMV). Magnified about 1,00,000–1,50,000X



**Figure :** (a) Colonies of bacteria growing in a petri dish; (b) Fungal colony growing in a petri dish

### Microbes in Household Products:-

- We use microbes & their products every day.
- Common example is production of curd from milk.
- Lactic acid bacteria (LAB) as *Lactobacillus*, grow in milk & convert it to curd. Action of LAB increases vitamin B<sub>12</sub> in curd.
- LAB are also present in our stomach & play beneficial role in checking disease causing microbes.
- Dough used for production of Idli & Dosa are also fermented by bacteria like *Leuconostoc* & *Enterococcus*.
- Puffed up appearance of dough is due to production of CO<sub>2</sub> by anaerobic respiration.
- Dough, used for making bread is fermented by using baker's yeast (*Saccharomyces cerevisiae*). Swelling of bread at high temperature is called leavening, which is done by amylase, zymase and maltase enzymes.
- Traditional drink like 'Toddy' in South India is made by fermenting sap from palms (*Caryota urens*).
- Microbes are also used to ferment fish, soyabean & Bamboo shoot to make food.
- Cheese is one of the oldest food items prepared using microbes.
- Different varieties of cheese are known by their characteristic texture, flavour & tastes & these specificities come from microbes used.
- Large holes in Swiss cheese are due to production of large amount of CO<sub>2</sub> by *Propionibacterium sharmanii*.
- Roquefort cheese is bluish & ripened by growing *Penicillium roqueforti* on them.
- Camembert cheese employs *Penicillium camembertii* for ripening.

### Microbes in Industrial product:-

- Industry uses a number of microbes to synthesize products valuable to human.
- Production at industrial scale requires growing microbes in large vessels called fermenters.

#### 1. Fermented Beverages:-

- Microbes especially Yeast have been used for production of beverages like wine, beer, whisky, brandy or rum.

- *Saccharomyces cerevisiae* (brewer's Yeast) is used for bread making.
- *Saccharomyces cerevisiae* is used for fermenting malted cereals & fruit juices to produce ethanol. *Saccharomyces ellipsoidens* is called wine yeast.
- Depending upon type of raw material used & type of processing (with or without distillation), different types of alcoholic drinks are obtained.
- Wine & Beer are produced without distillation.
- Whisky, Brandy & Rum are produced by fermented broth, by distillation.
- Nutrient medium is Barley malt for Beer, Rye malt for Gin. Potato for Vodka, Cereals for Whisky, Mollases for Rum, Juices for Wine & Brandy.



Figure : Fermentors



Figure : Fermentation Plant

## 2. Antibiotics:-

- Antibiotics produced by microbes are one of the most significant discoveries of 20<sup>th</sup> century.
- Antibiotics are chemicals produced by some microbes and can kill or retard growth of disease causing microbes.
- Chloromycetin is obtained from *Streptomyces venezuelae*.
- Term antibiotic was coined by Selman Waksman.
- Penicillin was first antibiotic, to be discovered.
- It was chancily discovered by Alexander Flemming, while working on *Staphylococci* bacteria.
- *Staphylococci* was unable to grow around petrydish as penicillin was formed from mould.
- Flemming coined the name Penicillin.
- Potential of Penicillin as antibiotic was established by Ernest chain & Howard Florey.
- Flemming, chain & Florey were awarded Nobel in 1945.
- Antibiotic was extensively used to treat soldiers wounded in World War-II.
- Antibiotics have greatly improved out capacity to treat deadly diseases as Plague. Whooping cough, Diptheria, Leprosy.
- Amensalism is used for production of antibiotics.

**Resonate the Concept**

- Name of the antibiotics :

- From Eubacteria

- |                 |                               |
|-----------------|-------------------------------|
| (i) Bacitracin  | <i>Bacillus licheniformis</i> |
| (ii) Subtilin   | <i>B. subtilis</i>            |
| (iii) Polymyxin | <i>B. polymyxa</i>            |
| (iv) Gramicidin | <i>B. brevis</i>              |

- From Actinomycetes

- |                                       |   |
|---------------------------------------|---|
| (i) Chlorotetracycline or aureomycin  | <i>Streptomyces aureofaciens</i> (or tetracycline)      |
| (ii) Chloramphenicol or chloromycetin | <i>Streptomyces venezuelae</i> and <i>S. lavendulae</i> |
| (iii) Erythromycin                    | <i>Streptomyces erythraus</i>                           |
| (iv) Neomycin                         | <i>Streptomyces fradiae</i>                             |
| (v) Oxytetracycline or terramycin     | <i>Streptomyces rimous</i>                              |
| (vi) Streptomycin                     | <i>Streptomyces griseus</i>                             |

### 3. Chemicals, Enzymes & other Bioactive Molecules:-

#### Acid Producer

- Aspergillus niger* (fungus) - Citric acid, used in preservation of food, candies, medicines.
- Acetobacter aceti* (bacteria) - Acetic acid, used for preparation of vinegar.
- Clostridium butylicum* (Bacteria) - Butyric acid, used as food & perfume additives for aroma.
- Lactobacillus* (bacteria) - Lactic acid.
- Modern Detergent contain enzyme preparation of Acidophiles.
- Yeast (*Saccharomyces cerevisiae*) is used for commercial production of enzymes.
- Lipase enzyme is used for detergent formulation & removing oil stains.
- Bottled juices are clearer due to use of protease (from *Mortierella renispora*, *Aspergillus* and *Bacillus*) & pectinase (from *Aspergillus niger* and *Byssoschlamys fulvo*).
- Streptokinase produced by *Streptococcus* and modified by genetic engineering is used as clot buster for removing clots from blood vessel of patients who have undergone myocardial infarction leading to heart attack.
- Statins produced by Yeast *Monascus purpureus* is used as blood - cholesterol lowering agent. It act by competitively inhibiting enzyme responsible for synthesis of cholesterol.
- Stains are competitive inhibitors of  $\beta$ -hydroxy, b-methylglutaryl coenzyme A reductase or HMG-CoA reductase
- Amylase is used in textile industry.
- Chakrawarthy bug is superbug of *Pseudomonas* with multiple plasmids, useful for removing oil spills in the sea.

## **Microbes in Sewage Treatment-**

- Large quantities of waste water are generated every day in cities & towns.
- Major component of this waste water is human excreta.
- Municipal waste water is also called sewage.
- Sewage contain large amount of organic matter & pathogenic microbes.
- Sewage can't be directly discharged into water bodies, it is firstly treated in sewage treatment plants (STPs).
- Treatment of sewage is done by heterotrophic microbes naturally present in sewage.
- Sewage treatment is carried out in two stages-

### **Primary Treatment / Physical Treatment**

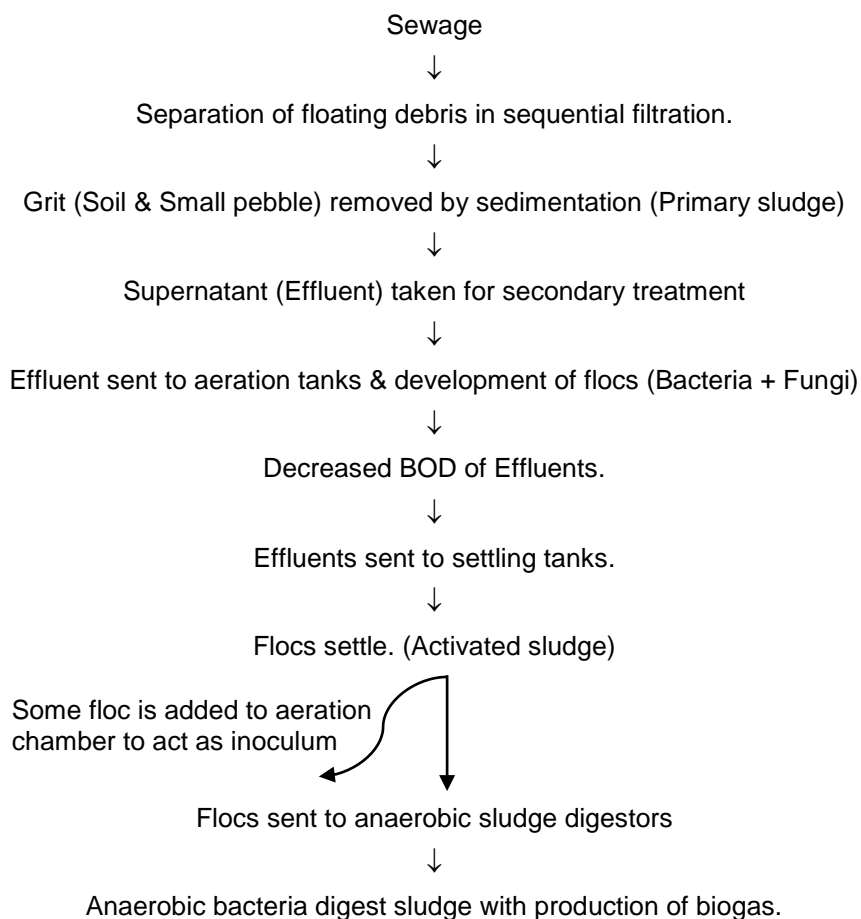
- Physically removal of large & small particles from sewage by filtration and sedimentation.
- It is done in stages-
  - (a) Floating debris is removed by sequential filtration.
  - (b) Grit (soil & Small pebbles) are removed by sedimentation. (Primary sludge) & then supernatant from effluents.
  - (c) Effluent from primary settling tank is taken for secondary treatment.

### **Secondary Treatment / Biological Treatment**

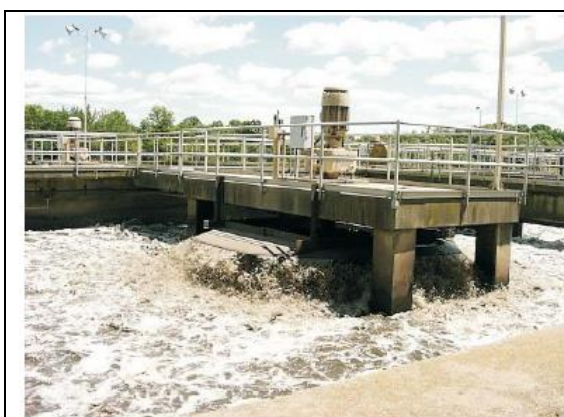
- (a) Primary effluent is passed into large aeration tanks, where it is aerated & consistently agitated. It allow vigorous growth of useful microbes into flocs. (Bacteria + fungal filaments form mesh like structures).

While growing these microbes consume major part of organic matter, reducing BOD (Biochemical oxygen demand) of effluent.

- If  $O_2$  supply to activated sludge flocs is decreased then centre of flocs will become anoxic, which would cause death of bacteria & eventually breakage of flocs.
  - BOD refers to amount of  $O_2$  that would be consumed if all the organic matter in 1 lit. of water is oxidized by bacteria.
  - BOD is measure of organic matter present in the water. Greater the BOD is, more is its polluting potential.
- (b) Once the BOD of sewage is reduced significantly, effluent is passed into settling tank, where bacterial flocks are allowed to sediment. This sediment is called activated sludge.
  - (c) Small part of activated sludge is pumped back into aeration tank to serve as inoculum.
  - (d) Remaining major part of sludge is pumped into large tanks called anaerobic sludge digesters; here anaerobic bacteria digest the bacteria & fungi in sludge. During digestion biogas ( $CH_4$ ,  $H_2S$ ,  $CO_2$ ) is produced.
  - (e) Effluents from secondary treatment plant is released in natural water bodies.



- Millions of Gallons of waste water is treated using microbes all over the world.
- Till date, no man made technology has been able to rival the microbial treatment of sewage.
- Ministry of environment & forest has initiated Ganga Action plan & Yamuna action plan to protect these major rivers from pollution.



**Figure :** Secondary treatment



**Figure :** An aerial view of a sewage plant



## Microbes in production of Biogas:-

- Biogas is a mixture of gases, (predominantly  $\text{CH}_4$ ) produced by microbial activity & may be used as fuel.
- Microbes produce different types of gaseous end products during growth & metabolism.
- Certain bacteria growing anaerobically on cellulose material produce large amount of  $\text{CH}_4$ , along with  $\text{CO}_2$  &  $\text{H}_2$ .
- Methane (Biogas) producing bacteria are called methanogens & one such common bacteria is *Methanobacterium*.
- Such bacteria are commonly found in anaerobic sludge during sewage treatment.
- Methanogens are also present in Rumen of cattle. In rumen these bacteria breakdown cellulose & play role in nutrition of cattle.
- Dung of cattle is rich in these bacteria.
- Dung can be used for generation of biogas; commonly called Gobar Gas
- During production of Biogas, Lignin remain undigested.

### Biogas plant

- Biogas plant consist of concrete tank (10-15 feet deep) in which bio wastes are collected and slurry of dung is fed.
- A floating cover is placed over slurry, which keeps on rising as on gas is produced in tank due to microbial activity.
- Biogas plant has an outlet. Which is connected to a pipe, to supply biogas to nearby houses.
- Spent slurry is removed through another outlet & may be used as fertiliser.
- Due to availability of cattle dung, gobar gas plant are set in rural areas.
- Technology of Gobar gas production was developed in India by IARI (Indian agricultural Research Institute) and KVIC (Khadi & Village Industries commission).

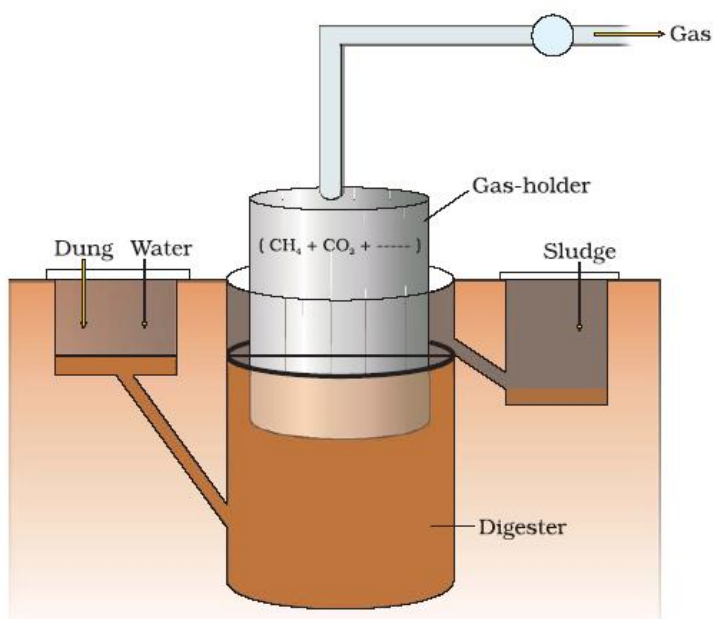


Figure: A typical biogas plant

## Microbes as biocontrol Agents:-

- Biocontrol is use of biological methods for controlling plant disease & pests.
- Currently this control is done by using Herbicide, Weedicide, Pesticide, Insecticide. Which are polluting environment & causing many diseases.
- Soil is also polluted using weedicides.
- Use of biocontrol measures will greatly reduce our dependence on toxic chemicals & pesticides.
- Organic farming used compost and not pesticides & urea.
- If natural predator is applied to other pathogen to control them, then it is biological control.

### Resonate the Concept

- **Smoother crops** are those which do not allow the weeds to grow nearby e.g., barley, rye, *Sorghum*, millet, sunflower, alfalfa, soyabean, marigold etc. Smoother crops eliminates weeds through chemicals. Crops rotation with naturally reduce the incidence of weeds.
- **Catch/trap crops:** Around the major crop in the field some early growing crop is sown in strips which is termed as catch or trap crop. The pests get attracted towards the early grown trap crop and then can be easily killed by cutting and destroying the trap crop. A good example of trap crop is bhindi (Okra) which is sown around the cotton field to attract the **jassid** and **spotted bollworm**. Sesame is also good trap crop to attract the red hairy caterpillar from the cotton field.

- Familiar beetle with red & black markings - the ladybird & dragon fly are useful to get rid of Aphids & Mosquitos; respectively.
- An example of microbial biocontrol agent that can be introduced in order to control butterfly caterpillars, is bacteria. *Bacillus thuringiensis* (Bt). Used on brassicas & fruit tree, where these are eaten by insect larvae. In gut of larvae toxin is released & larvae is killed. This method will kill caterpillars, but leave other insects unharmed.
- By genetic engineering scientists have introduced *Bacillus thuringiensis* gene into plants. Bt cotton is one such example.
- *Trichoderma harzianum* is a fungus, (free living) which is common in root ecosystems. These are effective biocontrol agent of several plant pathogens.
- *Crotalaria juncea* & *Alhagi camelorum* are used as green manure.
- *Agrobacterium* is not biofertiliser.
- *Rhizobium* is used for soyabean crops.
- *Baculovirus* are pathogen that attack insects and other arthropods.
- Most of *Baculovirus*, being used as biological control agents are in genus Nucleopolyhedrovirus.
- These viruses are species specific narrow spectrum, insecticidal.
- They have no negative impact on plants, mammals, bird, fish & even to non-target insects.
- Useful in IPM, or when ecologically sensitive area is treated.
- *Pseudomonas cepacia* is effective agent for biological control of Nematode disease in plants.
- Problem with biological control is that predators does not always survive, when transferred to new environment.
- **Bioherbicides:** It involves the biological control of weeds by some living organisms.



- (a) In India and Australia, the overgrowth of *Opuntia* was checked by the introduction of the cochineal insect (*Cactoblastis cactorum*).
- (b) The first bioherbicide was mycoherbicide called **Devine**, derived from a fungus *Phytophthora palmivora* which controls the growth of milk weed vines of *Citrus* orchards.
- (c) Another mycoherbicide called **Collego** has been derived from **conidia** of fungus *Colletotrichum gloeosporioides*. It controls the growth of northern Jointvetch (*Aeschynomene virginica* fam. Leguminosae) growing in rice field.
- (d) Extensive growth of *Hypericum perforatum* or *kalmath* weed was checked in USA by the introduction of *Chrysolina* beetles.
- (e) Water hyacinth has been successfully controlled in Florida using the indigenous fungus *Cercospora rodmanii*.

### Microbes as Bio fertilisers:-

- With our present day life styles, environmental pollution is a major cause of concern.
- Use of chemical fertilisers has contributed to this concern.
- Due to problem of environmental pollution, because of fertilisers, there is large pressure to switch to organic farming by use of bio fertilisers.
- Biofertilisers are organisms that enrich the nutrient quality of soil.
- Main source of biofertilisers are bacteria, fungi & cyanobacteria.
- Root nodules of leguminous plants form symbiotic association with *Rhizobium* that fixes atmospheric nitrogen.
- *Azospirillum* & *Azotobacter* fixes atmospheric Nitrogen while free living in soil.
- Symbiotic association of fungi with plants is called mycorrhiza.
- Many members of genus *Glomus* form mycorrhiza.
- Fungal symbiont absorb phosphorus from soil & pass it to plant.
- Plants with such association show resistance to root borne pathogen, resistance to salinity & drought and overall increase in plant growth development but do not increase its resistance to insects.

#### Resonate the Concept

- (i) **Ectomycorrhizae (Ectotrophic or Ectophytic)** : Hyphae of fungus only form mantle on the outer surface of the root, increasing absorption of water and minerals e.g., *Pinus*, *Oak*.
- (ii) **Endomycorrhizae (Endotrophic or Endophytic)** : Fungal hyphae penetrate into cortex and cells of root e.g., orchids, coffee and woody plants. These are also called as vesicular arbuscular mycorrhizae or VAM, because cortical cells swell and form vesicles or arbuscles.

- A number of cyanobacteria (autotrophs) can fix atmospheric nitrogen. e.g, *Anabaena*, *Nostoc*, *Oscillatoria*.
- In paddy fields, cyanobacteria serve as important bio fertiliser.
- BGA (Blue green algae) also add organic matter to the soil & increase its productivity.
- Beside paddy fields, cyanobacteria are also found in vegetative part of *Cycas*.
- *Anabaena* is associated with *Azolla*.
- Cyanobacteria reduce alkalinity of soil.