RAMA UNIVERSITY

www.ramauniversity.ac.in

FACULTY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF BIOTECHNOLOGY

Fermentor (bioreactor)

•A fermentor (bioreactor) is a closed vessel with adequate arrangement for aeration, agitation, temperature and pH control, and drain or overflow vent to remove the waste biomass of cultured microorganisms along-with their products.

•A fermentor is used for commercial production in fermentation industries and is a device in which a substrate of low value is utilized by living cells or enzymes to generate a product of higher value. Fermentors are extensively used for food processing, fermentation, waste treatment, etc.

Batch culture

•Many biochemical processes involve batch growth of cell populations. A limited supply of nutrients for growth is provided; when these are used up, or some other factor becomes limiting, the culture declines. Cells, or products that the organisms have made, can then be harvested from the culture.

• After seeding a liquid medium with an inoculums of living cell, nothing is added to the culture or remove from it as growth proceeds.
• In such a reactor, concentrations of the nutrients, cells and products vary with time as the growth proceeds**.**

•.

A technique used to grow microorganisms or cells.

•A limited supply of nutrients for growth is provided; when these are used up, or some other factor becomes limiting, the culture declines.

•Cells, or products that the organisms have made, can then be harvested from the culture.

Batch culture technique is also called as closed system of cultivation

•Salient feature of batch culture

•In this technique at first nutrient solution is prepared and it is inoculated with inoculum (culture organism) and then nothing is added in the fermentation tank except aeration.

•In batch culture, neither fresh medium is added nor used up media is removed from the cultivation vessel. Therefore volume of culture remains same.

•Since fresh media is not added during the course of incubation, concentration of nutrition decreases continuously. Furthermore various toxic metabolites also accumulate in the culture vessel.

•Therefore batch culture technique gives characteristics growth curve with lag phase, log phase, stationary phase and decline phase.

•Chance of contamination of culture is minimum in batch culture technique because it is closed system of cultivation.

Continuous culture system

•*Cultures* that require a *continuous* supply of the cell suspension or the product in the medium are known as *continuous cultures*.

•This system is maintained in a steady state for prolonged periods by draining out the used liquid medium and adding fresh medium to stabilize the physiological state of growing cells.

•Continuous culture technique is also called as open system of cultivation.

Salient feature of continuous culture system

•In this technique, bacteria grow continuously in their log phase. This type of growth is known as steady state growth.

•The cell density in continuous culture remains constant and it is achieved by maintaining constant dilution and flow rate.

•A microbial population can be maintained in the exponential growth phase and at a constant biomass concentration for extended periods in a continuous culture system

Continuous Stirred Tank Bioreactors:

•A continuous stirred tank bioreactor consists of a cylindrical vessel with motor driven central shaft that supports one or more agitators (impellers). The shaft is fitted at the bottom of the bioreactor (Fig. A).

•The number of impellers is variable and depends on the size of the bioreactor i.e., height to diameter ratio, referred to as aspect ratio.

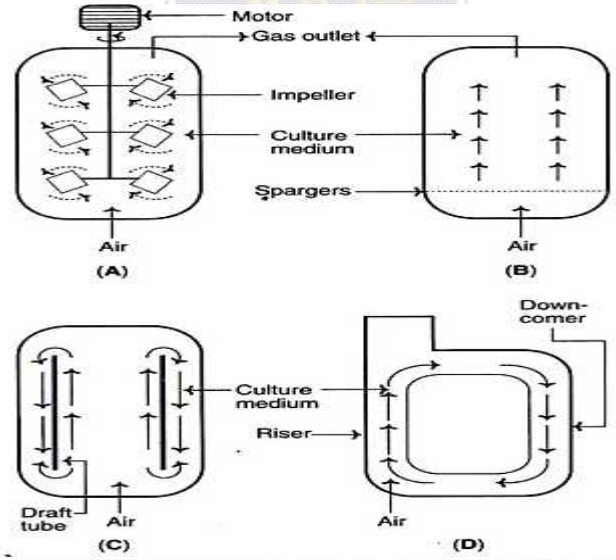


Fig. : Types of bioreactors (A) Continuous stirred tank bioreactor (B) Bubble column bioreactor (C) Internal-loop airlift bioreactor (D) External-loop airlift bioreactor.

•The aspect ratio of a stirred tank bioreactor is usually between 3-5. However, for animal cell culture applications, the aspect ratio is less than 2. The diameter of the impeller is usually 1/3 rd of the vessel diameter. The distance between two impellers is approximately 1.2 impeller diameter. Different types of impellers (Rustom disc, concave bladed, marine propeller etc.) are in use.

•In stirred tank bioreactors or in short stirred tank reactors (STRs), the air is added to the culture medium under pressure through a device called sparger. The sparger may be a ring with many holes or a tube with a single orifice. The sparger along with impellers (agitators) enables better gas distribution system throughout the vessel.

•The bubbles generated by sparger are broken down to smaller ones by impellers and dispersed throughout the medium. This enables the creation of a uniform and homogeneous environment throughout the bioreactor.

Fed-Batch Reactor

•In fed-batch Reactor, intermittent or continuous feeding of nutrients is used to supplement the reactor contents and provide control over the substrate concentration. By starting with a relatively dilute solution of substrate and adding more nutrients as the conversion proceeds, high growth rates are avoided.

•This is important, for example, in cultures where the oxygen demand during fast growth is too high for the mass transfer capabilities of the reactor, or when high substrate concentrations are inhibitory or switch on undesirable metabolic pathways. Fed-batch culture is used extensively in the production of bakers' yeast to overcome catabolite repression and control oxygen demand; it is also used routinely for penicillin production.

•Space must be allowed in fed-batch reactors for the addition of fresh medium; in some cases, a portion of the broth may be removed before injection of additional material. The flow rate and timing of the feed are often determined by monitoring parameters such as the dissolved oxygen tension or exhaust gas composition. As enzyme reactions are rarely carried out as fed-batch operations, we will consider fed-batch reactors for cell culture only.

•Fed-batch cultureis, in the broadest sense, defined as an operational technique in biotechnological processes where one or more nutrients (substrates) are fed (supplied) to the bioreactor during cultivation and in which the product(s) remain in the bioreactor until the end of the run.

•An alternative description of the method is that of a culture in which "a base medium supports initial cell culture and a feed medium is added to prevent nutrient depletion.

• It is also a type of semi-batch culture. In some cases, all the nutrients are fed into the bioreactor. The advantage of the fed-batch culture is that one can control concentration of fed-substrate in the culture liquid at arbitrarily desired levels (in many cases, at low levels).

•Fed-batch culture is superior to conventional batch culture when controlling concentrations of a nutrient (or nutrients) affect the yield or productivity of the desired metabolite.

Airlift reactor

•An airlift reactor is one type of bubble reactor with an internal draft-tube that promotes gas–liquid mass transfer and mixing.

•Airlift reactors have been largely used for algae cultures. Airlift reactor contains three regions: air-riser, down-comer, and disengagement zone.

•Airlift bioreactors are tower reactors for large-scale aerobic cultures where the mixing of the culture broth is done by the inserted gas via an airlift pump (Fig.). This pump injects compressed air at the bottom of the discharge pipe, which is immersed in the liquid.

•The compressed air mixes with the liquid, causing the gas–liquid mixture to be less dense than the rest of the liquid around it and therefore is displaced upwards through the discharge pipe by the surrounding liquid of higher density.

•Solids may be entrained in the flow and, if small enough to fit through the pipe, will be discharged with the rest of the flow at a shallower depth or above the surface. The only energy required is provided by compressed gas, which is prepared by a compressor.

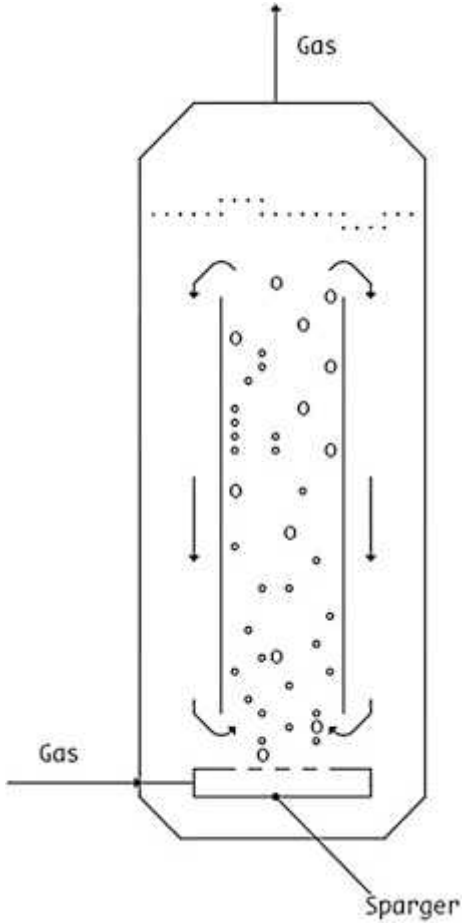
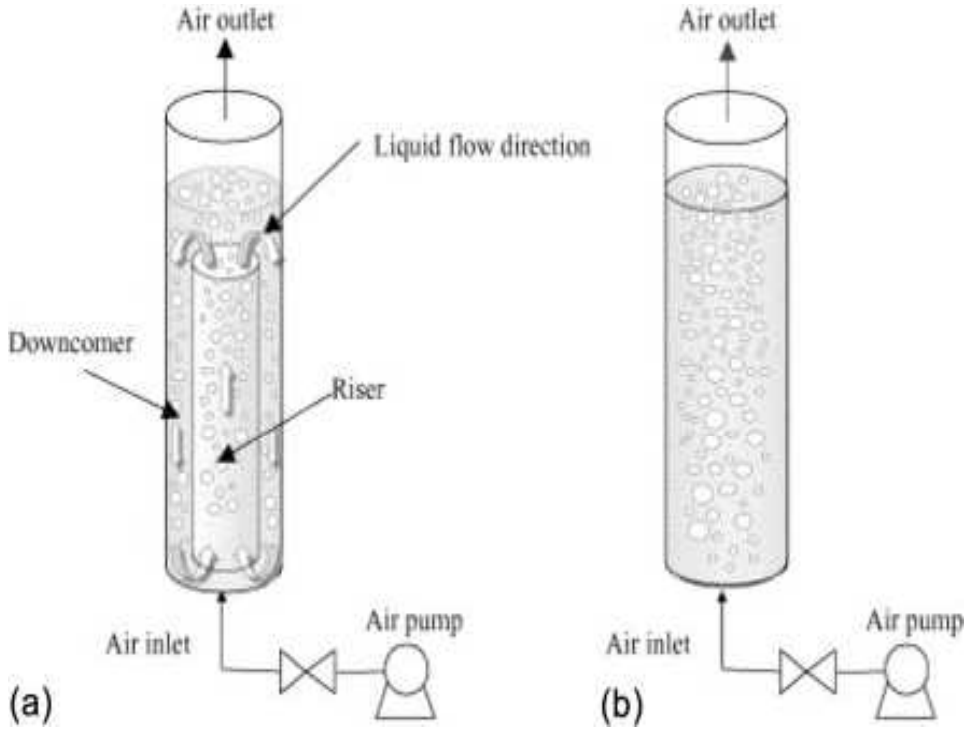


Fig. Principle of an airlift bioreactor.



Advantage: Only compressed air (or other gas) required, low shear forces.

Disadvantage: Relatively high costs for compressing flow rate, difficult to adjust.

Fluidized Bed Bioreactors:

•Fluidized bed bioreactor is comparable to bubble column bioreactor except the top position is expanded to reduce the velocity of the fluid.

•The design of the fluidized bioreactors (expanded top and narrow reaction column) is such that the solids are retained in the reactor while the liquid flows out (Fig. A).

• These bioreactors are suitable for use to carry out reactions involving fluid suspended biocatalysts such as immobilized enzymes, immobilized cells, and microbial flocs.

•For an efficient operation of fluidized beds, gas is spared to create a suitable gas-liquid-solid fluid bed.

•It is also necessary to ensure that the suspended solid particles are not too light or too dense (too light ones may float whereas to dense ones may settle at the bottom), and they are in a good suspended state.

•Recycling of the liquid is important to maintain continuous contact between the reaction contents and biocatalysts. This enable good efficiency of bioprocessing.

•

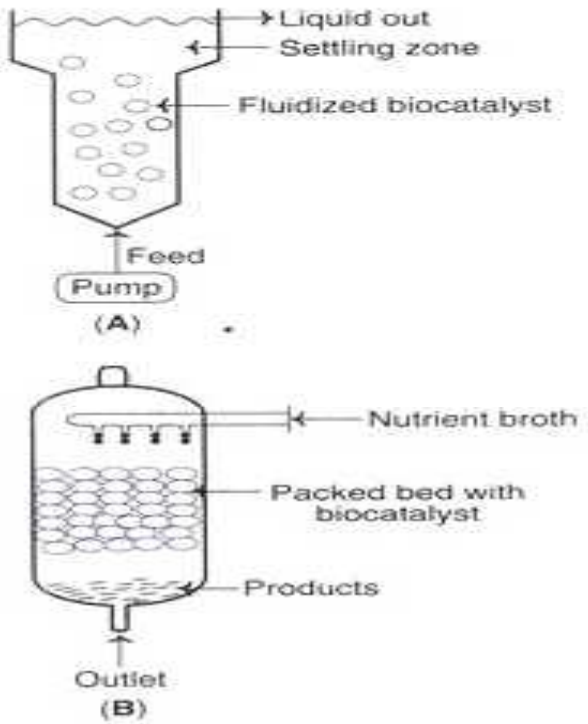


*Fig. : Types of bioreactors (**A**) Fluidized bed bioreactor (**B**) Packed bed bioreactor.*