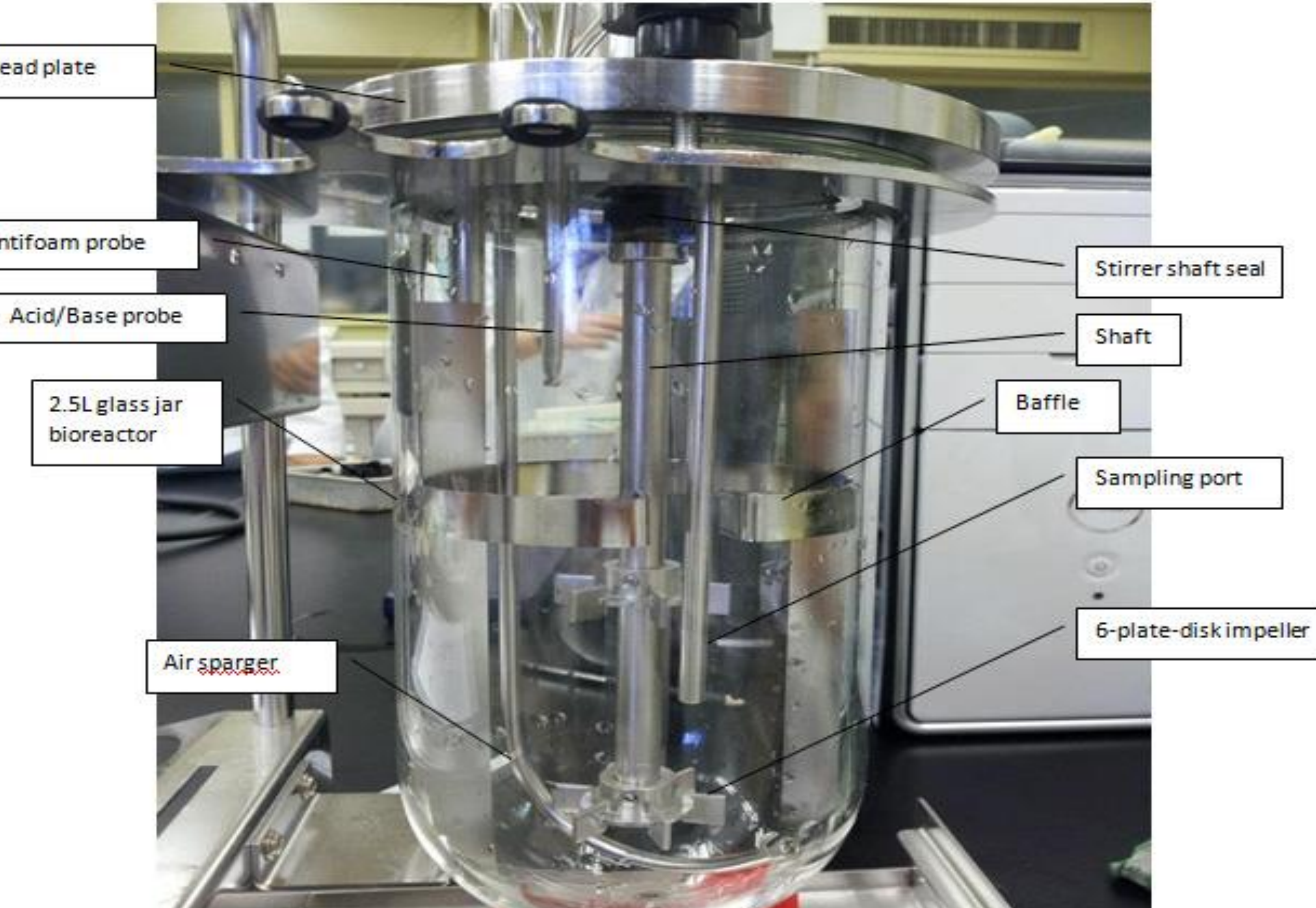
BIOREACTOR BASICS

By
Mrs REKHA KANDULA
Lecturer in Biotechnology

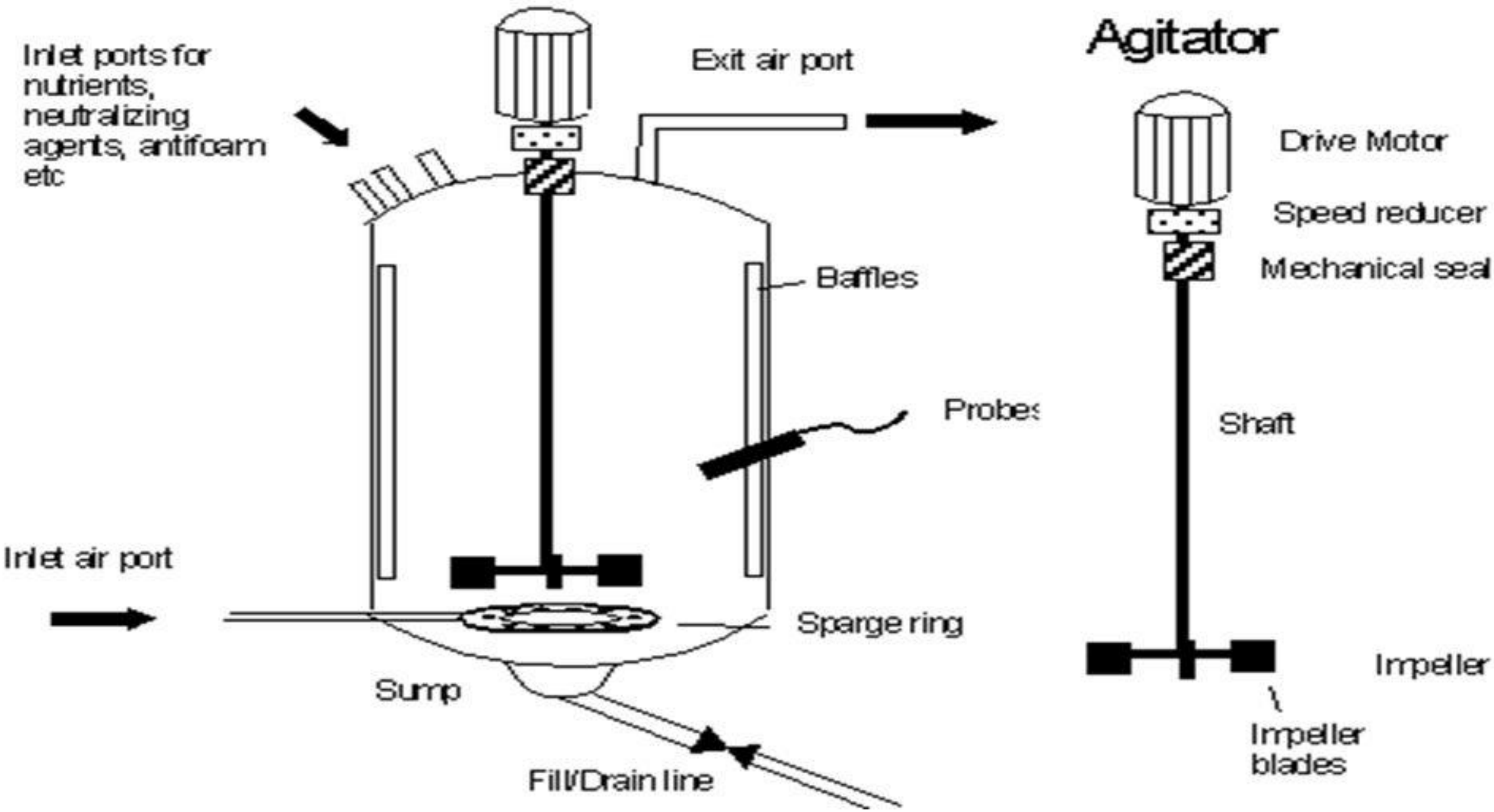
Contents

Definition

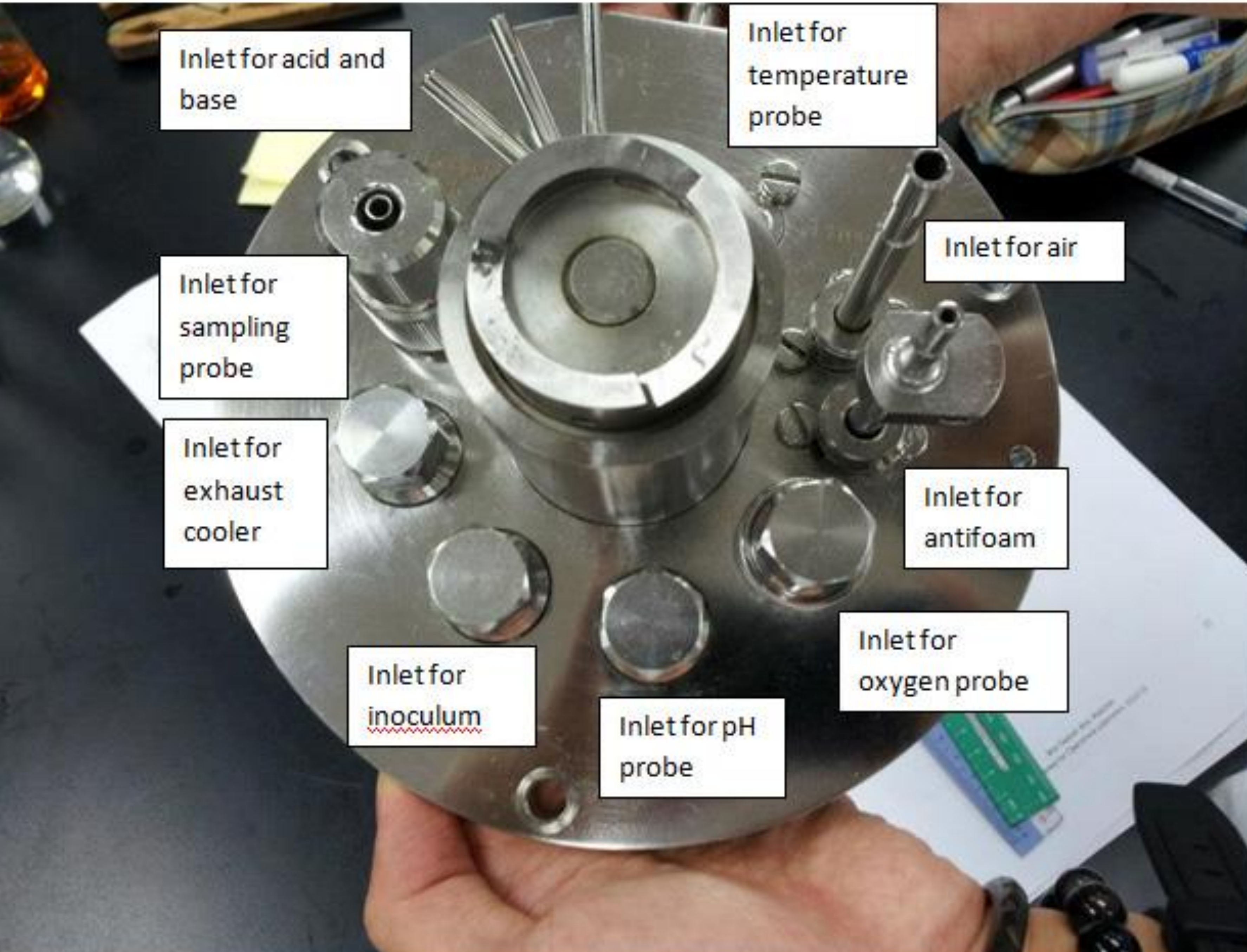
A **bioreactor** may be referred to as any device or system that supports a biologically active environment especially on an industrial scale , for multiplication of cells and microorganisms that produce substances which are useful for mankind such as pharmaceuticals, antibodies, or vaccines, or for the bioconversion of organic waste.


ead plate
ntifoam probe
Acid/Base probe
2.5L glass jar
bioreactor
Air sparger
Stirrer shaft seal
Shaft
Baffle
Sampling port
6-plate-disk impeller

A typical bioreactor used for microbial fermentations:



PARTS	USE
Head plate	to cover the top of vessel of bioreactor
Stirrer shaft seal	To hold the stirrer and head plate
Shaft	Not allow the medium to escape or microorganism enter
6- bladed disk impeller	a. To diminish the size of air bubbles to give a bigger interfacial area for O_2 transfer b. To maintain uniform environment throughout the vessel content.
Baffles	To prevent a whirl pool effect that could impede proper mixing
Air sparger	To ensure better dispersal of air
Sampling port	A valve to get the sample of the fermentation


Inlet for acid and base
Inlet for temperature probe
Inlet for air
Inlet for sampling probe
Inlet for exhaust cooler
Inlet for antifoam
Inlet for oxygen probe
Inlet for inoculum
Inlet for pH probe

Monitoring and controlling parts of fermenter are:

S.No	Part	Use
1	Pt100	temperature sensor (platinum resistance electrode)
2	Foam probe	kept above the medium level to sense foam formation
3	pH electrode	senses pH
4	O_2 sensor	Monitors dissolved oxygen level
5	Heater pad	directly heats the medium
6	Cold finger	after direct heating – used to cool the vessel contents (closed coil/pipe to pass cool water)
7	Rotameter	variable air flow meter – indicates rate of air flow into vessel – attached to air sparger
8	Pressure valve	attached to rotameter for safer operation
9	Air pump	supply of air
10	Peristaltic pump	to pump in medium, acids, bases, antifoam

TYPES OF BIOREACTORS

Based on the Design of the Bioreactors they are:

1. Stirred Tank Bioreactor

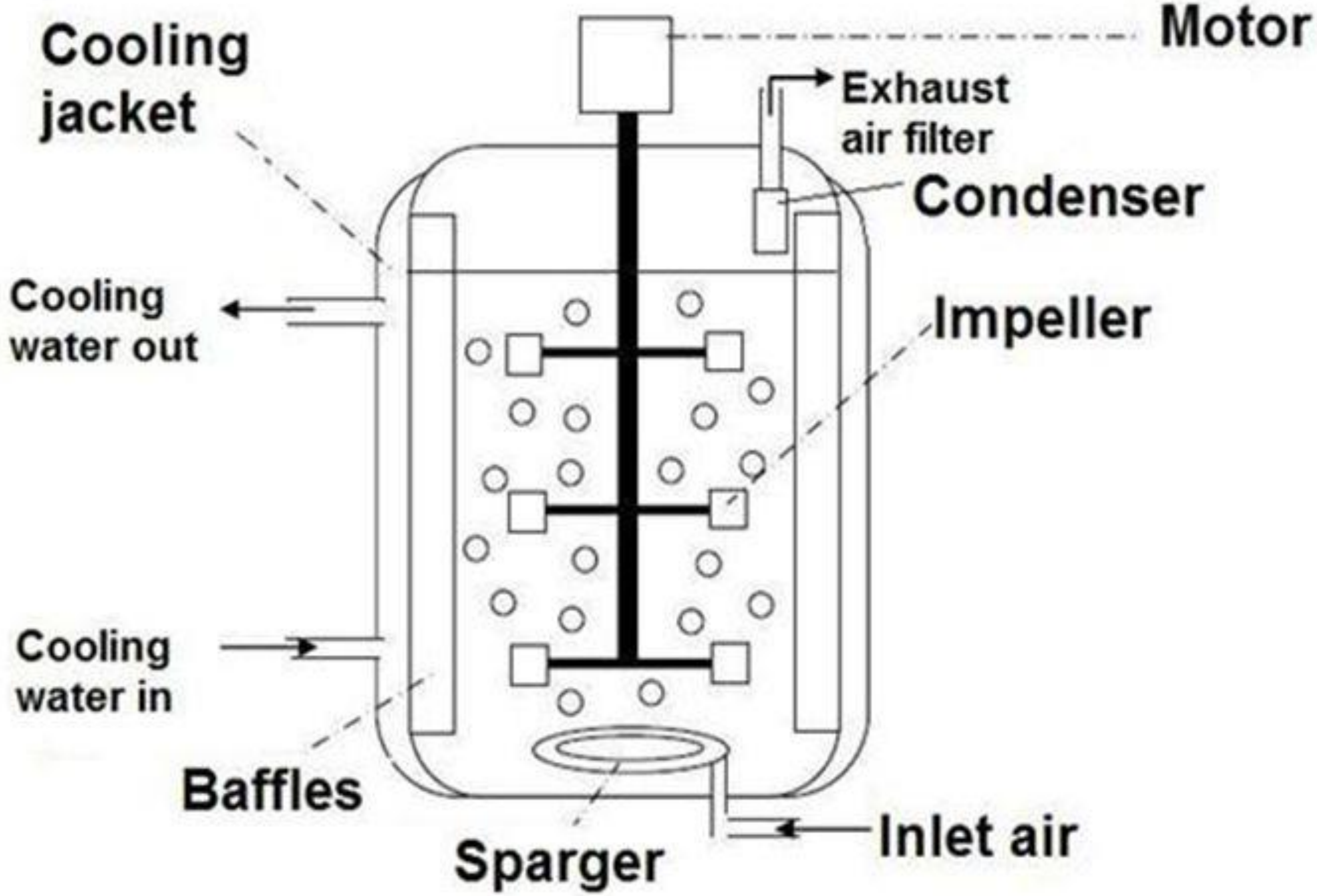
2. Bubble Column Bioreactor

3. Air Lift Bioreactor

4. Fluidized bed Bioreactor

5. Packed bed Bioreactor

Schematic Diagram of a Stirred Tank Bioreactor



-also known as vat- or backmix reactor.
-consists of a cylindrical vessel
-central shaft that supports one or more impellers (agitator)
-The aspect ratio i.e., height to diameter ratio, of a stirred tank bioreactor is between 3-5.
•-The liquid medium is continuously introduced and liquid contents are continuously removed from the reactor.
-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.

Microbial culture may or may not be introduced to the reactor under normal operation.

If operated properly micro- organisms that grow within the reactor continuously replace the micro organisms removed from the reaction in the effluent.

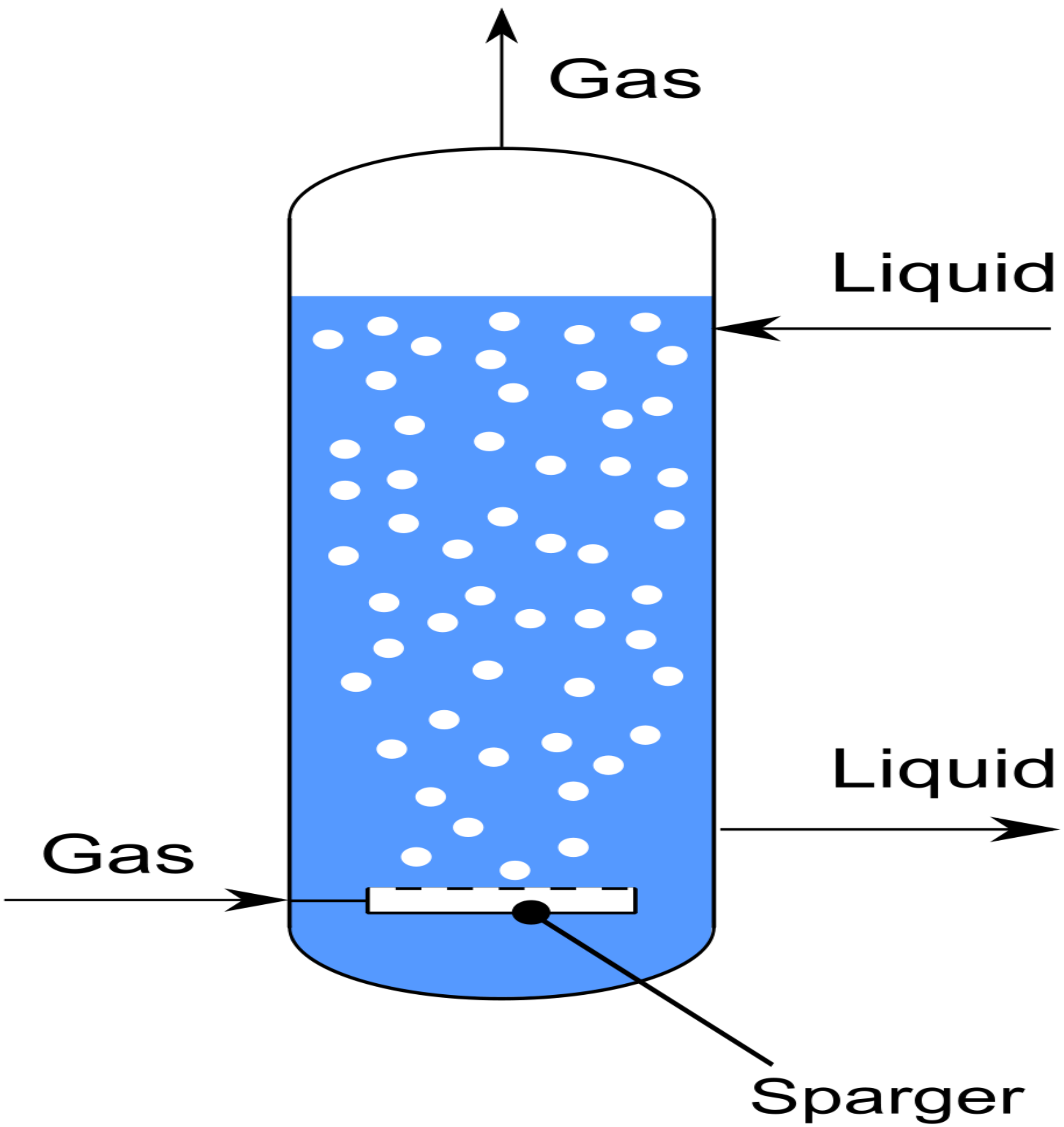
The basic characteristic of the ideal CSTR is that the concentration of the substrate and microorganisms are the same everywhere through out the reactor.

ADVANTAGES :The rate of many chemical reactions is dependent on concentration, continuous reactors are generally able to cope with high concentrations due to their superior heat transfer capabilities.

DISADVANTAGES: consumption of more power due the presence of mechanical pumps

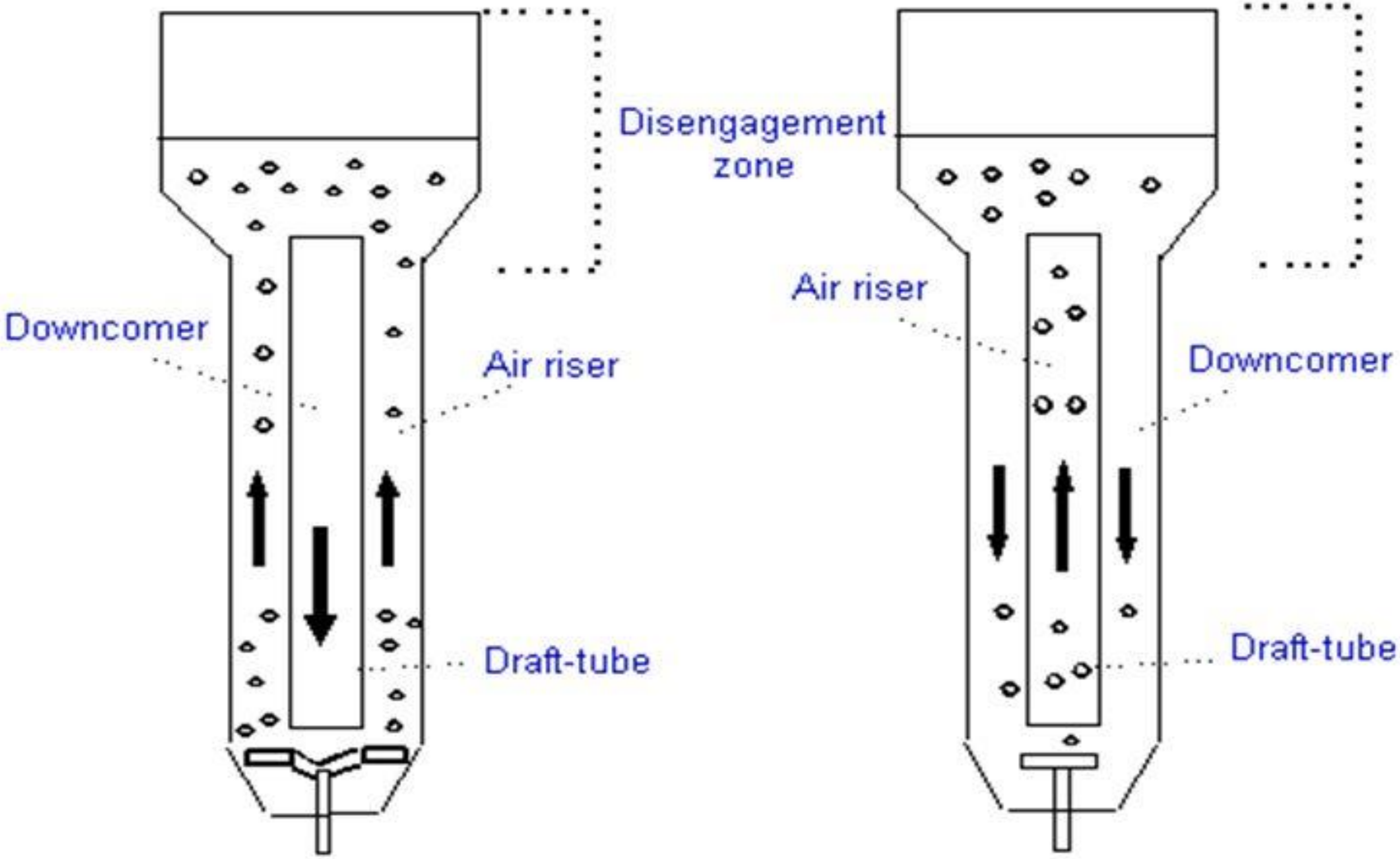
APPLICATIONS: Used in waste water treatment, production of primary metabolites, SCP, Lactic acid and methanol

2.Bubble Column Bioreactor



- This type of Bioreactors lack impellers
- Air is pumped into the reactor by sparger at the bottom of the reactor
- As the air is passed into the medium bubbles are formed which help in uniform mixing of the medium
- The vessel used for bubble column bioreactors is usually cylindrical with an aspect ratio of 4-6
- ADVANTAGES: Simple design , Good heat and mass transfer rate
- DISADVANTAGES: The sparger gets clogged with the cells in the long run
- APPLICATIONS : Used in production of Baker's yeast, beer, vinegar and in aeration and treatment of waste water treatment

Airlift bioreactor



An air-lift reactor is divided into three regions by draft tube: - the air-riser , down-comer , disengagement zone.

The region into which bubbles are sparged is called the air-riser .
The rising bubbles in the air-riser cause the liquid to flow in a vertical direction.

To counteract these upward forces, liquid will flow in a downward direction in the down-comer region. This leads to liquid circulation and thus improved mixing efficiencies and causes bubbles to move in a uniform direction at a relatively uniform velocity.

The roles of the disengagement zone are to
• add volume to the, • reduce foaming and • minimise recirculation of bubbles through the down comer.
The sudden widening at the top of the reactor slows the bubble velocity and thus disengages the bubbles from the liquid and also leads to a reduction in the loss of medium due aerosol formation.

ADVANTAGES

Hence, homogenous mixing/ distribution of gas/ oxygen.

• Simple design with no moving parts or agitator for less maintenance, less risk of defects

•Easier sterilization (no agitator shaft parts)

• Low Energy requirement Homogenous distribution of nutrients and shear force.

DISADVANTAGES

•Greater air throughput and higher pressures needed Inefficient break the foam when foaming occurs

• NO bubbles breaker

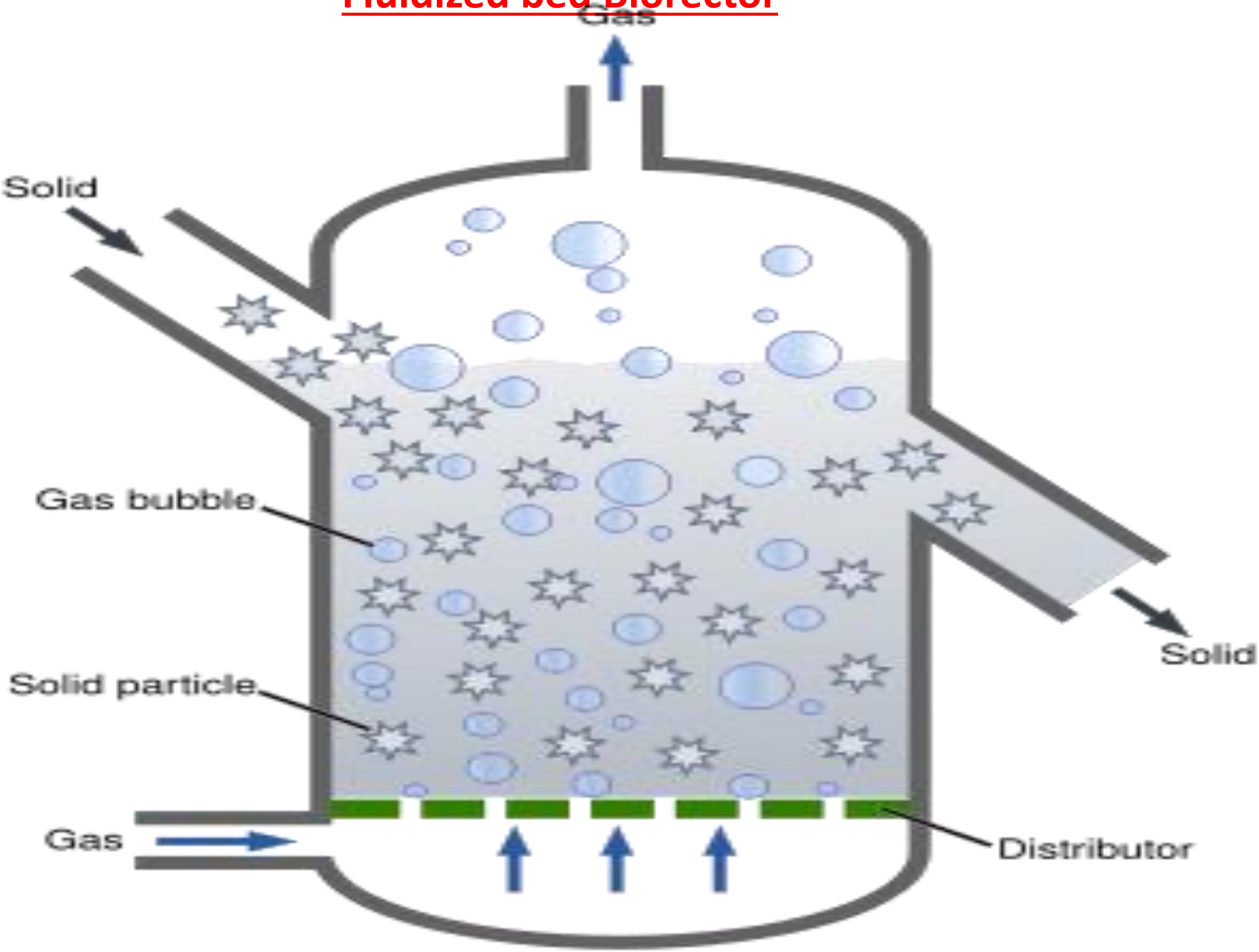
APPLICATIONS

•Mammalian cell cultures.

•Waste water treatment

•Biological processes involving biocatalysts as solids To produce biopharma proteins etc from fragile cells.

Fluidized bed Biorector



The fluidized bed reactor is has a porous plate, known as a distributor which supports the catalytic material.

The fluid is forced through the distributor up through the solid material.

At lower fluid velocities, the solids remain in place as the fluid passes through the voids in the material and is similar to packed bed reactor.

As the fluid velocity is increased, the reactor will reach a stage where the force of the fluid on the solids is enough to balance the weight of the solid material.

Once the minimum velocity is surpassed, the contents of the reactor bed begin to expand and swirl around like an boiling pot of water. The reactor is now a fluidized bed.

ADVANTAGES:

1. Uniform particle mixing
2. Uniform temperature gradients
3. The ability to operate reactor in continuous state.

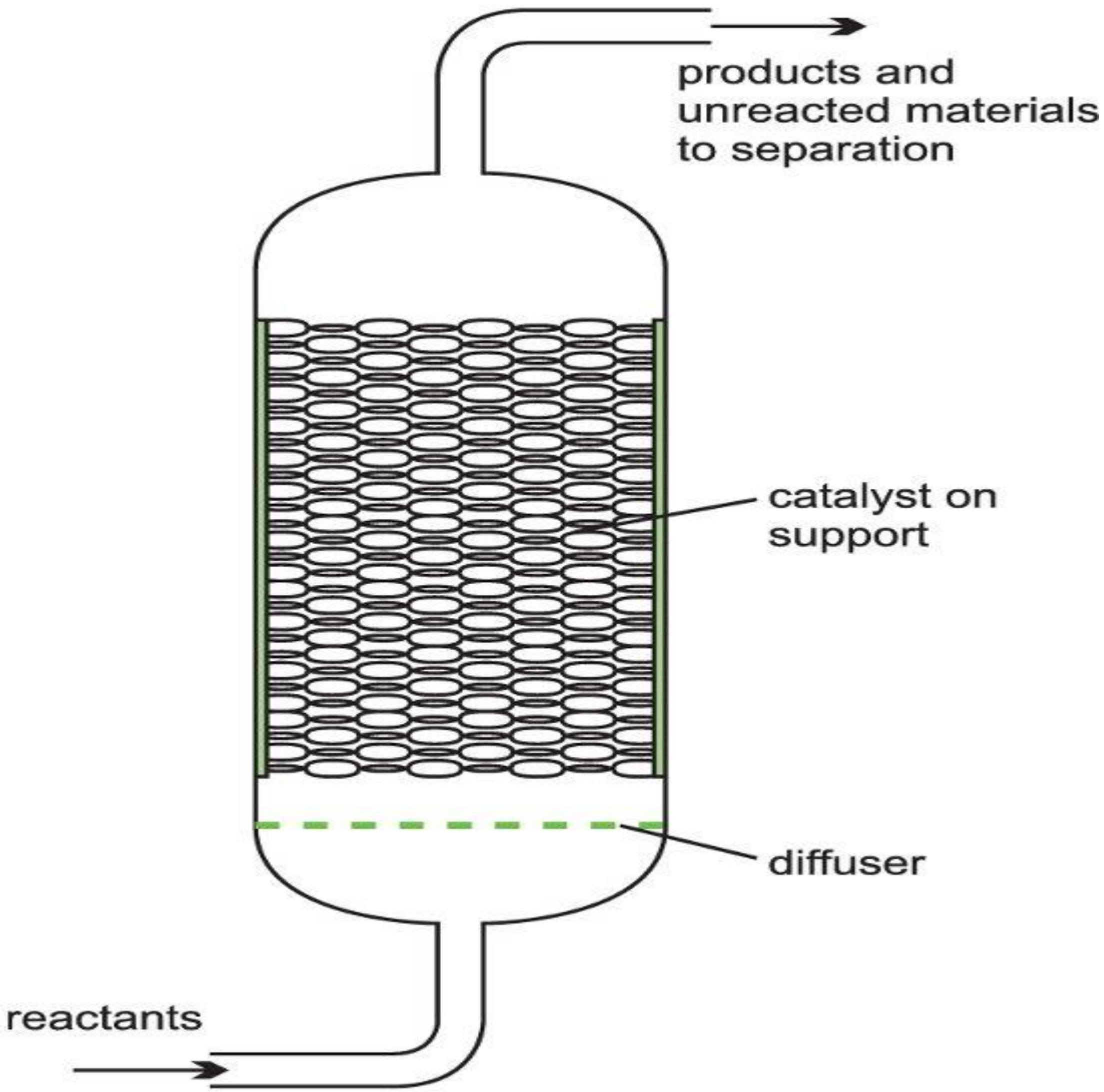
DISADVANTAGE:

1. Increased reactor vessel size
2. pumping requirements and pressure drop
3. Pressure loss scenario

APPLICATION:

Waste treatment with sand or similar material supporting microbial populations, brewing and production of vinegar.

Packed bed Bioreactor



Typical reactors consist of a chamber, such as a tube or channel that contains immobilized catalyst particles or pellets and a liquid that flows through the catalyst.

The liquid interacts with the catalyst across the length of the tube, altering the chemical composition of the substance.

These particles do not move with the liquid ie., immobilized on substances- polymer, ceramic, glass and natural (wood or bark), porous or non-porous in a variety of shapes and sizes

ADVANTAGES 1. Easy, automatic control and operation

2. Reduction of labor costs

3. Stabilization of operating conditions

4. Easy quality control of products

DISADVANTAGE: Suffer from blockages and from poor oxygen transfer.

APPLICATION: Aerobic treatement of waste in waste water treatement plants

Difference Between Bioreactors and Fermenters

Bioreactor:	Fermenters:
•Device which supports a biologically active environment easily and effectively	•The device that is able to perform the process of fermentation is known as fermentor.
•Capacity can be accessible to several liters.	•The fermenter device is rather small as it only ranges ~2 liters.
•Aerobic and Anerobic coditions can be maintained	•Anerobic environment only
•Under aerobic conditions Oxygen is the final electron acceptor	•In this method, an organic molecule is used as the final electron acceptor and the device which can perform this function is called a fermentor.
• Has to be sterilized empty	•Has to be sterilized full
•The employment of the bioreactors can be observed in the tissue engineering and the biochemical engineering.	•The procedure of the fermentation is occurred in the yeast and bacteria in addition to the oxygen-starved muscle cells

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THANK YOU