

Introduction to Bioprocess Engineering

SQBI2513

Basic to bioreactor

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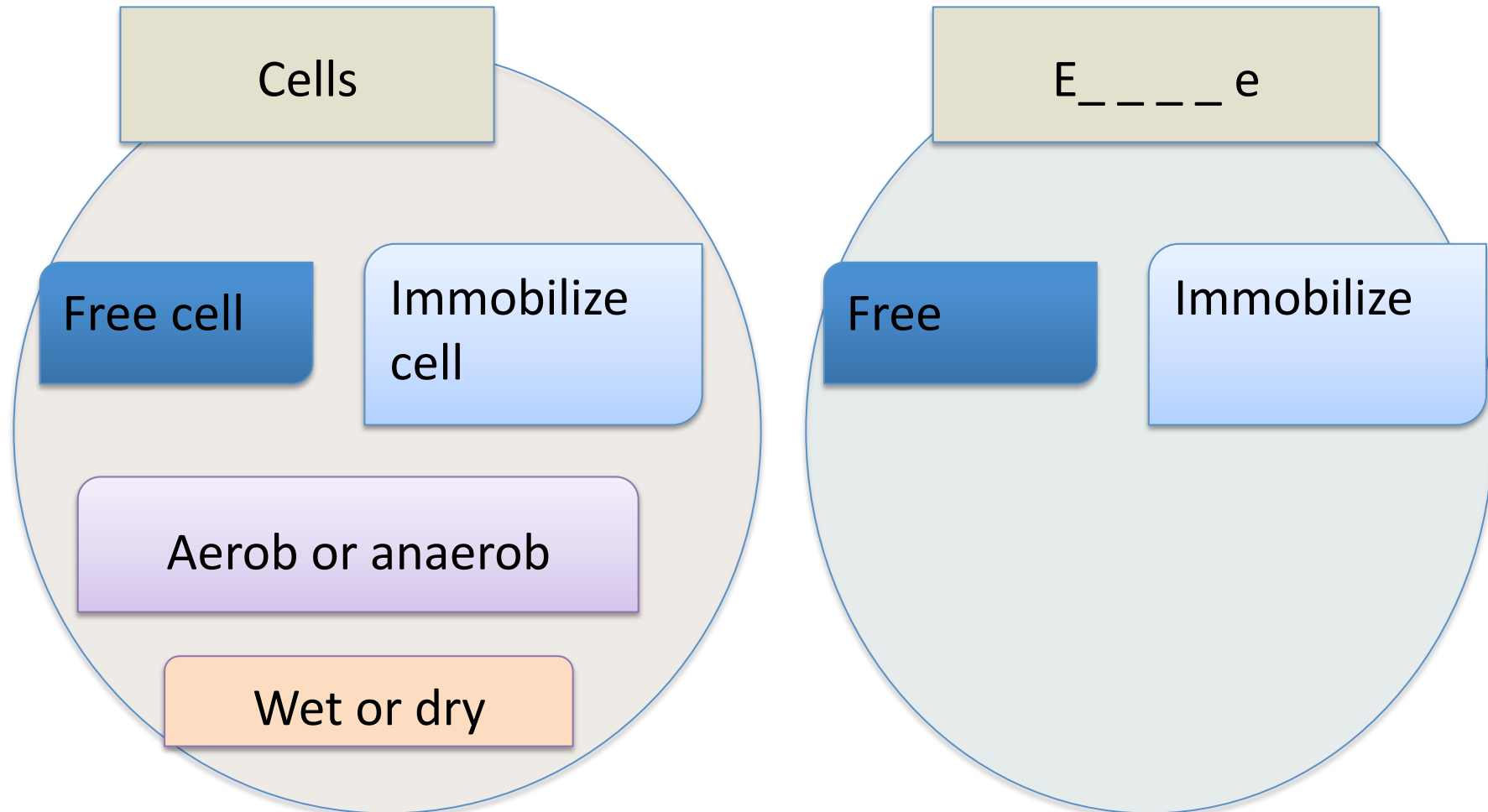
Suggested References:

- *Chapter 5- Introduction to Biochemical Engineering.*
- *Bioprocess Engineering. Shuler. (9.1, 9.2, 9.3, 9.5, 15.4.1,10.4)*
- *Bioprocess Engineering Principles. Pauline M. Doran. (P248.3 B56 1995)*
- *Operation modes of bioreactors. (TP.248.25.B55 063 1992)*
- *Bioreactor Design and product yield (TP248.25 B55 B56 1992).*

What is bioreactor?

- The bioreactor = a vessel where biological/ biochemical reaction takes place
- bioreactor \cong biochemical reactor \cong biological reactor \cong fermenter \cong microbial reactor.

The use of bioreactor



Parts and functions

Part	Function
Stirrer/impeller	
sparger	
motor	
jacket	
Air inlet filter	
Exhaust air port	
Exhaust air filter	
Inoculum port	
antifoam	
Sampling port	
Cold water	
Flow meter	

Monitoring in bioreactor

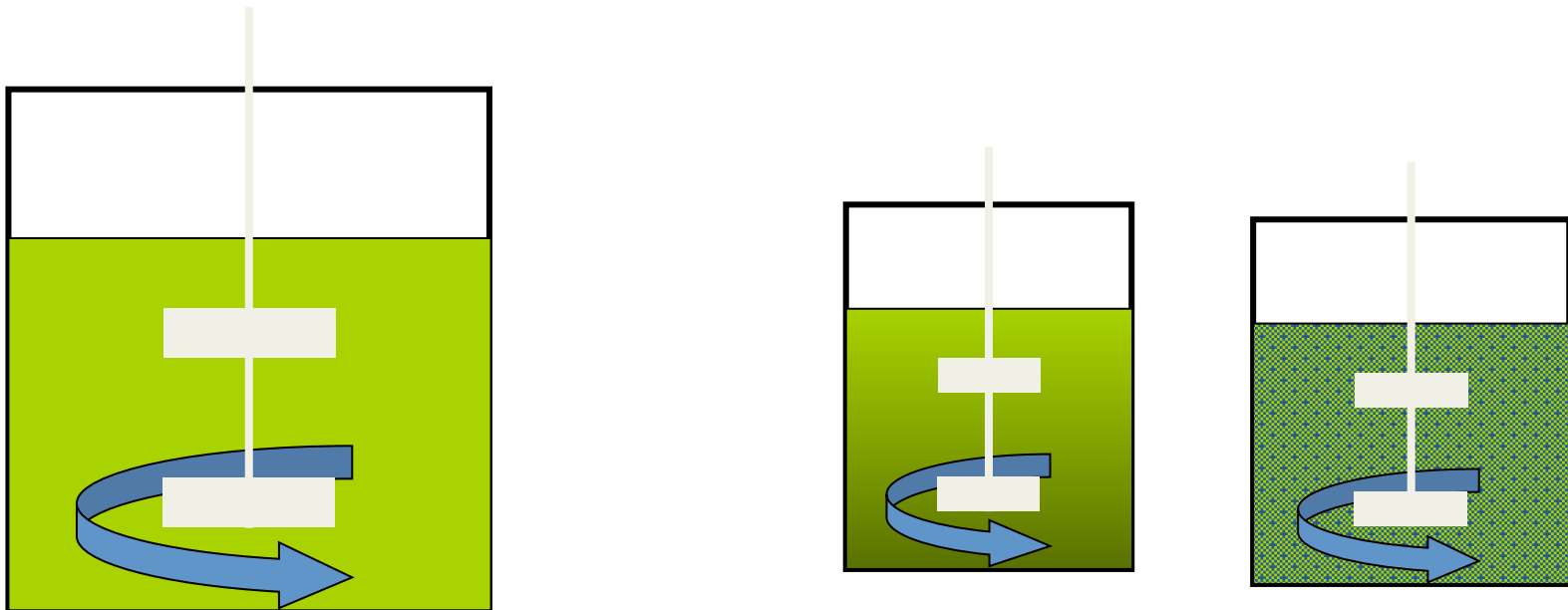
- Monitoring = use of device to observe something.
- Parameters usually been monitored:
 - Temperature
 - Concentration
 - Pressure
 - pH
 - Dissolved oxygen
 - Production of bioproduct
 - Cell growth

Basic knowledge

- Only 70-80% of the volume of batch reactors is filled with liquid;
 - this allows adequate headspace for disengagement (breaking off) of droplets from the exhaust gas and to accommodate any foam which may develop.
- Forming can be solved by:
 - Install foam breaker
 - Add antiform

Batch bioreactor-ideal mixing

What is ideal?



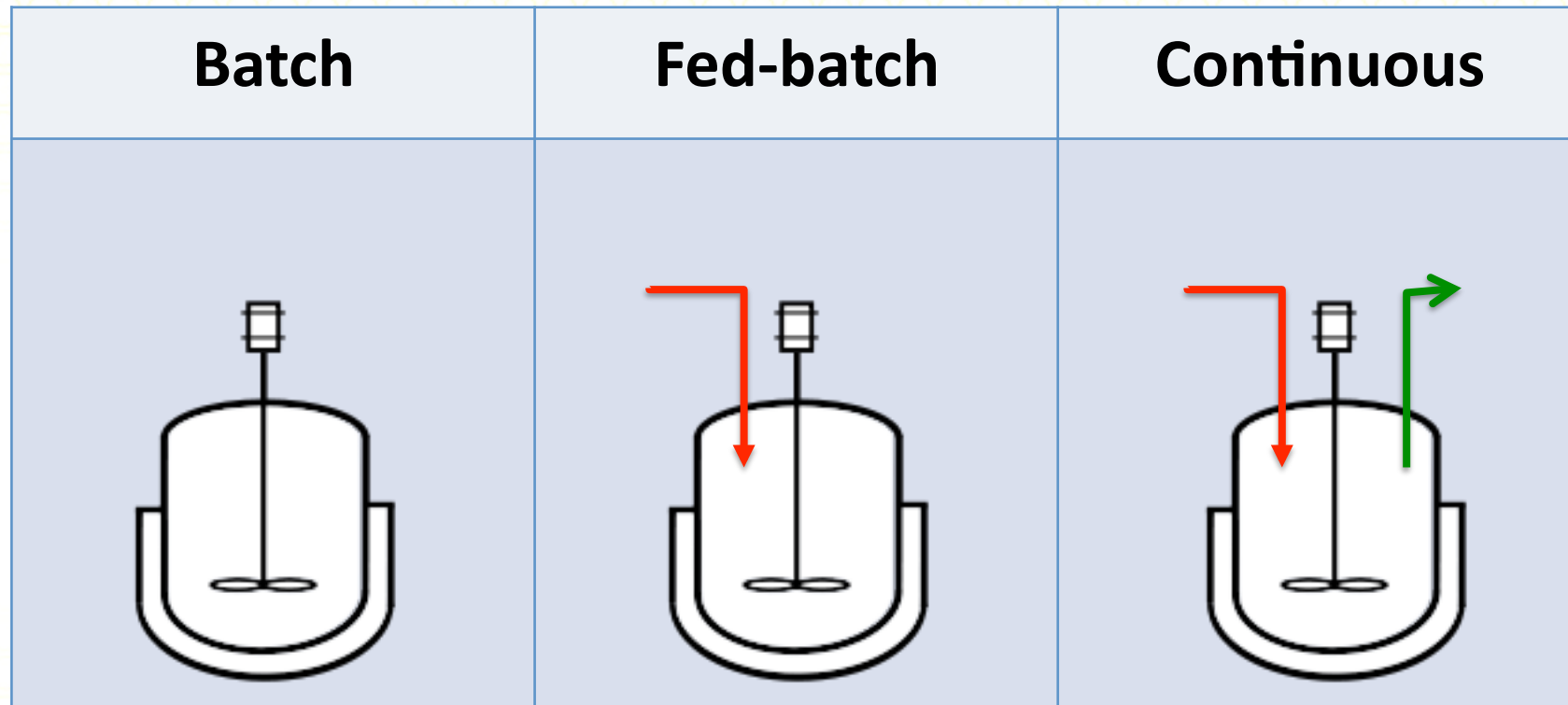
Batch bioreactor-ideal mixing

- Ideal well-mixed bioreactor=
 - fluid is homogeneous through the reactor.

- Homogeneous=
 - no dead zones
 - No clumps of undissolved solid substrate
 - no concentration gradients.

Fermentation/cell culture mode

Please name the differences?



Batch bioreactor

- After inoculation, the process is left untouched, ie no material is added to or removed from the reactor.
- However, the reactor might be aerated.
- Batch reactors are often referred to as closed systems.
- The term 'closed' refers to the fact that material can neither enter nor leave the reactor. (exceptional: air in and air out)

Fed-batch bioreactor

- The fed-batch reaction (FBR) is a batch reactor to which, when the nutrients approach depletion, fresh nutrients are added.
- In other words, the reactor is fed.
- It is assumed that the concentration of the nutrients added is so high that volume changes are negligible (justifying the batch part of the name).

Engineering problem

- Some time a stirred tank cannot be used in certain application.
- Therefore, some new designs have been proposed and designed based on individual needs.

Alternative design

- Bubble column
- Airlift reactor
- Membrane bioreactor
- Immobilized bioreactor
- Fluidized bioreactor
- Trickle-bed reactor
- Wave bioreactor
- Photo bioreactor
- Solid state fermentation

Bubble column

- NO mechanical agitation.
- Aeration and mixing are achieved by gas sparging
- requires less energy than mechanical stirring.
- Height-to-diameter ratio is usually high (why?)

Brainstorming

- Is the mixing in bubble column
 - Random? Why?
 - Non random? Why?

Airlift bioreactor

- Their distinguishing feature compared with the bubble column is that of liquid flow are more defined owing to the physical separation of up-flowing and down-flowing streams.
- gas is sparged into a part of the vessel section called the riser.
- Gas disengages at the top of the vessel leaving heavier bubble-free liquid to recirculate through the downcomer.

- Liquid circulates in airlift reactors as a result of

Fluidized bed bioreactor

- Normally the vessel is not fully packed with the bead for the expansion and movement of the bed.
- When packed beds are operated in upflow mode with beads of appropriate size and density, the bed expands at liquid flow rates due to upward motion of the particles.
- Because particles in fluidized beds are in constant motion, channeling and clogging of the bed are avoided and air can be introduced directly into the column.

Trickle-bed bioreactor

- Trickle-bed reactor is another variation of the packed bed.
- Liquid is sprayed onto the top of packing and trickles down through the bed in small rivulets.
- Air may be introduced at the base. Trickle-bed -bioreactors are used widely for aerobic wastewater treatment.

Wave bioreactor

- Disposable reactor
- Normally for mammalian cell-culture

Photo bioreactor

- Lately developed for microalgae

Membrane bioreactor (MBR)

- In a membrane reactor continuous processing is possible if production and separation can be incorporated in one system.
- One application of the membrane bioreactor is to remove product that is formed, especially for those that can inhibit the enzyme reaction.