



SECTION II: KINETICS AND BIOREACTOR DESIGN:
LESSON 8.- Introduction to Bioprocesses, Biocatalysts and Bioreactors.



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AIMS FOR TODAY'S LESSON

1.- ABOUT BIOPROCESSES:

Infer the role of Bioprocesses in Biotechnology.

2.- ABOUT BIOCATALYSTS:

Identify the main types of mediator for a Bioprocess.

3.- ABOUT BIOREACTORS:

Define what a Bioreactor is.

Outline its requirements.

REFERENCES:

- **Bailey, J.E., Ollis D.F. (1986)**, *Biochemical Engineering Fundamentals*, McGraw-Hill (New York).
- **Doran, P.M. (2013)**, *Bioprocess Engineering Principles*, Academic Press (London).



ISSUES IN THIS UNIT

INTRODUCTION TO BIOREACTOR DESIGN



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ISSUES IN THIS UNIT

WHAT WE ARE GOING TO TALK ABOUT...

BIOPROCESSES:

BIOCATALYSTS:

BIOREACTORS:



WHAT WE ARE GOING TO TALK ABOUT...

BIOPROCESSES:

Biotechnology.

Biochemical Engineering, ¿a human knowledge?

Definition of “bioprocess”.

What do we mean by “biological systems”?

Examples and applications

BIOCATALYSTS:

BIOREACTORS:

WHAT WE ARE GOING TO TALK ABOUT...

BIOPROCESSES:

BIOCATALYSTS:

What do we mean by “biocatalysts”?

Sorting.

Enzymes.

Cells.

BIOREACTORS:

WHAT WE ARE GOING TO TALK ABOUT...

BIOPROCESSES:

BIOCATALYSTS:

BIOREACTORS:

Definition of “bioreactor”.

What do we need from a bioreactor?

PROPOSAL:

Bioreactor design and society

What we need to refresh from previous courses.

The background of the slide is a photograph of an industrial facility. On the right side, there are several large, vertical, cylindrical storage tanks or bioreactors, painted in a light grey or off-white color. They have various pipes, ladders, and access points. To the left, there is a long, low-profile industrial building with a light-colored facade. The sky is blue with scattered white clouds. The overall scene is an outdoor industrial setting.

1.- BIOPROCESSES

2.- BIOCATALYSTS

3.- BIOREACTORS

1.- BIOPROCESSES

INTRODUCTION TO BIOREACTOR DESIGN



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1. BIOPROCESSES, AN INTRODUCTION

TISSUE ENGINEERING

HIGH THROUGHPUT PROCESSES

GMO

BIOETHICS

ENVIRONMENTAL IMPACT REDUCTION

SYSTEM BIOLOGY

DATA MINING

BIOTECHNOLOGY?

BIOMATERIALS

FOOD QUALITY, FOOD SAFETY

GENETIC LABELLING

NUTRIENT BIOAVAILABILITY

BIOFUELS

MONOCLONAL ANTIBODIES

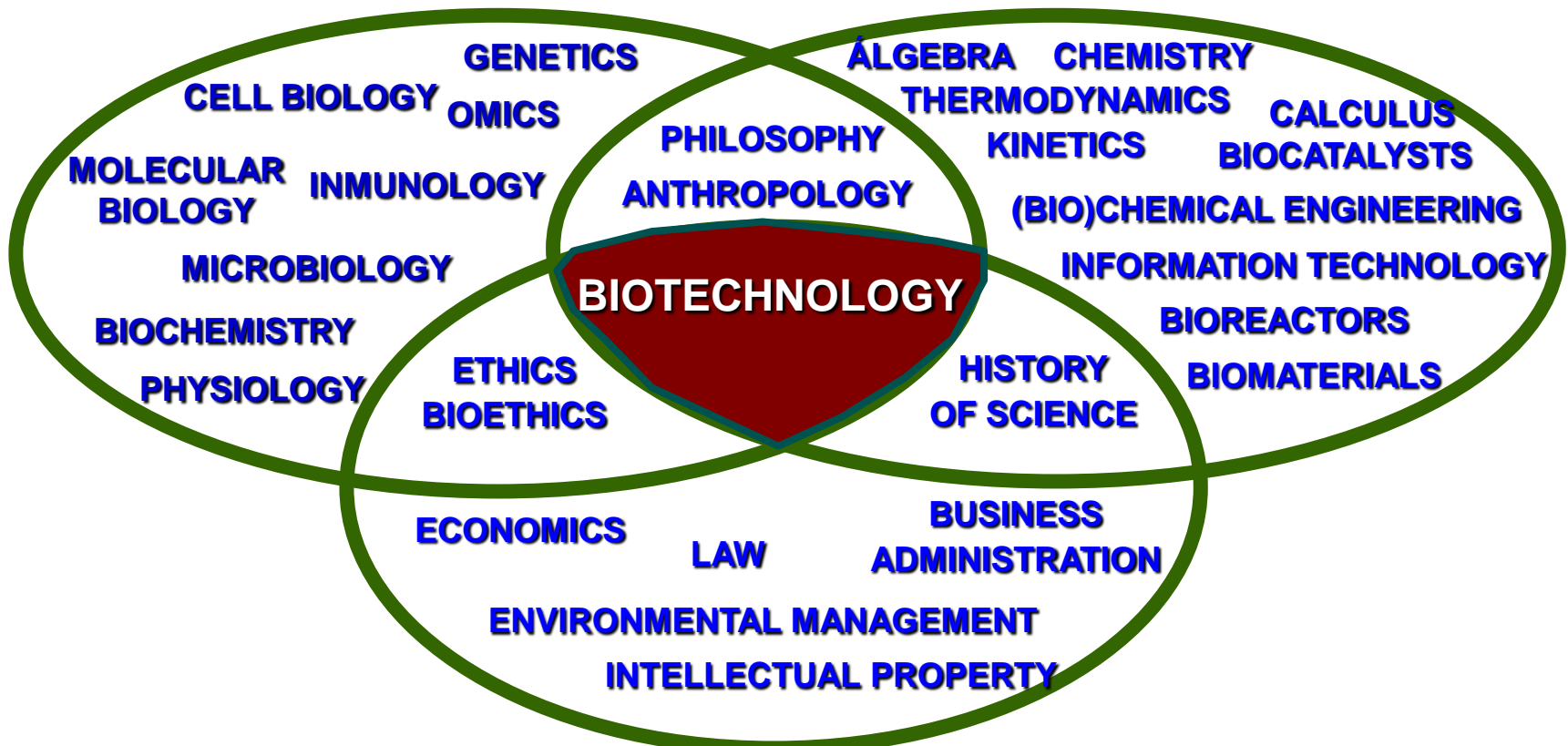
MOLECULAR DIAGNOSIS



1. BIOPROCESSES, AN INTRODUCTION

BIOTECHNOLOGY:

employment of **biological systems** or **substances coming from organisms** (enzymes, proteins,...) in order to obtain **knowlegde, goods and services**.

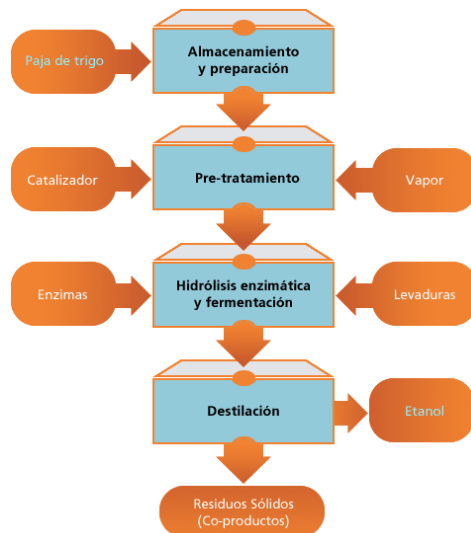


1. BIOPROCESSES, AN INTRODUCTION

BIOCHEMICAL ENGINEERING:

“It is the skill of **thinking up**, **calculating**, **designing**, **building up** an **industrial scale instalation** and **make it work**, in order to carry on any **(bio)chemical reaction** or even an immediate separation operation”

Joseph Cathala (Institut du Génie Chimique de Toulouse)



1. BIOPROCESSES, AN INTRODUCTION

BIOCHEMICAL ENGINEERING:

“(...) chemical engineering is not an isolated subject; it is not limited to applied science but is a **significant part of daily life**, related to **health**, to **human relations**, to **politics** and **sociology** and **law**, to the way we think and feel about ourselves as individuals and members of society, to our aspirations, hopes and fears” .

PRAUSNITZ, J. M., “Chemical Engineering and the others Humanities”

1. BIOPROCESSES, AN INTRODUCTION

DIFFERENT DISCIPLINES INVOLVED...

1. THERMODYNAMICS.
2. **BIOCHEMICAL KINETICS.**
3. TRANSPORT PHENOMENA.
4. UNIT OR BASIC OPERATIONS.
5. **BIOREACTORS DESIGN.**
6. ECONOMY.
7. **PROCESS ENGINEERING.**
8. INDUSTRIAL CHEMISTRY.
9. AS WELL AS: MATERIAL RESISTANCE.
CONTROL AND INSTRUMENTATION

1. BIOPROCESSES, AN INTRODUCTION

BIOPROCESS:

Set of **operations** carried out in order to **transform** some **initial raw materials** into **final products** by way of any **BIOLOGICAL SYSTEM**.

It involves the application of **biological sciences** to **industrial scale production** of socially interesting goods.

1. BIOPROCESSES, AN INTRODUCTION

BIOLOGICAL SYSTEM?

1. BIOPROCESSES, AN INTRODUCTION

WHAT DO WE MEAN BY “BIOLOGICAL SYSTEMS”?:



Bioreactor Technology linked to development of Industrial

Microbiology due to:

- Variety of applications of **microorganisms** in industry.
- Use of **microorganisms** as catalyst in industrially interesting processes.

1. BIOPROCESSES, AN INTRODUCTION

WHAT DO WE MEAN BY “BIOLOGICAL SYSTEMS”?:

Table 1.1 Major products of biological processing

(Adapted from M.L. Shuler, 1987, *Bioprocess engineering*. In: *Encyclopedia of Physical Science and Technology*, vol 2, R.A. Meyers, Ed., Academic Press, Orlando)

<i>Fermentation product</i>	<i>Typical organism used</i>	<i>Approximate world market size (kg yr⁻¹)</i>
Organic acids		
Citric acid	<i>Aspergillus niger</i>	$2-3 \times 10^8$
Gluconic acid	<i>Aspergillus niger</i>	5×10^7
Lactic acid	<i>Lactobacillus delbrueckii</i>	2×10^7
Itaconic acid	<i>Aspergillus itaconicus</i>	
Amino acids		
L-glutamic acid	<i>Corynebacterium glutamicum</i>	3×10^8
L-lysine	<i>Brevibacterium flavum</i>	3×10^7
L-phenylalanine	<i>Corynebacterium glutamicum</i>	2×10^6
L-arginine	<i>Brevibacterium flavum</i>	2×10^6
Others	<i>Corynebacterium</i> spp.	1×10^6
Microbial transformations		
Steroids	<i>Rhizopus arrhizus</i>	
D-sorbitol to L-sorbose (in vitamin C production)	<i>Acetobacter suboxydans</i>	4×10^7

1. BIOPROCESSES, AN INTRODUCTION

WHAT DO WE MEAN BY “BIOLOGICAL SYSTEMS”?:

However, we can think about other **biological systems**:

- **Enzymes**
- **Microorganisms**
- **Higher cells**
 - **Animal cells**
 - **Vegetal cells**

1. BIOPROCESSES, AN INTRODUCTION

a) PRODUCTS VIA ENZYMATIC PROCESSES:

➤ Food Technology:

Lactose hydrolysis ← β -galactosidase

Aspartame ← thermolysin

Invert sugar syrup ← invertase or β -fructofuranosidase

Cheese ← proteases: chymosin, pepsin

← lipases

Fruit juice extraction ← pectinases

Meat tenderizing and processing ← proteases.

Malted barley ← amylases.

...

1. BIOPROCESSES, AN INTRODUCTION

a) PRODUCTS VIA ENZYMATIC PROCESSES

➤ Papermaking:

Bleaching ← xylanases

Dye removal ← lipases, estearases, pectinases,
hemicellulases, cellulases y ligninases.

➤ Textile industry: amylases.

➤ Leather industry: proteases, lipases.

➤ Detergents: proteases, cellulases, lipases, amylases.

1. BIOPROCESSES, AN INTRODUCTION

a) PRODUCTS VIA ENZYMATIC PROCESSES:

➤ Environment decontamination:

Phenol oxidation ← peroxidases

Explosive removal ← peroxidases

Nitrites to Nitrates ← nitrite oxidases

➤ Sanitary applications:

Diagnosis kits: glucose, cholesterol, lactic acid,...

Treatment: L-asparaginase → leukemia.

1. BIOPROCESSES, AN INTRODUCTION

b) PRODUCTS VIA MICROBIAL PROCESSES

1. Cell production
2. High added value enzymes and proteins.
3. Primary and secondary metabolites.
4. Food additives and preservatives, bioplastics, vitamins,...
5. Waste treatment: sewage, solid waste, xenobiotics,...
6. Analytic applications: biodegradability, toxicity, mutagenic essays,...
7. Bioleaching...

1. BIOPROCESSES, AN INTRODUCTION

c) PRODUCTS VIA PROCESSES INVOLVING HIGHER animal CELLS:

➤ Health applications:

Insulin → diabetes.

Erythropoietin → anemia

Factor VIII → haemophilia.

Growth hormone (hGH) → hormone deficiency.

Tissue plasminogen activator (t-PA)

→ Ischemic stroke, Pulmonary embolism.

α Interferon → leukemia.

β Interferon → antiviral.

1. BIOPROCESSES, AN INTRODUCTION

d) PRODUCTS VIA PROCESSES INVOLVING HIGHER vegetal CELLS:

➤ Food industry:

Colourants (saffron)

Spices ((strawberry, garlic, onion, ...)

Fragrances (lemon, mint ...)

Sweeteners

➤ Farming applications:

pyrethrins (insecticides)

➤ Cosmetics:

Essences



1. BIOPROCESSES, AN INTRODUCTION

d) PRODUCTS VIA PROCESSES INVOLVING HIGHER vegetal CELLS:

➤ Health applications

Codeine (analgesic)

Diosgenin (fertility)

Quinine (malaria)

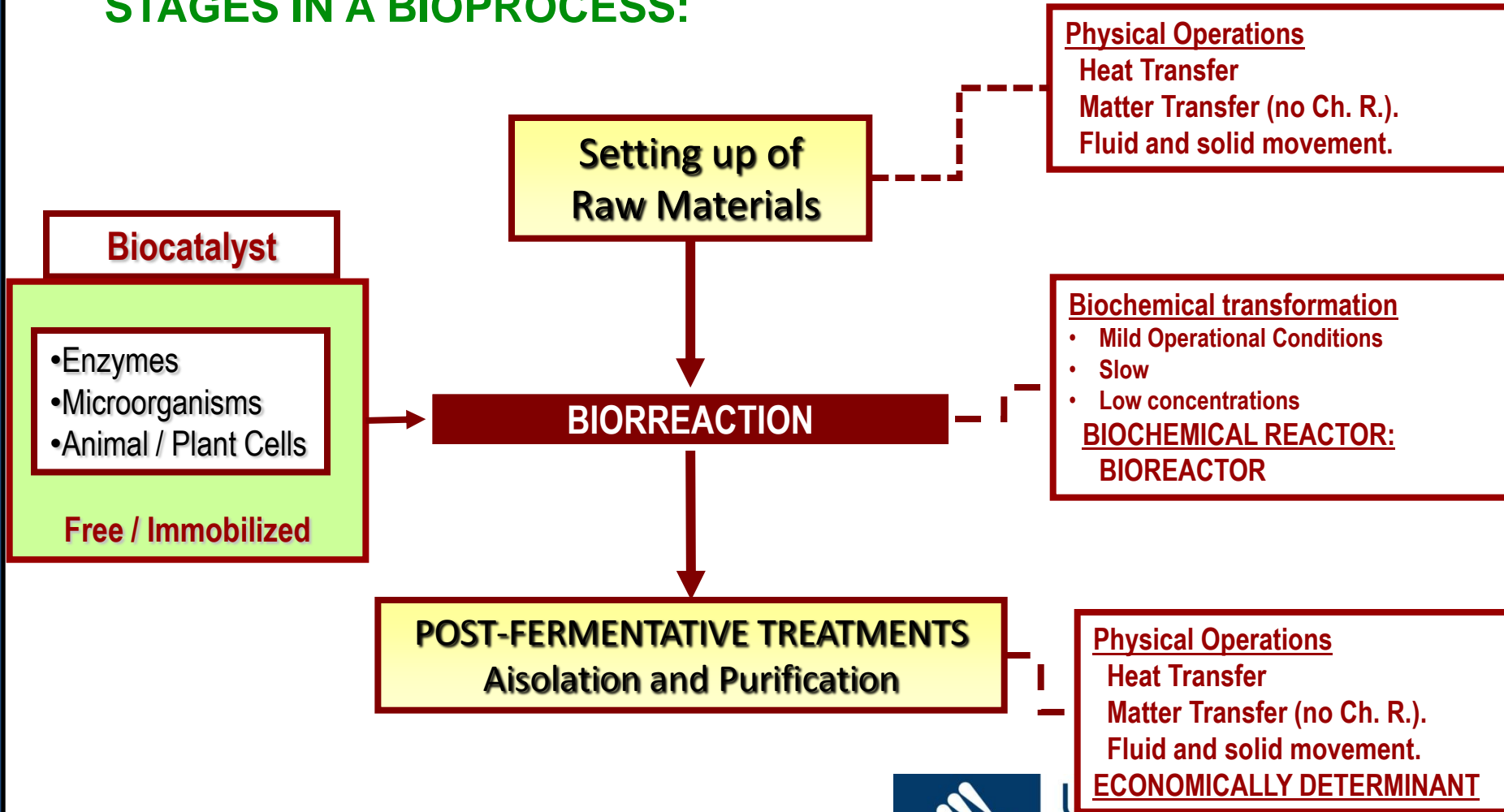
Digoxin (cardiac)

Scopolamine (hypertension)

Vincristine (leukemia)

1. BIOPROCESSES, AN INTRODUCTION

STAGES IN A BIOPROCESS:





1.- BIOPROCESSES

2.- BIOCATALYSTS



1.- BIOPROCESSES

2.- BIOCATALYSTS

2. BIOCATALYSTS

BIOCATALYST:

a living organism (cells from different nature) or a substance coming from a living organism (enzymes) used in order to obtain a service or a product.

According to their
NATURE or COMPLEXITY

Enzymes

Cells

Microorganisms

Higher cells

Plants

Animals

2. BIOCATALYSTS

BIOCATALYST:

a living organism (cells from different nature) or a substance coming from a living organism (enzymes) used in order to obtain a service or a product.

According to their
MOBILITY or FREEDOM

Free / in solution / in suspension

Immobilized

2. BIOCATALYSTS

BIOCATALYST:

a living organism (cells from different nature) or a substance coming from a living organism (enzymes) used in order to obtain a service or a product.

ONLY FOR CELLS

According to
cell growth

Growing

Resting cells

According to their
physical state

Whole cells

Semipermeable cells

1.- BIOPROCESSES

2.- BIOCATALYSTS

3.- BIOREACTORS

1.- BIOPROCESSES

2.- BIOCATALYSTS

3.- BIOREACTORS

3. BIORREACTORS

**IS THERE ANYTHING IN
COMMON IN THE
FOLLOWING DEVICES?**

3. BIORREACTORS







3. BIORREACTORS







3. BIORREACTORS

BIOREACTOR:

Vessel where a **transformation** catalized by a **biological system** is carried out.

- Equipment where a bioprocess takes place.
- Also known as **fermentor**.
- Need to mantain every condition needed for the bioprocess.

3. BIORREACTORS

BIORREACTOR :

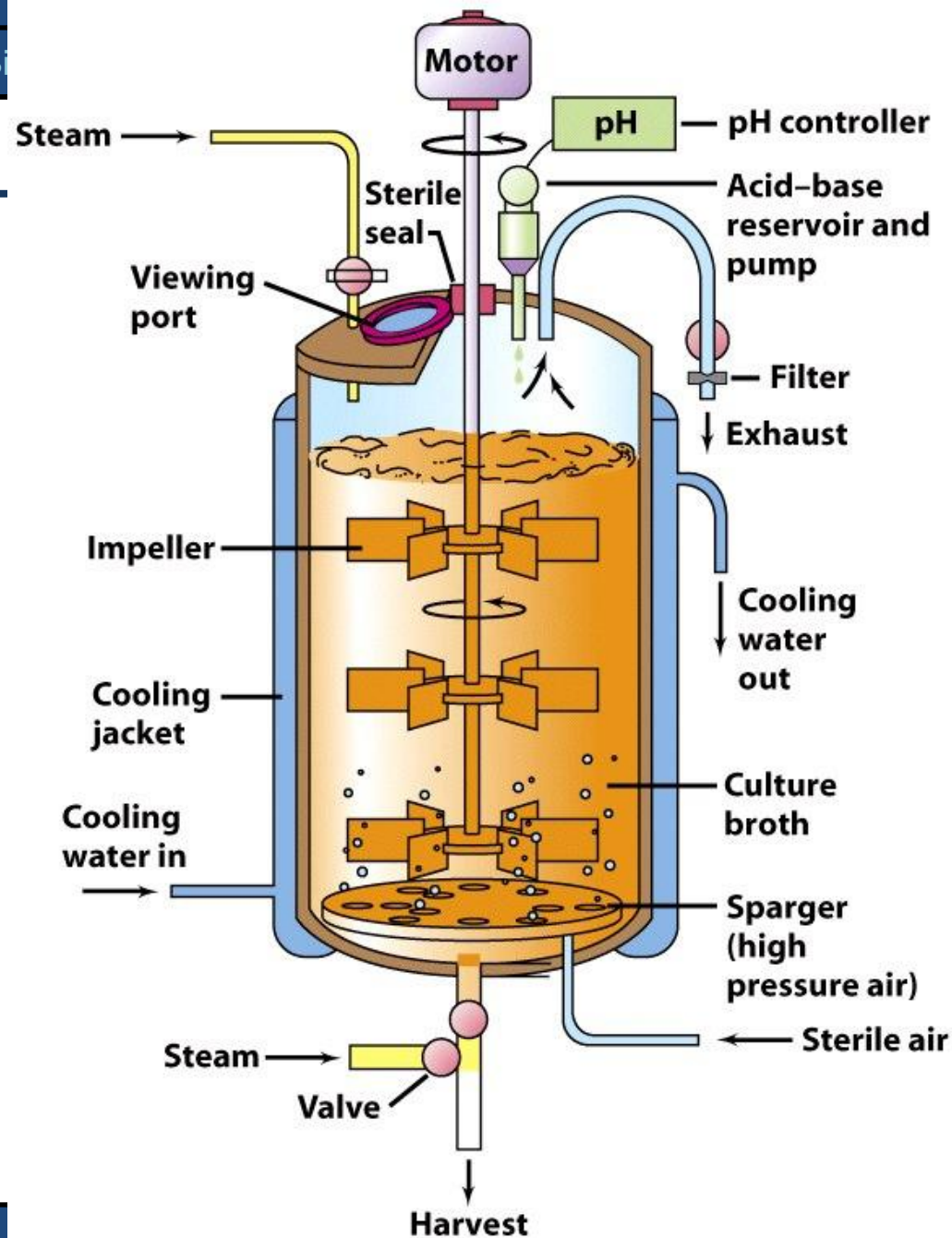
Therefore, the following services need to be covered:

- Mixing system.
- Control and recording of:
 - Temperature.
 - Agitation power.
 - Foam turning up.
 - Gas flow.
 - Feed flow.
 - Level
 - Pressure
 - Viscosity
 - Turbidity
 - ...

3. BIORREACTORS

BIORREACTOR:

- Oxygen supply.
- Inlets for nutrient addition.
- Outlet for product and regular sampling.



3. BIORREACTORS

Check out this videopaper from JoVe:

<https://www.jove.com/video/50582/operation-of-a-benchttop-bioreactor>



3. BIORREACTORS

BIOREACTOR DESIGN:

→ Design involves answering the following questions:

1. What is the best configuration for the bioprocess?
2. What is the right size for the bioreactor?
3. What operational condition should be fix or programmed during the bioprocess?
4. What is the most interesting way of operation for the bioprocess?

TO SUM UP...

BIOPROCESSES:

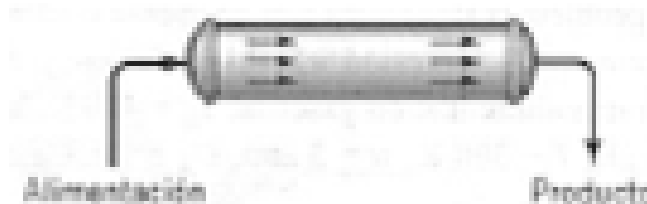
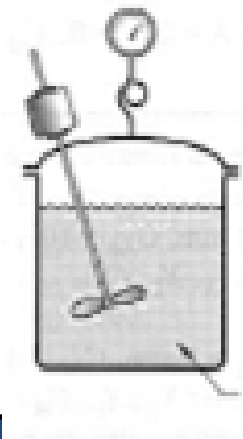
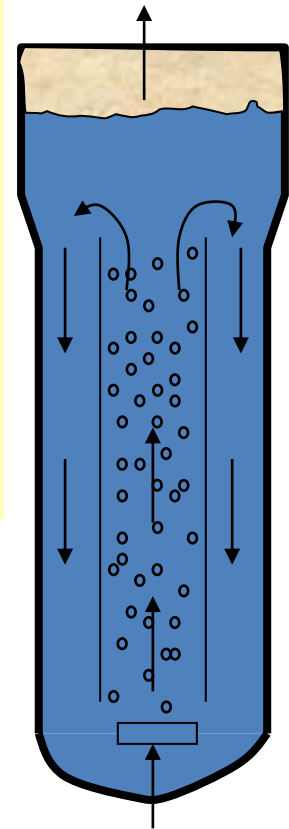
What a bioprocess is within Biochemical Engineering and Biotechnology.

BIOCATALYSTS:

What a biocatalysts is and what kinds of systems involves.

BIOREACTORS:

Definition and requirements.



PROPOSAL:

Homework:



- **Mass Balance** from Biochemical Engineering course.
- **Steady State ?**
- Advantages of **Biocatalyst Immobilization**.



ANY QUESTION?

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