



## 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.

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## REFERENCES:

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

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## ISSUES IN THIS UNIT

### WHAT WE ARE GOING TO TALK ABOUT...

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BIOPROCESSES:

BIOCATALYSTS:

BIOREACTORS:

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## ISSUES IN THIS UNIT

### WHAT WE ARE GOING TO TALK ABOUT...

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#### BIOPROCESSES:

Biotechnology.

Biochemical Engineering, ¿a human knowledge?

Definition of “bioprocess”.

What do we mean by “biological systems”?

Examples and applications

#### BIOCATALYSTS:

#### BIOREACTORS:

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## ISSUES IN THIS UNIT

### WHAT WE ARE GOING TO TALK ABOUT...

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#### BIOPROCESSES:

#### BIOCATALYSTS:

What do we mean by “biocatalysts”?

Sorting.

Enzymes.

Cells.

#### BIOREACTORS:

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## ISSUES IN THIS UNIT

### WHAT WE ARE GOING TO TALK ABOUT...

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#### 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.

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**1.- BIOPROCESSES**

**2.- BIOCATALYSTS**

**3.- BIOREACTORS**

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# 1.- BIOPROCESSES

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# 1. BIOPROCESSES, AN INTRODUCTION

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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

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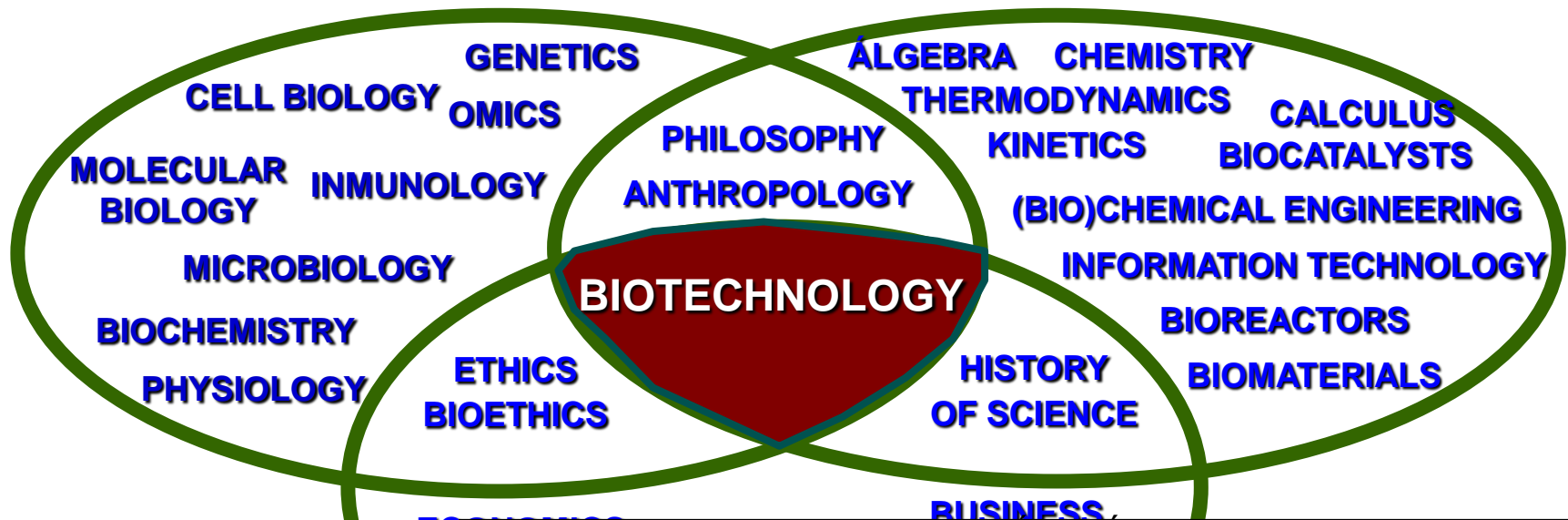
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# 1. BIOPROCESSES, AN INTRODUCTION

## BIOTECHNOLOGY:

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



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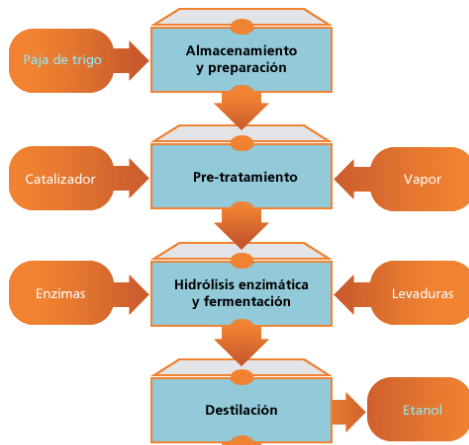
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# 1. BIOPROCESSES, AN INTRODUCTION

## 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)*



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## 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”*

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# 1. BIOPROCESSES, AN INTRODUCTION

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## 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.

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## 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.

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## 1. BIOPROCESSES, AN INTRODUCTION

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# BIOLOGICAL SYSTEM?

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## 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.

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# 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<sup>-1</sup>)</i>
<b>Organic acids</b>		
Citric acid	<i>Aspergillus niger</i>	$2-3 \times 10^8$
Gluconic acid	<i>Aspergillus niger</i>	$5 \times 10^7$
Lactic acid	<i>Lactobacillus delbrueckii</i>	$2 \times 10^7$
Itaconic acid	<i>Aspergillus itaconicus</i>	
<b>Amino acids</b>		
L-glutamic acid	<i>Corynebacterium glutamicum</i>	$3 \times 10^8$
L-lysine	<i>Brevibacterium flavum</i>	$3 \times 10^7$
L-phenylalanine	<i>Corynebacterium glutamicum</i>	$2 \times 10^6$
L-arginine	<i>Brevibacterium flavum</i>	$2 \times 10^6$
	<i>Acetobacter suboxydans</i>	$4 \times 10^7$

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D-Sorbitol to L-Sorbitose

Aspergillus niger

*Acetobacter suboxydans*

$4 \times 10^7$

# 1. BIOPROCESSES, AN INTRODUCTION

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## WHAT DO WE MEAN BY “BIOLOGICAL SYSTEMS”?:

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

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

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## a) PRODUCTS VIA ENZYMATIC PROCESSES:

### ➤ Food Technology:

Lactose hydrolysis ←  $\beta$ -galactosidase

Aspartame ← thermolysin

Invert sugar syrup ← invertase or  $\beta$ -fructofuranosidase

Cheese ← proteases: chymosin, pepsin

← lipases

Fruit juice extraction ← pectinases

Meat tenderizing and processing ← proteases.

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## a) PRODUCTS VIA ENZYMATIC PROCESSES

### ➤ Papermaking:

Bleaching ← xylanases

Dye removal ← lipases, esterasas, pectinases,  
hemicellulases, cellulases y ligninasas.

➤ Textile industry: amylases.

➤ Leather industry: proteases, lipases.

➤ Detergents: proteases, cellulases, lipases, amylases.

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## 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.

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## 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 assays,...
7. Bioleaching...

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# 1. BIOPROCESSES, AN INTRODUCTION

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## 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.

$\alpha$  Interferon → leukemia.

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## 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:

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## d) PRODUCTS VIA PROCESSES INVOLVING HIGHER vegetal CELLS:

### ➤ Healt applications

Codeine (analgesic)

Diosgenin (fertility)

Quinine (malaria)

Digoxin (cardiac)

Scopolamine (hypertension)

Vincristine (leukemia)

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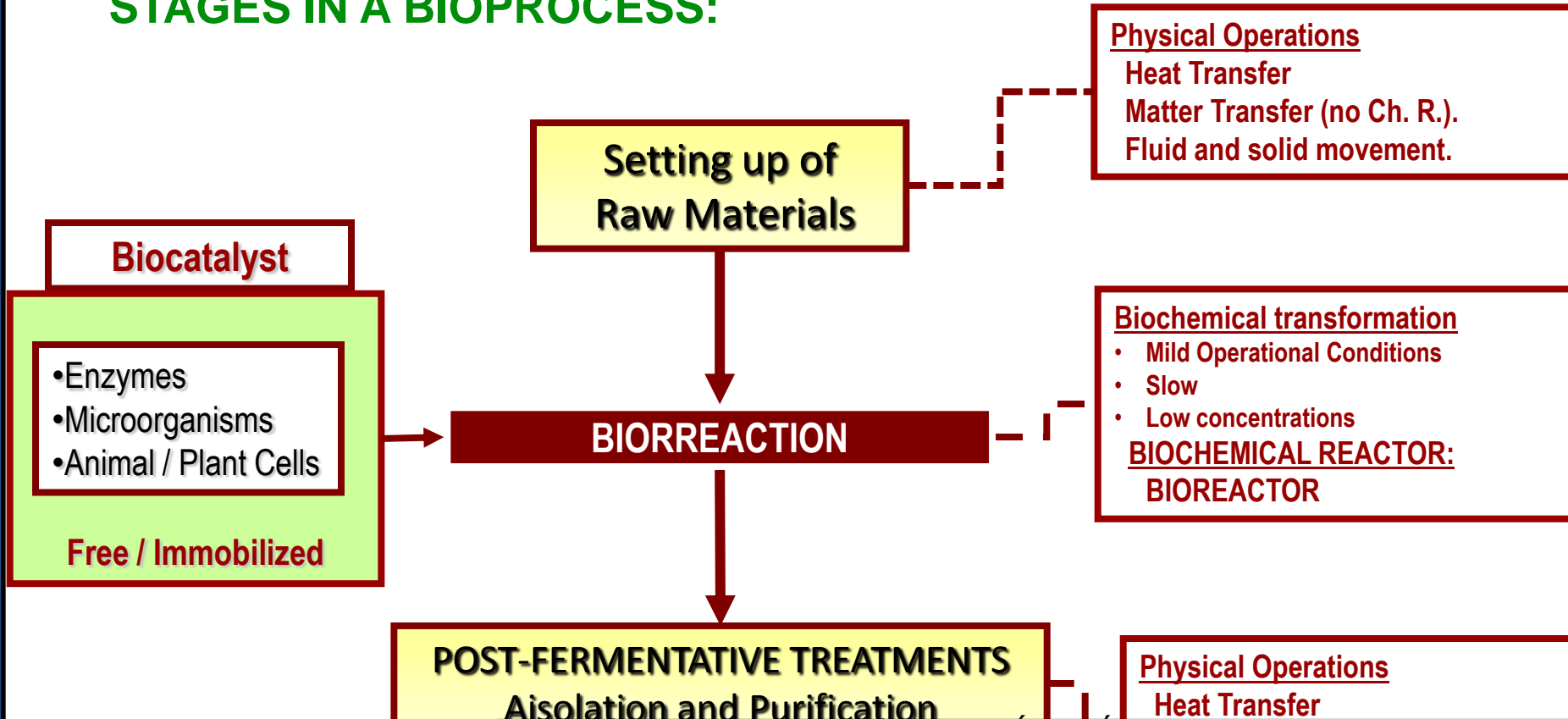
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# 1. BIOPROCESSES, AN INTRODUCTION

## STAGES IN A BIOPROCESS:



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**1.- BIOPROCESSES**

**2.- BIOCATALYSTS**

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# **1.- BIOPROCESSES**

# **2.- BIOCATALYSTS**

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## 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

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## 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

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## 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

Whole cells

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**1.- BIOPROCESSES**

**2.- BIOCATALYSTS**

**3.- BIOREACTORS**

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### 3. BIORREACTORS

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

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### 3. BIORREACTORS



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### 3. BIORREACTORS



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### 3. BIORREACTORS

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#### 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.

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### 3. BIORREACTORS

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#### 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.
  - Pressure
  - Viscosity
  - Turbidity
  - ...

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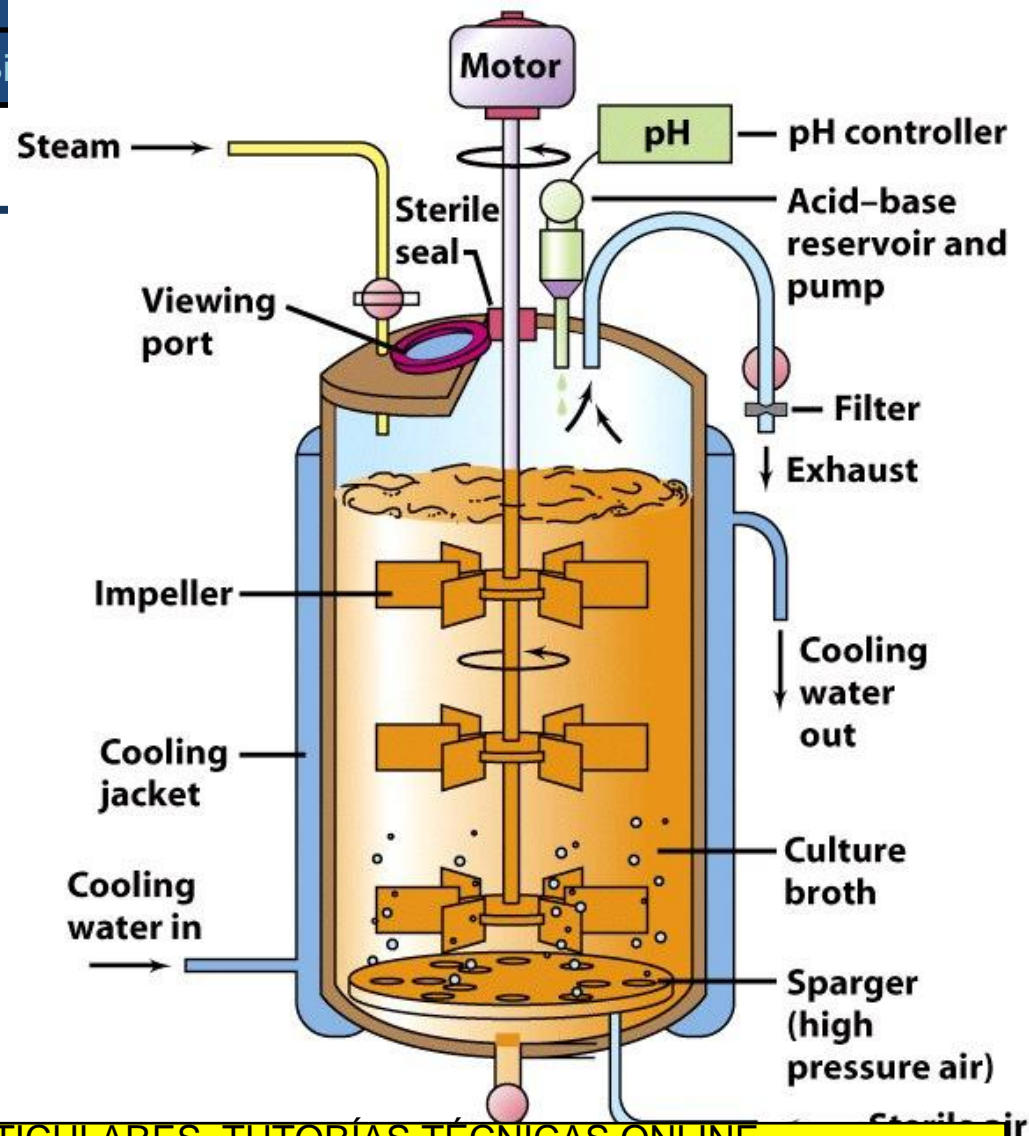
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### 3. BIORREACTORS

#### BIORREACTOR:

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



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### 3. BIORREACTORS

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Check out this videopaper from JoVe:

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

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### 3. BIORREACTORS

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#### 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

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## TO SUM UP...

### BIOPROCESSES:

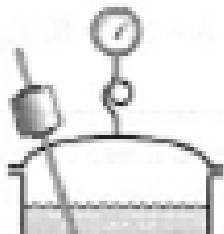
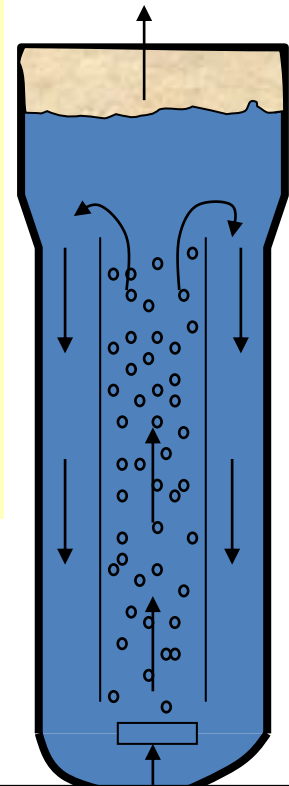
What a bioprocess is within Biochemical Engineering and Biotechnology.

### BIOCATALYSTS:

What a biocatalysts is and what kinds of systems involves.

### BIOREACTORS:

Definition and requirements.



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## PROPOSAL:

### Homework:



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

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**ANY QUESTION?**

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**Francisco de Vitoria  
UFV Madrid**



## SECTION II: KINETICS AND BIOREACTOR DESIGN:

### LESSON 8.- Introduction to Bioprocesses, Biocatalysts and Bioreactors.

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