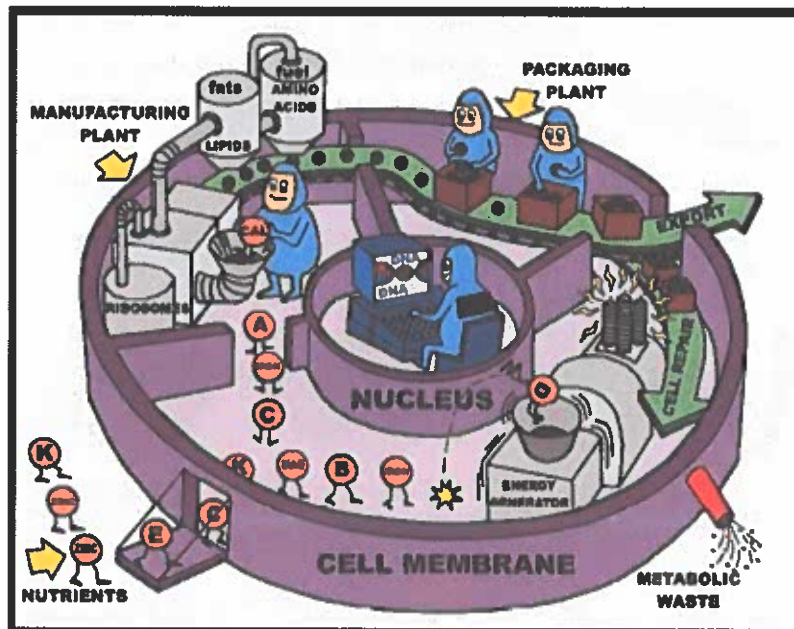


## ENZYMES in BIOPROCESSING

### 1. Cells are Like Microbial Factories

ROLES IN A FACTORY	CELL ORGANELLE	FUNCTION OF ORGANELLE IN A MICROBIAL FACTORY
Support Structure (walls, ceilings)	Cytoskeleton	Maintains the shape of the cell
Shipping/Receiving Department	Plasma Membrane	Regulates what enters and leaves the cell
Chief Executive Officer (CEO)	Nucleus	Controls all cell activity; determines what proteins are produced
Power Plant	Mitochondria/Chloroplasts	Transforms one form of energy to another
Factory Floor	Cytoplasm	Contains the organelles
Assembly Line Workers	Ribosomes	Responsible for building proteins
Assembly Line	Endoplasmic Reticulum	Where ribosomes perform their work
Finishing/Packaging Department	Golgi Apparatus	Prepares proteins for use or export
Break Room	Vacuoles	Location for nutrient storage and trash disposal
Maintenance Crew	Lysosomes	Repair items in the factory and break down/clean up materials taken in by the cell



#### i. How Many Cells/Microorganisms are Present in the Human Body?

- Scientists estimate that the average person is comprised of approximately 30 trillion human (eukaryotic) cells with an additional 40 trillion bacterial (prokaryotic) cells living in or on the body. This means that for every 10 human cells, there are 13 bacterial microorganisms present!
- Researchers believe that more than 10,000 different microbial species occupy the human ecosystem. Approximately 81-99% of these species have now been identified.

# ENZYMES in BIOPROCESSING

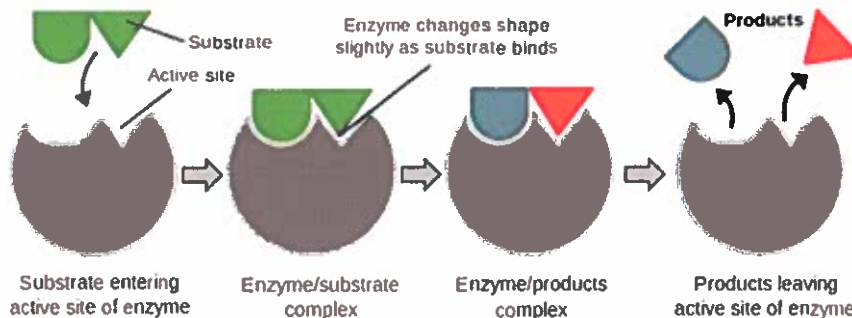
## 2. Enzymes

### i. What are Enzymes?

- Enzymes are substances that are present in every animal, plant and microbial cell and act as biocatalysts by either starting biochemical reactions or making them run faster.
- Enzymes are composed of two parts: (i) a protein (strings of amino acids) portion and (ii) a non-protein portion, either a coenzyme (biological) or cofactor (non-biological).
- An enzyme's job is determined by the types and ordering of its amino acid strings, as well as its shape.
- Enzymes don't lose activity after they perform their job. They can be used over and over again.
- Scientists estimate that approximately 75,000 types of enzymes exist in the human body (primarily found in our saliva, stomach, pancreas and small intestine).
- Because enzymes have so many applications, scientists have found it helpful to classify them based on what they do, what substances they act on and the reactions they start or accelerate. There are six key groups of enzymes (hydrolases, isomerases, ligases, lyases, oxidoreductases and transferases), each having different jobs.

### ii. How do Enzymes Work?

- Enzymes are highly specific, meaning that each type of enzyme only reacts with the substance that it was made for. This is important so that enzymes don't cause reactions that they are aren't meant to.
- Enzymes have a special pocket on their surface called an active binding site. The molecule they are supposed to react with (the substrate) fits perfectly into that pocket.
- After an enzymatic reaction is complete, the new product molecule(s) is released by the enzyme.



### iii. What Factors Can Affect Enzyme Performance?

- The environment surrounding enzymes and their substrates can affect the speed of biochemical reactions. If the conditions are harsh enough, the shape of enzymes can be altered, preventing it from performing its job. When this occurs, we say that the enzymes are denatured.
- Temperature can affect the rate of enzymatic reactions. Typically, the higher the temperature, the faster the reaction will occur. However, if the temperature becomes too high, enzymes will denature and stop working.
- In many cases the pH of the environment around the enzyme and substrate can affect the reaction rate. An extreme pH (high or low) will typically slow or even stop enzymatic reactions.
- Increasing or decreasing the concentration (amount) of substrate or enzyme can influence the reaction speed.

### iv. Enzyme Feedback Inhibition

- Enzyme inhibitors are molecules that are specially made to slow or stop the activity of enzymes.
- Typically, inhibitors bond with the enzyme at a binding site causing it to change shape and not work correctly.
- A key purpose of feedback inhibition is to prevent too much product from being made.
- Molecules called activators can re-start biochemical reactions that have been slowed or stopped by inhibitors.

## **Bioprocessing – Enzymes in Action**

### **Introduction**

Pectinases are enzymes that breakdown the polysaccharide (sugar) pectin, which is located primarily in the middle portion of cell walls. Pectin compounds are found inside plant tissues, especially in fruits. They are large molecules which are responsible for keeping particles in suspension in fruit juices (like oil in water in salad dressing after mixing). Pectin can influence both the amount of particles and where they are located. Pectin can also affect the amount of juice and its thickness. When most people buy apple juice, they would prefer for it to be clear of suspended particles unlike tomato juice or orange juice. We can add pectinase to the juice to make this happen. Today, we will mimic what happens in the apple juice processing plant to make this clear apple juice using pectinase.

### **PPE (Personal Protective Equipment)**

Gloves  
Lab coat  
Safety glasses

### **Materials**

Coffee filters (2)  
Funnels (2)  
Graduated cylinders, 100-mL (2)  
Colored Solo cups, (2)  
Spoons (2)  
Apple sauce  
Enzyme solutions A and B  
Small containers for enzyme solution (2)

### **Experiment Procedure**

1. Place approximately 25 ml of apple sauce into each of the two solo cups
2. Add enzyme A in cup A and enzyme B into cup B
3. Stir the contents of each cup thoroughly using a separate spoon
4. Let stand 10 minutes
5. Place filter cloth in a funnel and place the funnel into respective graduated cylinder
6. Using the spoon, pour the contents of cup A into funnel A and cup B into funnel B
7. Record the amount of juice that is collected in each graduated cylinder

## **Bioprocessing – Enzymes in Action**

### **Results**

<b>Volume of Juice in Cylinder A (mL)</b>	<b>Volume of Juice in Cylinder B (mL)</b>

### **Discussion Questions**

If you used a cotton t-shirt, how would this affect your results?

What parameters could you change to increase the yield of juice?

How does pectinase help create apple juice?

### **Notes:**

## Industries that Use Enzymes to Make Valuable Products

