



# Enzyme Science and Engineering

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Ravikrishnan Elangovan,

Department of Biochemical Engg and  
Biotechnology,

Indian Institute of Technology, Delhi

# Evaluation model

Minor 1	- 15 marks
Minor 2	- 15 marks
Major	- 30 marks
Lab component	- 20 marks
Quiz	- 20 marks

Class ethics:

1. Come ON time and participate!
2. Do not disturb
3. No mal practice

Less than 70% attendance is one grade down!

# Schedule for this semester

Class timing: Tue, Wed, Friday 9.00-10.00 AM

Lab timing: Mon, Friday 2.00-4.00 PM

Minor 1: 6-9<sup>th</sup> Feb 2023

Minor 2: 23-26<sup>th</sup> March 2023

Major: 1-10<sup>th</sup> May 2023

Every two weeks one quiz!

All lab practical's report will be submitted in MS teams

# Topics to be covered!

## Minor 1:

- Enzyme chemical and functional nature
- Enzyme source
- Enzyme purification
- Enzyme kinetics, inhibition and inactivation

## Minor 2:

- Enzyme immobilization
- Enzyme reactors
- Diffusion restriction
- Enzyme improvement
- High throughput screening

## Major:

- Enzyme for therapeutic applications
- Enzyme for biosensing
- Enzyme in bioethanol & biodiesel
- Non aqueous enzymology
- Biocatalysis

# Why Enzymes?

- Chemical reactions at mild condition
- Highly specific reaction
- High catalytic rate
- 10000 and more enzymes

Some misconception:

Unstable:

Half life Aspartase – 24 months  
Fumarase – 180 months  
Protease – 2 months

Expensive:

Bacterial  $\alpha$  amylase cost 2.4\$/Kg  
Glucose isomerase cost 11 \$/Kg

Low productivity:

e.g., acrylonitrile to acrylamide is produced at 400 g/L/hr

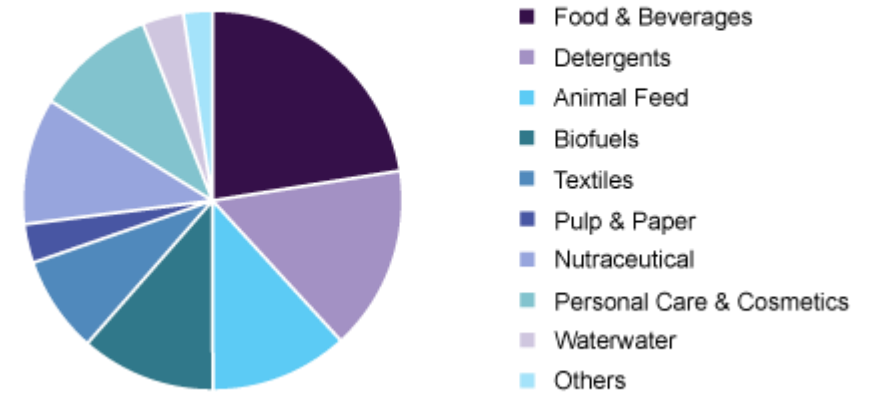
# Motivation!

PRECEDENCE  
RESEARCH

ENZYMES MARKET SIZE, 2021 TO 2030 (USD BILLION)



Global industrial enzymes market share, by application, 2019 (%)

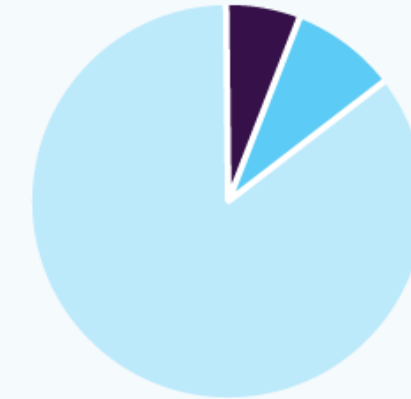


Source: [www.grandviewresearch.com](http://www.grandviewresearch.com)

# Motivation!

## Global Enzymes Market

share, by source, 2021 (%)



● Plants ● Animals ● Microorganisms

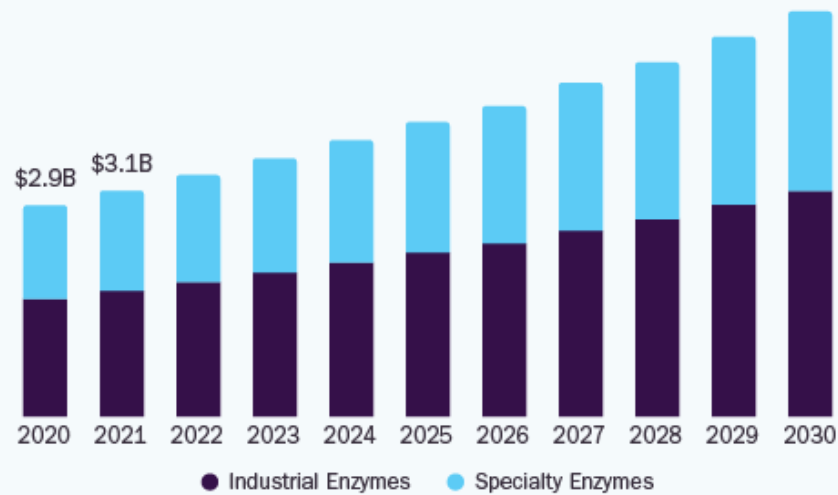


**\$11.5B**  
Global Market Size,  
2021

Source:  
[www.grandviewresearch.com](http://www.grandviewresearch.com)

## U.S. Enzymes Market

size, by type, 2020 - 2030 (USD Billion)

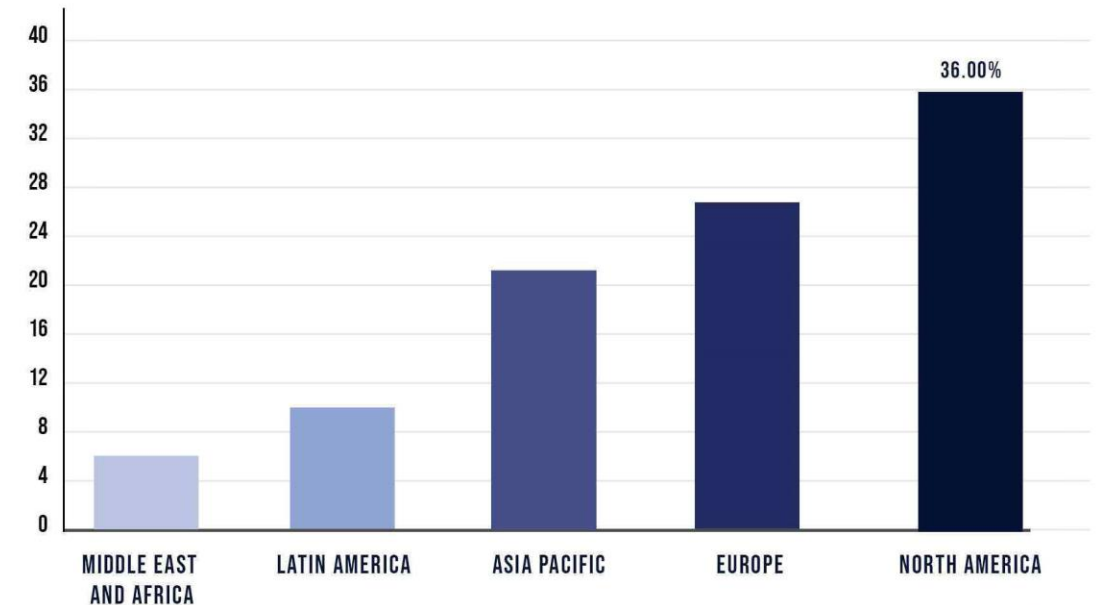


**6.8%**

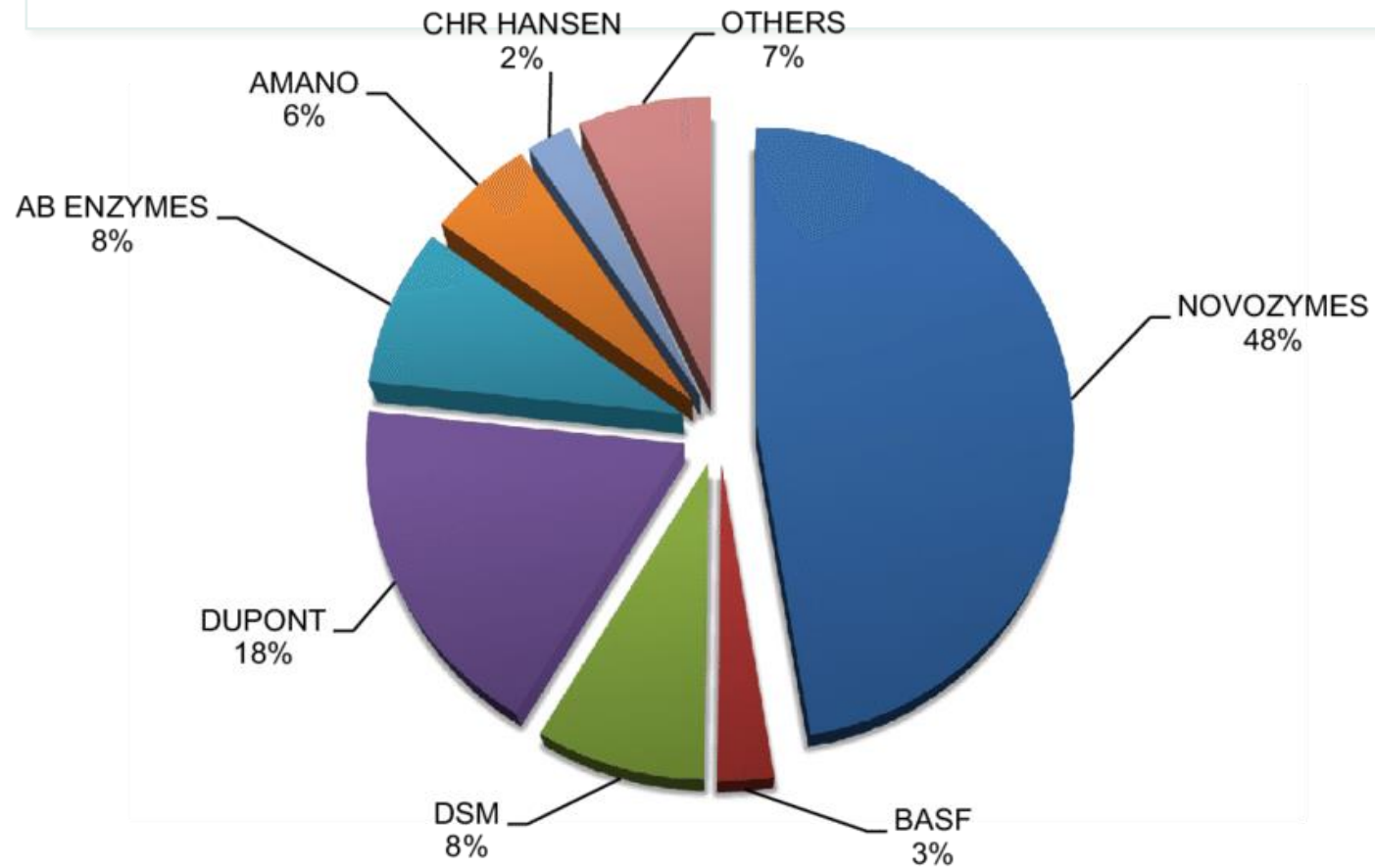
U.S. Market CAGR,  
2022 - 2030

Source:  
[www.grandviewresearch.com](http://www.grandviewresearch.com)

## ENZYMES MARKET SHARE, BY REGION, 2021 (%)



# Motivation!





# Novozymes

## Sales by business area

<https://report2021.novozymes.com/#Facts-and-figures>

### Performance

Three out of five of our business areas grew in 2021. Food, Beverages & Human health, Agriculture, Grain & Tech Processing and Bioenergy all contributed with double-digit growth while Household Care and Agriculture, Animal Health & Nutrition performed much as expected.

### Household Care

**32%**

of total sales  
2020: 35%

### Agriculture, Animal Health & Nutrition

**12%**

of total sales  
2020: 13%

### Grain & Tech Processing

**15%**

of total sales  
2020: 14%

### Bioenergy

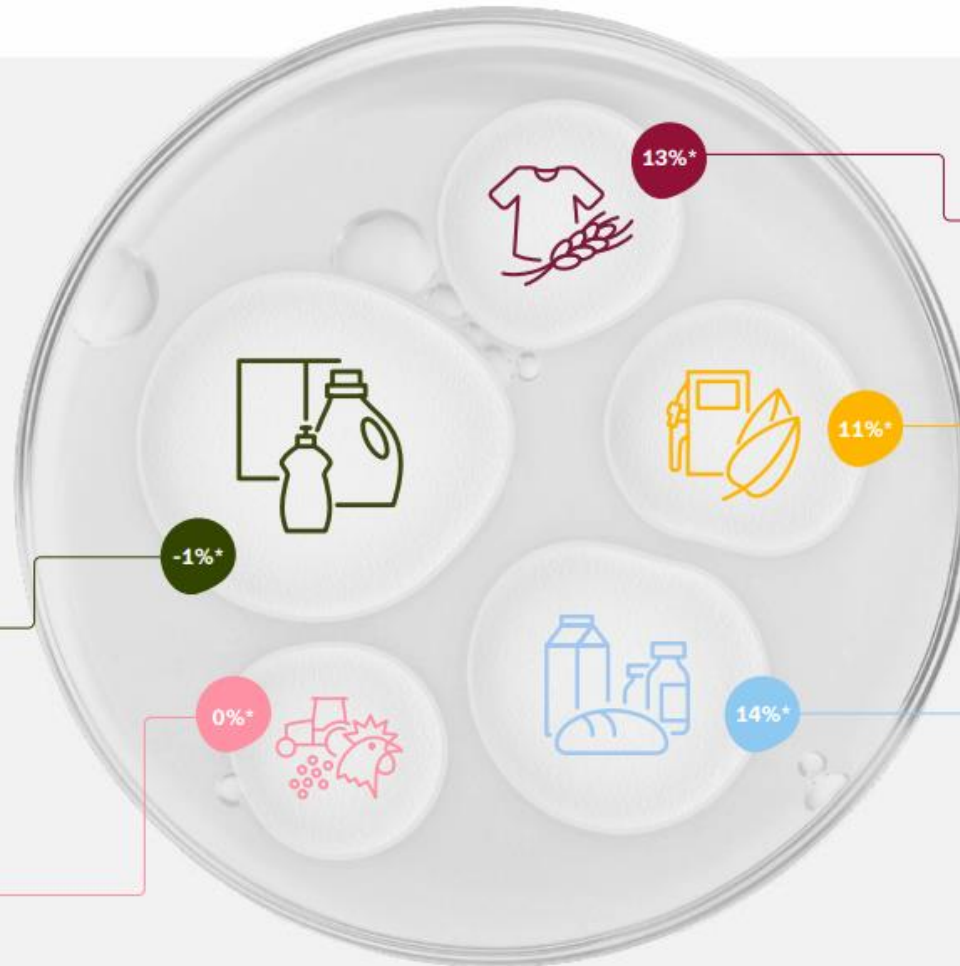
**18%**

of total sales  
2020: 18%

### Food, Beverages & Human Health

**23%**

of total sales  
2020: 19%



\* Organic sales growth

# Enzyme applications

## 1. Starch conversions

- Production of glucose syrup
- Production of high fructose corn syrup
- Production of high maltose conversion syrups
- Production of cyclodextrins
- Production of ethanol

## 2. Lignocellulosic Biomass conversions

- Cellulose conversion
- Hemicellulose conversion
- Lignin conversion

3. Enzymes in the Production of Functional Oligosaccharides and Other Nutraceuticals

4. Enzymes in the Modification of Fats and Oils

5. Enzymes in the Animal Feed Industry

6. Enzymes in the Pulp and Paper Industry

7. Enzymes in the Fruit Juice Processing Industry

8. Enzymes in the Meat and Fish Processing Industry

9. Enzymes in the Dairy Industry

10. Enzymes in Detergents

11. Enzymes in the Leather Industry

12. Enzymes in the Production of Bulk and Fine Chemicals

13. Analytical Applications of Enzymes

14. Enzyme-Replacement Therapy



## TEXTILE ENZYMES

For Cotton and Hosiery  
Biopolishing

For Cotton and Denim Biofading

For Textile and Denim Desizing

For Textile Fabric Bioscouring

Concentrated Thermostable Alpha  
Amylase

Concentrated Low Temperature  
Alpha Amylase

Concentrated Cellulase for  
Formulation (Biopolishing)

Concentrated Cellulase for  
Formulation (Biofading)

Concentrated Pectinase for  
Formulation (Bioscouring)

Concentrated Catalase for  
Formulation (Peroxide Killer)

## LEATHER ENZYMES

For Beamhouse Soaking

For Fat and Oil Degreasing

For Acid Bating and Softening

For Alkaline Bating and Dewrinkling

For Enzymatic Dehairing

Concentrated Alkaline protease for  
Formulation

Concentrated Acid Protease for  
Formulation

Concentrated Alkaline Lipase for  
Formulation

Concentrated Acid Lipase for  
Formulation

## STARCH ENZYMES

For Starch Liquefaction

For Starch Saccharification

For Viscosity Reduction

For Dextran Hydrolysis

## ANIMAL FEED ENZYMES

Phytase Enzyme for Animal Feed

B-Glucanase Enzyme for Animal  
Feed

Cellulase Enzyme for Animal Feed

Xylanase Enzyme for Animal Feed

Amylase Enzyme for Animal Feed

Bacterial Protease Enzyme for  
Animal Feed

Fungal Protease Enzyme for Animal  
Feed

Lipase Enzyme for Animal Feed

## DIETARY SUPPLEMENT ENZYMES

Fungal Amylase Enzyme for Dietary  
Supplements

Fungal Xylanase Enzyme for Dietary  
Supplements

Fungal Lipase Enzyme for Dietary  
Supplements

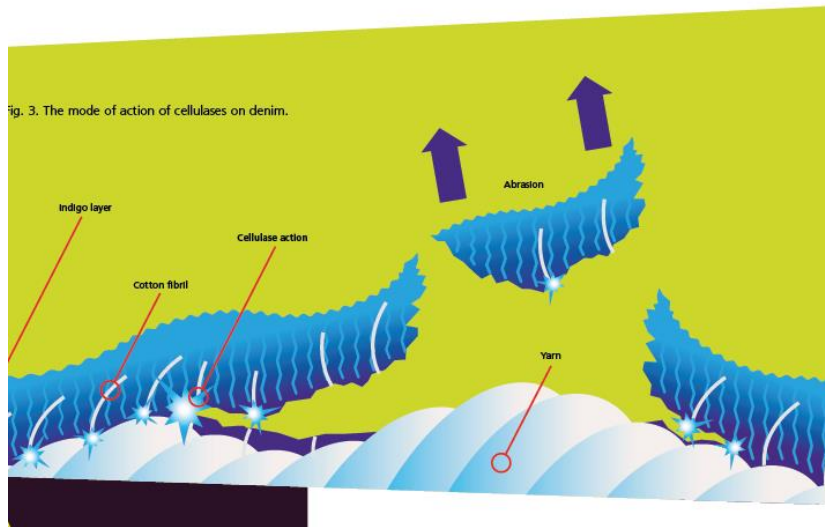
Fungal Protease Enzyme for Dietary  
Supplements

Fungal Cellulase Enzyme for Dietary  
Supplements

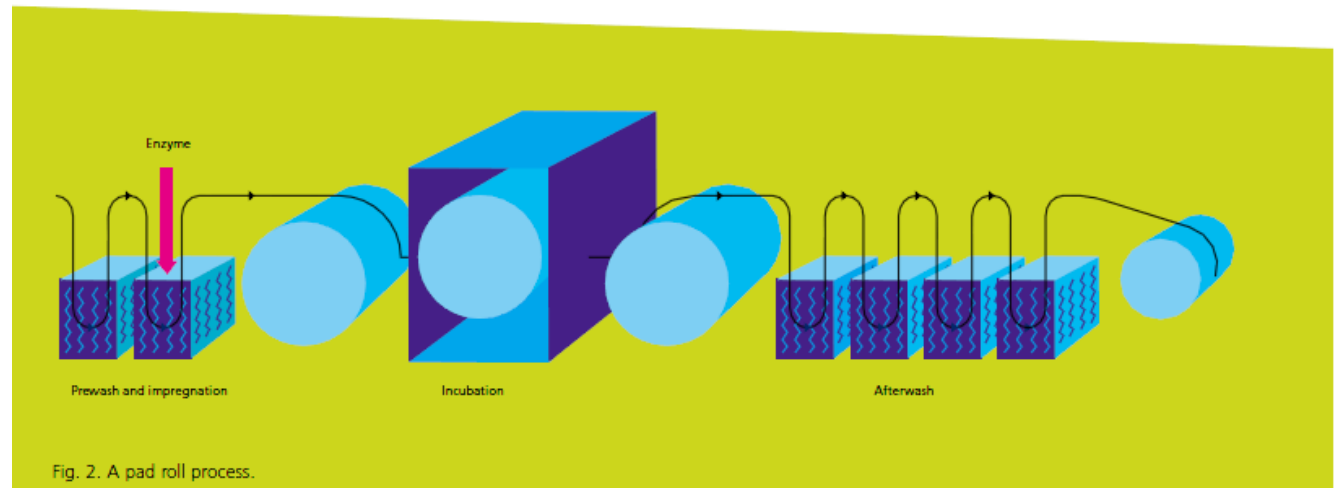
# Cloth Industry

## Faded Jeans

## Enzymatic desizing of cotton fabric



cellulase



Otto Rohm first patented the use of pancreatic enzymes in 1913, since then use of enzymes in detergent  
Come a long way



- Proteases
- Lactases
- Maltases
- Lipases
- Alpha-amylase
- Cellulases

Lower temperature  
Efficient  
No environmental hazard  
Softer fabric





•Papaya contains an enzyme, papain, which is a mild whitening agent and is used in toothpastes to remove enamel stains.

