ADVANCED ENZYME TECHNOLOGY

INDUSTRIALLY IMPORTANT ENZYMES

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Chapter Description

- Expected Outcomes
  - To be able to explain the enzymes that are important in industries.
  - To be able to compare the Chemical transformation processes versus enzymatic processes.
  - To be able to discuss about Safety or environmental issues of enzyme usage.
- References
  - Ryan SM, Fitzgerald GF and Van Sinderen D. Screening for and identification of starch-, amylopectin-, and pullulan degrading activities in bifidobacterial strains. Appl. Environ. Microbiol. 2006;72:5289- 5296.

CONTENT

- Introduction to industrially important enzymes.
- History of enzyme technology.
- Chemical transformation processes versus enzymatic processes.
- Source of industrial enzymes.
- Safety or environmental issues of enzyme usage.
- Most common industrial enzymes.

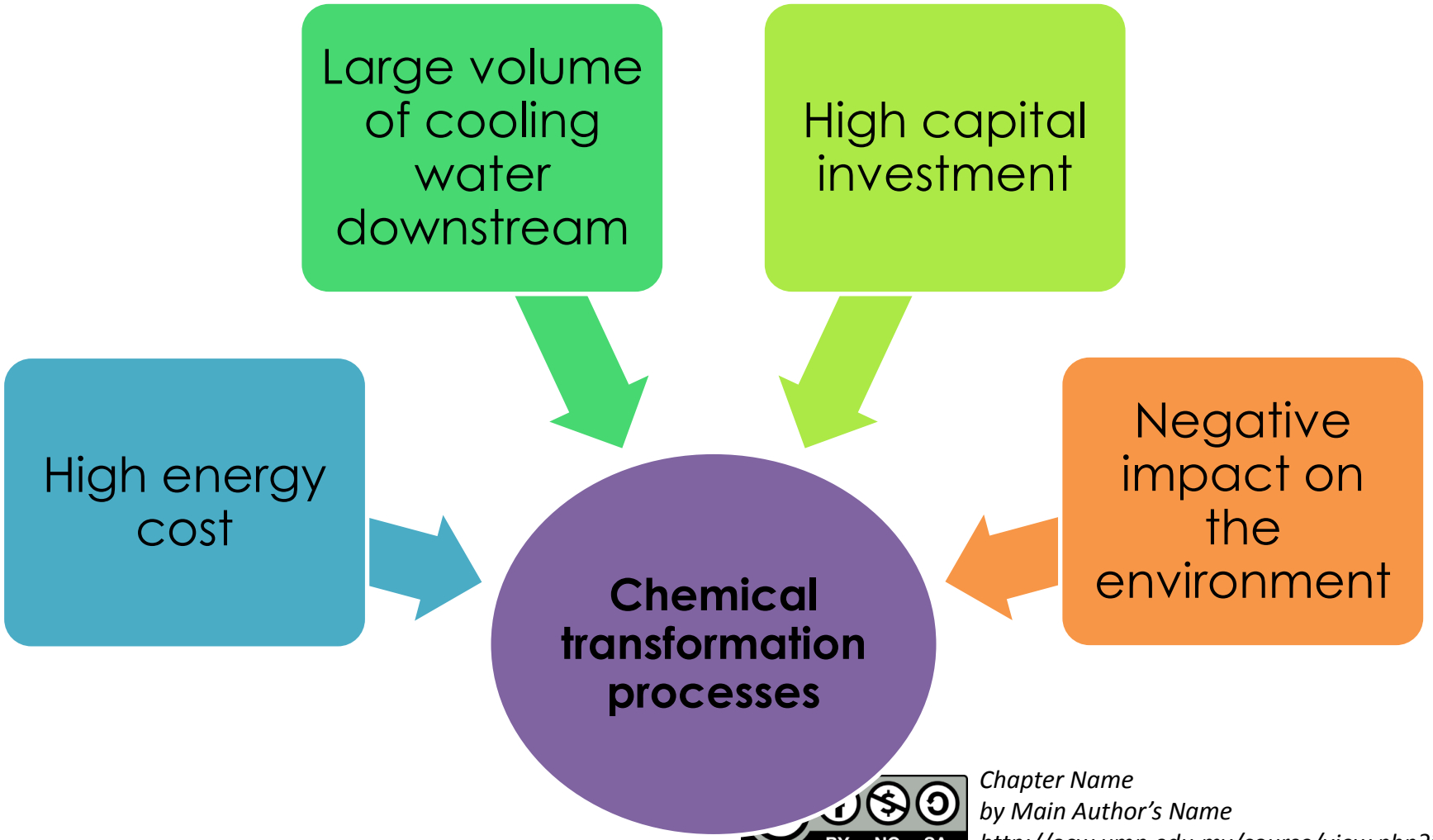
INTRODUCTION

- Currently, the **amount of candidate enzymes** that shown **high impact** for processes industry and chemical reactions industry is **fast growing**.

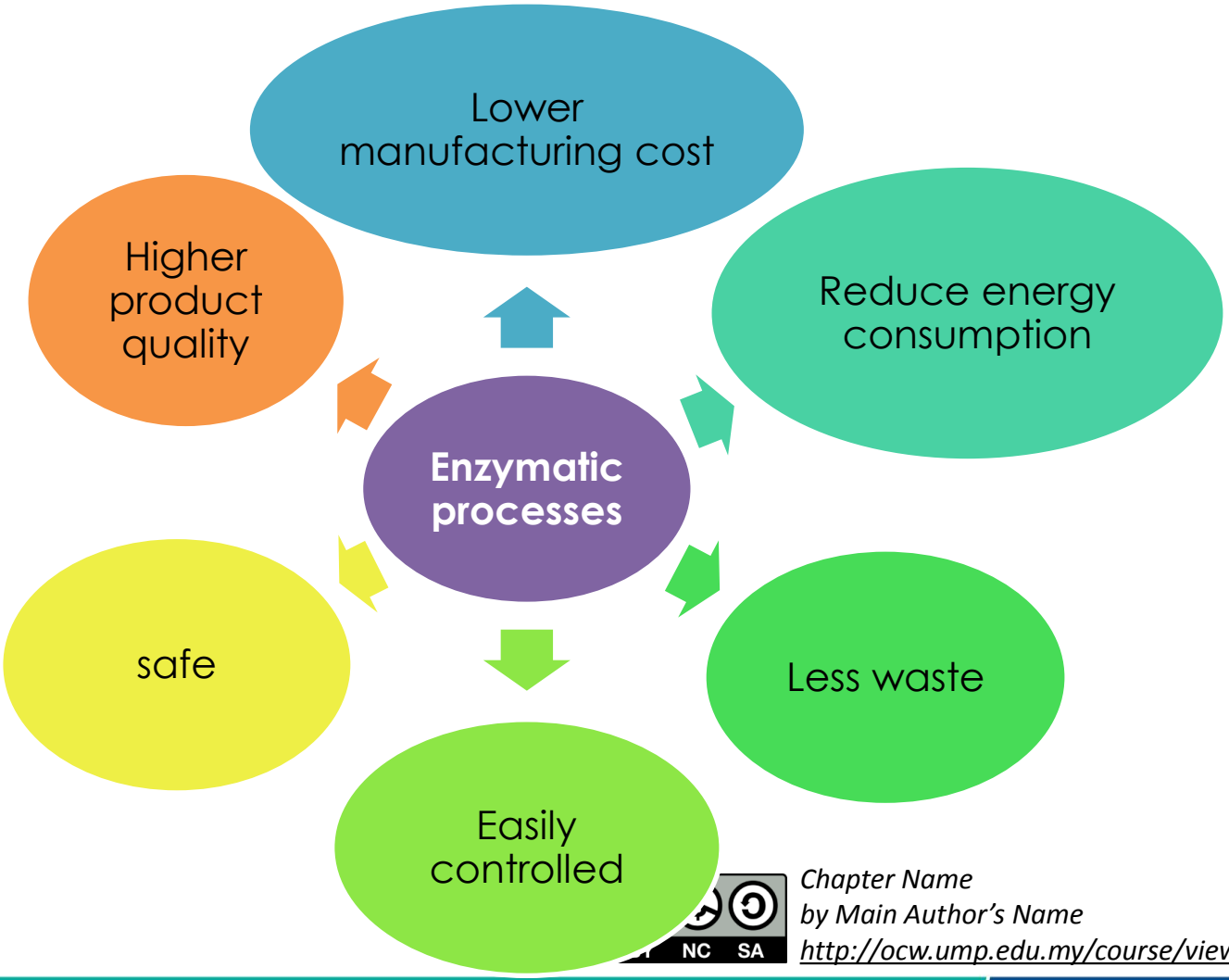
- This growth was encouraged by a **growing demand for biocatalysts that outfit industrial application**.

- Enzyme technology can be defines as **the production of goods and services via the applications of biocatalysts including free enzymes and whole cell**.

What is the drawback of chemical transformation processes?



Why industrial enzymes?



Sources of Industrial Enzymes

- **Any living organism** can be a source of biologically active enzyme:
- Of the hundred enzymes being used in industry:
    - **half** of them are isolated from **fungi**
    - **over a third** have been isolated from **bacteria** while the **leftover sources is** come from **animal** (8%) and **plant** (4%).

Source: Ryan et al., 2006

Why enzymes from microbes?

Microbes are preferred to plants and animals as sources of enzymes due to:

- **Low-cost** production.
- Easy to predict and control their enzyme contents.
- **No potential harmful materials** compared to **plant and animal tissues** , (e.g: **phenolic compounds** from plants).

- Wide range of catalysis,
- **high catalytic activities**,
- **Simple genetic manipulation**,
- **Consistent supply** (No seasonal fluctuations)
- **Fast cultivation using** low-cost media.

ENZYMES PRODUCTION FROM FUNGI SOURCES WITH ITS APPLICATION

Enzyme	Sources	Application
a-Amylase	*Aspergillus*	Baking
Catalase	*Aspergillus*	Food
Cellulase	*Trichoderma*	Waste
Dextranase	*Penicillium*	Food
Glucose oxidase	*Aspergillus*	Food
Lactase	*Aspergillus*	Dairy
Lipase	*Rhizopus*	Food
Rennet	*Mucor miehei*	Cheese
Pectinase	*Aspergillus*	Drinks
Protease	*Aspergillus*	Baking

ENZYMES PRODUCTION FROM FUNGI SOURCES WITH ITS APPLICATION

Enzyme	Sources	Application
a-Amylase	*Bacillus*	Starch
b-Amylase	*Bacillus*	Starch
Asparaginase	*Escherichia coli*	Health
Glucose isomerase	*Bacillus*	Fructose syrup
Penicillin amidase	*Bacillus*	Pharmaceutical
Protease	*Bacillus*	Detergent

Enzymes for safety or environmental issues

- Used as an agent that can **replace acid and alkalis** in the starch processing and fabric desizing industries, respectively .
- **Decrease sulphide usage** in tanneries.
- **Substitute pumice stones** for "stonewashing" of denim.
- **Less production of animal waste** resulted from efficient digestion of animal feed.

Enzymes for safety or environmental issues

- Can replace **chlorine bleach** for stains removal on cloth.
- Can reduce the amount of surfactants in laundry process and allow the washing of clothes in the absent of **phosphates**.
- Reduce the number of **chemical treatment** in production processes which lead to safer working environment.

Most common industrial enzymes

lipase breaks down fats

protease breaks down proteins

carbohydrase breaks down carbohydrates

Carbohydrases

- Carbohydrases contribute to the largest group of important industrial enzymes.
- responsible to catalyse the hydrolysis of **carbohydrate substrates into its reducing or simple sugars.**
- For example:

Maltase hydrolyse maltose into glucose:

$C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6$

Maltose + Water → a-Glucose

Carbohydrases

- Other examples of carbohydrases including **amylase, cellulose, lactase,** and **pectinase**.
- They also constitute the **largest market share** in detergent, textile, food and beverage industries.

Lipases

- A group of enzymes which capable to catalyse the hydrolysis of long chain triglycerides.
- Lipases is categorized among the most essential group of biocatalysts for biotechnological applications.
- Commonly have been utilized in baking, textile and detergent industries.
- New biotechnological applications of lipases is for the biopolymers and biodiesel synthesis, enantiopure pharmaceuticals formation, agrochemicals, and flavour compounds production.

Isolation of Lipases from various microorganisms

Lipase producing Microorganisms	Reference
Bacillus sp.	[36,191,42,35]
Bacillus subtilis	[192,193]
Bacillus thermoleovorans	[194]
Bacillus thermocatenulatus	[180]
Bacillus coagulans	[181]
Pseudomonas sp.	[195]
Pseudomonas aeruginosa	[196,197]
Pseudomonas fluorescens	[198]
Pseudomonas fragi	[199]
Enterococcus faecalis	[200]
LactoBacillus plantarum	[201]
Staphylococcus haemolyticus	[202]
Staphylococcus aureus	[203,204]
Staphylococcus warneri	[205]
Staphylococcus xylosus	[206]
Penicillium cyclopium	[207,208]
Penicillium simplicissimum	[209]
Aspergillus niger	[210]
Aspergillus oryzae	[211]
Botrytis cinerea	[212]
Chromobacterium viscosum	[213]
Streptomyces flavogriseus	[214]
Trichosporon asteroides	[215]
Trichosporon laibacchii	[216]
Rhizopus sp.	[92]
Rhizomucor miehei	[217]
Geotrichum candidum	[218,219]
Pichia burtonii	[220]
Candida cylidracae	[221]
Acinetobacter sp.	[51]
Fusarium solani	[222]

Source: F. Hasan et al. Enzyme and Microbial Technology 39 (2006) 235–251

Proteases

- Classified as proteolytic enzymes which **catalyze the degradation of peptide bonds** in proteins.
- Have been applied in several important industries such as **pharmaceutical, food, detergents, leather bioremediation processes**.
- Used in laundry detergent for **protein based stains removal from clothing.**



Proteases

- In **textile industry**, proteases help in improved lustre and softness of raw silk fibre by removing the stiff and dull gum layer of sericin .

- Also, protease treatments can **modify the surface of wool and silk fibres** to provide new and unique finishes.