

INTRODUCTION TO BIOLOGICAL CHEMISTRY

Assoc. Prof. Inthawoot Suppavorasatit, Ph.D.

2314375 Biological Chemistry for Biotechnology

Introduction

2

□ Biotechnology

▣ Technology based on biology

- Biotechnology controls cellular and biomolecular processes to develop technologies and products to improve something!
 - For example, bread can be made by using yeast to produce CO_2 gas to raise dough volume before baking



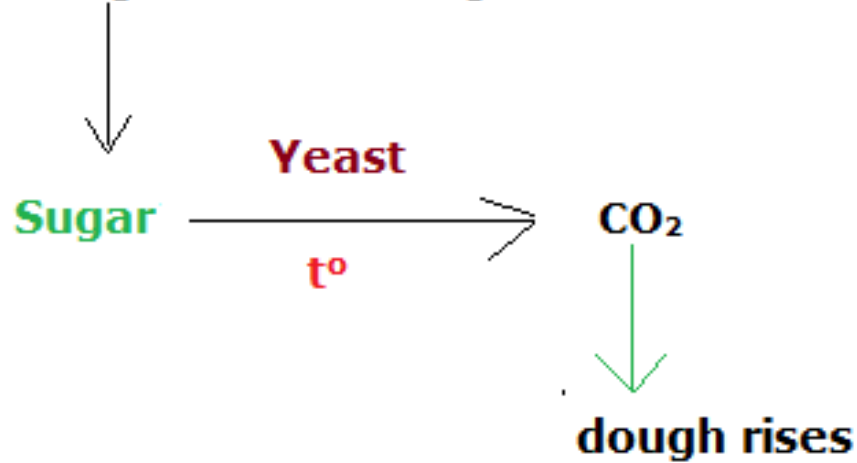
Introduction (cont.)

3

□ Baking yeast

Using yeast in baking

yeast + flour + sugar + H₂O → dough



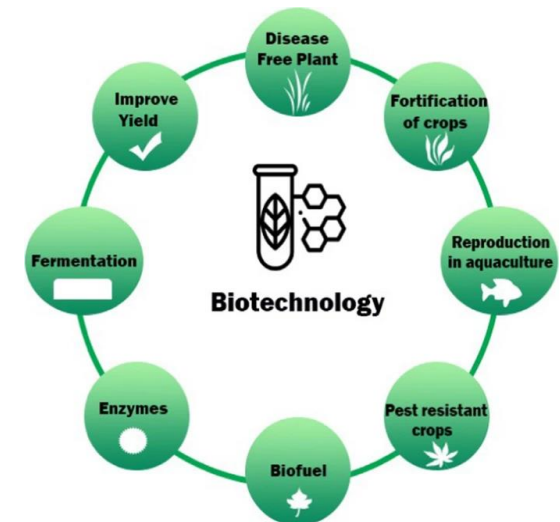
Introduction (cont.)

4

□ Biotechnology (another thought)

- Biotechnology is technology that utilizes biological systems, living organisms or parts of this to develop or create different products

■ Biotechnology in Food and Agriculture



Introduction (cont.)

5

- Modern biotechnology provides breakthrough products and technologies to
 - ▣ Combat diseases
 - ▣ Providing sustainable fuels (cleaner energy)
 - ▣ Feed the hungry
 - ▣ Give more efficient industrial manufacturing processes

Introduction (cont.)

6

- In order to know how to earn those benefits from biotechnology, one of important subjects describing about things in living organisms is **Biological Chemistry of Biochemistry!**
- Biochemistry/Biological Chemistry is the field of science that studies the chemical processes taking place within living organisms at the molecular level
 - ▣ For example: interaction of small molecule with large macromolecules such as protein

Biological Chemistry

7

- Subject that explores chemical processes related to living organisms by studying substances in term of their
 - ▣ Structure
 - ▣ Composition
 - ▣ Chemical reactions
- Also, studying their functions and ways to control them

Metabolism

8

- In cells of a living organisms, the chemical reactions can be occurred to sustain their life called “metabolism”
- Metabolism
 - ▣ Metabolic processes in living organisms lead to
 - Growth and reproduction
 - Maintain their structures
 - Respond to the surrounding environment
 - ▣ All chemical reactions that occur in living organisms can be part of metabolism, including digestion, transportation of substances from cell to cell, etc.

Metabolism (cont.)

9

- There are two categories of metabolism

- Catabolism

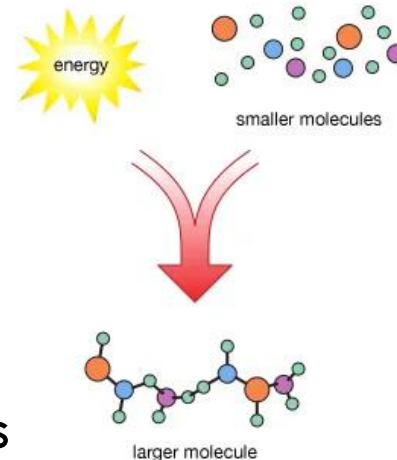
- The breakdown of organic matter

- Anabolism

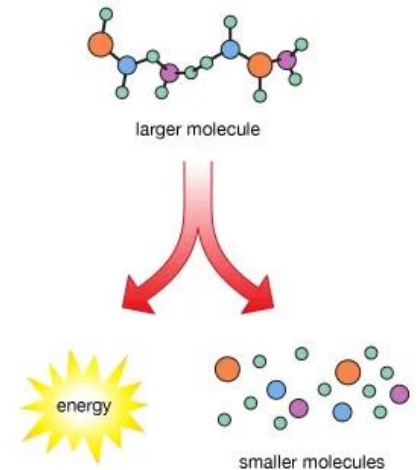
- The construction of components of cells, such as proteins and nucleic acids by using energy

Metabolism

anabolic reaction



catabolic reaction



© 2013 Encyclopædia Britannica, Inc.

Macromolecules and Metabolites

10

- Metabolites are the intermediate products produced during metabolisms, e.g. antibiotics and pigments
 - ▣ Primary metabolites
 - ▣ Secondary metabolites
- These metabolites can be formed from **macromolecules** in the organisms

Macromolecules and Metabolites (cont.)

11

- Macromolecules are large molecules formed by the polymerization of smaller molecules called monomers
 - ▣ There are 3 main types of macromolecules
 - Carbohydrates
 - Proteins
 - Lipids

Macromolecules and Metabolites (cont.)

12

□ Carbohydrates

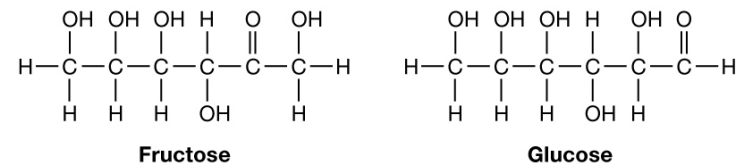
- ▣ Most abundant biomolecules on earth
- ▣ Carbohydrates are polyhydroxy aldehydes or ketones

- Monosaccharides

- Oligosaccharides

- Polysaccharides

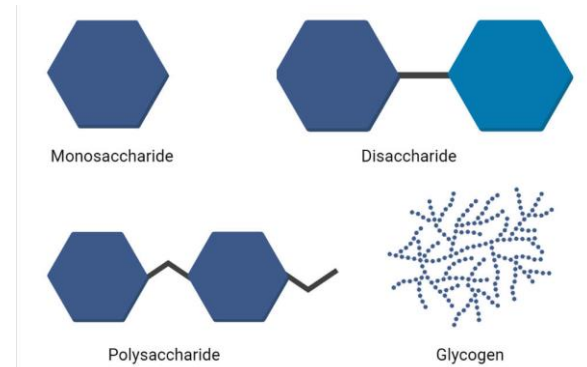
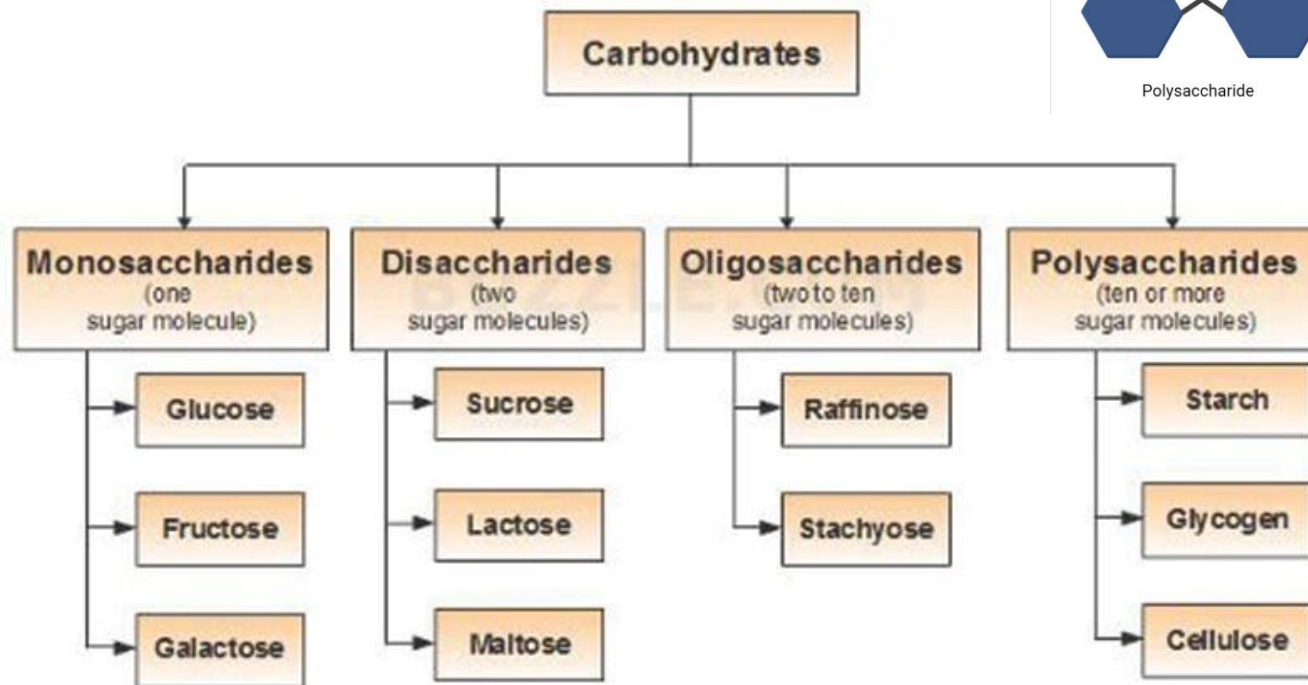
- ▣ Can cause so many reactions or interactions and produce so many products



Macromolecules and Metabolites (cont.)

13

□ Carbohydrates



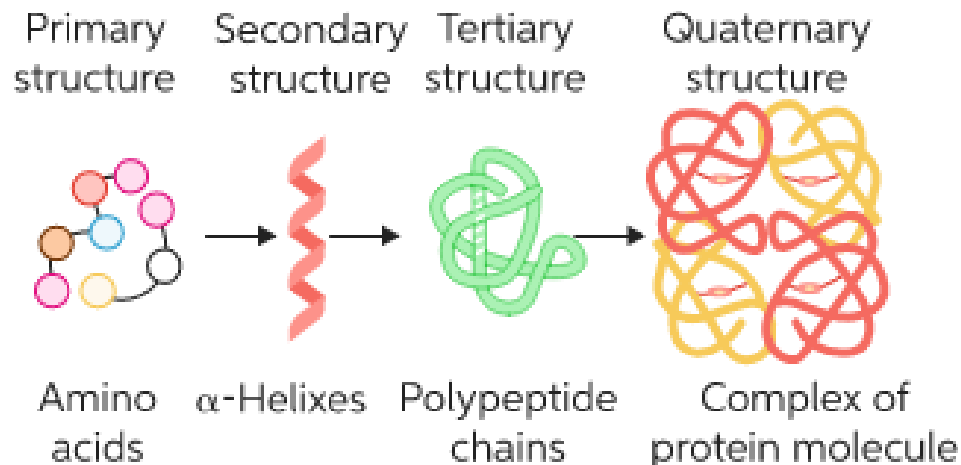
Macromolecules and Metabolites (cont.)

14

□ Proteins

- ▣ Polymers of amino acids linked by peptide bonds
- ▣ Most diverse range of functions of all macromolecules

Protein structure

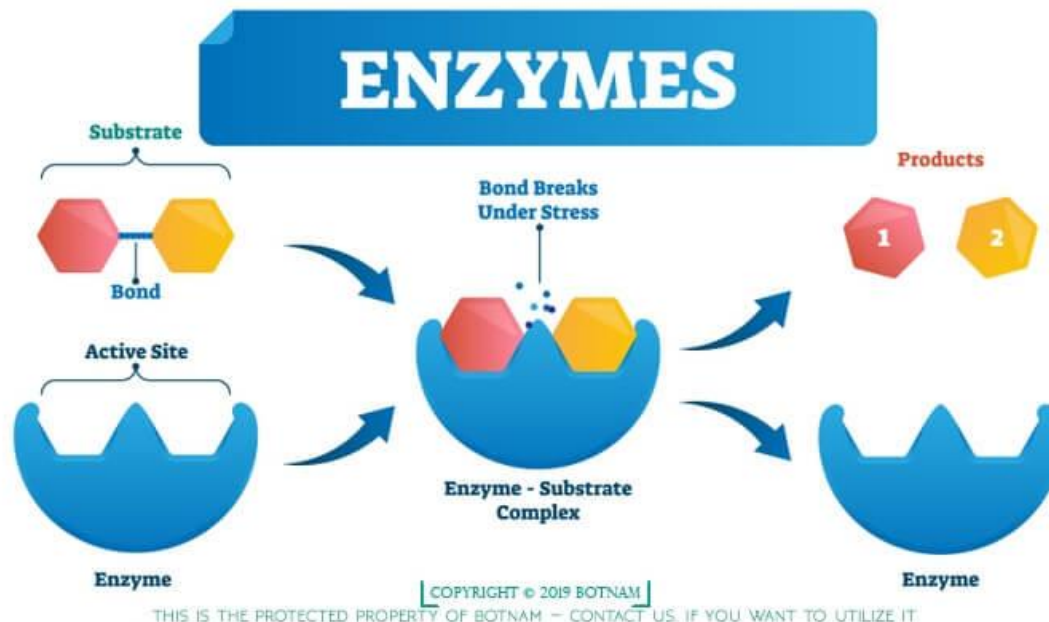


Macromolecules and Metabolites (cont.)

15

□ Proteins

- Enzymes are proteins that contain biological catalysts property to accelerate biochemical reactions



Macromolecules and Metabolites (cont.)

16

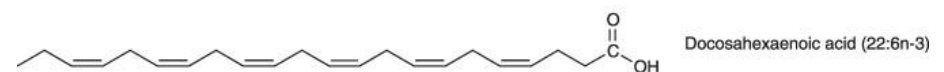
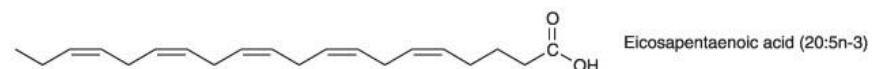
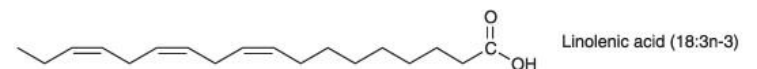
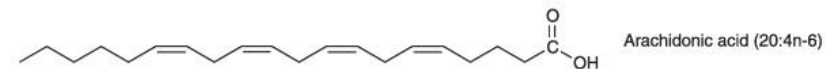
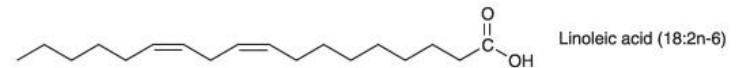
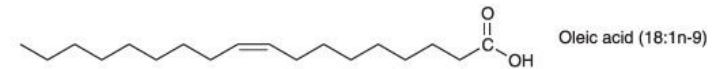
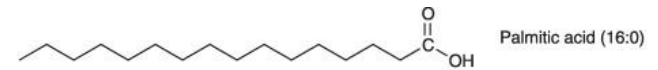
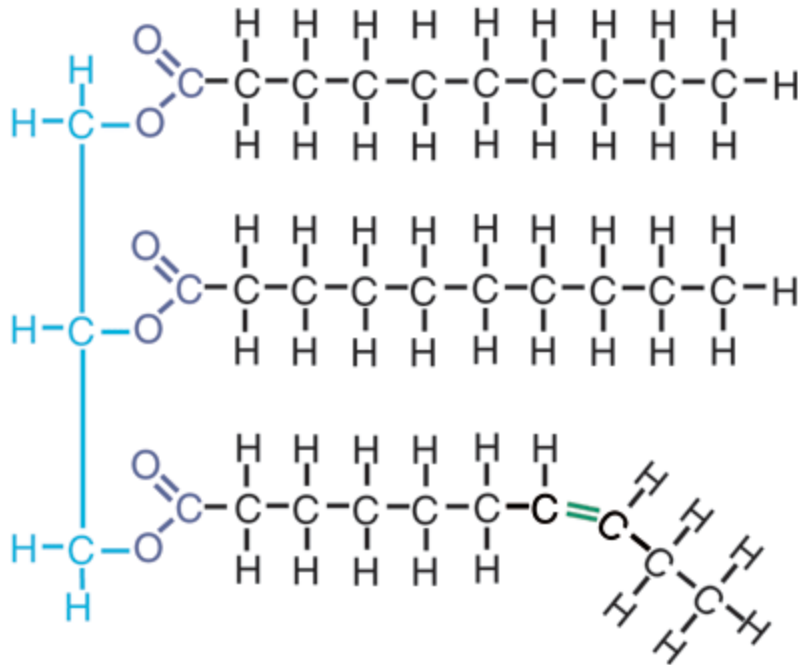
□ Lipids

- ▣ An essential component of the cell membrane
- ▣ Hydrophobic set of macromolecules
 - Do not dissolve in water
- ▣ Lipid structure consists of 2 main components
 - Glycerol
 - Fatty acids

Macromolecules and Metabolites (cont.)

17

□ Lipids



Macromolecules and Metabolites (cont.)

18

□ Primary metabolites

- ▣ The chemical compounds produced during the growth, development, and reproduction processes of organisms
- ▣ They are also involved in the primary metabolic processes of respiration and photosynthesis
 - Maintain the physiological functions of the body
 - Known as central metabolites
- ▣ They are the intermediate products of anabolic metabolism
 - Used by the cells for the formation of essential macromolecules

Macromolecules and Metabolites (cont.)

19

□ Primary metabolites

▣ For example:

- Amino acids
- Vitamins
- Organic acids
- Alcohols

Macromolecules and Metabolites (cont.)

20

□ Secondary metabolites

- Organic compounds produced by the organisms that are **not required** for primary metabolic processes
 - Do not play role in the growth, development, and reproduction
- Considered to be the end products of primary metabolites since they are derived by the pathways that the primary metabolites involve
- Many of secondary metabolites have a role in ecological function, including defense mechanism(s)

Macromolecules and Metabolites (cont.)

21

□ Secondary metabolites

▣ For example:

- Antibiotics
- Toxins
- Pheromones
- Enzyme inhibitors

Biological chemistry in biotechnology

22

- As we know that biological chemistry is the study of chemical processes taking place within living organisms
- ▣ Biotechnology can apply technology to the biological knowledges
 - The application of known mechanisms within the field of biological chemistry for further production of useful products
 - For example, producing a drug that can be utilized at the precise target within a cell

Biological chemistry in biotechnology (cont.)

23

□ Biochemical technology

- ▣ A biochemical process that can be applied to biotechnology
 - The use of enzymes within the industry is offering an environmentally friendly and highly efficient alternative to traditional chemical synthesis

Biological chemistry in biotechnology (cont.)

24

□ Biochemical technology

- ▣ The enzymes were already being utilized as catalysts for industrial applications such as
 - Production of glycerol by the fermentation of yeast
 - Production of citric acid using *Aspergillus niger*
 - Production of several antibiotic precursors from an enzyme found in some bacteria, yeast, and fungi
 - Immobilizing enzymes onto a solid substrate
 - Can be recycled and reused without the high costs in the isolation and purification of large quantities of enzymes

Biological chemistry in biotechnology (cont.)

25

- Advances in DNA technology
 - ▣ Produce proteins of interest in much greater numbers from bacteria or yeast than normal sources
 - The DNA sequence can be identified and inserted into a plasmid and expressed
 - ▣ Increase availability of enzymes produced
 - For example: recombinant chymosin replacing that sourced from calf stomachs in the production of cheese

Biological chemistry in biotechnology (cont.)

26

- A trends in food industry: Meat analogues
 - ▣ Meat analogues can be made from
 - Cell cultured
 - Plant-based proteins



<https://www.new-harvest.org/>

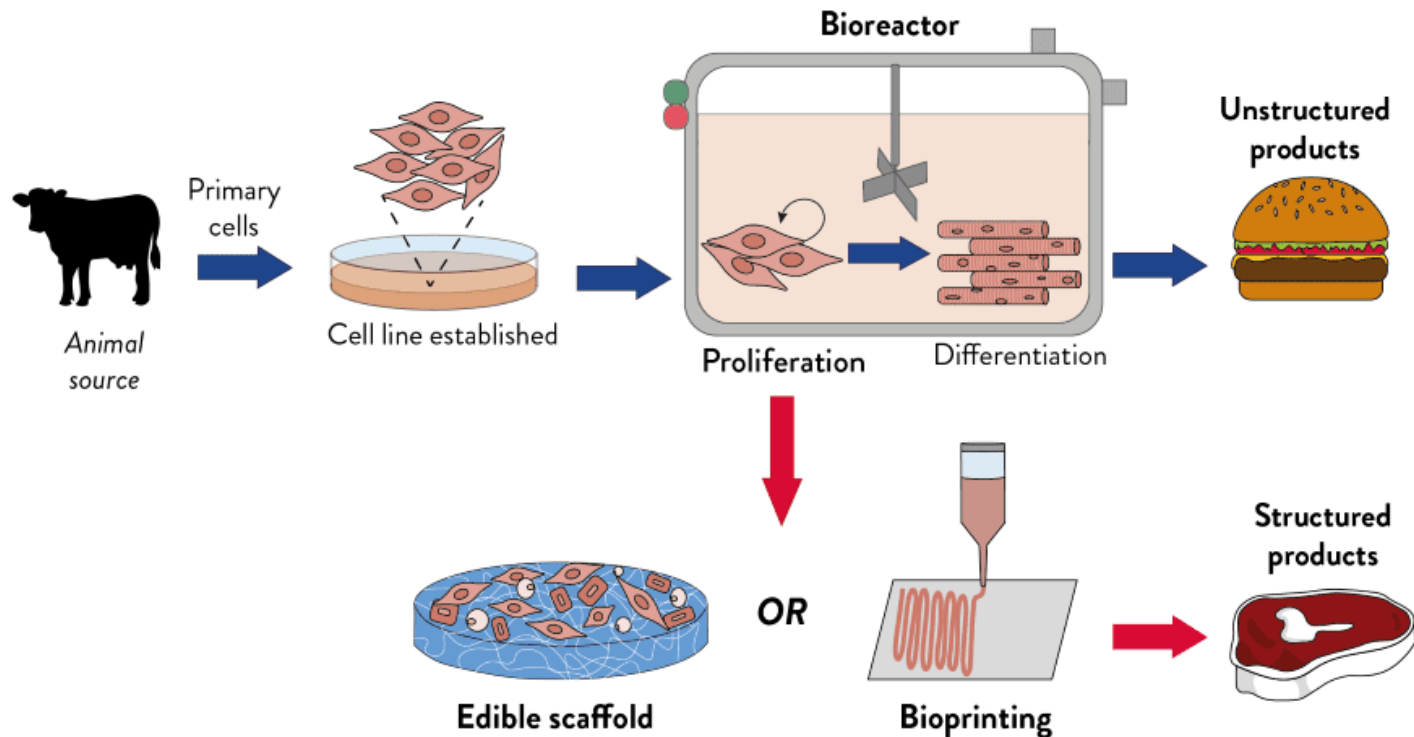
<https://www.foodbusinessnews.net/articles/11501-plant-protein-options-for-meat-alternatives>

<https://www.wur.nl/en/project/Microencapsulation-of-iron-and-vitamins-in-plant-protein-based-structured-foods.htm>

Biological chemistry in biotechnology (cont.)

27

- A trends in food industry: Meat analogues
 - ▣ Meat analogue from cell cultured



Biological chemistry in biotechnology (cont.)

28

- A trends in food industry: Meat analogues
 - ▣ In order to scale up for mass production, there are 5 main areas that need to be concerned

Cost of Cell Media and Growth Factors

Cost-effective serum-free medium is essential to reduce the price of cultured meat products.

Availability of Suitable Cell Lines

The industry needs to develop the best cell lines for making high volumes of good quality, cultured animal tissue.

Affordable & Suitable ECM

Availability of affordable and best-suited extracellular matrices for each individual cell line to enable efficient growth in initial cell cultures.

Bioreactor Design and Efficiency

The best-suited and most efficient bioreactors need to be developed for different cell types to allow for industrial-scale cell cultivation.

Scaffolding Materials and Design

Identification of the best scaffolding materials, ideally edible, and methods to enable large-scale production is vital for the commercialisation of structured meat products.

Biological chemistry in biotechnology (cont.)

29

□ A trends in food industry: Meat analogues

▣ Plant-based proteins

■ Impossible burger (one of success products)

- Start working on research in 2011, > \$800 million
- Identifying the molecule that makes meat taste like meat called “**heme**”
- Tastes like burger
- Cooks like burger
- “**Bleeds**” like burger

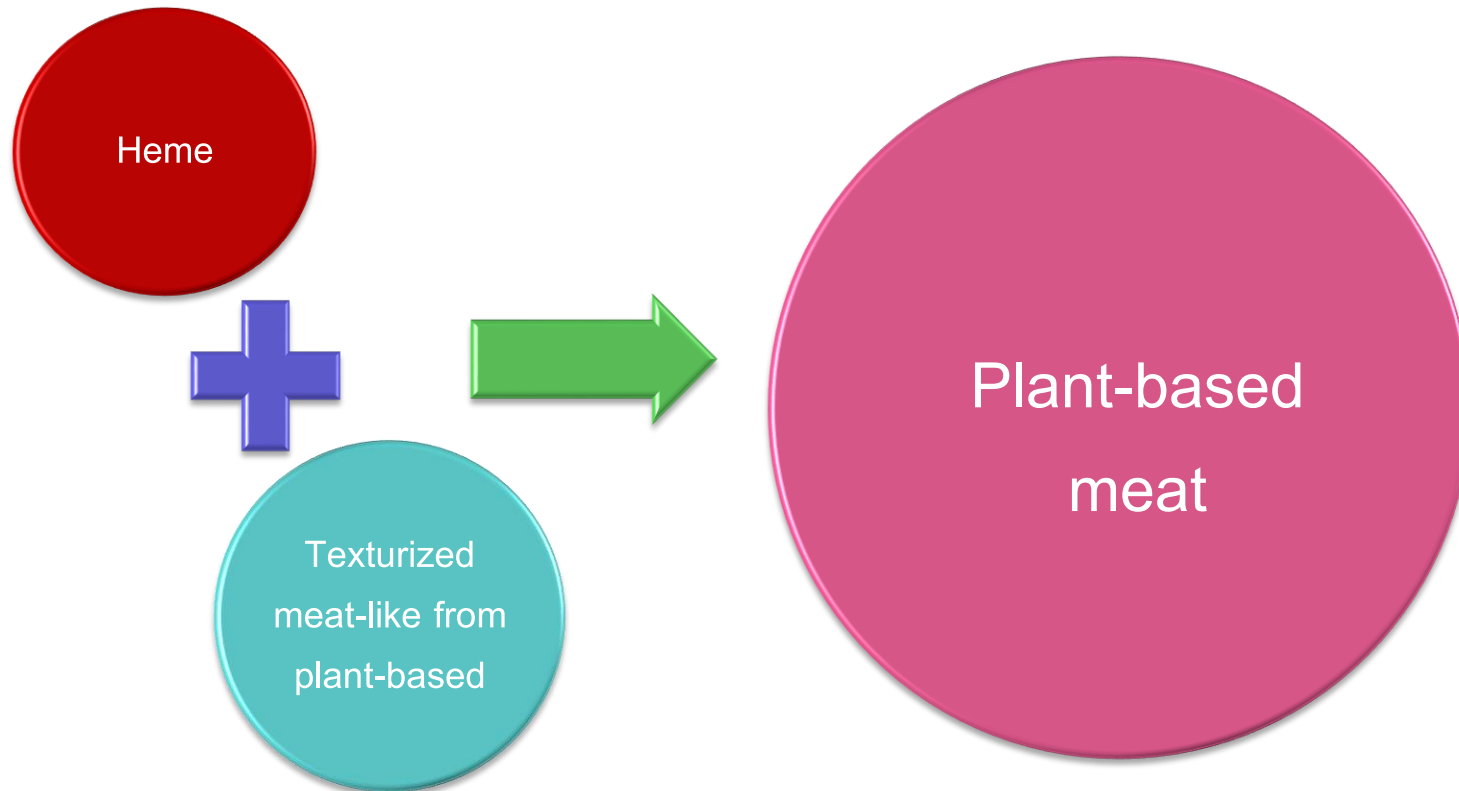
■ **Heme** is made by genetically modified



Biological chemistry in biotechnology (cont.)

30

- A trends in food industry: Meat analogues
 - ▣ Impossible burger (one of success products)



Biological chemistry in biotechnology (cont.)

31

- A trends in food industry: Meat analogues
 - ▣ Impossible burger (one of success products)



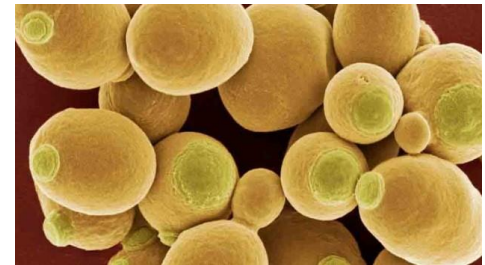
Biological chemistry in biotechnology (cont.)

32

- A trends in food industry: Meat analogues
 - ▣ Impossible burger (one of success products)

- Heme

- Important to form flavor in meat
 - Produce heme by GMO



<https://medium.com/impossible-foods/heme-health-the-essentials-95201e5affa>

<https://www.geek.com/news/soon-well-be-eating-real-egg-whites-that-never-passed-through-a-chicken-1627782/>

<https://medium.com/impossible-foods/how-gmos-can-save-civilization-and-probably-already-have-6e6366cb893>



The END

Any Questions?