http://smtom.lecture.ub.ac.id/
Password:

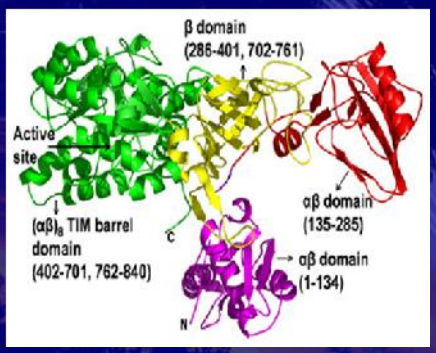
Plant Biochemistry
Lecture 1: General Introduction

SUBSTRATE(S) + EMZYME(S) → PRODUCT(S)

The conversion of substrates to products through biochemical reactions which catalyzed by enzymes

Science without religion is lame, religion without science is blind.
--Albert Einstein

Catalase



Balasubramanian & Ponnuraj, 2010

WELCOME TO THE COURSE OF PLANT BIOCHEMISTRY

Who am I?: Prof. Dr. S.M. Sitompul

These are my rules

- Come on time (± 10') with a proper dress
- Get into the lecture room, don't hang around
- Use English in my lecture and exam (75-99%)

- These are my philosophies
  - Turn your enemies to be your friends
  - Turn your useless time to be useful time
  - Make big problems to be small problems
  - Simplify the systems or problems

STRUCTURED TASK

1. English Presentation
   - Every student has to make English Presentation
2. Dictionary
   - Take your English dictionary every time I give my lecture
3. My Dictionary
   - Buy a writing book (100-pages) and name it MY DICTIONARY
   - Write down all English words with Indonesian meanings that you do not know yet

4. Literature Study
   - Every student has to undertake literature study to obtain more and detail information as to the lecture materials
5. Study Groups
   - Organize your study group, 5 member each to discuss the lecture materials
6. Paper (NO COVER)
   - *Write a paper about Plant Biochemistry or a summary of* a published papers in international Journal (internet)
   - *One (1) page only, (single space) arranged in several paragraphs (4-5 sentences/ paragraph), font (Times New Roman 12)*

EXAMPLE **Urease**

Siti

Paragraf 1. Uraikan informasi umum mengenai Urease (kapan ditemukan & siapa penemunya, dimana terdapat umumnya, dll)

Paragraf 2-3. Uraikan fungsi catalase khususnya pada tanaman termasuk reaksi yang dikatalisis dan pengaruh faktor lingkungan (mis. pH, temperatur, dll.)

Paragraf 4-5. Uraikan perkembangan hasil penelitian tentang urease paling terakhir termasuk gambar kristalmya)

Paragraf 5. Kesimpulan

References (3 at least for paper, and 1 for a summary, international)

http://www.dina.dk/efita-conf/program/papers.htm

PAPER TOPICS

ENZYMES

1. Catalase
2. Amylase
3. Urease
4. Sucrase
5. Cellulase
6. Lipase
7. Lactase
8. Pectinase
9. Phytase
10. Pectinase
11. Xylanase
12. Maltase
13. Papain
14. Bromelain
15. Trypsin
16. Supetoxide dismutase
17. Ascorbate peroxidase
18. Alanine aminotrasferase
19. Nitrite reductase
20. Nitrate reductase
21. Glutamine synthetase
22. Glutamate synthase
23. Glutamate dehydrogenase
24. Glutaminase
25. Asparagine synthase
26. Arginine deiminse
27. Ficin

28. Dextrase
29. Pectinase
30. Actinidin

COMPOUNDS

Chemical Structure, Function and Synthesis

31. Cathecin
32. Theaflavins
33. Capsaicinoids
34. Berberine
35. Capsidiol
36. Hyoscyamine
37. Codeine
38. Rishitin
39. Jasmonic acid
40. Anthraquinones
41. Diosgenin
42. Rosmarinic acid
43. Saponin
44. Scopoletin
45. Anthocyanin
46. Kinobeon
47. Methoxymellein
48. Salidroside
49. Shikonin

LEARNING OUTCOMES

Students, after mastering materials of the present lecture, should be able

1. to explain plant biochemistry in general
2. to identify the basic molecules which make up plant
3. to describe the way in which chemical components are synthesized and utilized by plants in the life process
4. to describe the process of pant life on a chemical level
5. to initiate ways from the standpoint of biochemistry to improve the growth of plants or to solve problems in plant growth

LECTURE OUTLINE

SUMMARY
LEARNING OUTCOMES
STRUCTURED TASK
COURSE PLAN
REFERENCES

I. INRODUCTION
1. Definition
2. Basic Principle

II. BIOMOLECULES
1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleic acids

III. BICHEMISTRY IMPORTANCE
1. Biochemistry Use
2. The Core of Plant Biochemistry

IV. BREAKTHROUGHS IN BIOCHEMISTRY
1. Enzyme and DNA
2. Genetic Engineering

Examples of Biochemistry

COURSE PLAN

NO.	TOPICS	Subject
1.	INTRODUCTION	
2.	ENZYME I	Introduction
3.	ENZYME II	Kinetics
4.	ENZYME II	Mechanism & Inhibitor
5.	CARBOHYDRATE I	Introduction
6.	CARBOHYDRATE II	Classification
7.	METABOLIC ENERGY	
8.	MID SMESTER EXAM	
9.	LIPID	
10.	AMINO ACIDS	
11.	BIOLOGICAL N FIXATION	
12.	NUCLEIC ACID	RNA and DNA
13.	PROTEIN SYNTHESIS I	Genome and gen
14.	PROTEIN SYNTHESIS II	Transcription and Translation
15.	SECONDARY METABOLITES	
16.	END SMESTER EXAM	

REFERENCES

1. Berg, J.M., Tymoczko, J.L. and Stryer, L., 2002. Biochemistry. 5th edition: W.H. Freeman and Co,. New York
2. Buchanan, B.B., Gruissem, W. and Jones, R.L., 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists
3. Conn, E.E. & Stumpf, P.K., 1976. Outlines of Biochemistry. John Wiley & Sons, New York.
4. Goodwin, T.W. & Mercer, E.I., 1990. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
5. Stryer, L., 1975. Biochemistry. W.H. Freeman and Company, San Francisco
6. Wood, W.B., Wilson, J.H., Benbow, R.M., & Hood, L. E., 1981. Biochemistry A Problems Approach.

I. INTRODUCTION

1. Definition

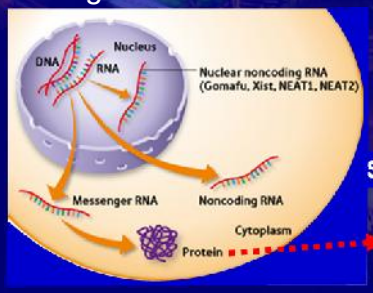
What is Plant Biochemistry ?

1. Biochemistry is *the study of molecular basis of life* (Stryer, 1975)
2. Biochemistry is the study of the way in which chemical components are synthesized and utilized by the organism in the life process (Goodwin & Mercer, 1990).

Plant Biochemistry is the study of molecular basis of plant life that includes the synthesis and utilization of compounds in the life process of plants (growth & development).

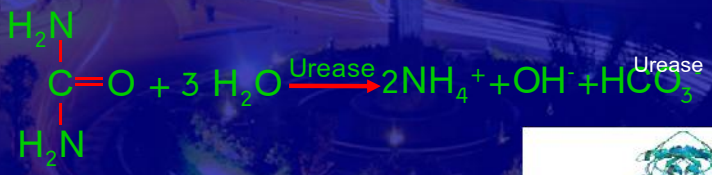
2. Basic Principle

- Living organisms, whether they are plants, animals or microbes, are made up basically of the same chemical components
- The formation of compounds (biomolecules) required in the living process of plants, from the chemical components, occurs through biochemical reactions catalyzed in most cases by enzymes under genetic control and environmental influence.



SUBSTRAT + ENZIM → PRODUK

- Enzymes, therefore, are crucial in the biochemical process of plant life. For example, the break down of urea to be ammonium occurs through a hydrolysis reaction catalyzed by enzyme *urease*.



- Urease from jack beans (*Canavalia ensiformis*) was the first enzyme ever purified and crystallised, an achievement of James B. Sumner in 1926 who earned a Nobel Prize in Chemistry in 1946

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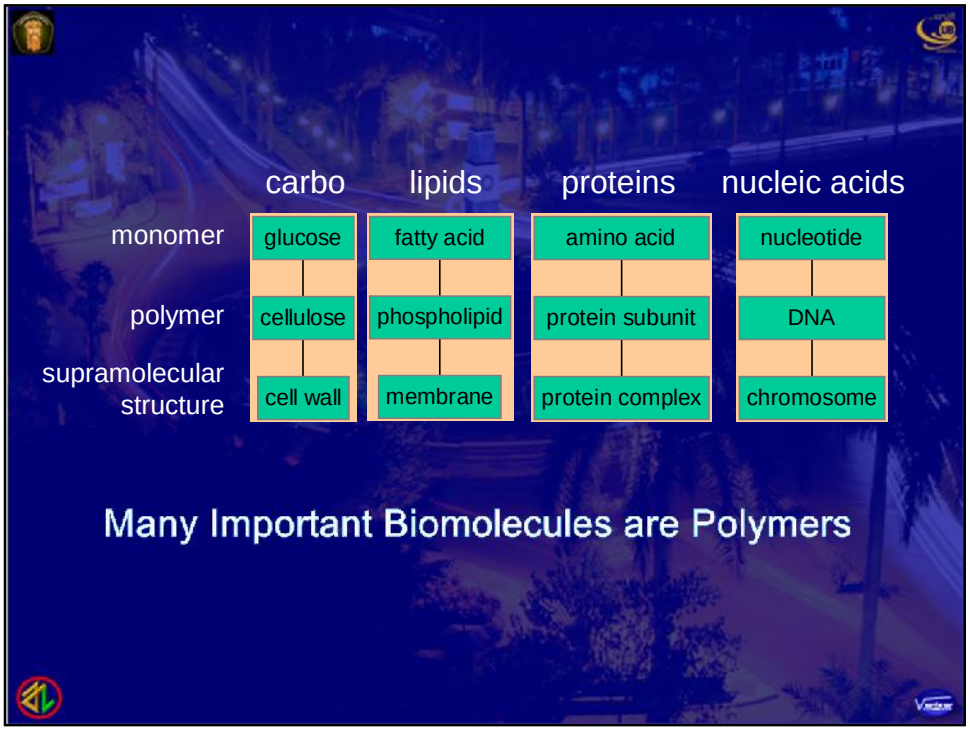
II. BIOMOLECULES

What are Types of Molecules studied in Biochemistry?

- The principal types of biological molecules, or biomolecules are:
  - carbohydrates
  - lipids
  - proteins
  - nucleic acids

- Many of these molecules are complex molecules called polymers which are made up of monomer subunits
- Biochemical molecules are principally based on carbon.



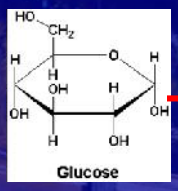
Many Important Biomolecules are Polymers

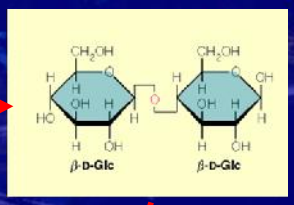
1. Carbohydrates

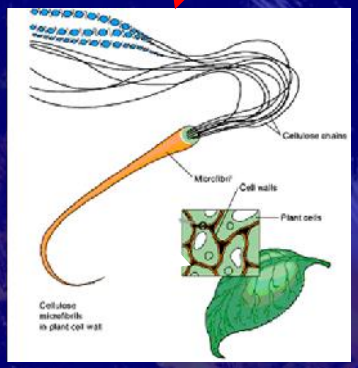
monomer — glucose

polymer — cellulose

supramolecular structure — cell wall

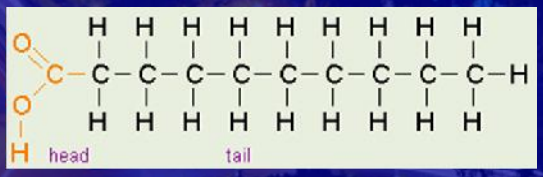






- Cellulose is the major structural material of plants. Wood is largely cellulose, and cotton is almost pure cellulose.

Lipids



One Fatty Acid

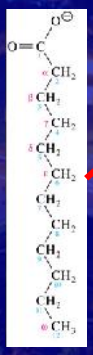
- The "head" of the molecule is a carboxyl group which is hydrophilic.
- The "tail" of a fatty acid is a long hydrocarbon chain, making it hydrophobic.
  - Fatty acids are the main component of **soap**, where their tails are soluble in oily dirt and their heads are soluble in water to **emulsify** and wash away the oily dirt. However, when the head end is attached to glycerol to form a fat, that whole molecule is hydrophobic.

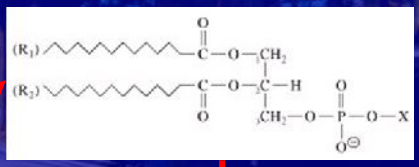
Lipids

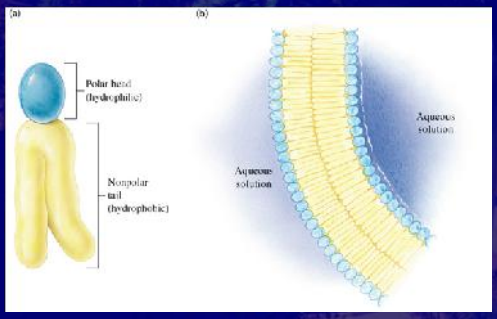
monomer — fatty acid

polymer — phospholipid

supramolecular structure — membrane



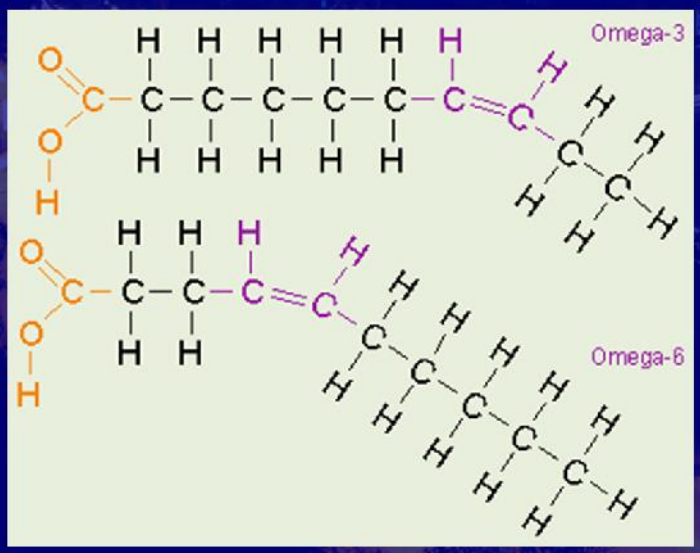




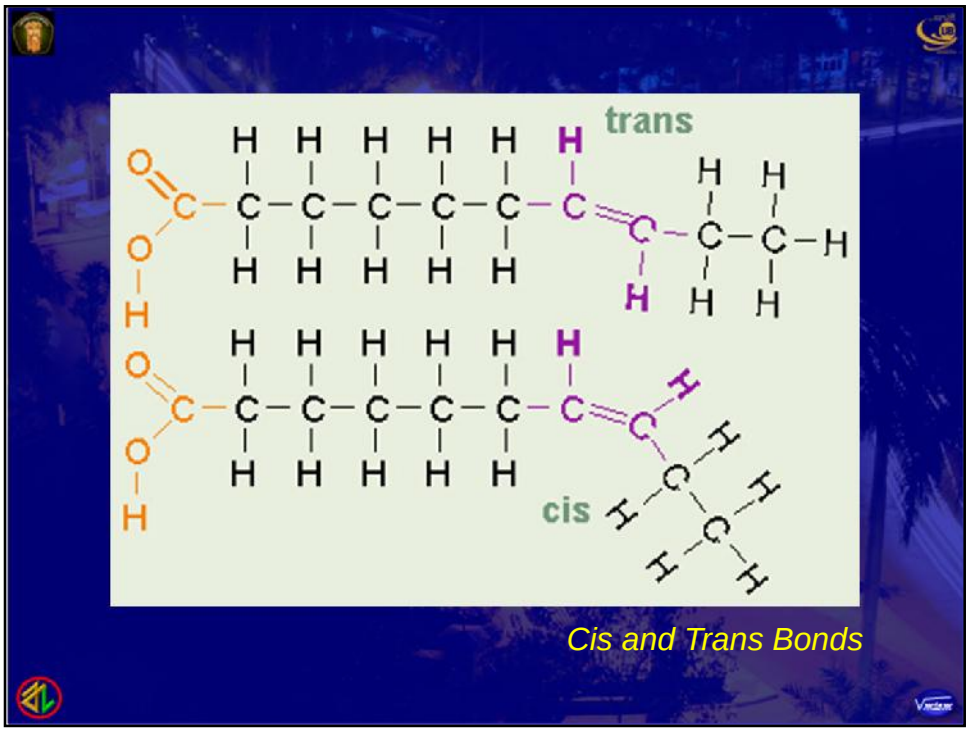
Description	Saturated Fats	Unsaturated Fats
Definition:	Saturated fats are fats with a single bond between the carbon atoms of the fatty acids	Unsaturated fats are fats with one or more double bonds between the fatty acids
Health:	Excessive consumption is not good because of their association with atherosclerosis and heart diseases.	Unsaturated fats are considered good to eat if you are watching your cholesterol
Cholesterol:	Saturated fats increase LDL (bad cholesterol) and decrease the HDL	Unsaturated fats increase HDL (good cholesterol) and decrease LDL
Form:	Solid at room temperature	Liquid at room temperature
Derived from:	Mostly from animal products	Plants
Hydrocarbon chain:	contains only single bonds between carbon atoms, no double bonds (ex: stearic acis)	contains one or more double bonds between carbon atoms -monounsaturated -polyunsaturated
Commonly found in:	Butter, coconut oil, breast milk, meat	Avocado, soybean oil, canola oil, olive oil
Life:	These are long lasting and do not get spoiled quickly	These get spoiled quickly
Recommended consumption:	Not more than 10% of total calories per day.	Not more than 30% of total calories per day

lipids

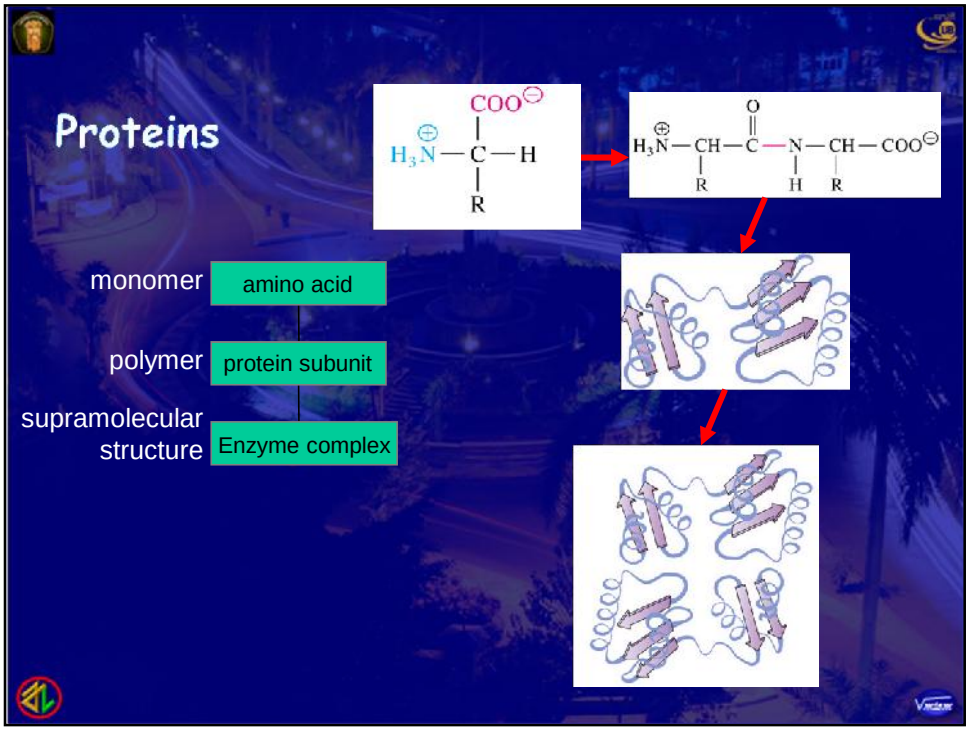
Saturated		
Formula	Common Name	Melting Point
$CH_3(CH_2)_{10}CO_2H$	lauric acid	45 ºC
$CH_3(CH_2)_{12}CO_2H$	myristic acid	55 ºC
$CH_3(CH_2)_{14}CO_2H$	palmitic acid	63 ºC
$CH_3(CH_2)_{16}CO_2H$	stearic acid	69 ºC
$CH_3(CH_2)_{18}CO_2H$	arachidic acid	76 ºC
Unsaturated		
Formula	Common Name	Melting Point
$CH_3(CH_2)_5CH{=}CH(CH_2)_7CO_2H$	palmitoleic acid	0 ºC
$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$	oleic acid	13 ºC
$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7CO_2H$	linoleic acid	-5 ºC
$CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7CO_2H$	linolenic acid	-11 ºC
$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2CO_2H$	arachidonic acid	-49 ºC



Omega-3 and Omega-6 Fatty Acids



Cis and Trans Bonds

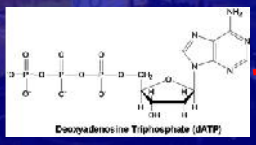


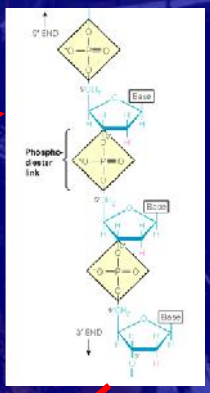
Nucleic Acids

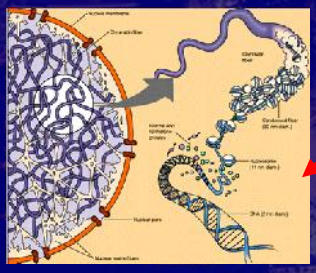
monomer — nucleotide

polymer — DNA

supramolecular structure — chromatin







III. THE IMPORTANCE OF BIOCHEMISTRY

1. Biochemistry Use

What Is Biochemistry Used For?

1. Biochemistry is used to learn about the biological processes which take place in cells and organisms.
2. Biochemistry may be used to study the properties of biological molecules, for a variety of purposes.
   - For example, a biochemist may study the characteristics of the keratin in hair so that a shampoo may be developed that enhances curliness or softness.
3. Biochemists find uses for biomolecules.
   - For example, a biochemist may use a certain lipid as a food additive.

4. Alternatively, a biochemist might find a substitute for a usual biomolecule. For example, biochemists help to develop artificial sweeteners.
5. Biochemists can help cells to produce new products. Gene therapy is within the realm of biochemistry. The development of biological machinery falls within the realm of biochemistry.

2. Molecular Characterization

The core of biochemistry is the characterization of organismal life at molecular level including the conversion mechanism of substrates to products through biochemical reactions catalyzed by enzymes under genetic control and environmental influence.

1. Isolation and Identification

- Biochemistry is firstly concerned with the isolation and identification of all different substances which make up plant and animal organisms
  - A living organism is composed of more than just fasts, carbohydrates and protein. Hundreds of other substances are necessary to the proper functioning of the organisms

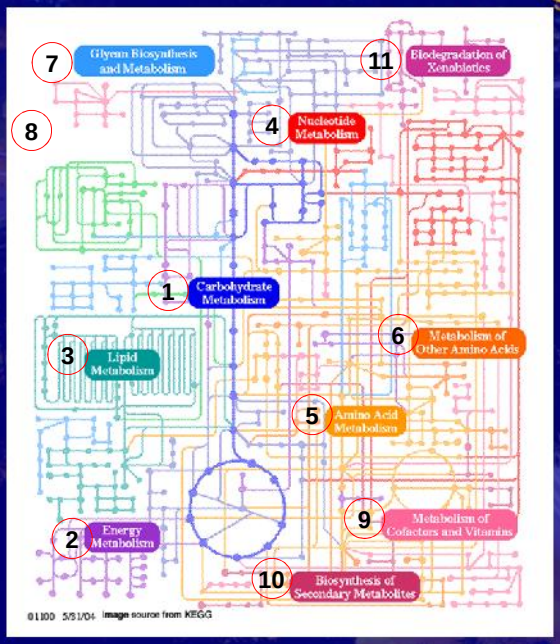
2. Chemical Changes

- Secondly, biochemistry is concerned with all chemical changes which take place in the cells to provide for energy, growth, reproduction, and aging.
  - Protoplasm is an aqueous solution of certain substances with other colloidally dispersed substances

Chemical Changes:
Metabolism

(146 pathways)

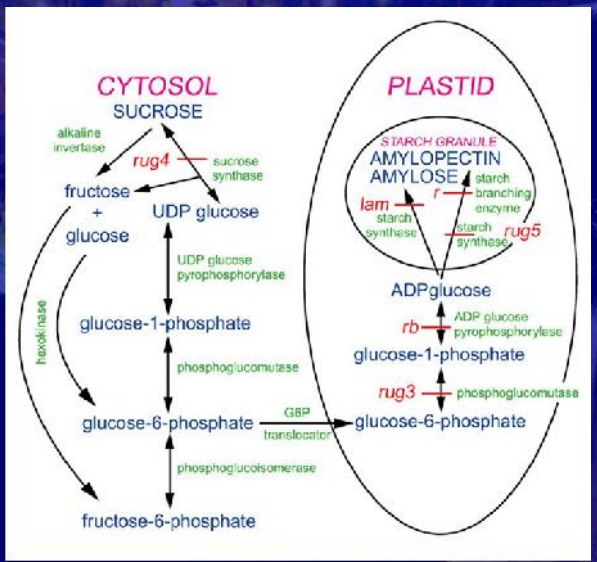
1. Carbohydrate Metabolism (17)
2. Energy Metabolism (8)
3. Lipid Metabolism (14)
4. Nucleotide Metabolism (2)
5. Amino Acid Metabolism (16)
6. Metabolism of Other Amino Acids (9)
7. Glycan Biosynthesis and Metabolism (18)
8. Biosynthesis of Polyketides and Nonribosomal Peptides (9)
9. Metabolism of Cofactors and Vitamins (11)
10. Biosynthesis of Secondary Metabolites (21)
11. Biodegradation of Xenobiotics (21)



http://manet.illinois.edu/pathways.php

Assume 10 reactions/pathway (glycolysis has 11 reactions), then 146 x 10 = 1460 reactions/cell

PLANT BIOCHEMISTRY



IV. BREAKTHROUGHS IN BIOCHEMISTRY

1. Enzyme and DNA

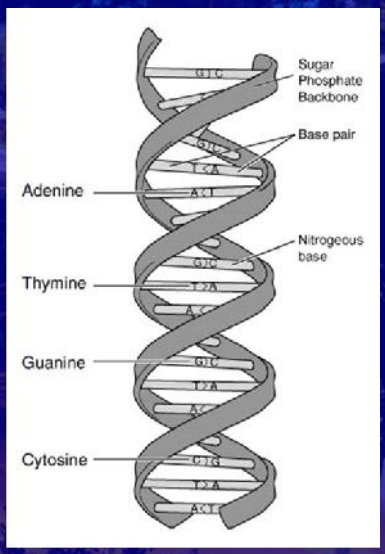
- Two notable breakthroughs in the history of biochemistry
  1. Discovery of the role of enzymes as catalysts
  2. Identification of nucleic acids as information molecules
- Flow of information: from nucleic acids to proteins

DNA → RNA → PROTEIN

At lunch Francis [Crick] winged into the Eagle to tell everyone within hearing distance that we had found the secret of life. — James Watson

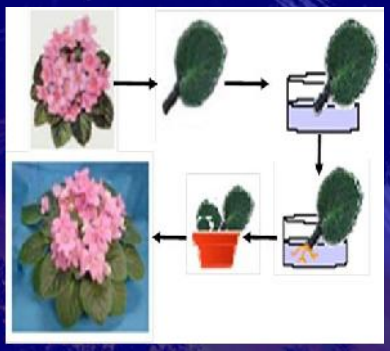
Short segment of a DNA molecule

- Two polynucleotides associate to form a **double helix**
- Genetic information is carried by **the sequence of base pairs**

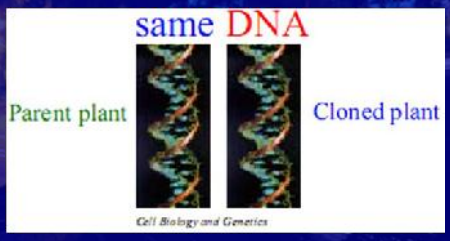


2. Genetic Engineering and Cloning

- Advances in the study of genetics (DNA) have led to the development of genetic engineering and cloning
- Genetic engineering is the manipulation of genes to create purposefully versions of organisms
- Cloning is to make a genetically identical organism through non-sexual means.
- Cloning of African violets:
  1. Take a leaf from a plant
  2. Immerse the stalk in water
     - Roots start to form after a week
  3. Pot the plant
     - A new plant is produced



The new plant is genetically identical to the parental plant



The color of the flowers are the same

How Dolly was cloned?

Sel telur dengan inti dari induk yang berkembang menjadi anak domba yang sama dengan induknya

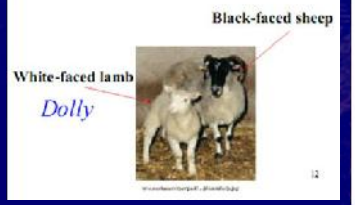
How Dolly was cloned?

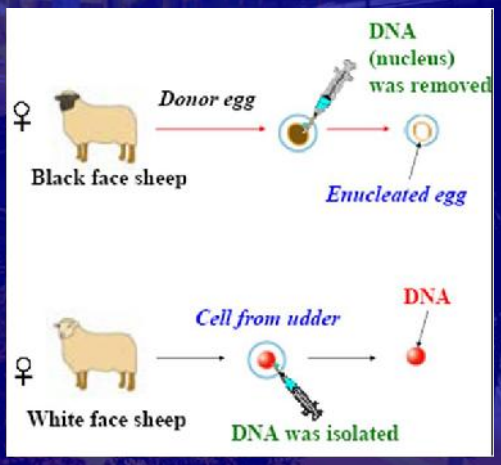
Cells of higher animals (mammals) are much more specialized than plant cells or lower animals.

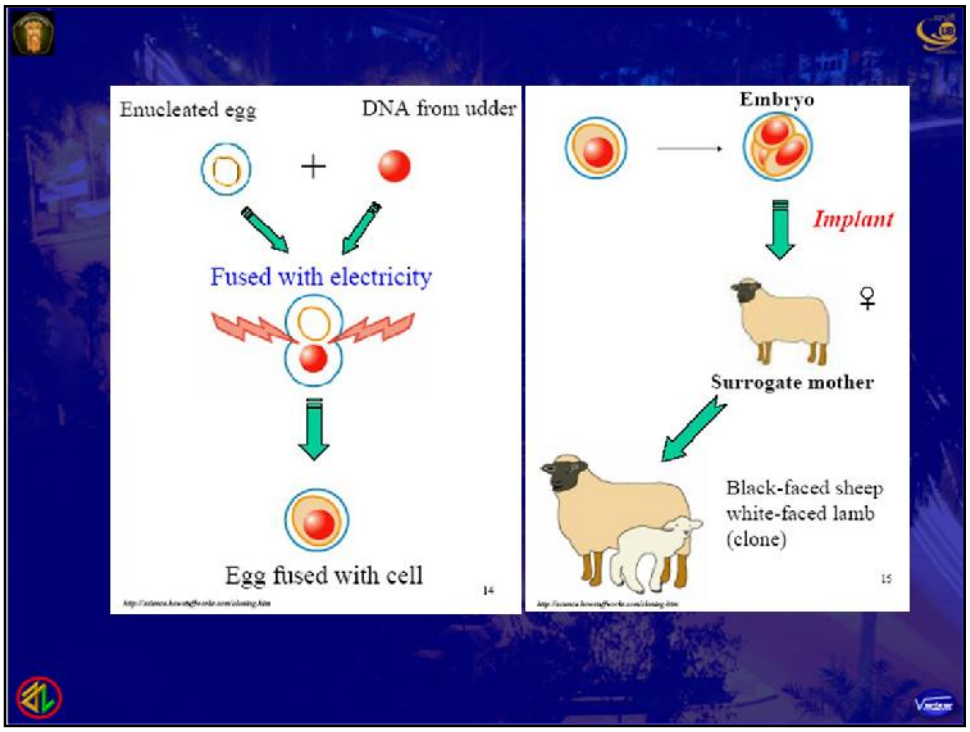
Therefore, much more difficult to change them to become unspecialized for cloning.

1996-2003 *Dolly the sheep*

The first clone of a mammal





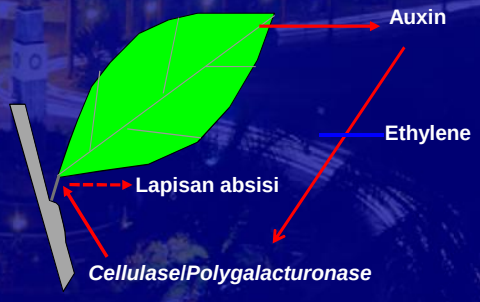

Enucleated egg
DNA from udder
Fused with electricity
Egg fused with cell
14
Embryo
Implant
Surrogate mother
Black-faced sheep
white-faced lamb
(clone)
15


THANK YOU
Спасибо
謝謝
شكراً

EXAMPLES OF PLANT BIOCHEMISTRY

1. Gugur Daun

- Perusakan dinding sel pada lapisan absisi oleh aktivitas enzim Cellulase dan Polygalacturonase
- Sintesis kedua enzim tersebut terhambat jika kadar hormon tumbuh auxin cukup tinggi

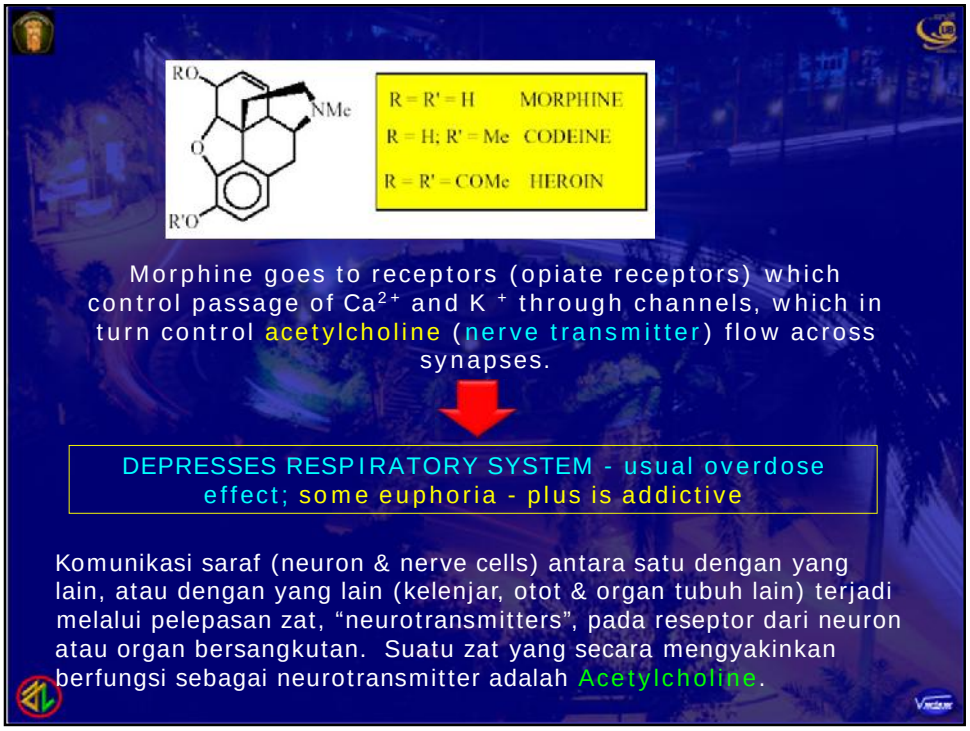


- Transpor auxin dari tempat ujung daun (tempat sintesis) ke lapisan absisi dihambat ethylene

2. The Narcotic Analgesics

- Narcotics block the transmission of the nerve signal across nerve gaps, [the minor analgesics blocked prostaglandin synthesis]
- The more important ones:
  - Morphine, codeine,
  - oxycodone (PERCODAN), hydromorphone (DILAUDID), methadone, + heroin [= not legal]
  - meperidine (DEMEROL), pentazocine (TALWIN),
  - fentanyl (SUBLIMAZE), buprenorphine (BUPRENEX)

- Morphine:
  - Opium [est. ~ 10,000 tons] extracted from the poppy Papaver somniferum, Afghanistan spring 06 6100 tons alone.

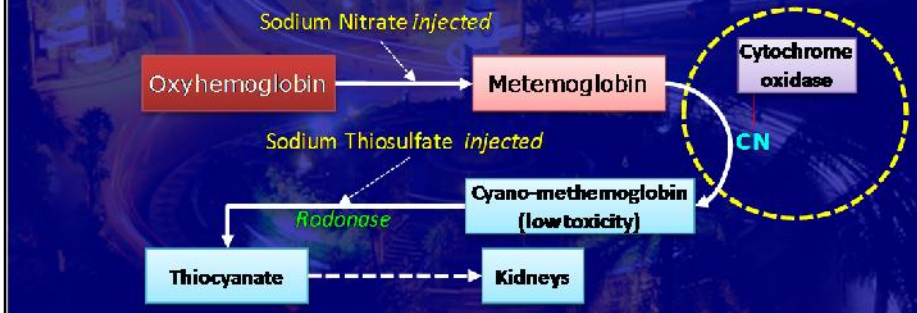


c. Cyanide Poisoning

- Disrupts metabolism by inhibiting metal containing enzymes, most notably, cytochrome oxidase.
  - Cytochrome A_3 catalyzes $O_2 \rightarrow H_2O$
  - Blocks ability of mitochondria to use O_2
  - O_2 saturation may be normal
- Poisoning can occur through percutaneous absorption and inhalation.
- Degree of symptoms depends on severity of exposure.

Antidote

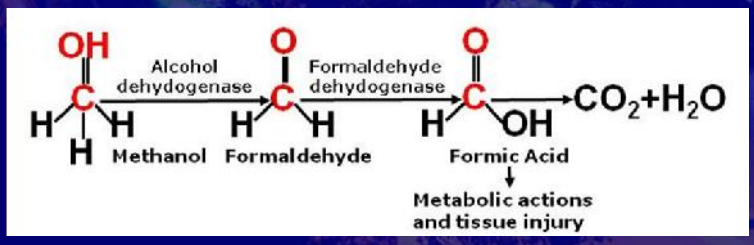
Specific antidotes available



1. Sodium nitrite reacts with hemoglobin to form methemoglobin that removes cyanide ions from various tissues to form cyanmethemoglobin (relatively low toxicity).
2. The function of Sodium thiosulfate is to convert cyanide to thiocyanate, by an hepatic enzyme known as rhodanese

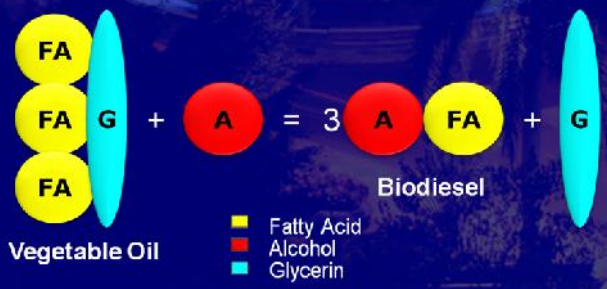
d. Methanol Poisoning

- Methanol itself has a relatively low degree of toxicity, but it is metabolized to formic acid which is responsible for the acidosis and blindness that characterizes methanol poisoning.
- The initial step in the metabolism of methanol occurs by the action of alcohol dehydrogenase (ADH).



e. What is Biodiesel?

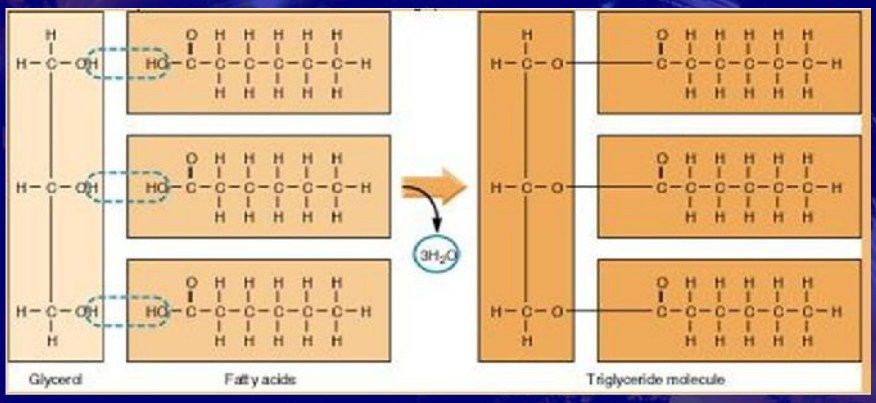
- Alternative fuel for diesel engines
- Made from vegetable oil or animal fat
- Meets health effect testing (CAA)
- Lower emissions, High flash point (>300F), Safer
- Biodegradable, Essentially non-toxic.
- Chemically, biodiesel molecules are mono-alkyl esters produced usually from triglyceride esters



Biodiesel Samples

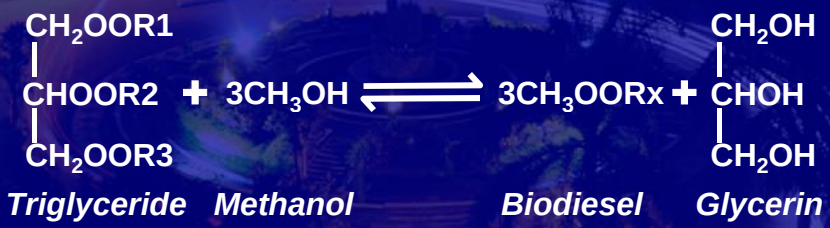
Chemistry of Triglycerides

- Biodiesel is made from the combination of a triglyceride with a monohydroxy alcohol (i.e. methanol, ethanol…).
- What is a triglyceride? Made from a combination of glycerol and three fatty acids:



Transesterification

While actually a multi-step process, the overall reaction looks like this:

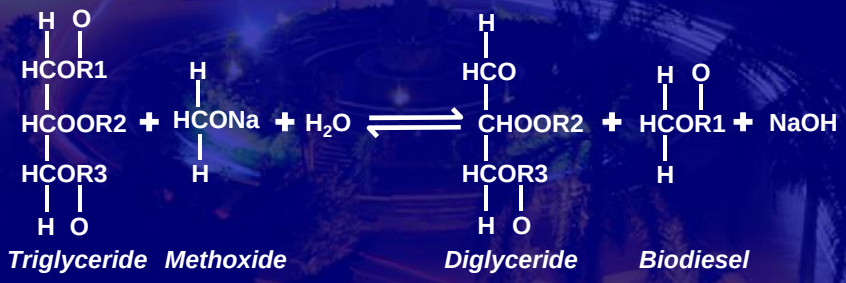


Triglyceride Methanol Biodiesel Glycerin

R1, R2, and R3 are fatty acid alkyl groups (could be different, or the same), and depend on the type of oil. The fatty acids involved determine the final properties of the biodiesel (cetane number, cold flow properties, etc.)

Individual step of Transesterification

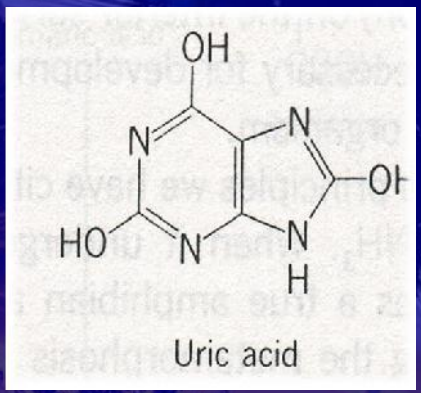
First step, triglyceride turned into diglyceride, methoxide (minus Na) joins freed FA to make biodiesel, Na joins OH from water (from methoxide formation) to make NaOH. Other H joins the diglyceride.



Triglyceride *Methoxide* *Diglyceride* *Biodiesel*

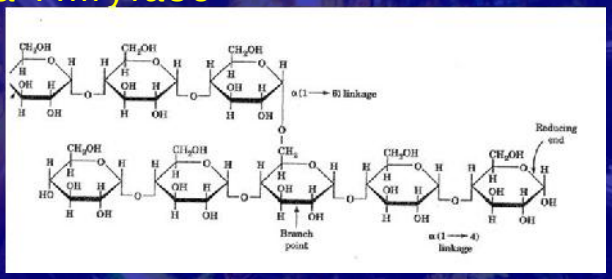
f. Penyakit encok (gout) yang mengakibatkan radang pada persendian adalah akibat akumulasi asam urat

- Radang sendi dipicu oleh presipitasi kristal urat natrium (sodium urate crystals)
- Penyakit Ginjal dapat juga terjadi karena deposisi kristal urat dalam organ tersebu

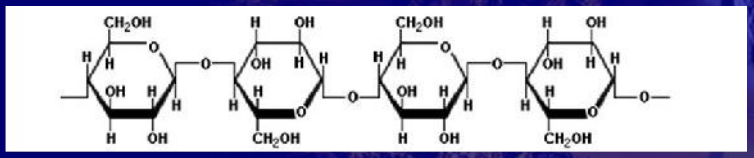


Uric acid

a. a-Amylase



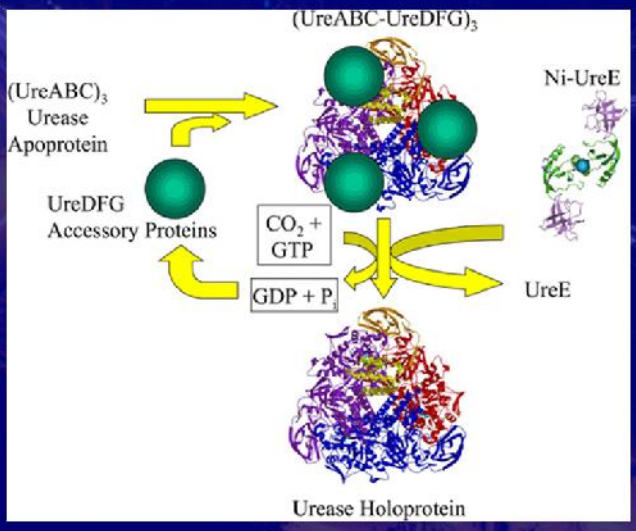
b. Cellulose



c. PIGMENT

ADENIUM OBESUM ' CHERRY'
Grafted Desert Rose
Family : Apocynaceae
Origin : East Africa
Size : 5'
Light Requirements : Full Sun/Light Shade
Water Requirements : Keep Dry
Min. Temp. : 35°
Flower : Year Round

Pigment Class	Compound Type	Colors
Porphyrin	chlorophyll	green
Carotenoid	carotene and lycopene xanthophyll	yellow, orange, red yellow
Flavonoid	flavone flavonol anthocyanin	yellow yellow red, blue, purple, magenta



Model of urease activation. Synthesis of active urease requires the formation of a complex between the $(UreABC)_3$ urease apoprotein and UreDFG.

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