IB Biology
SBI3U7

BIOCHEMISTRY
Topic 3

Biological Macromolecules

Essential Questions:

1. What are the 4 main types of biological macromolecules and what is their function within cells?
2. How does the structure of each macromolecule contribute to their function within cells?

Carbon: The Central Atom

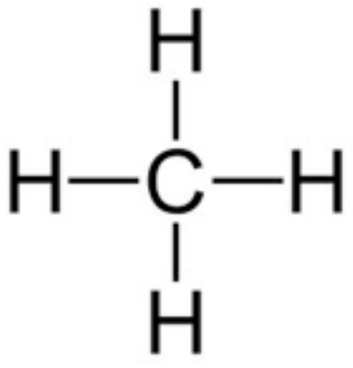
What's so special about 

?

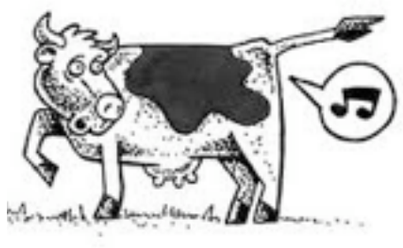
The diversity of life relies on carbon!!!

- ✓ **Virtually all chemicals of life are carbon based (exceptions – H_2O, CO_2) – called organic compounds.**
- ✓ **It can form four covalent bonds (H, O, N, P, S, C)**
- ✓ **C-C bonds enable carbon to form a variety of geometrical structures (e.g., straight chains, branched chains, rings)**

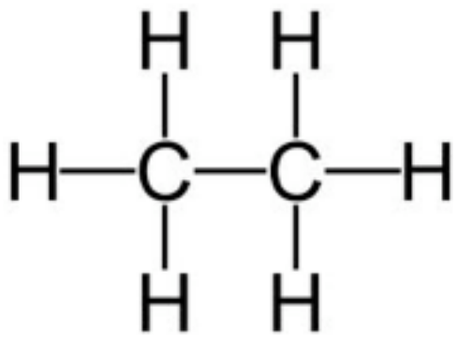
Methane CH_4



+ CH_2 →

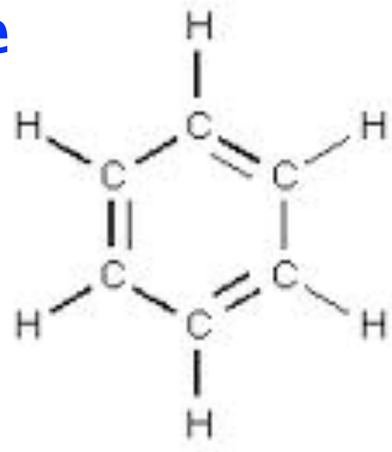


Ethane C_2H_6



+ C_4 →

Benzene C_6H_6



Molecular Isomers: The same, yet different

What's so special about

?

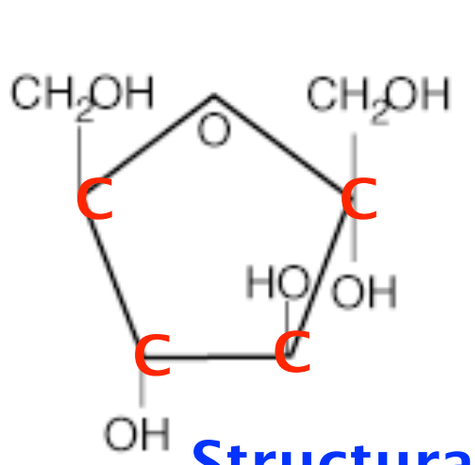
<u>Isomer</u> – an organic compound with the same molecular formula, but different <u>structure</u>

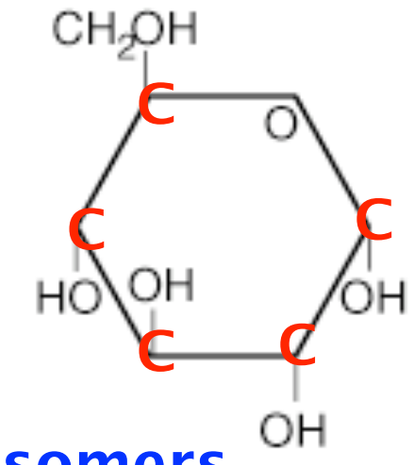
Example: $C_6H_{12}O_6$

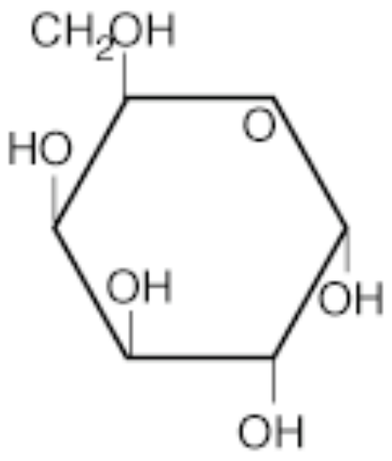
Glucose
(simple sugar)

Fructose
(fruit sugar)

Galactose
(milk sugar)







Structural isomers

Fructose — Glucose — Galactose

Metabolized by cells differently due to structure

Molecular Isomers: The same, yet different

What's so special about

?

<u>Isomer</u> – an organic compound with the same molecular formula, but different <u>structure</u>

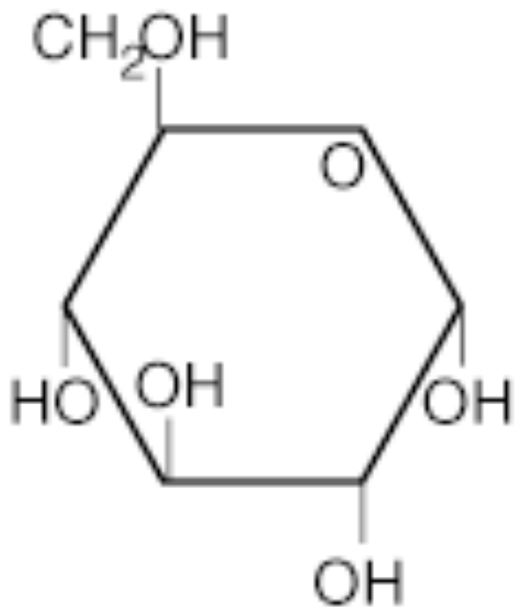
Stereoisomers

↓

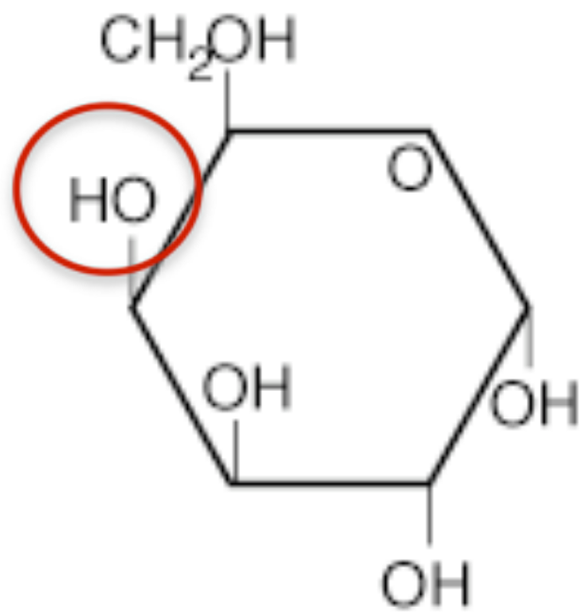
Same atoms,
Same bonds,
Differently arranged in space

↙ ↘

Geometrical **Optical**



Glucose



Galactose

Molecular Isomers: The same, yet different

What's so special about 

?

Isomer – an organic compound with the same molecular formula, but different structure

Stereoisomers

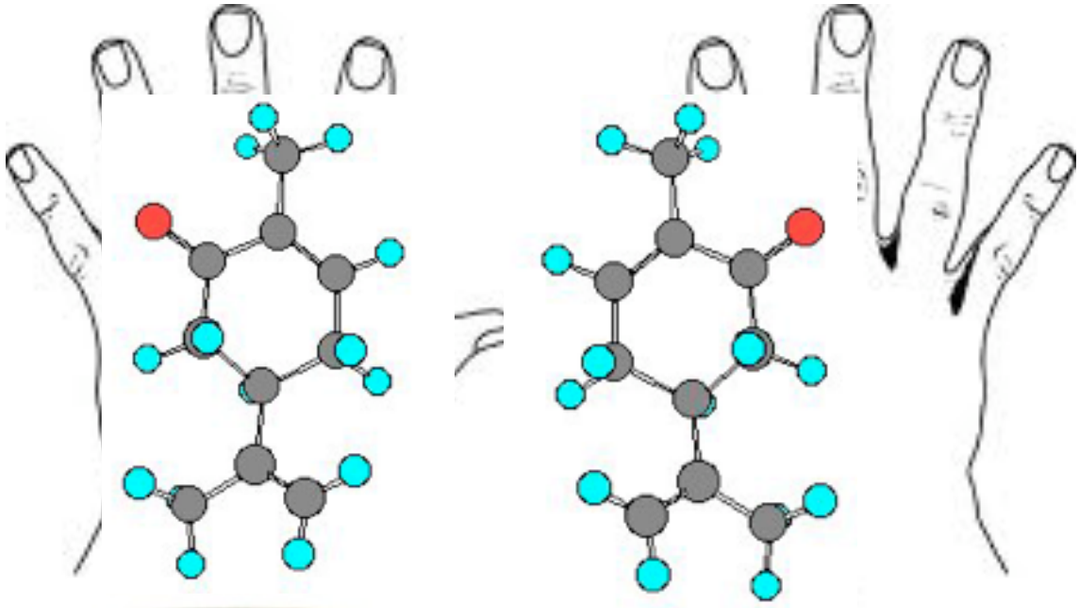
↓

Same atoms,
Same bonds,
Differently arranged in space

↙ ↘

Geometrical Optical

Carvone



Macromolecules

What is the relationship between atoms, bonding and macromolecules?

Atoms

join together

Bonds

that form

Molecules

that form large structures called

Macromolecules

Macromolecules and their subunits

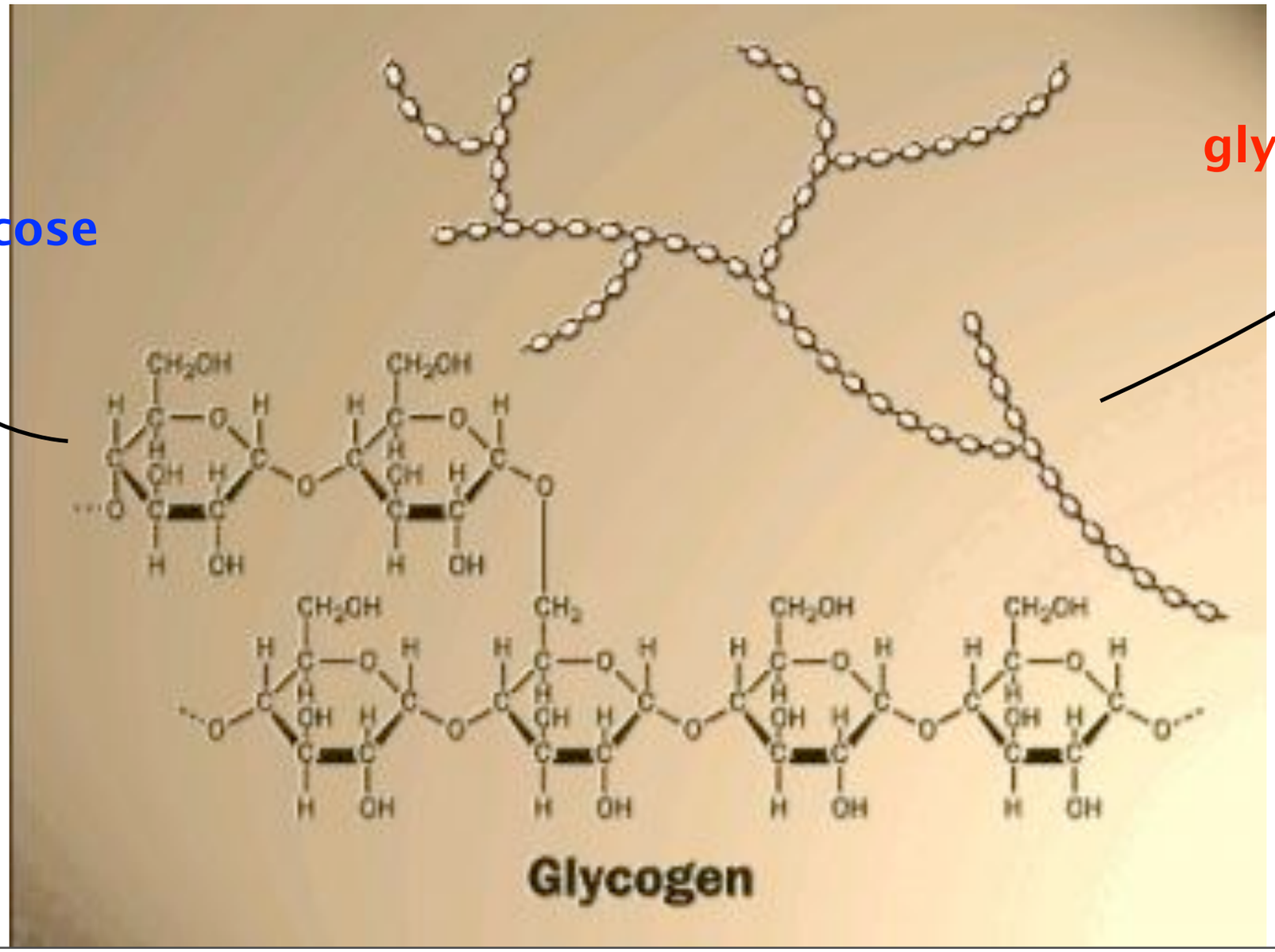
Monomer + **Monomer** + **Monomer** = **Polymer** = **Macromolecule**

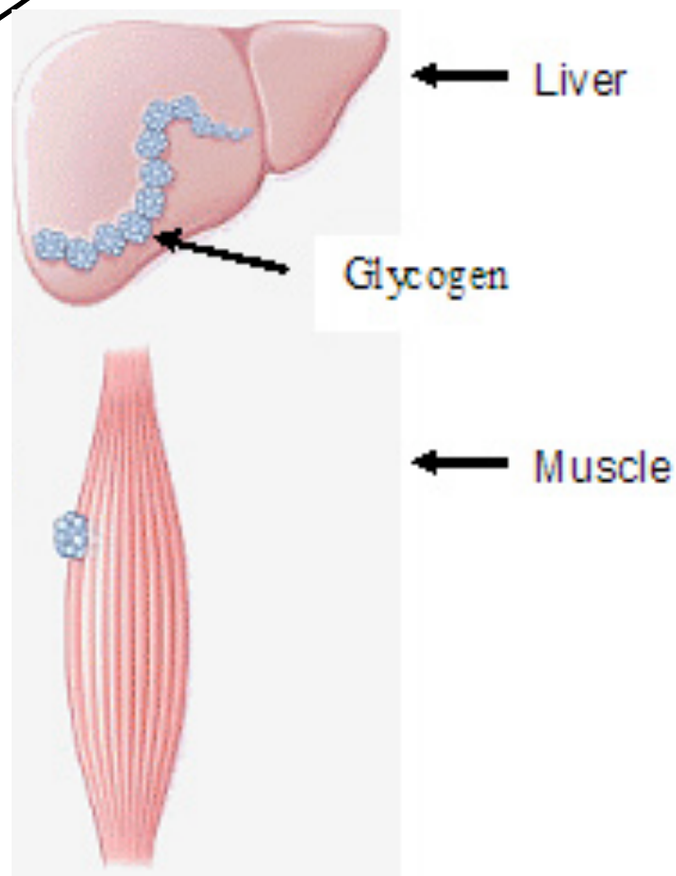
smaller subunits

long chain of monomers

glucose

glycogen





Macromolecules and their subunits

Carbon Compounds

include

1	2	3	4
Carbohydrates	**Lipids**	**Nucleic acids (e.g., DNA/RNA)**	**Proteins**
Which are made of	Which are made of	Which are made of	Which are made of
Simple sugars (e.g., glucose)	**Glycerol & 3 Fatty Acids**	**Nucleotides**	**Amino Acids**
which contain	which contain	which contain	which contain
Carbon, hydrogen, oxygen	**Carbon, hydrogen, oxygen**	**Carbon, hydrogen oxygen, nitrogen, phosphorus**	**Carbon, hydrogen, oxygen, nitrogen,**
main function	main function	main function	main function
ENERGY STORAGE short-term	**ENERGY STORAGE** long-term	**ENCODING HEREDITARY INFORMATION**	**CATALYSIS & STRUCTURE /SUPPORT**

Carbohydrates

- ✓ **Main Function:** quick and short-term energy storage (4 cal/g)
- ✓ **Groupings**: C, H, and O atoms (1 : 2 : 1 ratio)
- ✓ **Two types**: 1. Simple Carbohydrate
  2. Complex Carbohydrates

1

Carbohydrates

Which are made of

Simple sugars (e.g., glucose)

which contain

Carbon, hydrogen, oxygen

main function

ENERGY STORAGE

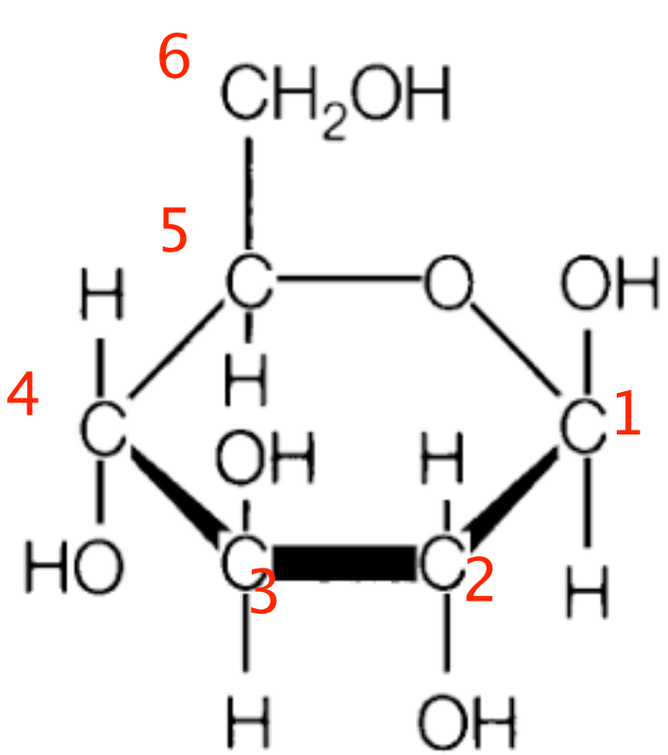
short-term

Glucose

✓ **The simplest carbohydrate is a MONOSACCHARIDE (mono = one, saccharide = sugar)**

✓ **Since they are so simple in structure, they are broken down quickly in the body to release energy**

e.g. GLUCOSE – hexose (six-carbon) sugar with 7 energy-storing C-H bonds



$C_6H_{12}O_6$ **(ring structure – when dissolved in water)**

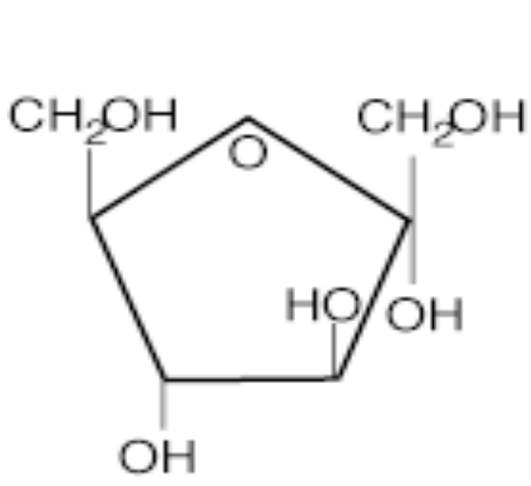
Primary source of energy used by all cells

Monosaccharides

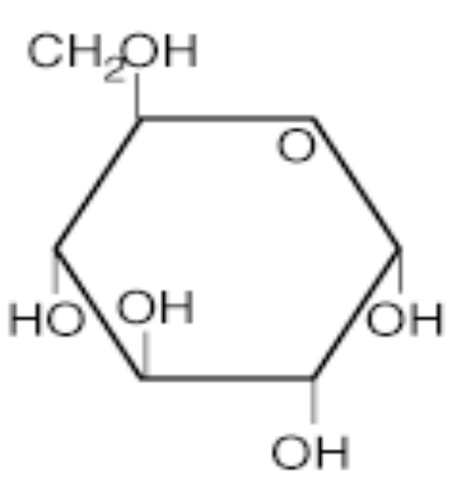
Monosaccharides:

- Galactose
- Fructose – plant sugar, honey
- Glucose – short term energy storage

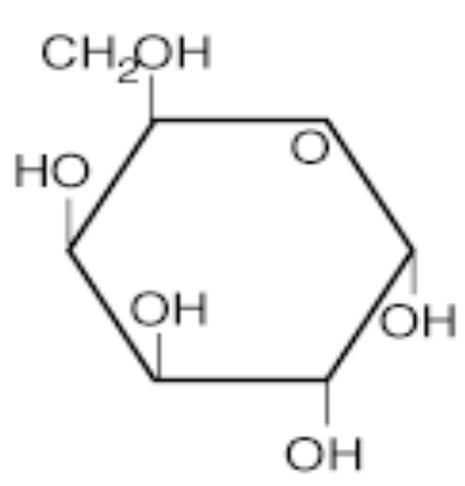
} All have the formula $C_6H_{12}O_6$!



Fructose



Glucose

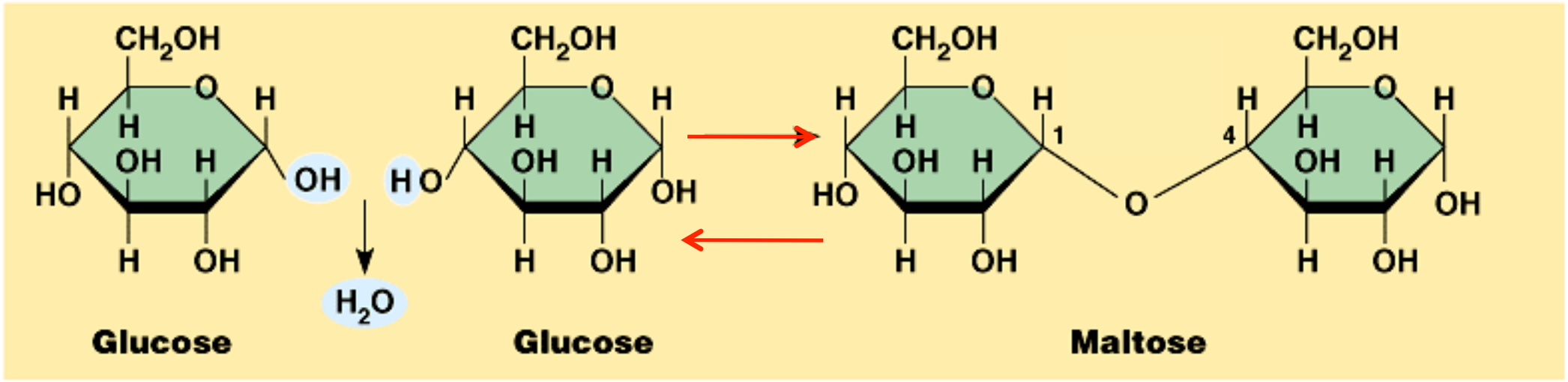


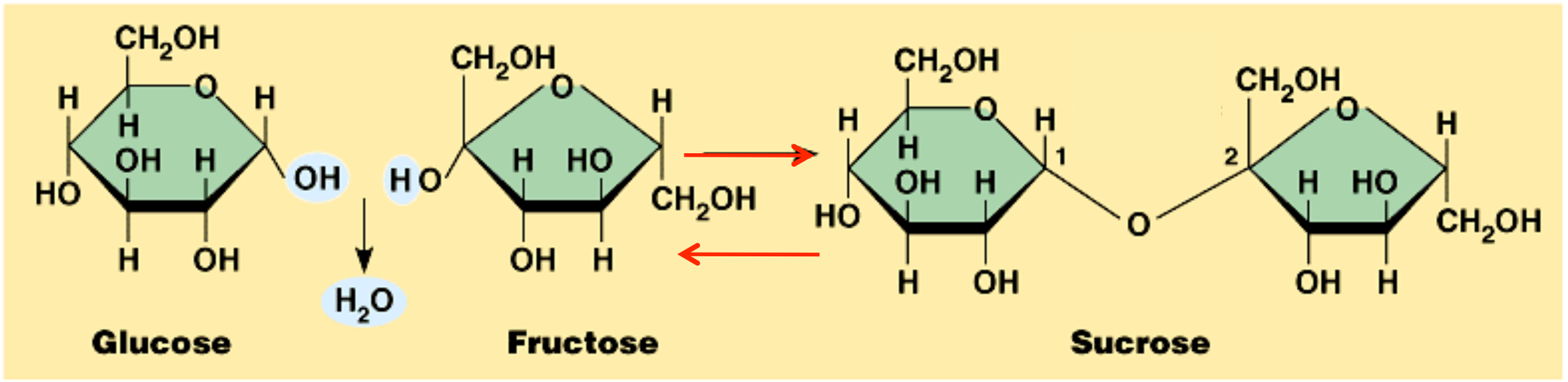
Galactose

ALL ISOMERS!!

Making & Breaking Carbohydrates

monosaccharide + monosaccharide → disaccharide





Condensation (dehydration) synthesis →

← Hydrolysis

Two important biochemical reactions

Disaccharides

Disaccharides are made of 2 monosaccharides

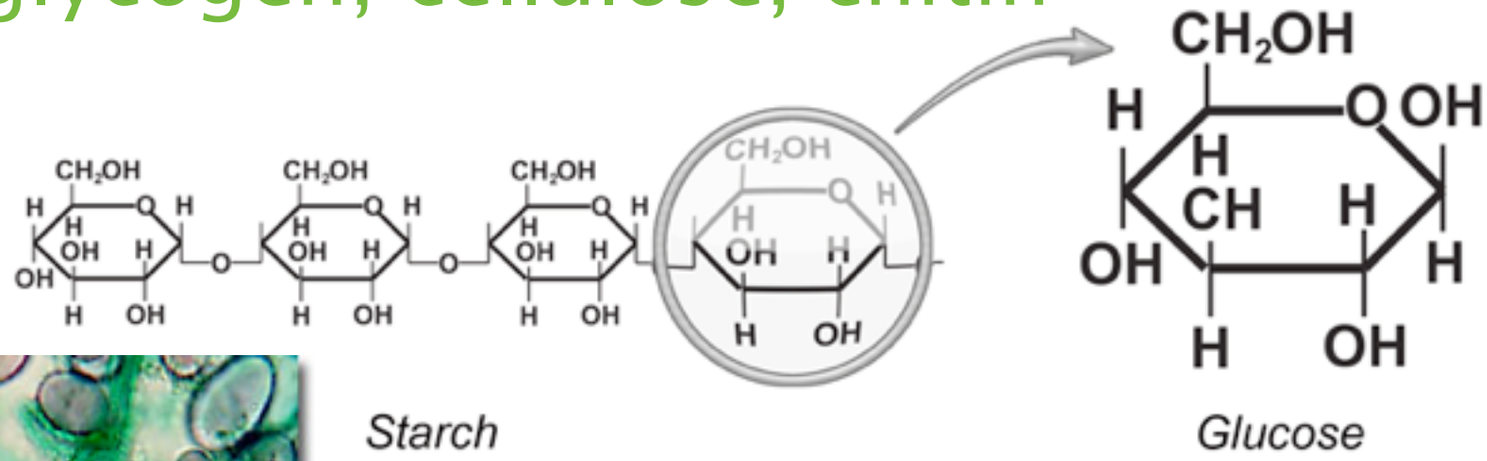
- **sucrose** = glucose + fructose
  - plant transport sugar
- **lactose** = glucose + galactose
  - milk sugar
- **maltose** = glucose + glucose
  - malt sugar

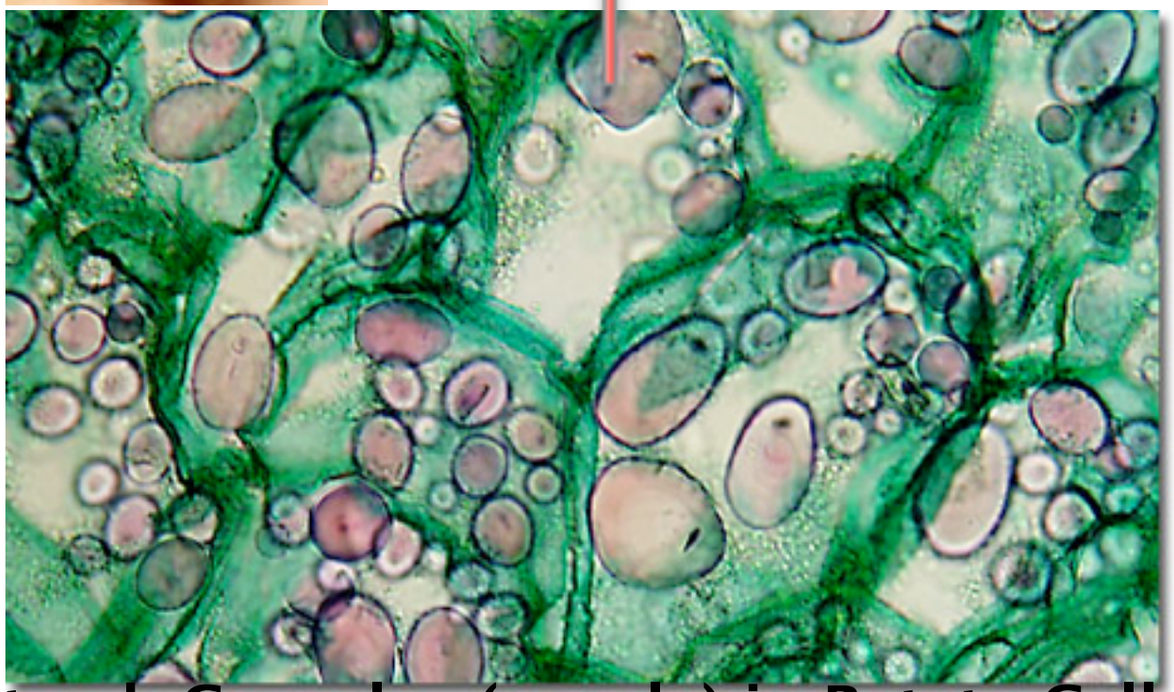
Polysaccharides

Polysaccharides are made of several monosaccharides all linked together

- ✓ **Main Function:** quick and short-term energy storage
- ✓ Contain many units of glucose in long chains

- ✓ **Examples**: Starch, glycogen, cellulose, chitin

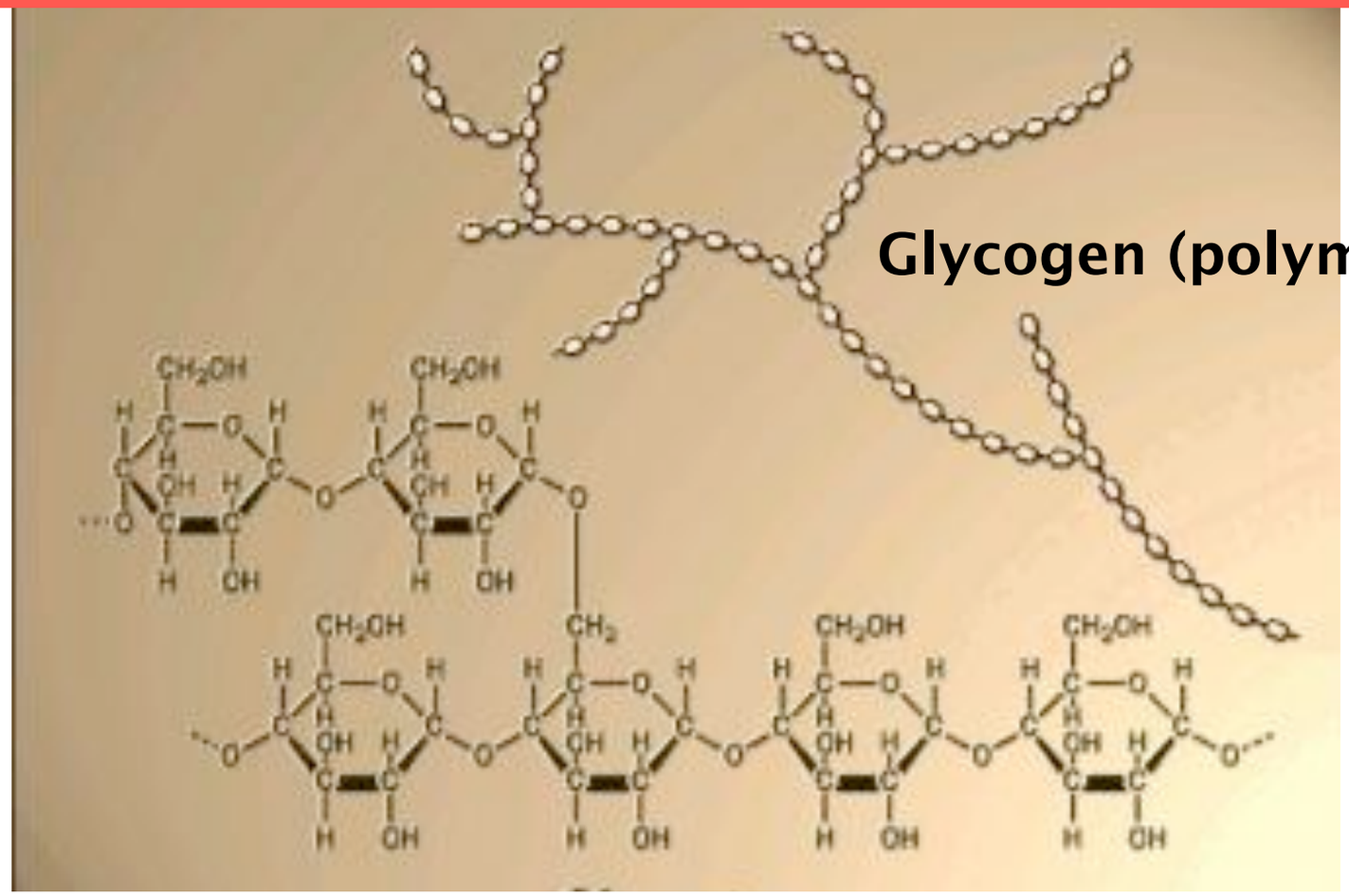




Starch Granules (purple) in Potato Cells

Starch = energy storage in plants

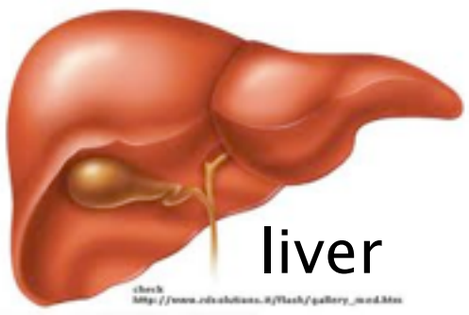
Glycogen



Glycogen (polymer)

Glucose (monomer)

Glycogen = energy storage in animals

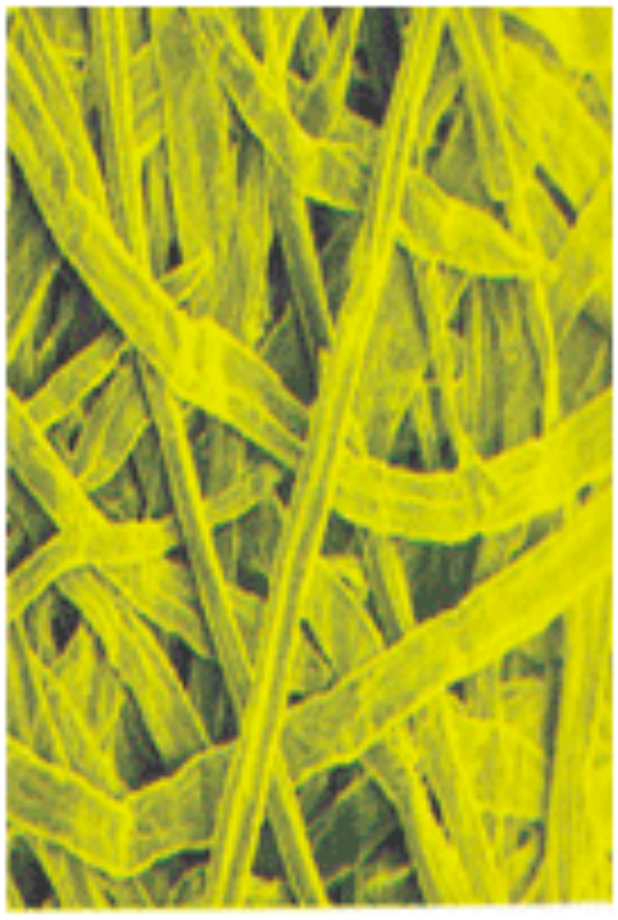


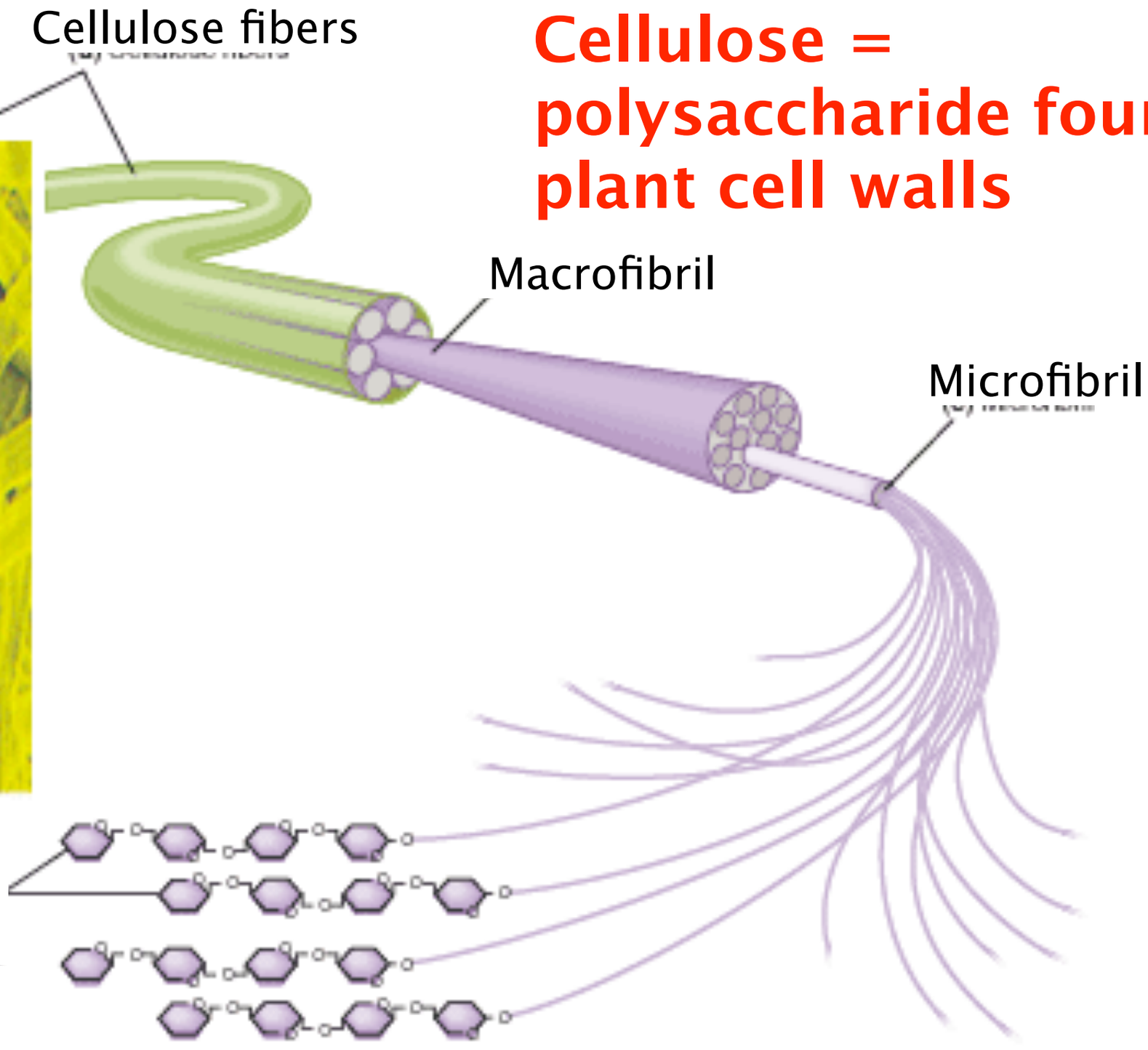
liver

muscle

Glycogen (red) in Hepatocytes (liver cells)

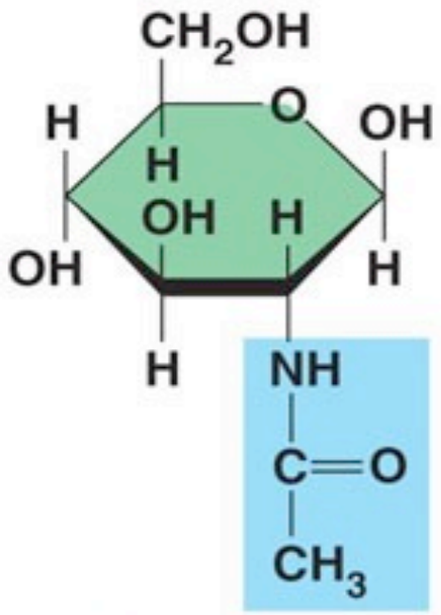
Cellulose





Cellulose = polysaccharide found in plant cell walls

Chitin



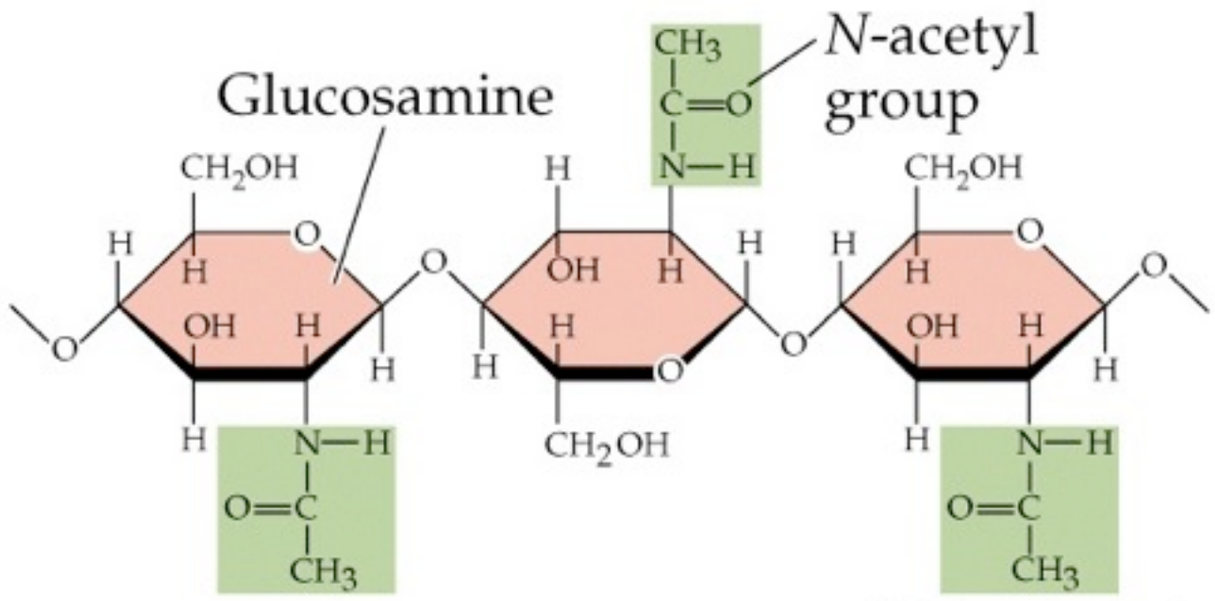
(a) The structure of the chitin monomer.

(b) Chitin forms the exoskeleton of arthropods.

(c) Chitin is used to make a strong and flexible surgical thread.

(*c*) **Chitin**

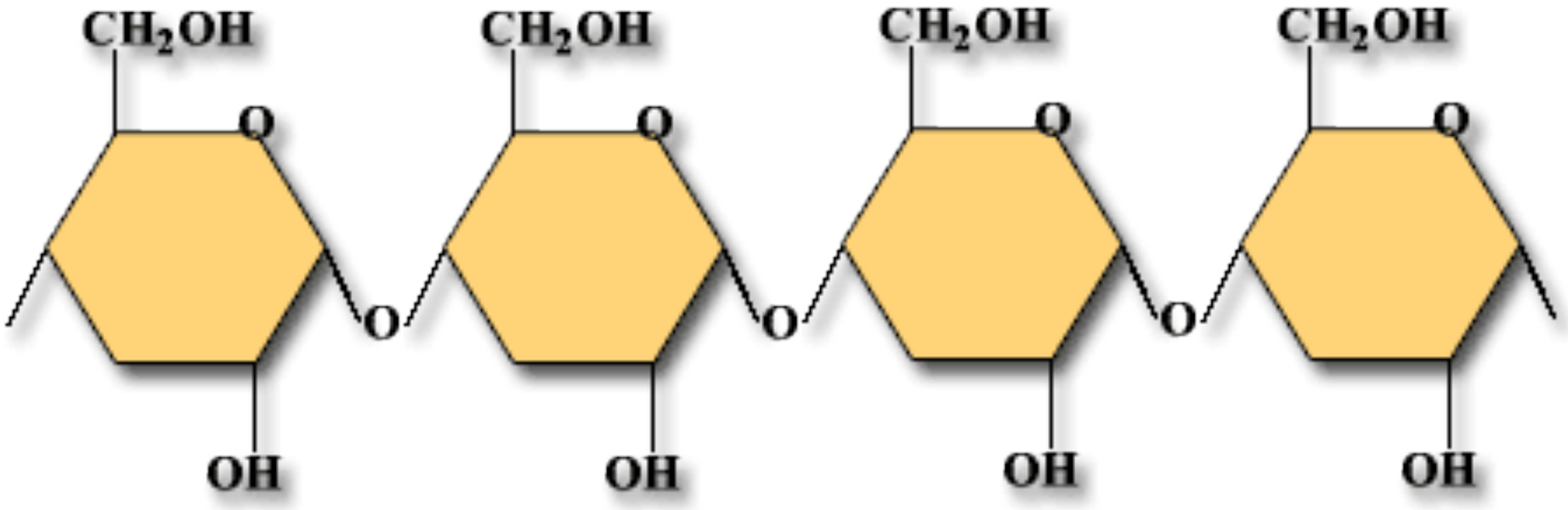
Chitin = polysaccharide found in fungi cell walls and exoskeletons



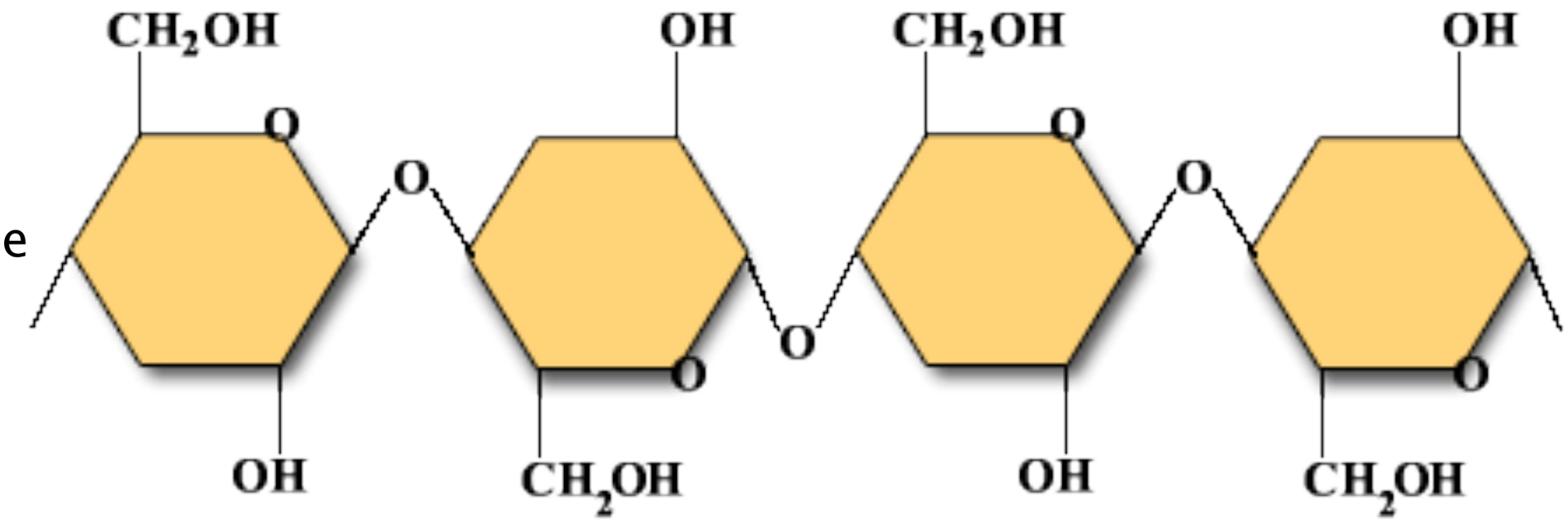
Starch v. Cellulose

What is the difference between starch and cellulose?

Starch



Cellulose



Starch

Cellulose

Glucose repeat units are facing the same direction

Enzymes to digest

Soluble

Weaker

Both polymers

Same monomer (glucose)

Same repeat base

Each successive glucose unit is upside-down in relation to each of the glucose molecules that it is connected to

Cannot digest (no enzymes)

Insoluble (fiber / roughage)

Stronger (good for building)