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Biochemistry

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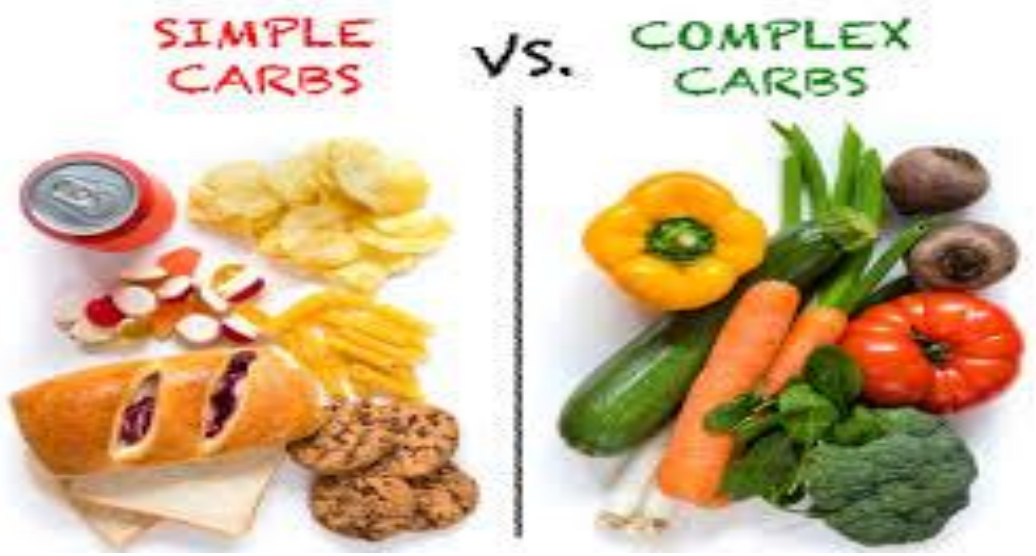
Polysaccharides

The carbohydrates that eat are digested by the body and broken down into simple sugars (glucose molecules) that can be absorbed into the bloodstream. Glucose is the primary energy source for cells, tissue, and organs in the body.



The term **Complex Carbohydrate**, or sometimes even just Carbohydrate refers to long chains of sugars.

Polysaccharides can be

- **Homopolysaccharide** or
- **Heteropolysaccharide** depending upon the type of the monosaccharides

Homopolysaccharides consisting of same type of monomeric units) e.g Polymer of glucose: Starch, glycogen, cellulose

Heteropolysaccharides (consisting of different types of monomeric units) e.g Heparin (D-glucosamine sulfate + D-sulfated iduronic acid) and Hyaluronic acid (D-β glucuronic acid + N-acetylglucosamine

Three common types of complex carb's are: **Starch, Cellulose, and Glycogen**

Starch

Occurrence

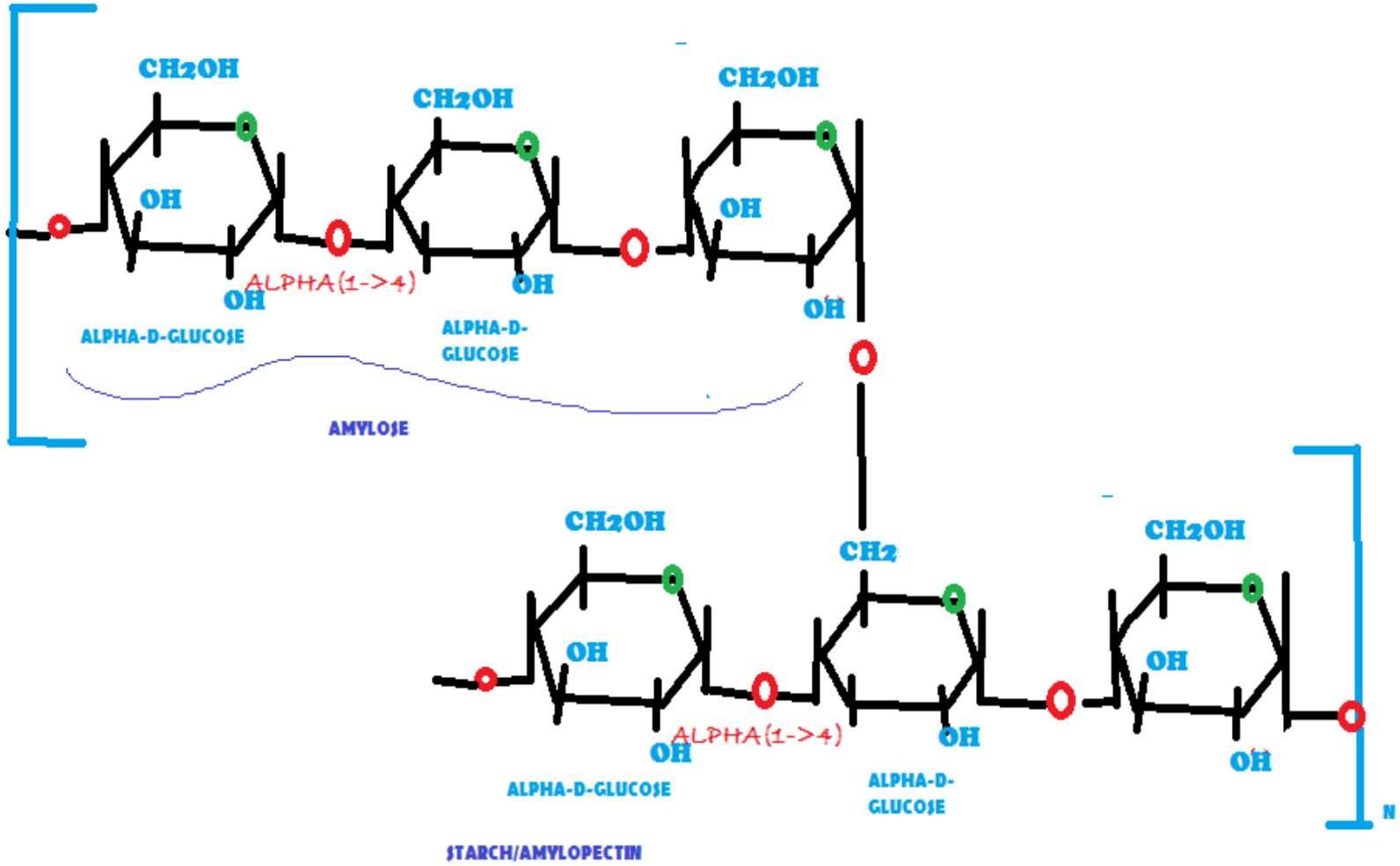
Starch is found in plants and plant sources such as potato , barley , wheat , maize, rice, cassava

maize

Sweet potato

cassava

Structure

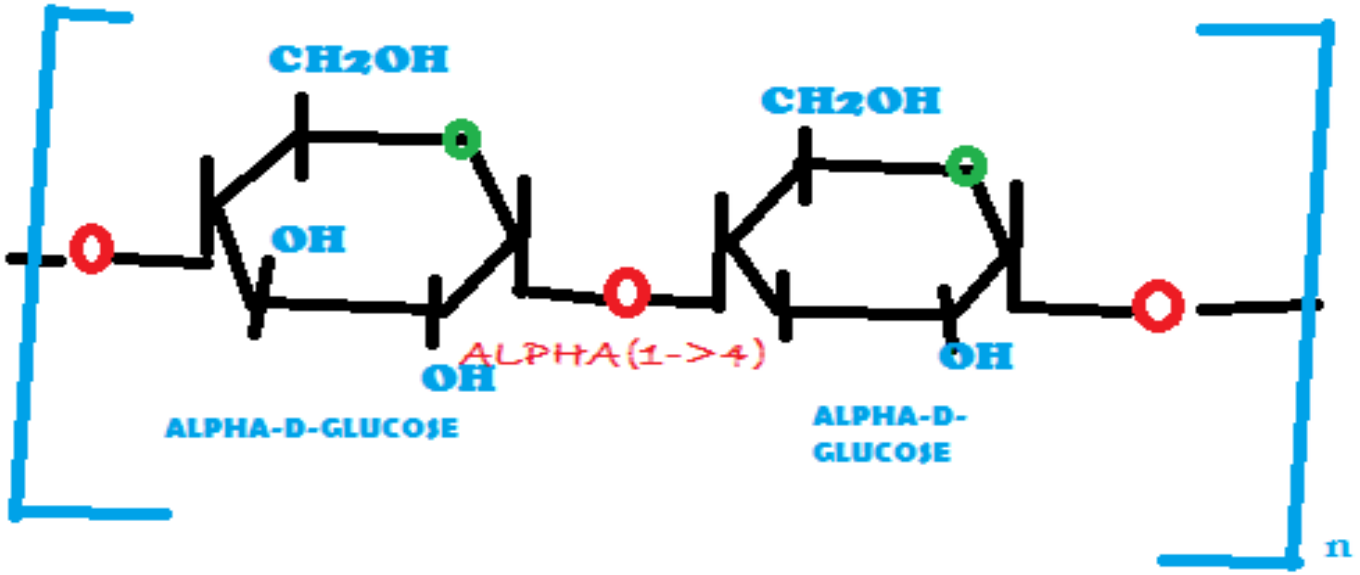

CH2OH
OH
OH
ALPHA(1->4)
CH2OH
OH
CH2OH
OH
OH
ALPHA-D-GLUCOSE
ALPHA-D-GLUCOSE
AMYLOSE
CH2OH
OH
OH
ALPHA(1->4)
CH2
OH
CH2OH
OH
OH
N
ALPHA-D-GLUCOSE
ALPHA-D-GLUCOSE
STARCH/AMYLOPECTIN

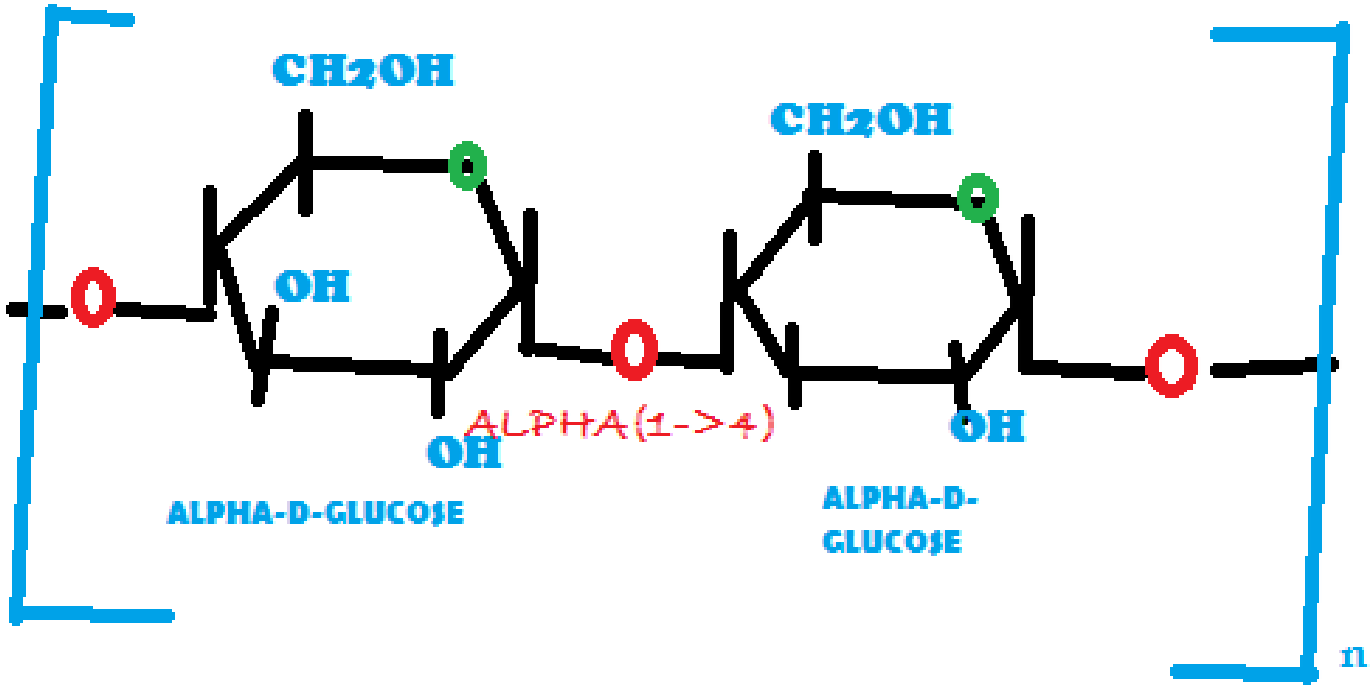
Structure

- starch is an branched homopolysaccharide. (contains same type of monomers)
- Starch is made up of repeating units of alpha-d-glucose monomers linked via alpha (1-4) and alpha (1-6) glycosidic linkages.
- Starch is made up of combination of both amylose and amylopectin

Amylose

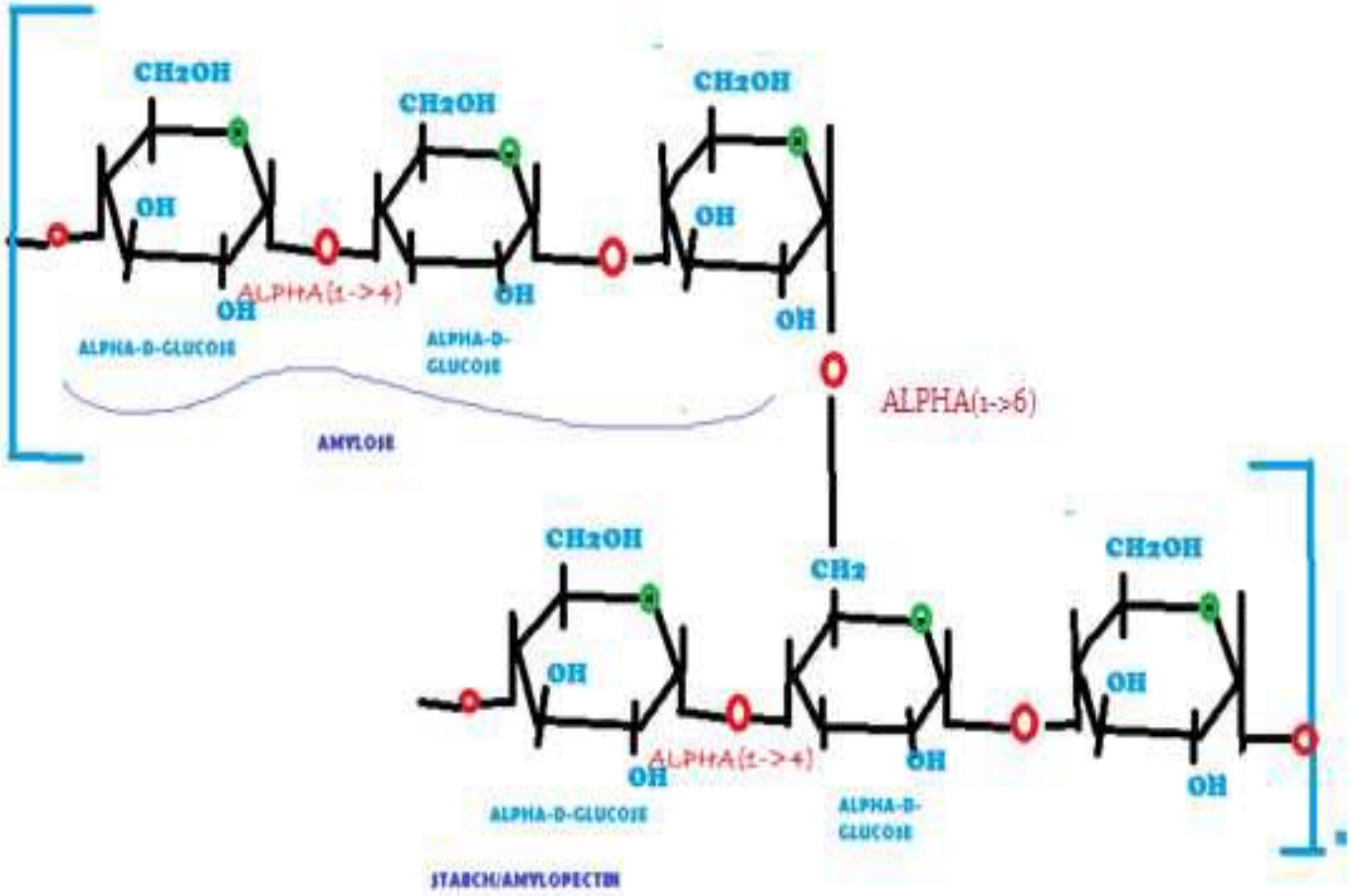
- It is made up alpha glucose monomers linked via alpha (1-4) glycosidic bond.
- The presence of alpha (1-4)glycosidic bond is responsible for the coiled and compact structure of starch.




CH2OH
CH2OH
OH
OH
OH
ALPHA(1->4)
ALPHA-D-GLUCOSE
ALPHA-D-GLUCOSE
n

Amylopectin

- It is made up of alpha glucose monomers joined via alpha (1-4) and alpha (1-6) glycosidic bonds.
- The presence of alpha(1-6)glycosidic bond is responsible for the branching structure of starch


CH2OH
CH2OH
CH2OH
OH
OH
OH
OH
OH
ALPHA(1->4)
ALPHA-D-GLUCOSE
ALPHA-D-GLUCOSE
AMYLOSE
ALPHA(1->6)
CH2OH
CH2
CH2OH
OH
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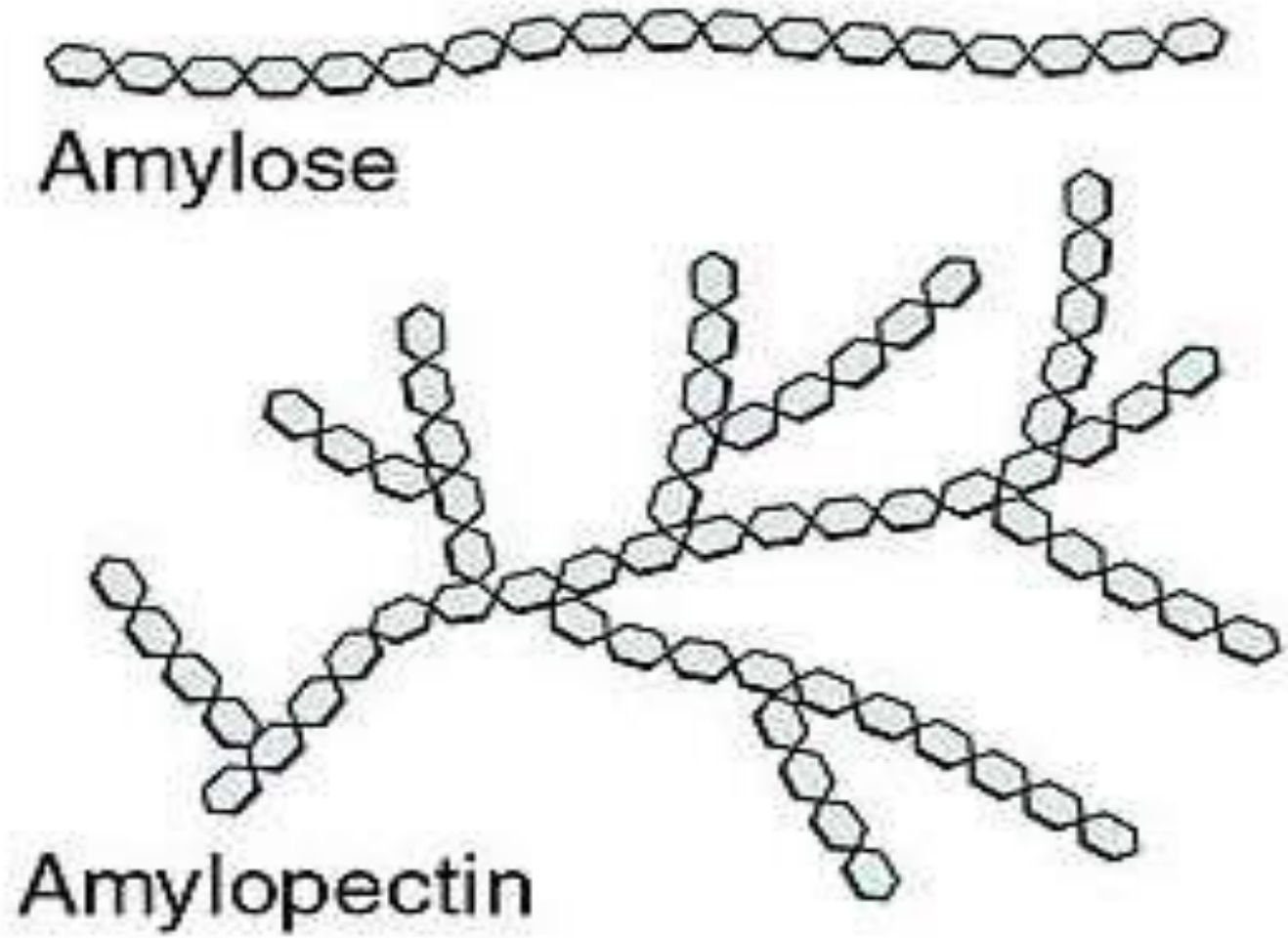
ALPHA(1->4)
ALPHA-D-GLUCOSE
ALPHA-D-GLUCOSE
STARCH/AMYLOPECTIN



Starch

Biological Functions

- It is the most common carbohydrate in human diet.
- Starch is the storage form of glucose in plants. The plants utilize the glucose by using enzymes like amylase.

Glycogen

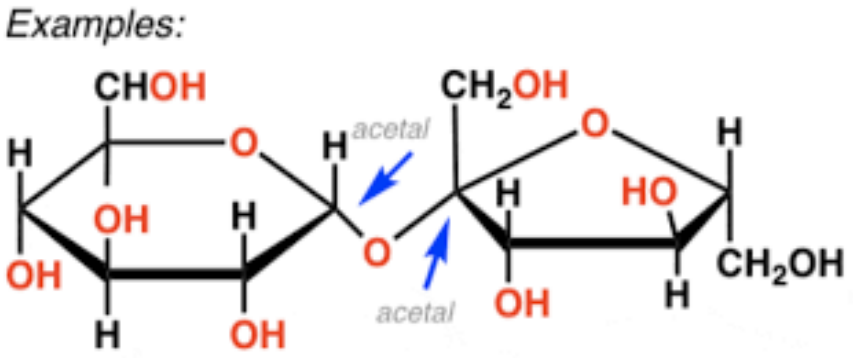
Glycogen is a polysaccharide composed of glucose units that acts as an energy storage molecule in animals. It is synthesized and stored primarily in the **liver** and **muscle tissue**, where it exists in branched chains bound in granules. Glycogen granules provide readily available glucose through breakdown during periods of high energy demand to maintain blood glucose levels and meet the energy needs of muscles. Glycogen helps regulate **homeostasis** by storing excess glucose and releasing it when glucose levels in the blood decrease.

Occurrence

Glycogen is only found in animals. In humans, it is mainly found in liver and skeletal muscles in large amounts. Other cells of the body also contains glycogen in small amounts for their own uses.
The glycogen stores present in liver fluctuate with the blood glucose levels. Its amount increases in well-fed state and depletes during fasting. On the other hand, the glycogen stores in muscles are almost constant. They only undergo little changes in the case of active exercise and are not affected by fasting. However, starvation depletes glycogen stores of both liver and skeletal muscles.

Structure of Glycogen

Glycogen is composed of long polymer chains of glucose units which are bonded with an **alpha acetal linkage.** This acetal linkage forms by the combination of the carbonyl group and alcoholic group



note

Acetal is an organic molecule having a central carbon atom attached to two oxygen atoms by single bond.

Structure

Glycogen is a polymer of alpha-D-glucose. Thousands of glucose molecules in glycogen are linked together via alpha 1-4 and alpha 1-6 glycosidic linkages. Glycogen is made up of long chains of glucose molecules that show abundant branching.

All the glucose molecules in the **linear** chain of glycogen are linked via alpha **1-4 glycosidic bonds**. **Branches** arise from this linear chain via an **alpha 1-6 glycosidic bond**. It means that the glucose molecule at the branch point is attached to the main chain via alpha 1-6 bond. The rest of the glucose molecules in the branch have alpha 1-4 linkages.

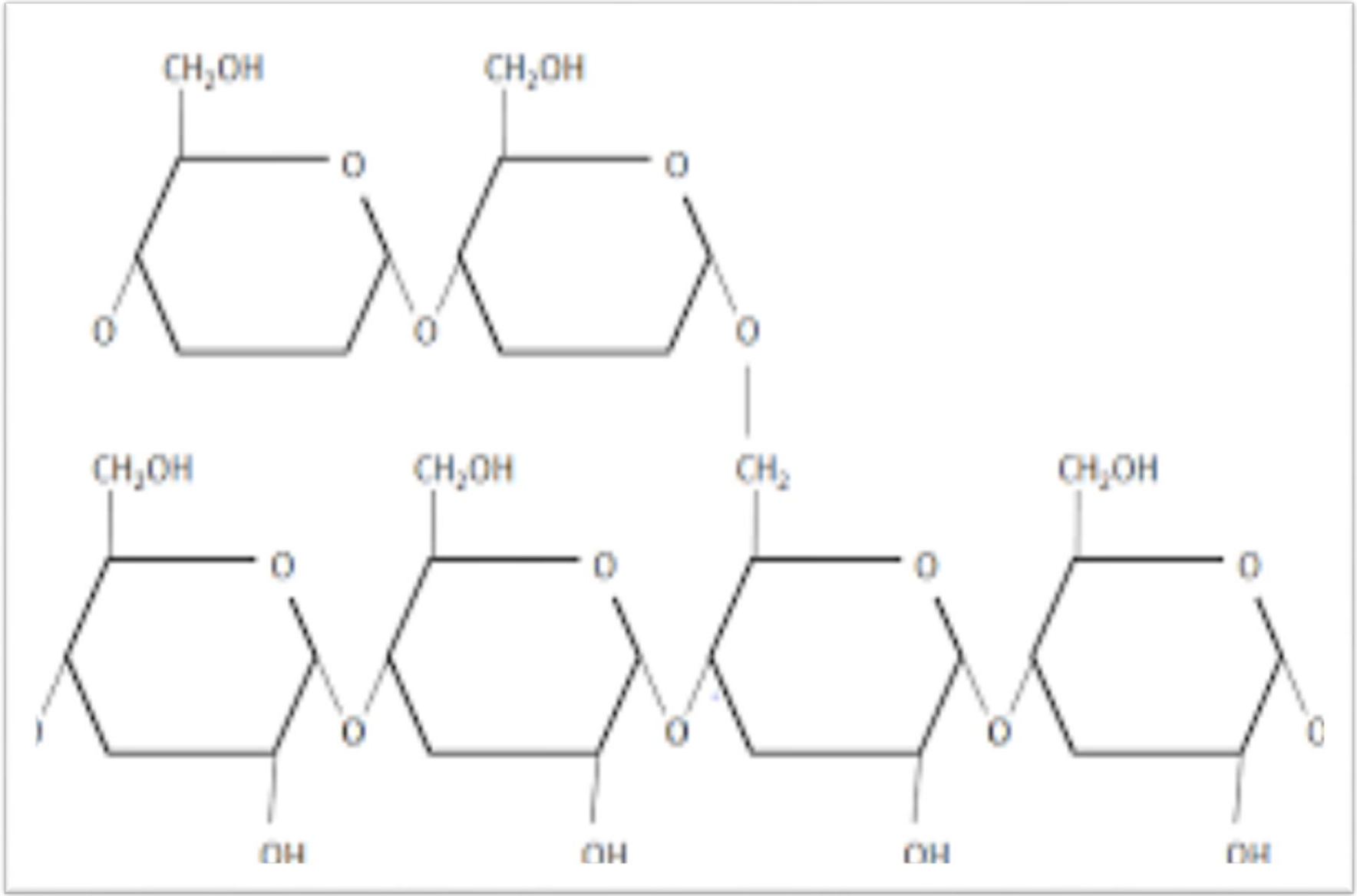
Structure

Branching takes place at an interval of 8 to 12 glucose subunits.Glycogen molecule also has a protein at its center known as **glycogenin protein**. This protein forms the core of the glycogen molecule.

Glycogen molecule organizes itself in a spherical form around the glycogen in protein in such a way that the whole structure looks like a tree with the branches arising from the center.

In the cytoplasm of living cells, glycogen is present in the form of **granules**. These granules are formed by glycogen with water present in the cytoplasm

Structure



Glycogen Function

Excess glucose gets stored short term in the liver and muscles as glycogen or long term as fat.
Liver glycogen acts as a **reservoir** for the body's glucose to help maintain normal blood glucose levels.
When eat a meal containing carbohydrates, glucose levels in the blood rise, triggering the pancreas to release **insulin**, a hormone that pulls glucose into cells to be used for fuel or stored for future use. Insulin also acts on liver cells to activate enzymes, including **glycogen synthase**, which links chains of glucose units together.
When we need additional energy, enzymes break down glycogen to supply the body with glucose.

Glycogen Function

Glucose broken down from liver glycogen is the body's main source of energy. Unlike glycogen stored in the liver that can be distributed throughout the body, glycogen stored in the muscles is only used to fuel the muscles themselves. This is because muscle cells do not produce the enzyme **glucose-6-phosphatase**, which is needed to release glucose into the bloodstream.

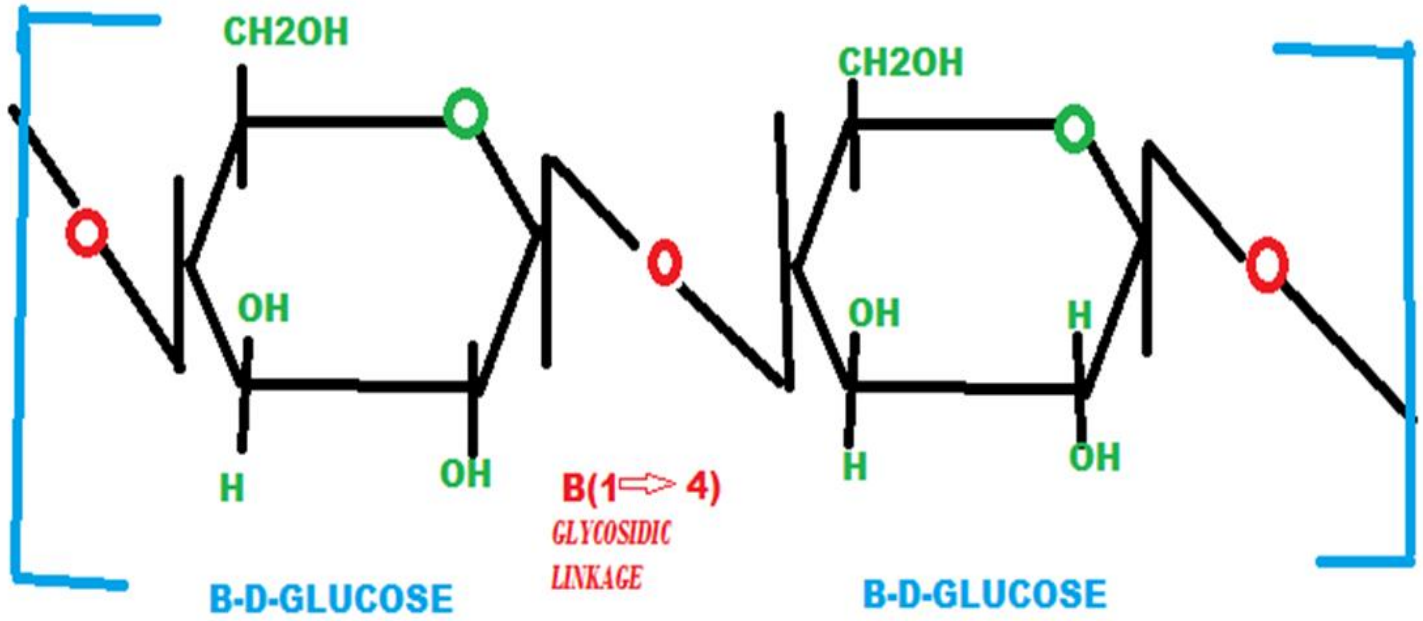
Glycogen has also been identified in other tissues in the body, including the **heart, brain, fat tissue, red blood cells, and kidney**. However, its functions in these areas are largely unknown

Cellulose

Occurrence

- Located in the cell wall of plants as structural component.
- Biofilms of certain species of bacteria
- Structural components of many forms of algae

And oomycetes


CH2OH
OH
H
OH
B(1⇨ 4)
GLYCOSIDIC
LINKAGE
CH2OH
OH
H
H
OH
B-D-GLUCOSE
B-D-GLUCOSE

Structure

- Cellulose is an unbranched homopolysaccharide.

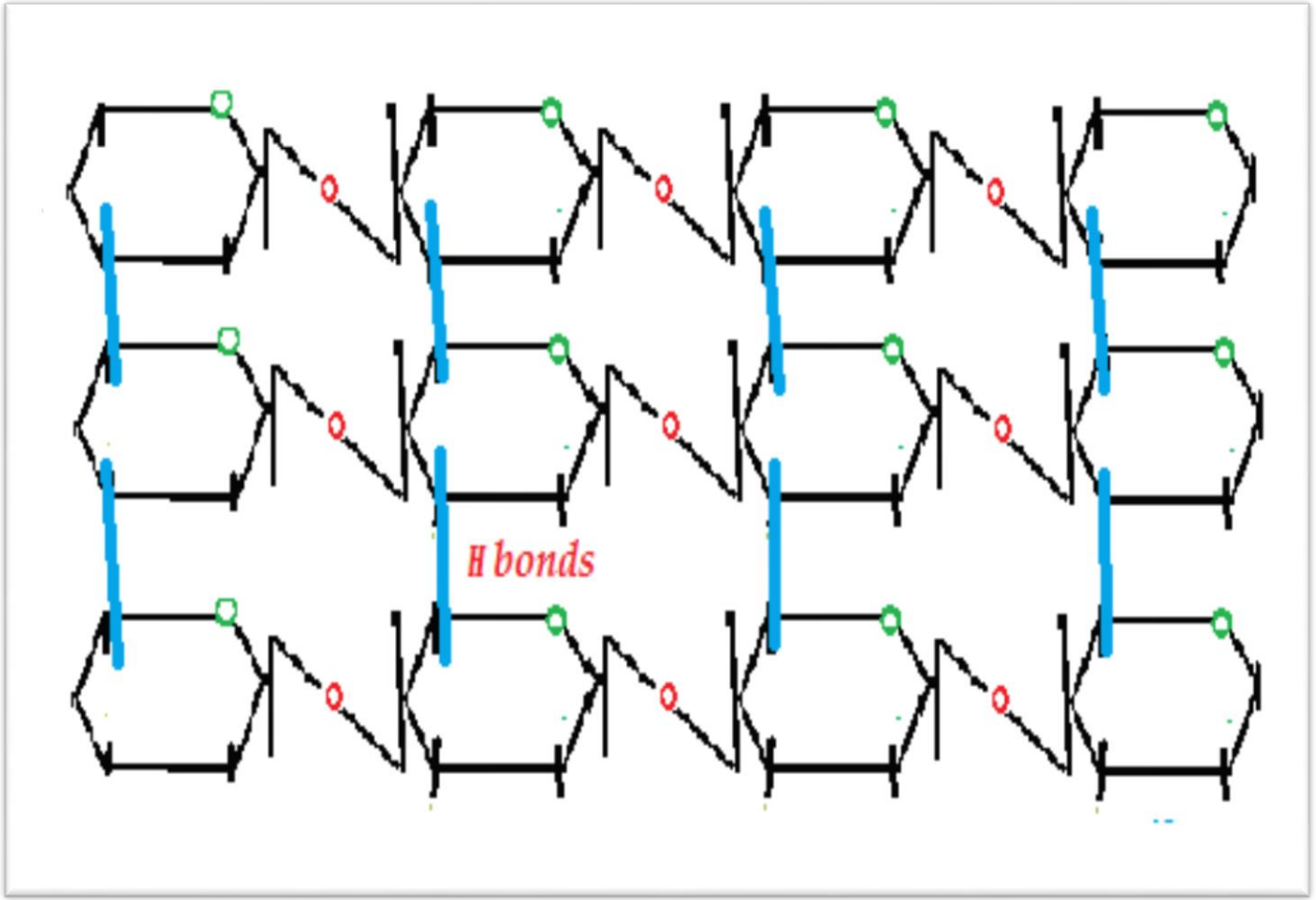
(contains same type of monomers)

- Cellulose is made up of repeating units of

B-d-glucose monomers linked via beta(1-4) glycosidic linkage . That is ,Beta d glucose monomers are joined by the plants by condensation/hydrolysis reaction.

- Cellulose is a linear straight chain polymer, it does not coil like starch.
- The Beta -d-glucose monomer chains lie parallel and are joined together by hydrogen bonds.

Structure



Micro fibrils

elongated structures in plant cell walls composed of cellulose chains arranged in a highly organized, crystalline fashion.

Structure

- This structure is called micro fibril which is present along with pectin in cell wall of plants.
- Micro fibrils are again joined by hydrogen bonds and become macro fibrils or cellulose fibers.
- These hydrogen bonds present both chains add tensile strength to the fibers.

Biological functions

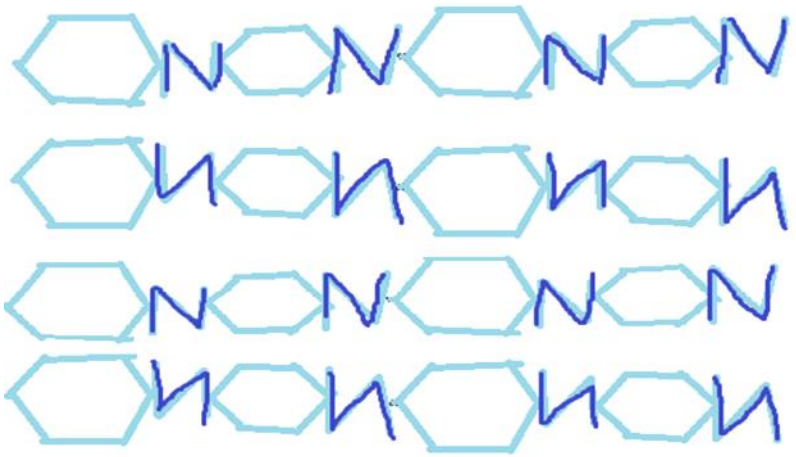
- Cellulose is an important dietary fiber in humans. it helps in digestion and excretion of waste by acting as a bulking agent for feces.
- Humans cannot digest cellulose fibers.
- however certain type of cellulose enzymes are found in human intestine.
- Cellulose is a major form of energy source for animals like cow ,horse , sheep etc.,. Who's gut microbiota secretes cellulase enzymes to break down cellulose in to glucose monomers for energy.
- Cellulose is broken down in to ethanol and hydrocarbon by cellulolytic bacteria's.
- Cellulose provides 70 percentage of carbon vegetation in the atmosphere

Chitin

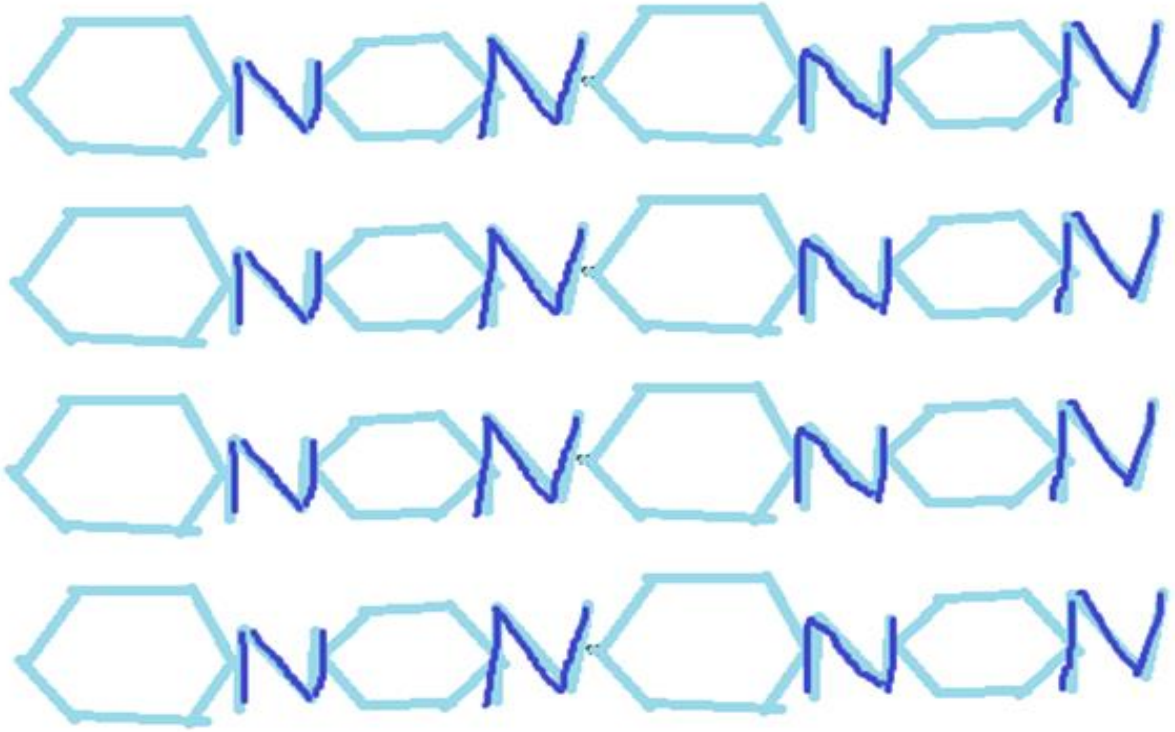
Occurrence

- Present in exoskeleton to protect the internal organs of crabs , lobsters , squids.
- and in insects like spider they are responsible for flexibility and softness and become hard with conjugation of certain proteins .
- These structural polysaccharides are also found in extracellular covering of arthropods , sponges , mollusks and annelids.
- They are also found in the cell wall of some green algae and most fungi.

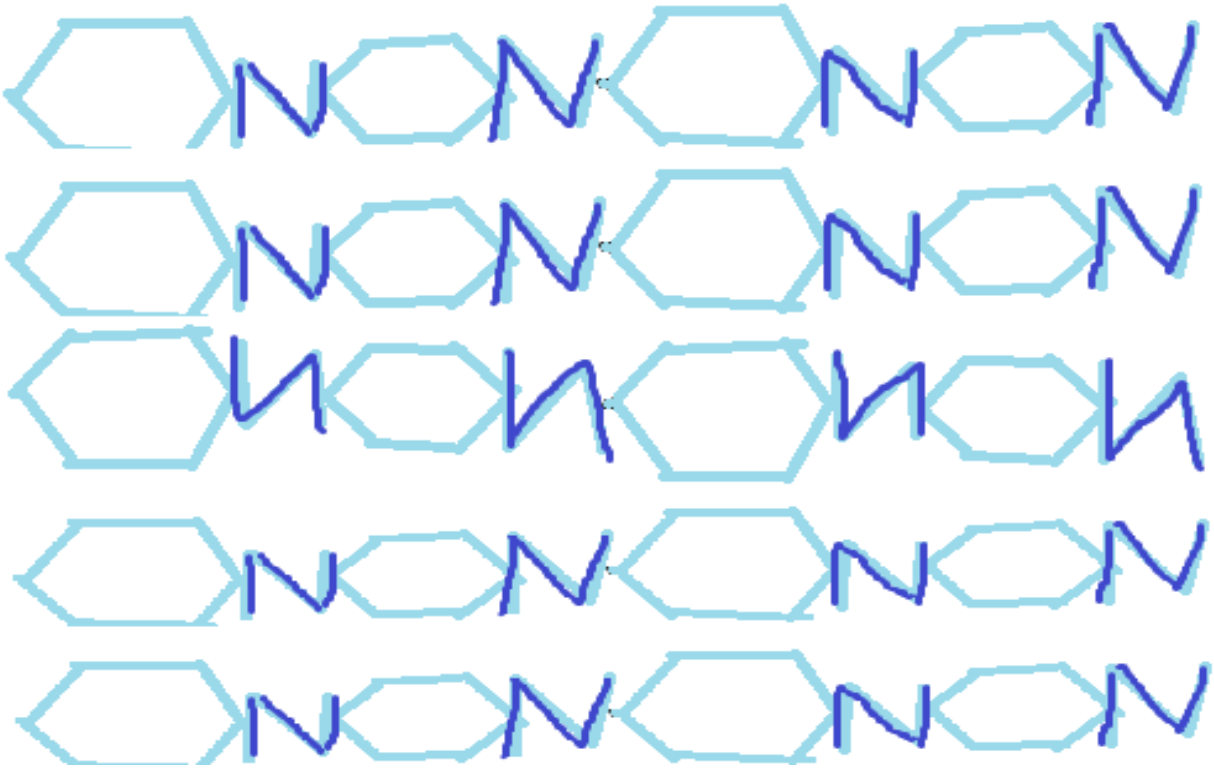
- It is also noted that the arrangement of these polysaccharide chains vary in different organisms.
- According to which there are alpha , beta and gamma forms of chitins
- **Alpha** – These are alternating anti parallel arrangement of polysaccharide chains.
- This form of chitin is found in crustaceans



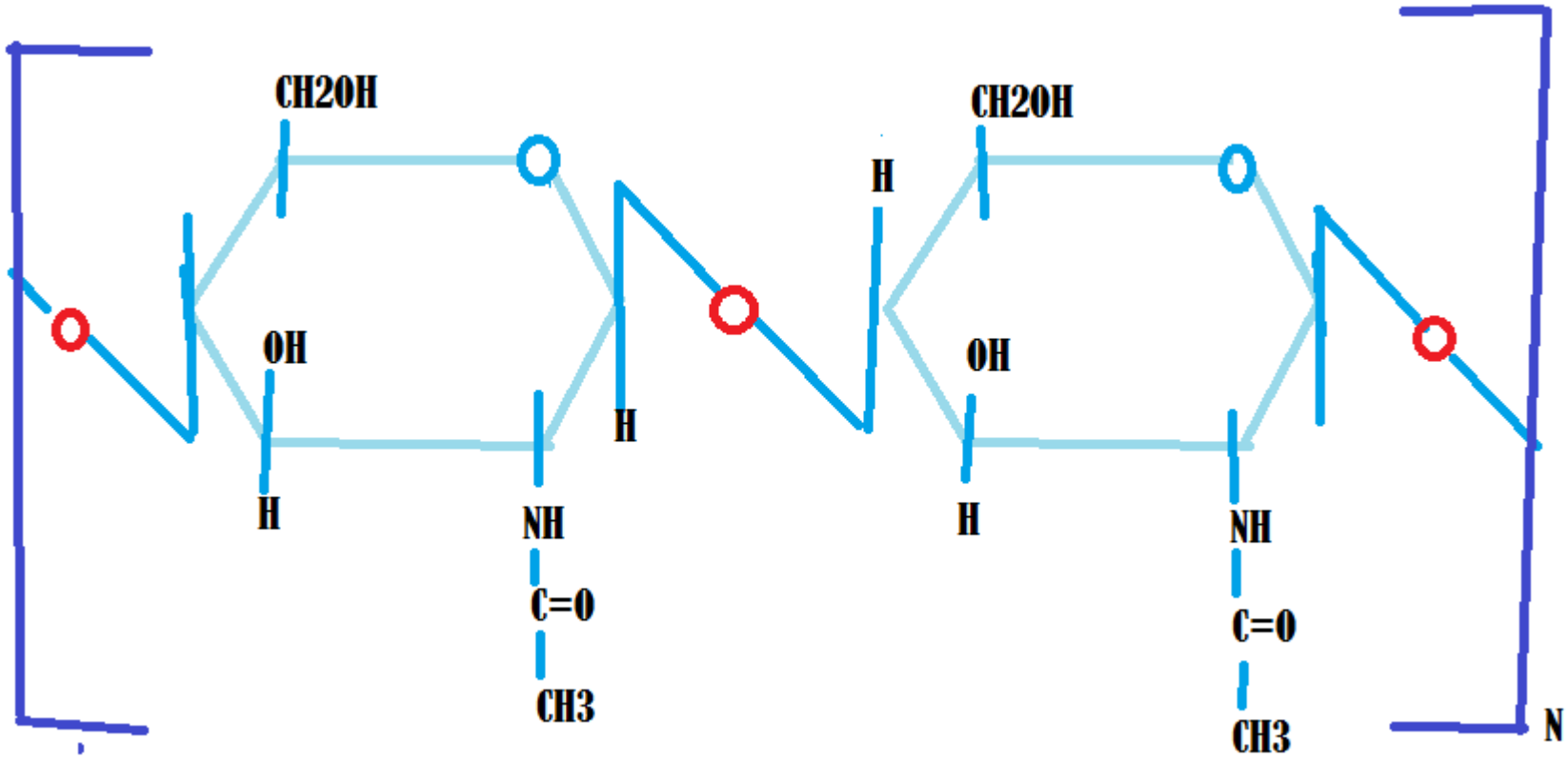
Beta-These are parallel arrangement of polysaccharide chains.
These arrangement of chitin are found in squids



Gamma –These are arrangement of two parallel chains with an alternating anti parallel chain.
This arrangement of chitin is found in fungi.



Structure



- Chitin is made up of repeating units of N-acetyl –D-glucosamine.
- The beta -1,4 linkage between each monomer's provides stability to the structure.
- chitin is a positively charged molecule , it can bind to skins and proteins.
- Chitin has similar structure of cellulose except cellulose have hydroxyl group ,
- while chitin has amide group.

Functions

- Cocoon thread of various insects are made up of chitin.
- chitin serves as a **protective layer** of many organism.
- they involve in the prevention of loss of fluids.


Thank
You