POLYSACCHARIDES
  - Two main functions:
    - Energy Storage
    - Structure
  - STORAGE POLYSACCHARIDES:
    - STARCH
      - Found in chloroplasts of plant cells – especially abundant in potatoes, corn and wheat
      - Mixture of 2 types of GLUCOSE POLYMERS
        - Amylose
          - Linear, unbranched chain of α(1→4) D-glucose molecules
          - Disaccharide repeating unit = MALTOSE
          - Each amylase has 2 ends:
            - Non-reducing End (Glucose molecule with free –OH on C4)
            - Reducing End (Glucose molecule with free –OH on C1 – anomeric carbon)
          - Forms a coiled, relatively compact helical structure (~6 glucoses/turn)

AMYLOSE

D-GLUCOSE REPEATING UNITS = α(1→4) glycosidic linkages
Structure of the main backbone of amylose, amylopectin and glycogen

One turn of the helix has SIX glucose units

**AMYLOSE**
\[ \alpha(1 \rightarrow 4) \text{ glucose} \]

Glucose = hexagons
Forms large left-handed helix

- **Amylopectin**
  - Main backbone is amylose (linear) with D-glucose molecules in \( \alpha(1 \rightarrow 4) \) linkage
  - Also has **BRANCHES**: Connect to backbone and to each other by \( \alpha(1 \rightarrow 6) \) linkages
  - Branch points every 25-30 glucoses
  - Has **ONE** reducing end
  - Has many non-reducing ends
DEGRADATION OF STARCH/AMYLOPECTIN

- Amylose [α(1→4) linked glucose] is degraded by enzymes called AMYLASES in the mouth and intestine to yield maltose and glucose
- Acid in your stomach also helps break down linkages
- Maltose (diglucose) is further degraded to 2 glucoses by maltase in the intestine
- All glucose is then absorbed by the body and used to make cellular energy
- Additional enzymes are needed to hydrolyze the α(1→6) linkages between glucoses at the branches – called a “debranching” enzyme
GLYCOGEN: Animal carbohydrate storage

FUNCTION:
• **All cell types:** Glucose reserve, ATP from glycolysis
• **Skeletal Muscle**
  o Used to generate ATP during anaerobic muscle contraction
    ▪ Glycogenolysis (degrading glycogen) and glycolysis (degrading glucose) active together
• **Liver:** The 1 source of glucose for maintaining blood glucose
  ▪ Glycogen degradation tied to glucose synthesis
    • Glycogenolysis and gluconeogenesis
• Stored in liver and muscle as granules or particles
  ▪ Up to 10% of liver mass and 1-2% muscle mass
• Branched glucose polysaccharide
  o Chains of glucose units
  o Similar in structure to amylopectin
  o Backbone linked by α-1,4 bond (like amylose)
  o Have α-1,6 branches every 8-10 residues (like amylopectin with more branches)
  o Has one reducing end and many non-reducing ends

GLYCOGEN (pink granules) IN LIVER CELLS
SIGNIFICANCE OF BRANCHING

- Branched structure allows several sites for simultaneous synthesis and degradation
- Branching speeds up degradation
  - Enzyme glycogen phosphorylase cleaves one glucose at a time from a NON-reducing end of glycogen; each end can be attacked separately by the enzyme at the same time! (Like picking grapes off of a bunch)
  - Debranching enzymes also play a part in complete degradation
- Makes glycogen is an efficient way to store glucose
  - Structure makes it compact and coiled
  - Each glucose is readily accessible
Short term energy storage – depleted within 24 hours of starvation

- **GLYCOPROTEINS**
  - Oligosaccharides can also be attached to proteins
  - Through glycosidic linkages to serine, threonine or asparagines
    - O-glycosidic linkages to Ser or Thr
    - N-glycosidic linkages to Asn

![Glycogen Particles in Liver](image)

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Different configurations of sugars on proteins
Great diversity!
FUNCTIONS OF OLIGOSACCHARIDES ON PROTEINS:
- Influence structure, folding and stability of protein
- May determine the lifetime of a protein (mark protein for age)
- Serve as markers to identify a cell type
- When glycosylated proteins are at the cell surface:
  - Can modulate cell-cell interactions
  - Changes in carbohydrate content may influence contact inhibition of cells
  - Can modulate cell-molecule interactions (e.g. hormone w/receptor)
  - Can serve as antigenic determinants (how antibody recognizes the protein) on proteins
    - e.g. The difference between blood types is due to glycosylation of red blood cell proteins

BLOOD TYPES AND GLYCOSYLATION

- Presence or absence of the terminal carbohydrate is genetically determined and determines the blood type.
- Blood plasma contains antibodies against foreign blood-group antigens that aggregate the foreign blood cells
- Type A blood has antibodies that recognize B sugars
- Type B blood contains antibodies against A sugars
- Type O blood has antibodies against both A and B sugars (universal donor)
- Type AB blood contains neither antibody (universal acceptor)
- Incompatible blood types cause precipitation of RBCs, block blood flow in organs and can cause death
- Also influenced by the presence or absence of Rh factor (blood protein)