Jonathan Lam
Mrs. McTague
H Bio. per. 3
12 / 30 / 14

Review Packet: Macromolecules

Introduction

1. **What are the four macromolecules essential to life?**
    - carbohydrates
    - proteins
    - lipids
    - nucleic acids

2. **What four elements make up these macromolecules?**
    - oxygen
    - hydrogen
    - carbon
    - nitrogen

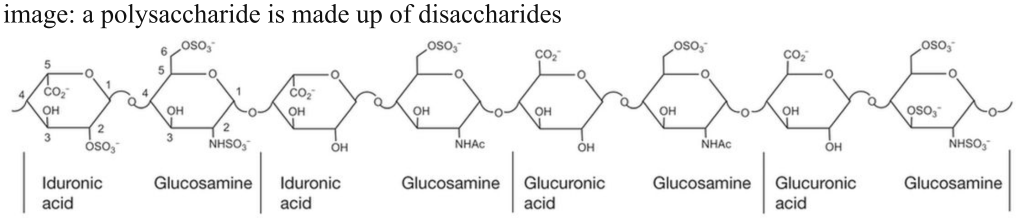
3. **What is a macromolecule?**
    - a molecule essential to life, usually long chains of monomers

Carbohydrates

4. **What are the five carbohydrate monomers?**
    - starch (amylose)
    - cellulose
    - glycogen
    - chitin
    - pectin

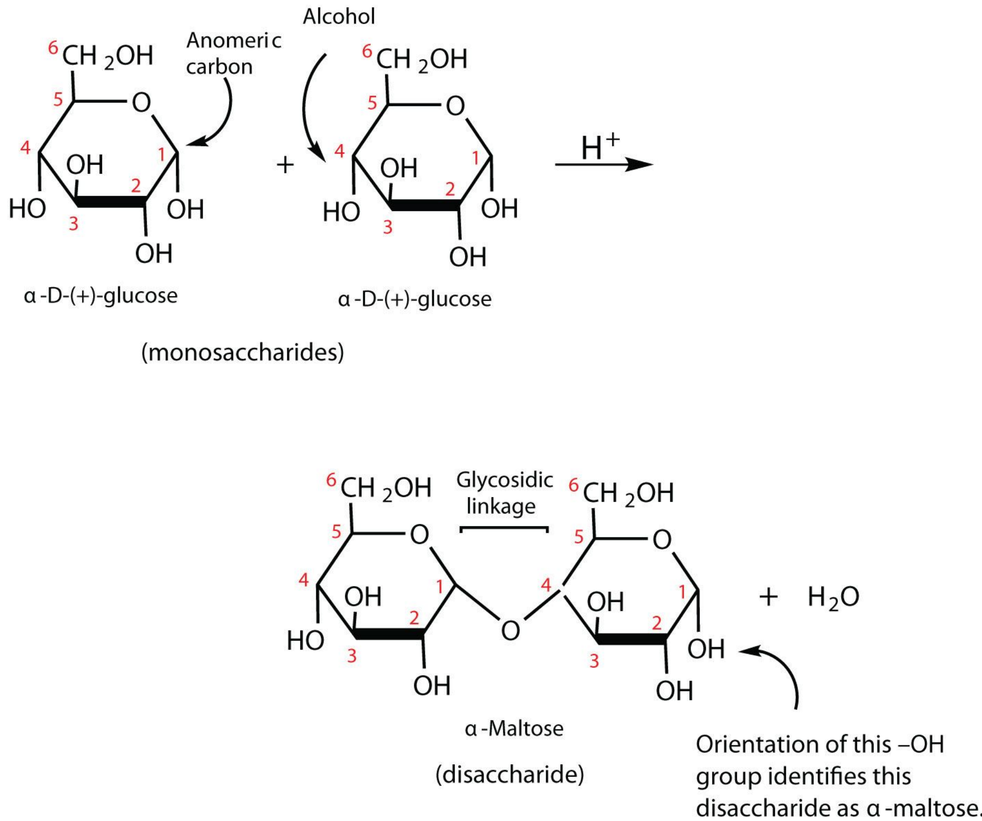
5. **How is a polysaccharide different from a monosaccharide?**
    - a polysaccharide is specifically a carbohydrate macromolecule

6. **How is a polysaccharide different from a disaccharide?**
    - a polysaccharide is a long chain of carbohydrate monomers
    - a disaccharide is made up of only two carbohydrate monomers- they are formed before a whole polysaccharide is created
    - image: a polysaccharide is made up of disaccharides



7. **How is a disaccharide different from a monosaccharide?**
    - a disaccharide is made up of two monosaccharide

- Image: disaccharide is made of two monosaccharides



8. **What are the three monosaccharides?**
   - glucose
   - fructose
   - galactose

9. **What is the chemical formula for all three of these monosaccharides?**
   - $C_6H_{12}O_6$

10. **How are these three monosaccharide different from each other?**
    - They have different structures/shapes.

11. **What are the three (most common) disaccharides?**
    - maltose
    - sucrose
    - lactose

12. **How are these three disaccharides structurally different from each other? Be specific.**
    - maltose is comprised of two glucoses
    - sucrose is comprised of a fructose and a glucose
    - lactose is comprised of a galactose and a glucose

13. **Starch, cellulose, and glycogen are all long chains of which monosaccharide?**
    - glucose

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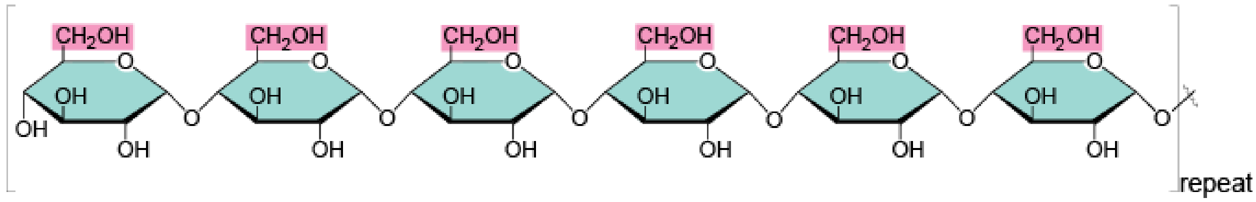
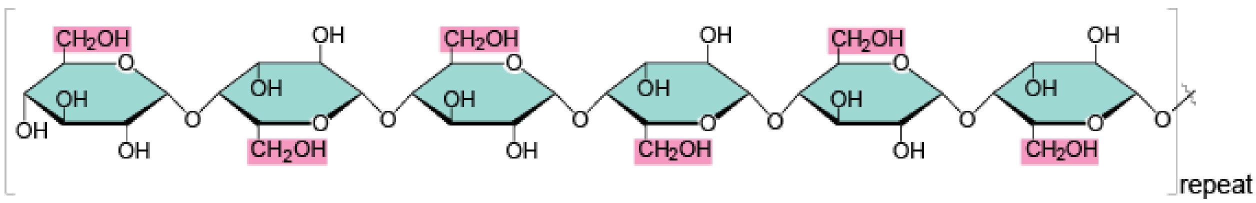
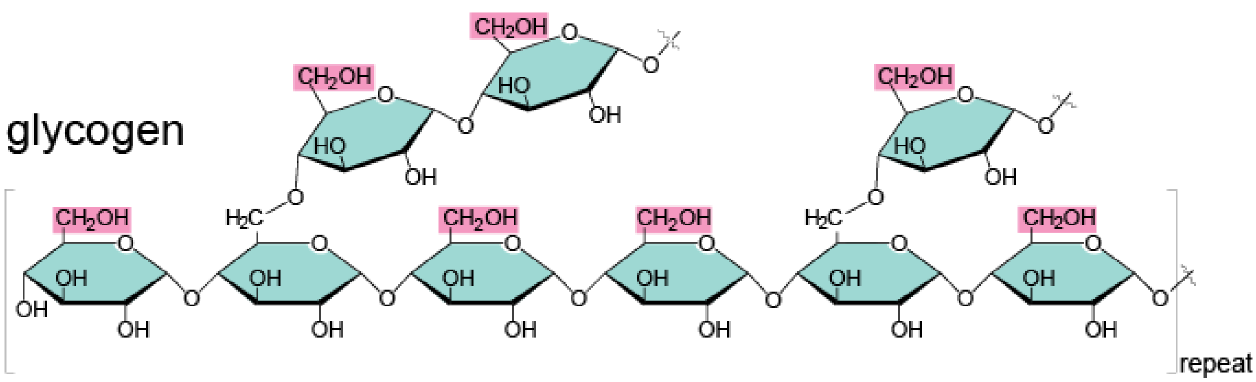
starch



cellulose



glycogen



14. **How are starch and cellulose structurally different from each other, if they are both made of chains of the same monosaccharide?**
    - starch is wavy, but doesn't branch, because all of its "stems" are facing the same direction
    - cellulose is flat and straight, because its top section alternating up and down, allowing it to form hydrogen bonds with another cellulose polymer, making it flat and rigid and strong

15. **Why does the body break down (digest) starch and disaccharides? (What does the body need, and why?)**
    - we need the carbohydrates in the larger molecules to fuel our bodies, but we cannot get the larger molecules into our bodies (they can't physically fit), and because our body burns the individual monosaccharides, not the whole molecule at a time

16. **How does the body break down starch and disaccharides?**
    - hydrolysis: adding water molecules to separate the individual monomers, usually sped up with an enzyme (a catalyst)

17. **Why can the human body break down starch, but not cellulose?**
    - we have enzymes that can hydrolyze the glycosidic bonds in the starch, so that we can break it down quickly enough to absorb it

- we don't have cellulase (enzyme) to quickly hydrolyze the glycosidic bonds in the cellulose

18. **Nearly all humans can digest sucrose and maltose for their entire lives, but there are many humans who lose their ability to digest lactose. What do their bodies cease to make that makes consuming lactose problematic?**
    - the lactase enzyme
19. **Which disaccharide is also known as "malt sugar"?**
    - maltose
20. **Which disaccharide is table sugar?**
    - sucrose
21. **Which disaccharide is also known as "milk sugar"?**
    - lactose
22. **Which disaccharide is found flowing in plants?**
    - sucrose
23. **Which polysaccharide is found in the cell walls of plants?**
    - cellulose
24. **Which polysaccharide is found in the cell walls of fungi?**
    - chitin
25. **Which polysaccharide is found in the cell walls of bacteria?**
    - peptidoglycans
26. **Which polysaccharide is the storage form of glucose in plants?**
    - starch
27. **Which polysaccharide is the storage form of glucose in animals?**
    - glycogen
28. **What is "synthesis by dehydration" ("dehydration synthesis")?**
    - the process of creating a macromolecule, linking together two monomers, by removing a water molecule from each of the molecules to force them to bond. An OH^- and an H^+ leaves from the molecules, one from each, which bond to form water. This bond is known as a glycosidic bond in carbohydrates and a peptide bond in proteins. It can be sped up by enzymes
29. **Could synthesis by dehydration be used to form fructose? Explain.**
    - no. Fructose is a monomer, and synthesis by dehydration can only be used to link monomers together to form larger molecules- not the other way around
30. **Could synthesis by dehydration be used to form starch? Explain.**
    - yes. Starch is a polysaccharide, formed by many monosaccharides joined through dehydration synthesis as glycosidic bonds

Proteins

31. **What is a protein macromolecule called?**

- polypeptide

32. **A protein macromolecule is a long strand of what type of smaller molecules (monomers)?**
    - amino acids

33. **How many different amino acids are there?**
    - 23 in total
        - 20 are common and can be produced in the human body
        - 3 are essential and can only be attained through consumption

34. **If only two amino acids are bonded together, what do you have?**
    - dipeptide

35. **What type of bond holds two amino acids together?**
    - peptide bond

36. **What is needed to break the bond between two amino acids?**
    - hydrolysis (addition of H_2O)

37. **Why does the human body break down polypeptides and peptides? (What does the body need, and why?)**
    - to be able to digest it (a polypeptide may be too large to absorb, or too large to fit into a cell)
    - to be able to get individual amino acids to build with again

38. **Does the human body ever put amino acids together to make polypeptides? If it does, for what purposes does it do so?**
    - yes, for all of the uses of proteins:
        - enzymes
        - protection in the immune system
        - movement (contractile proteins)
        - transportation
        - hormones (signal proteins)
        - storage
        - receiving signals (receptor proteins)
        - structure

39. **Does the human body use synthesis by dehydration to bond amino acids together to make dipeptides and polypeptides?**
    - yes

40. **What is produced when you bond two amino acids together?**
    - H_2O

Lipids

41. **What is a lipid macromolecule called?**
    - triglyceride (fat)
    - phospholipid
    - steroid

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42. **A lipid macromolecule is made up of what other smaller molecules?**
    - glycerol
    - fatty acids

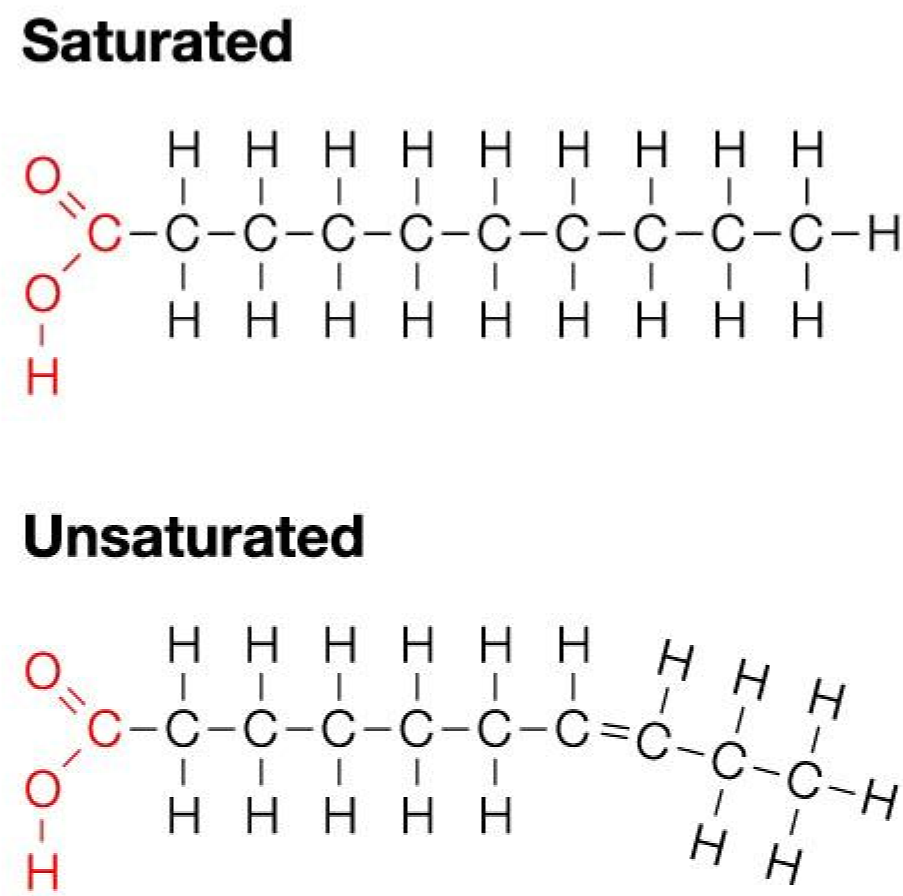
43. **Exactly how many of each type of the above smaller molecules are needed to make one lipid macromolecule?**
    - triglyceride: 1 glycerol, 3 fatty acids
    - phospholipid: 1 glycerol, 2 fatty acids
    - steroid: ?

44. **Are all glycerol molecules the same?**
    - yes (chemical formula: C3H8O3)

45. **Are all fatty acid molecules the same?**
    - no: the differ in
        - length
        - saturation of hydrogen molecules and number of double bonds

46. **Explain the difference between a saturated and monounsaturated fatty acid molecule.**
    - a saturated fatty acid has no double bonds, and all of its carbons except for the ones on its end are attached to two hydrogen atoms- it is totally saturated with hydrogen, not able to accept any more; this evenness allows for the saturated fat to stay flat, so it is easily stackable; when it is stacked, it forms hydrogen bonds easily, which makes it rigid and solid at room temperature
    - a monounsaturated fatty acid has exactly one double bond, and two hydrogens are missing (on the same side), which forms a "kink", or bend, in the shape of the fatty acid; this does not allow them

to stay flat, so it does not become rigid and solid at room temperature

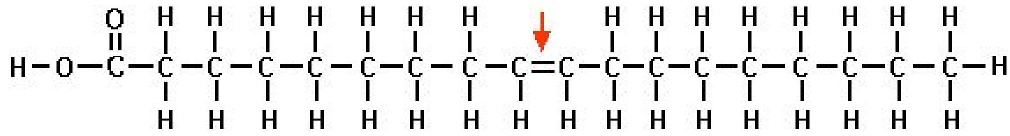


47. Explain the difference between a monounsaturated and polyunsaturated fatty acid molecule.

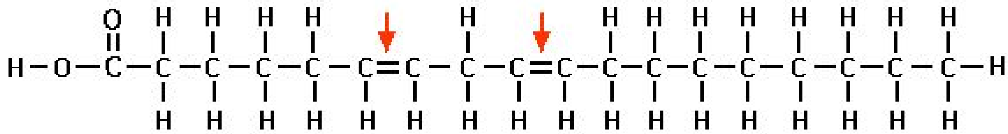
- monounsaturated explained above
- polyunsaturated fatty acids have at least two "kinks" in their backbone, formed by at least two double bonds, and at least four hydrogen bonds; they are even more bent than monounsaturated

fats

Oleic Acid- Monounsaturated Fatty Acid



Linoleic Acid- Polyunsaturated Fatty Acid



48. Which are worse for you: saturated or unsaturated fatty acids? Why?
- saturated fats are worse: because they are flat and rigid, they tend to build up- when they build up in arteries, they can be deadly
- unsaturated fats do not build up because their kinks prevent them from sticking together, and are healthier

49. What types of foods contain saturated fats?
- meat or byproducts (not fish)
  - beef
  - dairy
  - eggs
- tropical plants
  - coconut

50. What types of foods contain unsaturated fats?
- plants (not tropical) and nuts
  - beans
- fish

51. Which type of fat (saturated or unsaturated) tends to be solid at room temperature? Why?
- saturated- because it tends to be flat, they can stack very closely together, allowing for hydrogen bonds to form between them, causing them to become rigid

52. Why does the human body break down triglycerides? (What does the body need, and why?)
- we need the fatty acids, to build other lipids

53. How does the human body break down triglycerides?
- hydrolysis, usually with enzymes (lipase)

54. Does the human body ever put glycerol and fatty acid molecules together to form lipid macromolecules? If it does, for what purposes does it do so? What is the function of lipids in the human body?
- yes, for all the reasons of lipids:
  - long-term energy storage

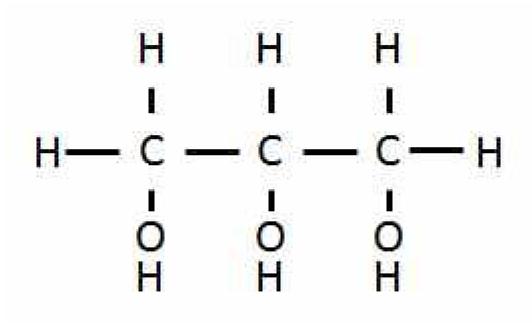
- waterproofing
- cell and organelle membranes
- insulation
- cushioning

55. Does the human body use synthesis by dehydration to bond glycerol and fatty acid molecules together to make lipid macromolecules?

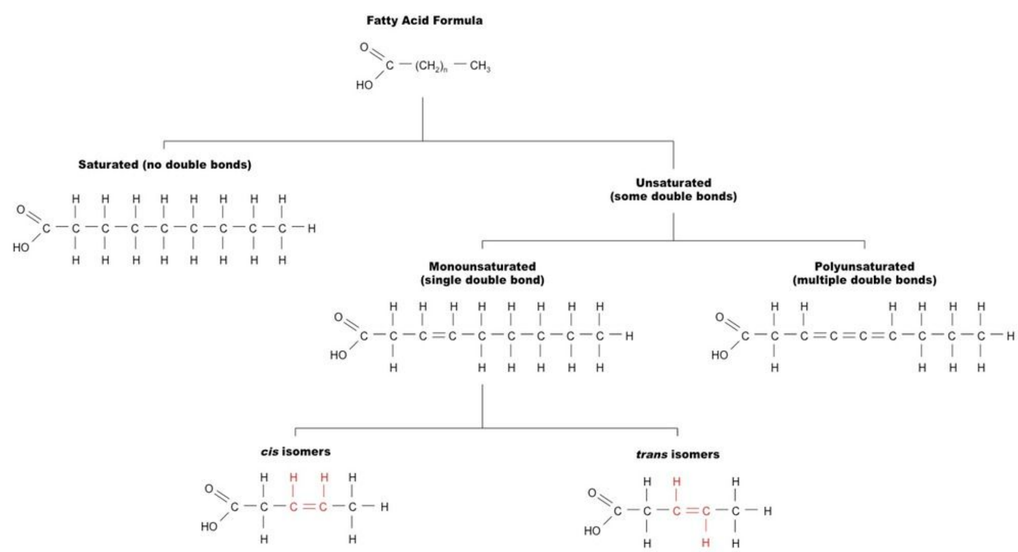
- yes

56. Draw the molecular structure of a glycerol molecule and three fatty acid molecules.

- glycerol:

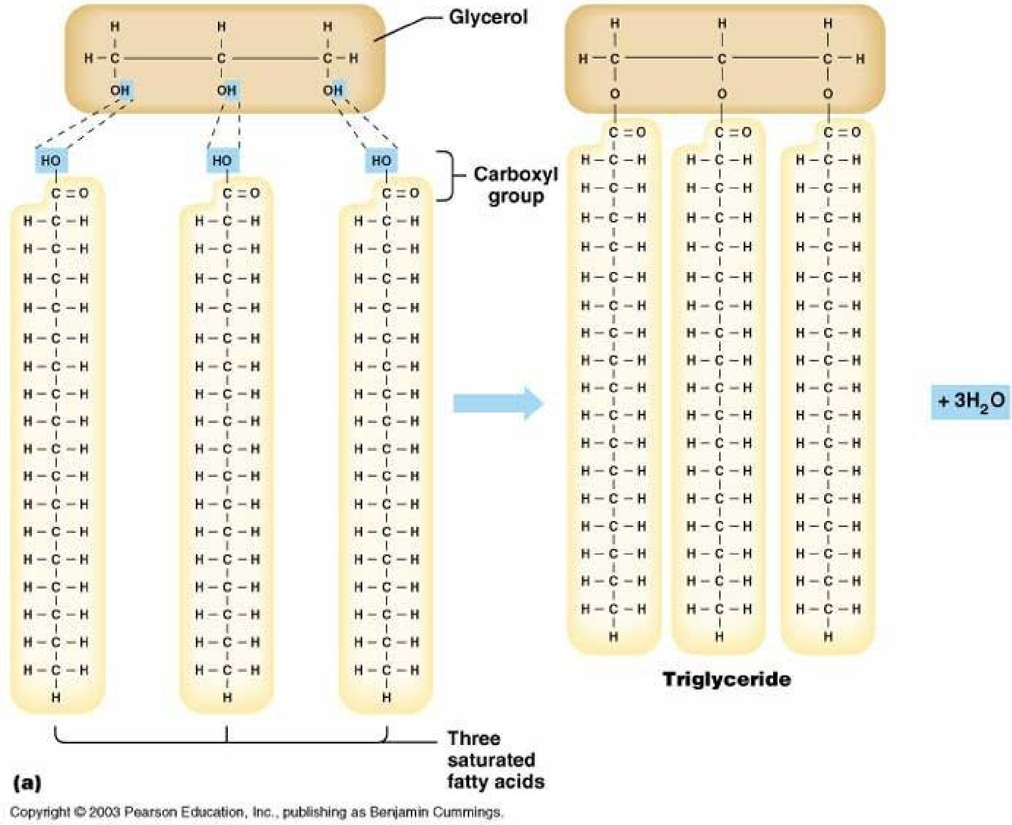


- types of fatty acids:



57. Bond three fatty acid molecules to a glycerol molecule. What is produced when you bond the three fatty acids to the glycerol molecule?

- a triglyceride (fat) molecule and three water (H_2O) molecules are created



Review Sheet: Biochemistry

Food Sources

Carbohydrates

Monosaccharides

- glucose
  - most sugars
- fructose
  - fruits
- galactose
  - milk

Disaccharides

- sucrose
  - fruits
  - table sugar
- lactose
  - milk
- maltose
  - beer
  - seeds
  - malt candy

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Polysaccharides

- starch
  - plants, especially
    - potato
    - grains (wheat, rice, barley, sorghum)
- glycogen
  - animals
- cellulose
  - plants (most abundant organic molecule on Earth)

Proteins

All Amino Acids

- animal products
  - red meats (beef, pork)
  - eggs
  - dairy
- beans
- nuts

Essential Amino Acids

- soy

Fats

Essential Fatty Acids

- omega-3
  - flax seeds
  - walnuts
  - vegetable oils
  - fish (unstable omega-3s)
- omega-6
  - leafy vegetables
  - nuts
  - seeds
  - grain
  - vegetable oils

Saturated Fatty Acids

- tropical vegetables
- animals (not fish)

Unsaturated Fatty Acids

- vegetables (not tropical)
- fish

Structure

Carbohydrates

Monosaccharides

- glucose, fructose, and galactose are the only monomers
- all have same chemical formula and number of atoms, different arrangements (different isomers of $C_6H_{12}O_6$)

- shaped differently

Disaccharides
- all contain only two monomers of sugar
- most have glucose, but not all- combinations are unique
- major ones are sucrose, lactose, and maltose

Polysaccharides
- all are long chains of sugars
- starch, glycogen, cellulose, pectin, and chitin are the major ones (all chains of glucose)
- differ in orientation / arrangement of monosaccharides
  - in glycogen, the "antennas" are all facing the same way, is branched
  - in starch, the "antennas" are facing the same way, no branches
  - in cellulose, the "antennas" alternate directions, no branches

Proteins

Amino Acids
- all contain the same "head" but a different "R"-group (side chain). Head contains:
  - alpha carbon in the center, connected to:
    - hydrogen
      - H
    - amino group
      - NH_2
    - carboxyl group
      - makes the amino acid an acid
      - COOH
    - side chain
- side chain determines their properties, especially those relating to acidity and polarity:
  - side chains with mostly C, H, and S are usually nonpolar and hydrophobic and neutral
  - side chains with O and N are often hydrophilic and polar or acidic

Polypeptides
- all contain multiple amino acids in a chain, but in a certain shape
- primary structure
  - chains of amino acids, with a unique sequence
- secondary structure
  - unique shape of amino acid
  - only made up of alpha helices or beta pleated-sheets
  - determined by hydrogen bonds forming at regular intervals down the backbone (not R-groups)
- tertiary structure
  - unique, functional shape
  - determined by R-groups
    - hydrophobic proteins gather in the center and the hydrophilic are on the outside
    - hydrogen bonds form between polar side groups
    - disulfide bridges form
- quaternary structure
  - fully functional shape for some proteins

Lipids

Fatty Acids
- all hydrocarbons (carbon backbone with hydrogens surrounding it)

- all have carboxyl group on one end (COOH)
- differ in length
- differ in saturation of hydrogen atoms

Triglycerides vs. phospholipids?

- triglycerides are a glycerol bonded to three amino acids with the three hydroxyl groups
- phospholipids are a glycerol bonded to two amino acids with the third hydroxyl group bonding with a charged phosphate group, which is hydrophilic

Steroids

- all are made of four fused rings
- different chemical groups attached to the rings yield different properties

Nucleic Acids

DNA vs. RNA

- made of nucleotides
    - each nucleotide is made of:
        - a phosphate group
        - a pentose sugar, one of the following:
            - deoxyribose for DNA
            - ribose for RNA
        - a nitrogenous base, one of the following:
            - adenine (A)
            - guanine (G)
            - thymine (T, U)
            - cytosine ©

Function

Carbohydrates

- main source of energy
    - starch
    - monosaccharides
- short-term energy storage
    - glycogen
- structure
    - cellulose
    - chitin
    - pectin
- taste, attracting animals with fruits for reproduction
    - sucrose
    - fructose

Proteins

- catalyst (enzyme)
    - catalase (breaks down hydrogen peroxide)
- structure
    - ligaments, tendons
- movement (contractile)
    - muscles

- defense
    - antibodies
- signal (signal and receptor)
    - hormones
- transport
    - hemoglobin
    - transporting sugar
- storage
    - milk for babies
    - ovalbumin for eggs
    - seeds for plant embryos

Lipids
- long-term energy storage
    - triglycerides
- protection
    - cushioning
    - insulation
- cell membranes
    - phospholipids
    - cholesterol
- grow muscle
    - steroids (hormones)

Nucleic Acids
- cell functions
- creation of proteins

Dehydration Synthesis and Hydrolysis

Dehydration Synthesis
- method used to link monomers together to form a medium-sized molecule or macromolecule
- removal of hydroxide group from one molecule and hydrogen from the other, which bond to form water, which leaves the two monomers
- the two monomers are left chemically unstable, one missing an electron from the removal of an OH^- molecule and the other with an extra from the removal of a H^+ molecule (they become ions), so they bond together with a covalent, intramolecular bond, sharing the electrons
- happens in cells, with proteins being built in the lysosomes
- happens in cells, with enzymes speeding up reactions to create carbohydrates, fats, and nucleic acids
- when we need to build functional or storage macromolecules that have a different or more advanced function than the individual monomers

Hydrolysis
- method used to break down macromolecules or medium-sized molecules into monomers
- addition of a water molecule allows an H^+ ion to bond with one monomer and an OH^- to bond with the other, breaking them apart by making each one chemically stable without the other
- happens often in digestion to allow individual monomers to be absorbed for body to use and build new macromolecules with

- also allows for individual monomers to be physically small enough to fit through cell walls and be absorbed
- body can't use all of the polymers that we ingest- sometimes we need to change them a little bit
- sometimes a storage form needs to be broken down to be functional- we cannot use a monomer

Conclusion

Functions of Macromolecules

Carbohydrates
- primary source of energy
- structure

Proteins
- enzymes
- defense
- signals/hormones/receptor
- transport
- storage
- movement
- structure

Lipids
- secondary source of energy, long term energy storage
- protection
  - insulation
  - cushioning
- cell and organelle membranes

Nucleic Acids
- instructions for making proteins to carry out functions in the cell and body

Why are these the essential macromolecules of living organisms?
Why are these molecules so critical for life on Earth?
What do they provide for living organisms?

The combination of these four different types of macromolecule allow for every kind of life to survive because they have the capability to carry out essential tasks of an organism. This process of "carrying out tasks" requires multiple parts: the instructions, the application of the instructions, the sources of energy necessary to carry out the task, and the protection and storage to allow tasks to happen. The DNA holds the instructions for all cellular tasks, such as reproduction. The mRNA holds a specific instruction, and a protein is created. The protein does the task, such as catalyzing a chemical reaction or moving a muscle or defending the cell by becoming an antibody. The carbohydrates provide the immediate energy that the cells use to carry out the task. Lastly, the fats store extra energy and cushion the cell from the outside, as well as making up the cellular membranes so that the cell stays together. These molecules, with the addition of water, allow every living task to happen.