2—BIOLOGICAL MOLECULES (AND NUTRITION)

WHAT WE'LL COVER:

The four types of biological molecules (proteins, carbohydrates, nucleic acids and lipids
The reactions that form and break up these large molecules!
What each type of molecule looks like (structure) and functions as

You explored these in lab, and thought about their nutritional roles for us.
All matter is made up of atoms: in living things, there are 4 main elements:
C=Carbon
H=Hydrogen
O=Oxygen
N=Nitrogen
These are found in varying amounts in the different biological molecules

REMINDER:

Atoms
Molecules
Macromolecules/Biological molecules
Organelles
Cells
Tissues
Organs
Organism

BUILDING POLYMERS FROM MONOMERS

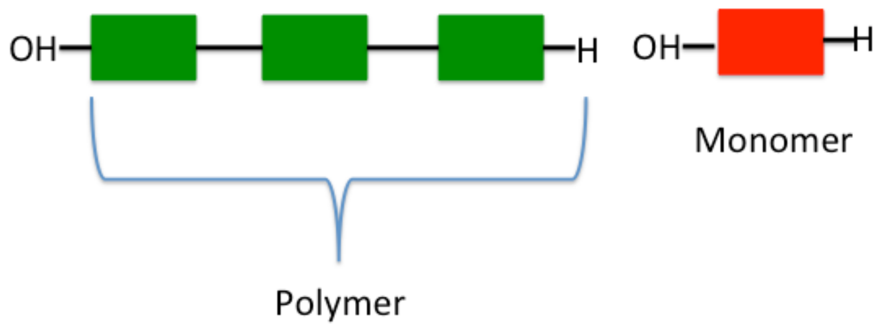
Mono=one
Poly=many
Mer=part (or thing)

So **monomer**: are single unit (small molecule)—different for different macromolecules
Polymer: made from many monomers

SYNTHESIS (MAKING) AND BREAKING (DIGESTION) OF POLYMERS

(This process in the body is made possible by proteins called enzymes)

monomer + monomer = polymer



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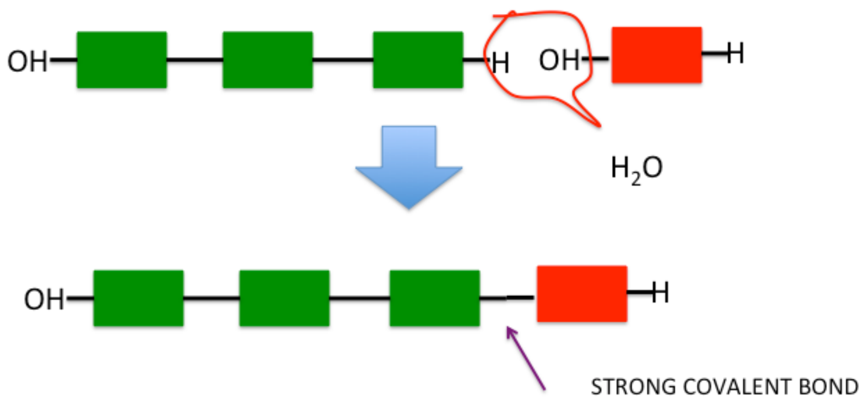


This type of reaction is **anabolic** and requires the *input of energy.*

Where do we (as consumers) get this energy from?
From eating other biological molecules and breaking them down.

Breaking up polymers into monomers=**catabolism**, and *releases energy*.
This is how we digest proteins, carbohydrates etc that we eat

Breaking up a polymer into monomers doesn't happen easily/on its own: these are STRONG chemical bonds that hold together the monomers. (This is what digestive enzymes that we produce are for)

BIOLOGICAL MOLECULE #1: CARBOHYDRATES

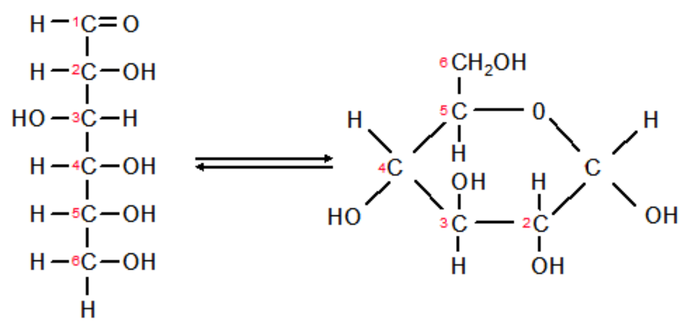
Formed of C, H, O
Carbohydrates- term includes **sugars** (simple, disaccharides) and polymers of sugars (**polysaccharides**)
Named because they're in the form of a hydrated (H_2O) Carbon (C)
So a generic formula: $C_xH_{2x}O_x$ (for every atom of carbon, there are 2 H's and 1 Oxygen)
Uses: energy storage (not as efficient as storing energy as fat)
structural

SUGARS: MONOSACCHARIDES AND DISACCHARIDES

Mono=one

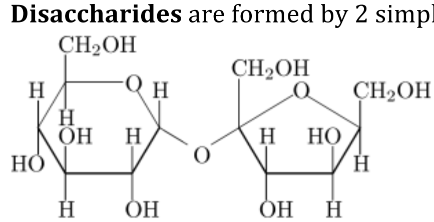
Di=two

Names of sugars usually end in **–ose**

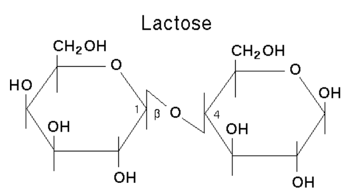


Monosaccharides are simple sugars—only 1 sugar molecule: for example glucose (Monomer of carbohydrates)

Disaccharides are formed by 2 simple sugars (monosaccharides) coming together:



glucose + fructose = sucrose



glucose + galactose = lactose

This is a strong chemical bond!

POLYSACCHARIDES

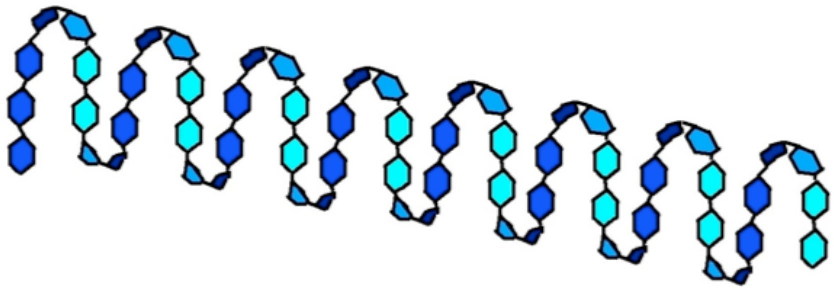
--macromolecules of 100-1000's of monosaccharides

2 main functions: energy storage

structural

STORAGE POLYSACCHARIDES

(Glycogen)



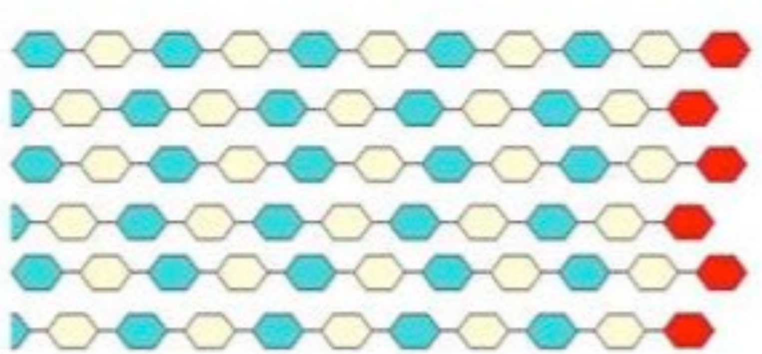
http://beerandwinejournal.com/wp-content/uploads/2014/10/amyloseBWJ.jpg

Plants store **starch**—a polymer of glucose monomers—*saw this in lab*

Most animals have an enzyme (a protein) to help hydrolyze starch to get the glucose

Structural polysaccharides

For us: structural roles inside us are mostly carried out by proteins (#3 below), but for plants, they tend to use more carbohydrates, which is why we often look for protein in our diets from animal products. BUT: plants definitely have proteins too: Tofu and gluten are examples of protein purified out of plant products.



http://polysac3db.cermav.cnrs.fr/discover_cellulose.html

Cellulose—makes up tough walls of plant cells

Like starch=polymer of glucose

Always linear—get lots of long molecules next to each other

BUT!! We call this insoluble fiber:

We can't digest it!

(Chitin on insects too!)

Dietary sources and roles for us:

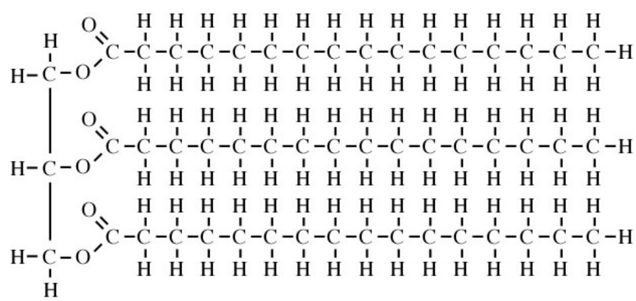
BIOLOGICAL MOLECULE #2: FATS (LIPIDS)

Made largely of C and H
Formed differently than other polymers: made of 2 different types of smaller molecules.
They also never get as big as the other macromolecules
--They are **hydrophobic!!**—lots of C-H, C-C bonds!
Great barrier in a watery environment
Great for energy storage!
1 gram of carbohydrates = 4 kcal (measure of energy)
1 gram of protein = 4 kcal
1 gram of fat = 9 kcal

We'll talk about general fats (triglycerides), and phospholipids (which make cell membranes)

TRIGLYCERIDES

Bulk of molecule is hydrophobic: fats are the scientists at the party—excluded from everyone else (H_2O)



http://www.indiana.edu/~oso/Fat/SolidNLiquid.html

SATURATED VS. UNSATURATED

Think saturated with hydrogens

If fatty chain is full of H's—each C gets two

If you have fewer H's (so non-saturated)—C will have four bonds as a double bond:

Unsaturated fats are KINKY!!! End up being **Liquid at Room** temp

Notes on drawing: 1. zigzag lines of carbon because of that tetrahedral shape
2. If there is no atom designated, it is a Carbon
3. every bond not shown with C assume a Hydrogen

When you have double bonds:
(Cis (R groups and H's are on the same side)

Trans (R groups are on opposite sides)

Omega-3 fatty acids)

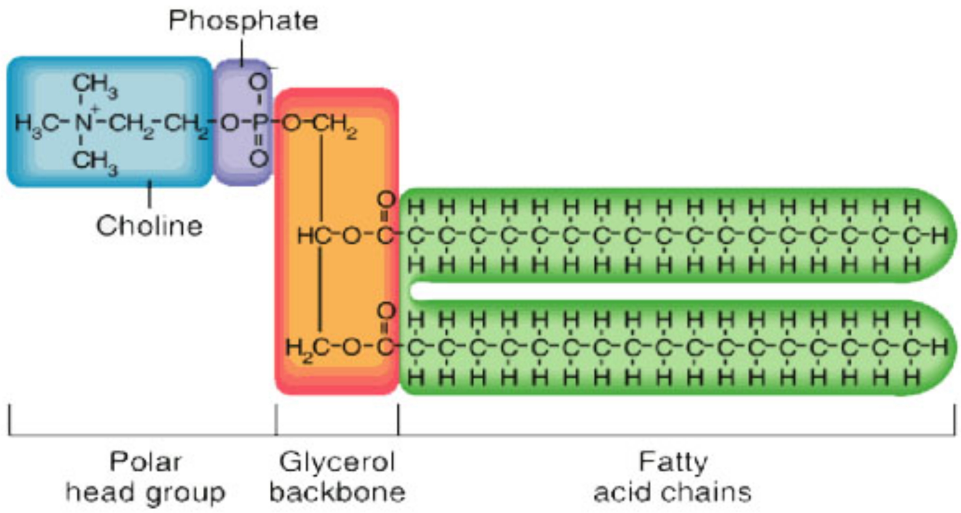
Dietary sources:

Fats as a barrier in a aqueous environment: Phospholipids

These make up the membranes of a cell (cells are the unit of life—you want to contain all the good chemical reactions you have, so you need a good barrier)

(*soaps* have a similar structure to these, which is why soaps are good at breaking up fats in a watery environment)

Formed like triglycerides: replace one fatty acid with a phosphate +X



http://bio100.class.uic.edu/lectf03am/phospholipid.jpg

Short-hand for phospholipids:

Polar on one side, non-polar on the other side

--if you place a bunch of these in water, they will form a bilayer: what will it look like?

So they form membranes naturally, based on their structure

MACROMOLECULE #3: PROTEINS!!!

Made up of C, H, O, and N (first time we've see N)

These vary the most in shape and since:

Shape determines function—they carry out the most jobs in the body

Roles include: enzymes (speed up (catalyze) reactions)

Structural

Storage

Cell communication

Defense (immune system)

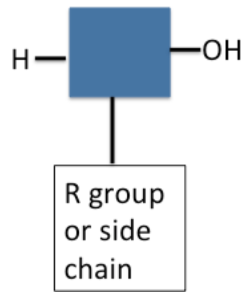
Most of the "jobs" that cells (living things) do are done by proteins

AMINO ACIDS ARE THE MONOMER THAT MAKE UP POLYPEPTIDES

There are 20 different **amino acids** (the monomer of proteins)

Polymer of amino acids =polypeptide, or longer = protein

General structure of an amino acid:



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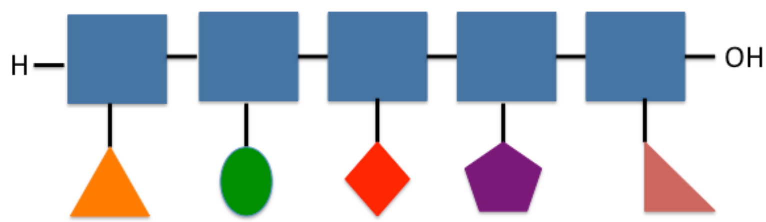
→ side change or R group varies—gives the variety



Essential and non-essential amino acids

Our bodies are excellent at carrying out chemical reactions. We can convert some amino acids into different ones. But there are some that we need from our diet, these are called essential amino acids.
There are nine of them (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, Tryptophan, threonine, and valine)
(more info: https://www.nlm.nih.gov/medlineplus/ency/article/002222.htm)

Protein structure and function

Amino acids don't stay as beads on a string: they wrap up on themselves.
How proteins fold is a very complicated problem

That said, the folding of a protein is determined by the sequence of the monomers (amino acids) and their side groups (some are hydrophilic, some are hydrophobic)

OF COURSE: the structure of a protein correlates to its function!
Since proteins can come in many different shapes, they can do lots of things
Analogy: lock and key (antibody example)

Levels of protein structure

Primary: sequence of the amino acids:

with just 3 aas together: 20 possible aas X 20 aas X 20 aa = 8000 possibilities: POINT: LOTS OF VARIETY!!

Tertiary structure: overall 3D shape

DRIVEN by hydrophobic interactions!!! all the hydrophobic stuff on the inside, and the hydrophilic stuff on the outside

Change structure = change function

Change in sequence of a.a.s (so primary structure) of hemoglobin can result in sickle-cell disease (affected hemoglobin changes shape of RBCs—looks like sickles)

How a protein knows how to fold: mostly in the primary sequence

We know this from examples like sickle-cell disease (change primary sequence, change folding)

If you GENTLY **denature** a protein (so heat it a little bit) the protein will unfold (like a ball of yarn unraveling—the amino acids DO NOT come apart!)—the protein sometimes can come back into shape all on its own

Dietary sources of protein:

Macromolecule #4: Nucleic Acids (DNA and RNA): store, transmit and play a role in the expression of hereditary information

We'll look at these on Friday!

So the sequence of amino acids (primary structure) determines how a protein folds. What determines the order of those amino acids? (see example #4!) The **genes** within our DNA.

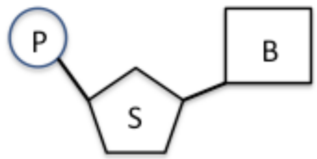
The flow of information goes from DNA→RNA→protein
(The Central Dogma)

The monomer of nucleic acids is a nucleotide

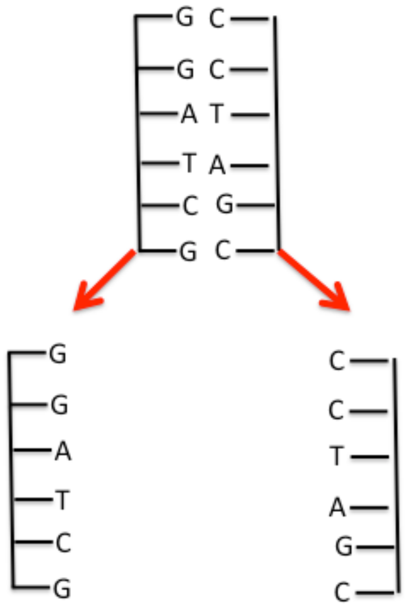
Nucleotides are made of three things:

The backbone: 1. a sugar

2. Phosphates
3. The bases: GATC (in DNA)



SPECIFIC BASE PAIRING



Very important if you're copying DNA