Descriptions of Scale

Macroscale vs. Microscale

Chemistry & Molecular Biology bridge these worlds

http://www.scaleoftheuniverse.com/

What is food made of?

Organic vs. Inorganic

Organic = "from life", contains C-H bonds

Inorganic = no C-H bonds

What is food made of?

Water

Inorganic components

Salts, minerals

"Small" Organic Molecules

Vitamins, metabolites

Macromolecules

Lipids, proteins, carbohydrates

Water

H_2O!

Very small, simple

Essential to all life on Earth

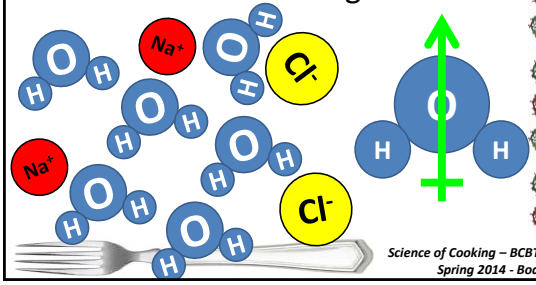
Search for Extraterrestrial Life

Most food is mostly water

Why is water liquid?

Water molecules are bent → polar

Polar molecules stick together



Water Content of Foods

Food	Water Content (%)
Meat	
Pork, raw, composite of lean cuts	53-60
Beef, raw, retail cuts	50-70
Chicken, raw meat without skin	74
Fish, muscle proteins	65-81
Fruits	
Berries, cherries, pears	80-85
Apples, peaches, oranges, grapefruit	85-90
Rhubarb, strawberries, tomatoes	90-95
Vegetables	
Peas (green)	74-80
Beets, broccoli, carrots, potatoes	80-90
Asparagus, beans, cabbage, cauliflower, lettuce	90-95

Source: http://class.fst.ohio-state.edu/fst605/605%20pdf/Water.pdf

Water in Foods

Water content of some foods

Food	Water content (%)
Beef	50 to 70
Chicken meat	74
Fish	65 to 81
Pears	80 to 85
Apples, peaches, oranges	85 to 90
Tomatoes, strawberries	90 to 95
Avocado, banana	74 to 80
Carrot, potato	80 to 90
Lettuce, lentils	90 to 95
Honey	20
Jam	28
Flour, rice	12
Milk powder	4

Source: http://www.azaquar.com/en/doc/water-in-food

Inorganic Components

"Salts" – charged particles

Sodium chloride → Na^+ and Cl^-

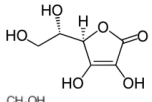
Other trace minerals

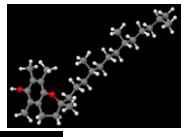
Iron, potassium, calcium, magnesium, etc

"Small" Organic Molecules

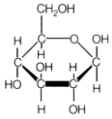
"Organic" = containing C and H

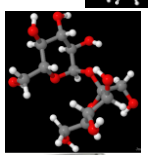
Vitamins





Sugars





Others

BIG Food Molecules

Lipids
Proteins
Carbohydrates
DNA/RNA

Lipids

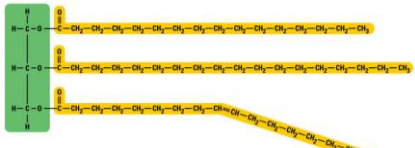
Fats
Long chains of (mostly) C and H
Lipids are non-polar
- Don't mix w/water = "hydrophobic"
- "like dissolves like"

Molecule animations: http://www.biotopics.co.uk/JmolApplet/jcontentstable.html
Fatty acids Jmol:
http://www.mpcfaculty.net/mark_bishop/Bishop_Jmol_fatty_acids_triglyceride.htm

Fatty Acids/Triglycerides

Vinegar = 2 carbons
- Water soluble

Stearic acid = 18 carbons
- NOT water soluble



Types of Fats

Saturated vs. Unsaturated

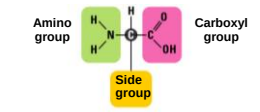
Mono- vs Polyunsaturated
"Hydrogenated"

"Omega-3"

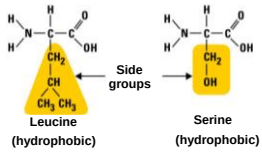
Macromolecules

Polymers –
poly="many", meros="parts"
Different "parts" result in different function/properties

Amino Acids

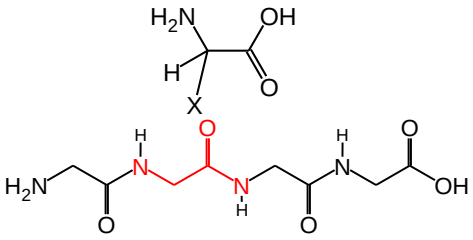


Central Carbon
Carboxyl group
Amino group
Side chain - varies

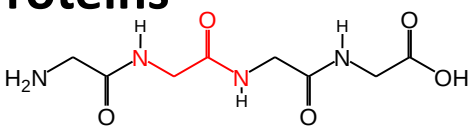


Proteins

Polymers made of amino acids



Proteins



Shape depends upon properties of side chains interacting with water

Shape = Function

20 “letters”, many “words”

4 Levels of Protein Structure

Primary – aa order

Secondary – near aa interactions

Tertiary – long range in 1 protein

Quaternary – clusters of proteins

Denaturing disturbs structure

Protein structure: http://en.wikipedia.org/wiki/File:Main_protein_structure_levels_en.svg

Carbohydrates

"Carbo" → carbon
"hydrate" → water, O and H

Common Sugars

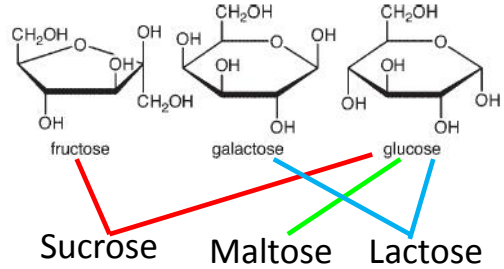


Image: http://en.wikipedia.org/wiki/File:Glycolysis2.svg

Common Sugars

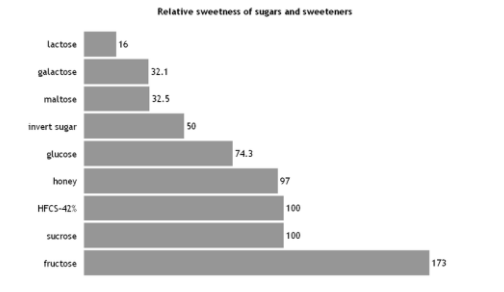
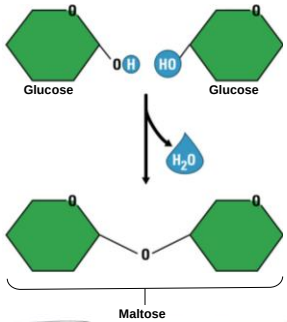


Image: http://en.wikipedia.org/wiki/File:Relativesweetness.png

Disaccharides

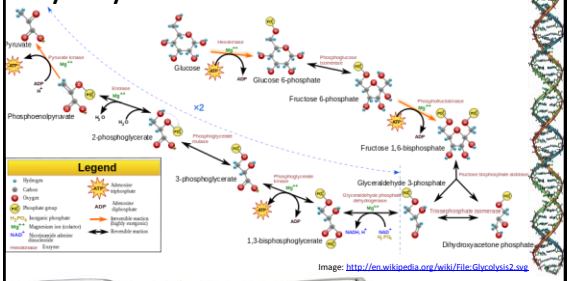


- Monosaccharides react to form disaccharides
- Liberate water
  - *Dehydration*
  - *Condensation*
- Reversible
  - *Hydrolysis*
  - *"-ase" enzymes*

Image: http://en.wikipedia.org/wiki/File:Glycolysis2.svg

Sugar Metabolism

Glycolysis



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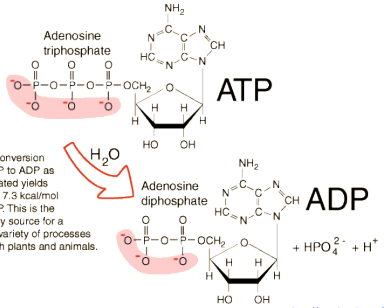
ATP ⇔ ADP ⇔ ATP



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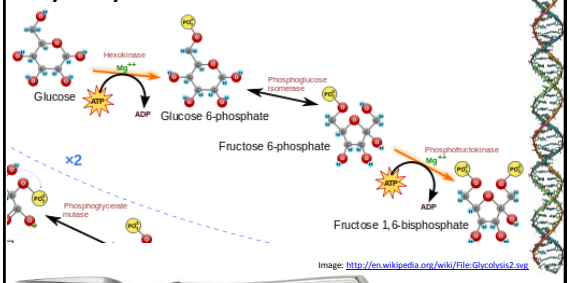
Sugar Metabolism

Glycolysis



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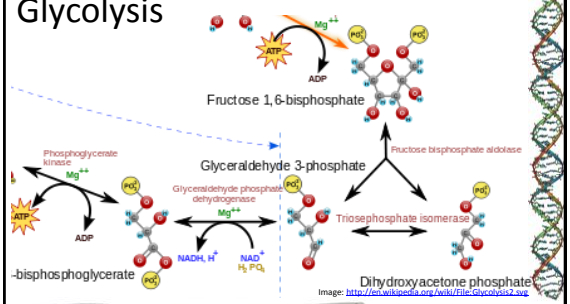
Sugar Metabolism

Glycolysis



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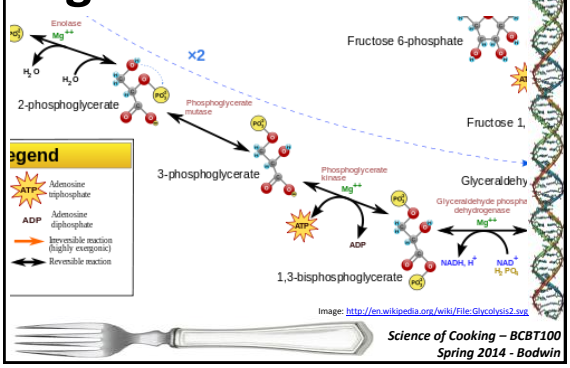
Sugar Metabolism



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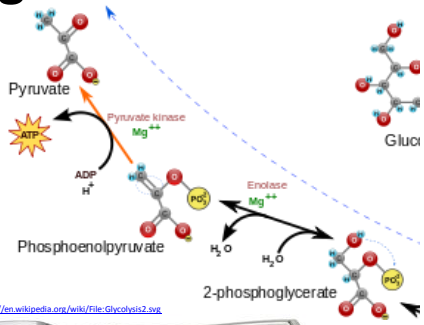
Sugar Metabolism



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Sugar Metabolism

Glycolysis

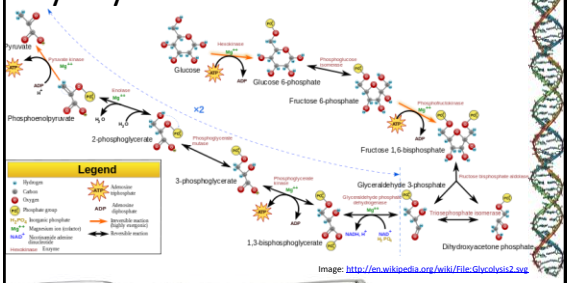


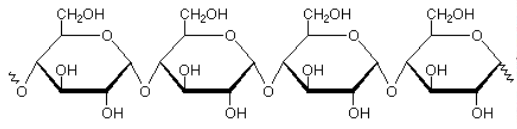
Image: http://en.wikipedia.org/wiki/File:Glycolysis2.svg

Polysaccharides

Storage and structure

Starch, Glycogen, Cellulose

Sugar polymers



polysaccharide (amylose starch)

Image: http://en.wikipedia.org/wiki/File:Amylose2.svg

Starch

Glucose polymers
Energy storage in plants
Potatoes, rice, grains

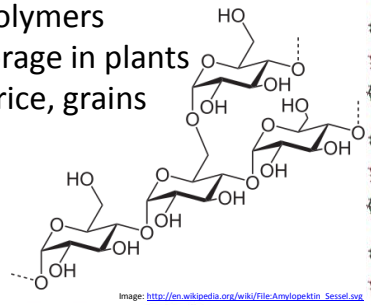
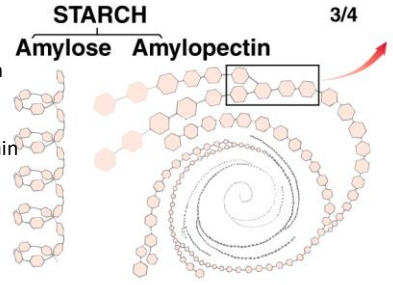


Image: http://en.wikipedia.org/wiki/File:Amylopektin_Sessel.svg

Starch - Structure



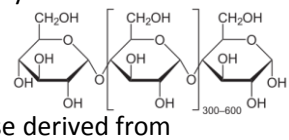
Straight chain
Amylose

Branched chain
Amylopectin

Image: http://en.wikipedia.org/wiki/File:Amylose2.svg

Starch – In foods

Thickener – binds a LOT of water
Provides energy - amylase



Industrially:

- Dextrose = glucose derived from hydrolyzed starch
- HFCS – dextrose treated with glucose isomerase

Image: http://en.wikipedia.org/wiki/File:Amylose2.svg

Glycogen – "animal starch"

Highly branched glucose polymer

Energy storage

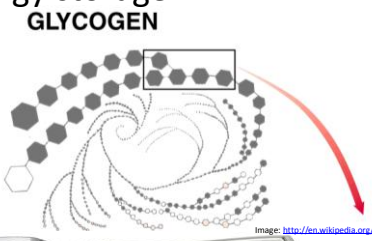
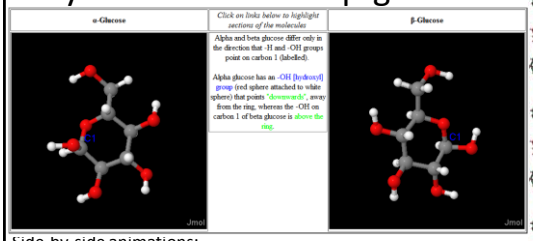


Image: http://en.wikipedia.org/wiki/File:Amylose2.svg

Cellulose

Polymers made from β-glucose



Side-by-side animations:
http://www.biotopics.co.uk/JmolApplet/alphabetajglucose2.html

Cellulose

Enzymes that break amylose can't break cellulose

Rigid, tough *fibers* that make plant cell walls and stalks

Cross-linking

Cellulose - Dietary

Insoluble Fiber

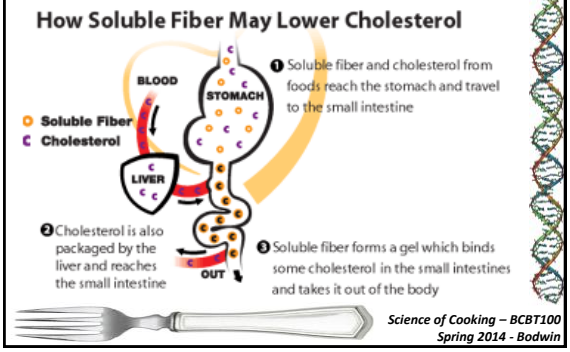
- Highly modified cellulose, up to ~1/2 the mass of a plant
- Binds water, "feel full"
- Draws water into gut
- Fruits, vegetables, whole grains

Cellulose - Dietary

Soluble Fiber

- Highly modified cellulose
- Forms gel with high water content
- Water-soluble substances absorbed by gel – "intestine sweeper"

Cellulose - Dietary



Cellulose – Food source?

Cellulosic fiber is indigestible

- Most animals lack enzymes to break down cellulose
- Ruminants have bacteria in the gut that {partially} digest cellulose to glucose

Image: http://www.publicdomainpictures.net/view-image.php?image=627&picture=black-cow http://www.cvm.ncsu.edu/vhc/efac/rhm/

Interactions

Fats and water

Amphiphiles

Micelles

Emulsifiers