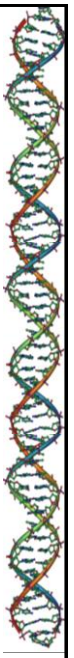
# Descriptions of Scale

Macroscale vs. Microscale

Chemistry & Molecular Biology bridge these worlds

http://htwins.net/scale2/



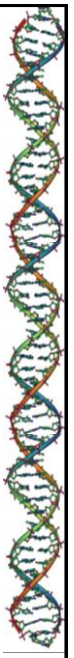


# What is food made of?

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

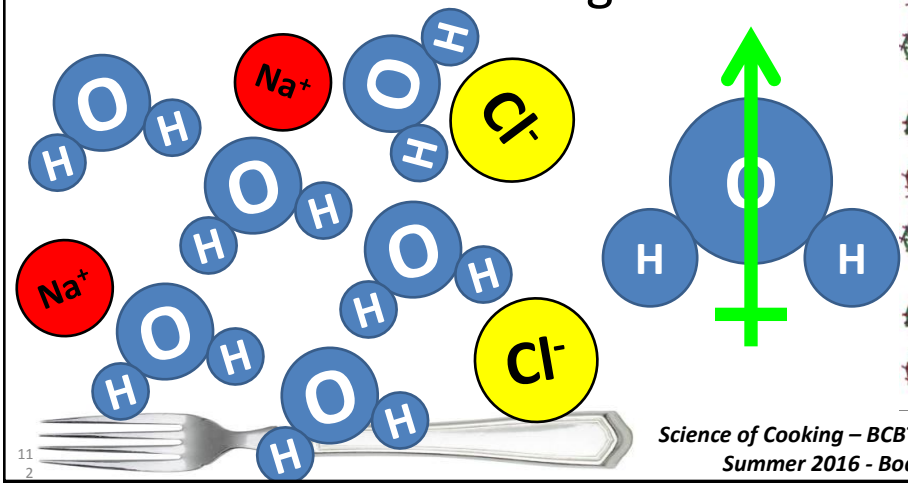
*Search for Extraterrestrial Life*

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 $Cl^-$

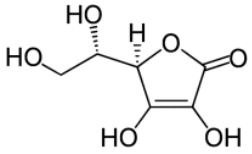
Other trace minerals

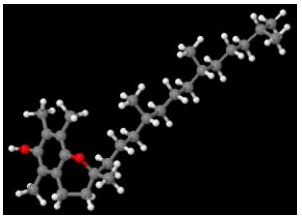
Iron, potassium, calcium, magnesium, etc

# "Small" Organic Molecules

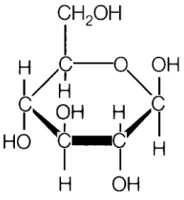
"Organic" = containing C and H

Vitamins

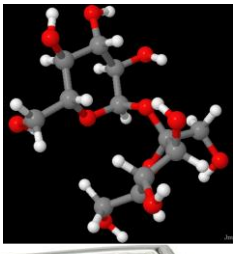


Sugars




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



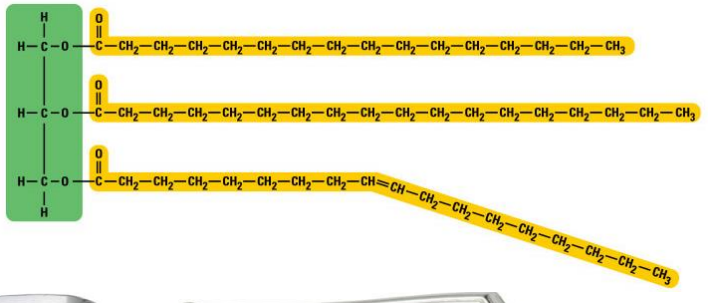
# Fatty Acids/Triglycerides

Vinegar = 2 carbons

- Water soluble

Stearic acid = 18 carbons

- NOT water soluble

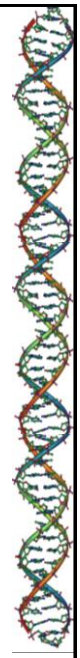


# Types of Fats

Saturated vs. Unsaturated

Mono- vs Polyunsaturated
*"Hydrogenated"*

"Omega-3"

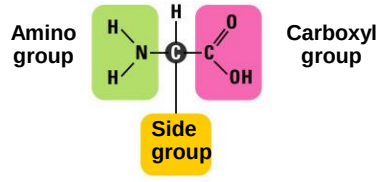




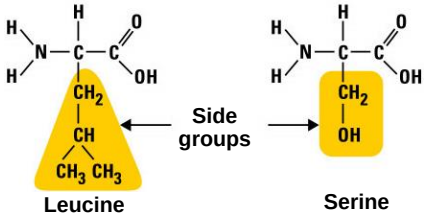
# Macromolecules

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

# Amino Acids




Central Carbon
Carboxyl group
Amino group
Side chain - varies



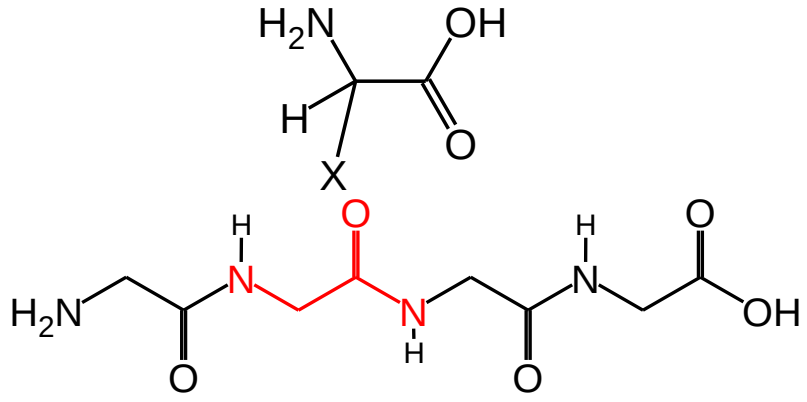

Leucine (hydrophobic)

Serine (hydrophilic)

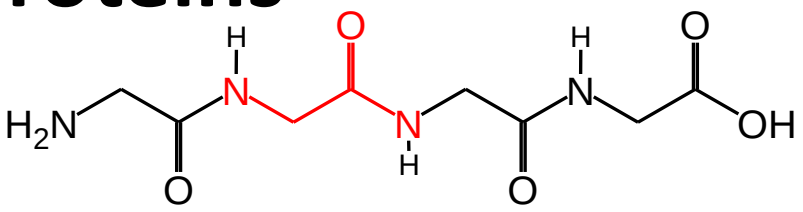


# Proteins

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

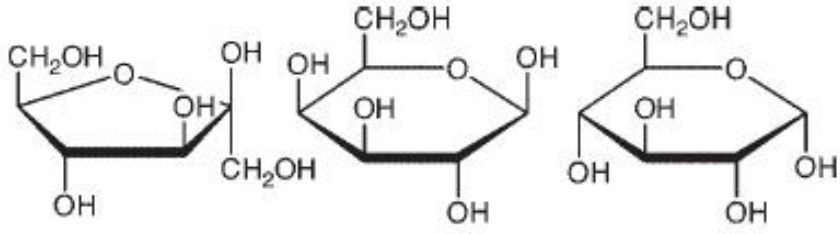
# Carbohydrates

"Carbo" → carbon

"hydrate" → water, O and H



# Common Sugars




Sucrose Maltose Lactose

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

# Common Sugars

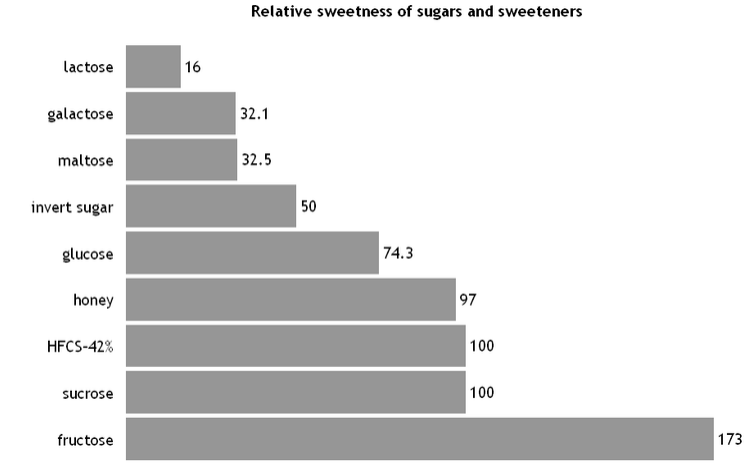
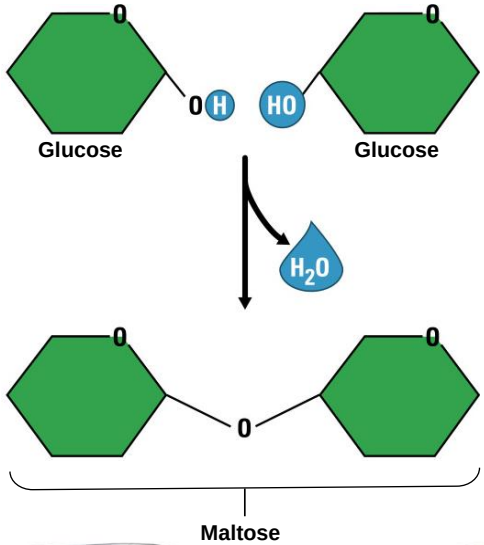



Image: http://en.wikipedia.org/wiki/File:Relativesweetness.png



# Disaccharides




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

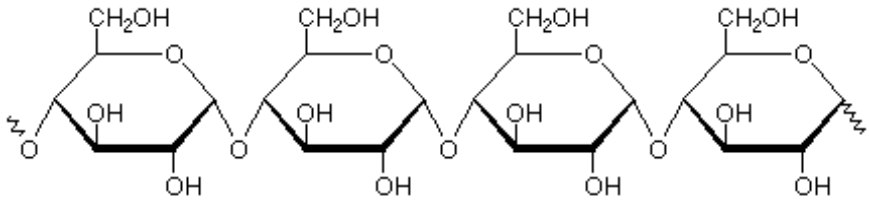
Image: http://en.wikipedia.org/wiki/File:Glycolysis2.svg

# 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

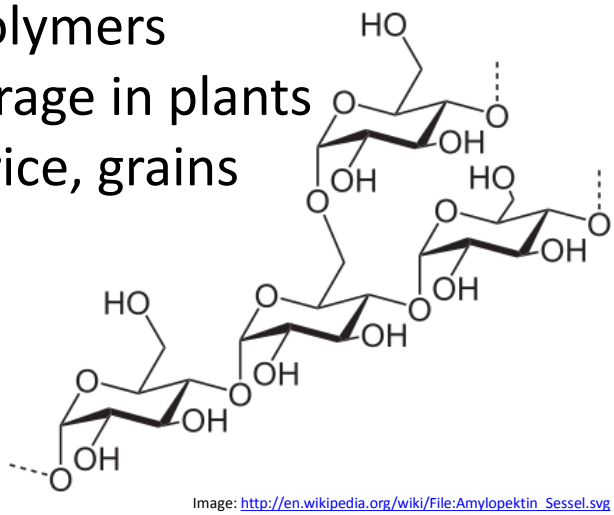
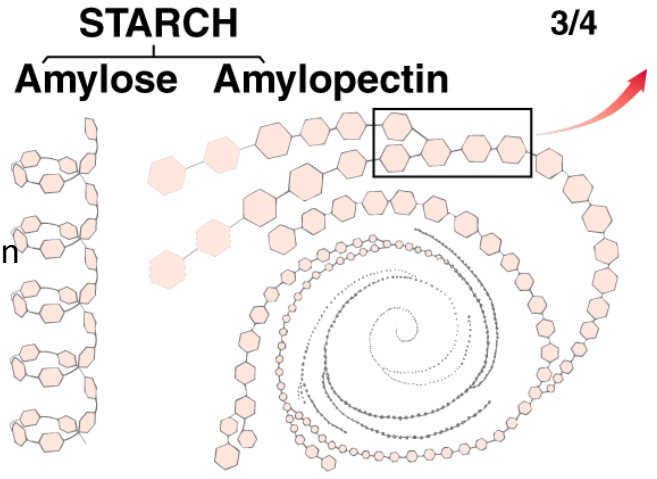



Image: http://en.wikipedia.org/wiki/File:Amylopektin_Sessel.svg

# Starch - Structure




Straight chain
Amylose

Branched chain
Amylopectin

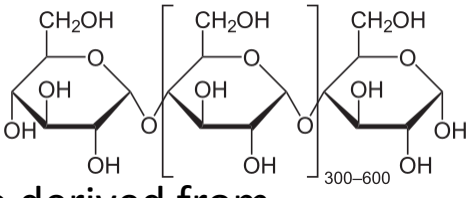
Image: http://en.wikipedia.org/wiki/File:Amylose2.svg



# 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

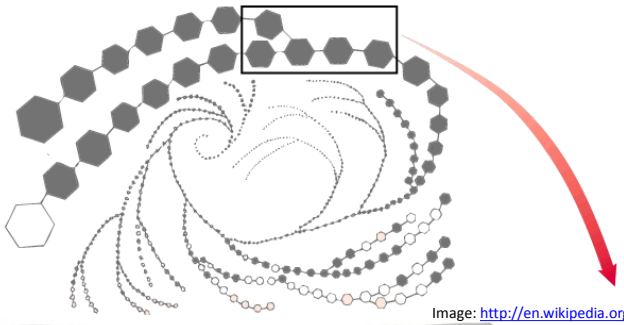
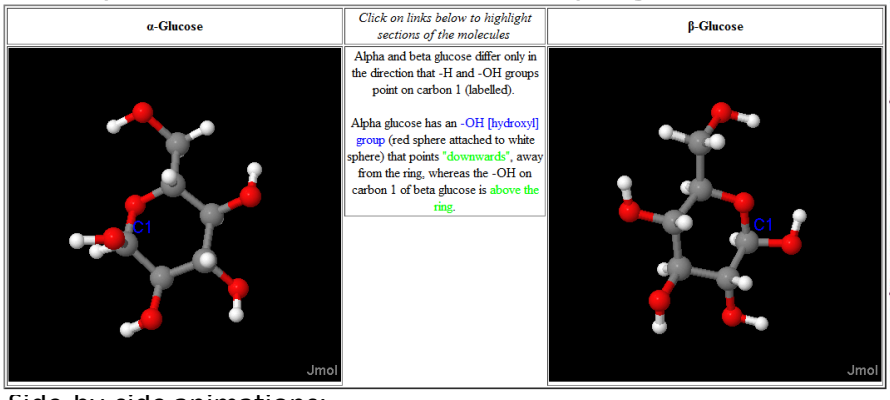



Image: http://en.wikipedia.org/wiki/File:Amylose2.svg



# 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

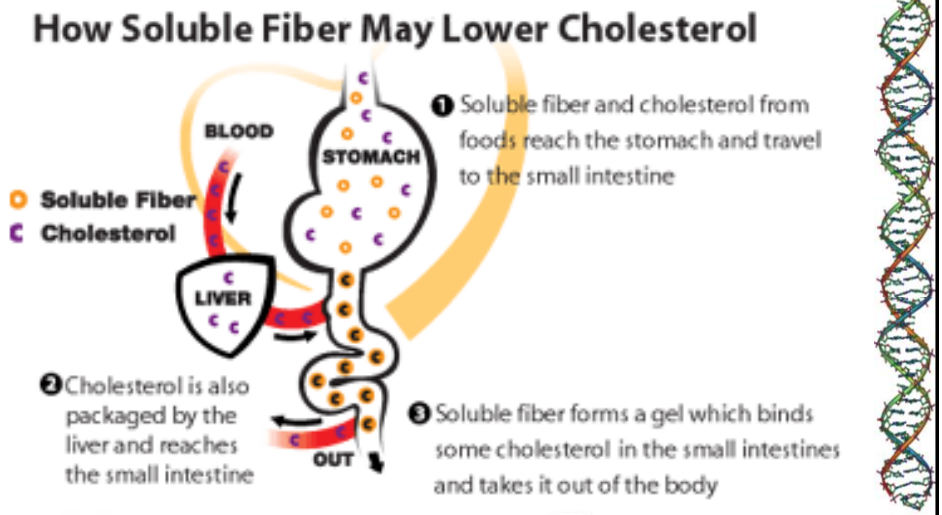
# Cellulose - Dietary

## 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