Food Chemistry

All the energy for all the activities we do, even breathing, come from the food and drink that we ingest.

The USDA has developed a food pyramid to inform the American public of proper nutrition. The pyramid has gone through several alterations over the past 50 years. The most current images for healthy eating look like:

Food Pyramid/Plate

The food pyramid is divided into several categories, based on the type of foods you eat:

a) Grains – bread, pasta, cereal, rice, etc.

b) Vegetables

c) Fruits

d) Milk – milk, cheese, yogurt, etc.

e) Meat and Beans – including eggs and nuts

f) Oils – oils, salad dressings, mayonaisse

g) Discretionary – sweets, sodas, extra of any of the above

Food Energy

All food energy originates from sunlight. Plants use sunlight to undergo an endothermic reaction that converts smaller molecules into larger molecules. This process of photosynthesis is often depicted as:

$$6\ CO_2\ (g) + 6\ H_2O\ (l) + 2800\ kJ \rightarrow C_6H_{12}O_6\ (s) + 6\ O_2\ (g)$$

The radiant energy from the sun gets transformed into chemical potential energy stored within the bonds of the glucose molecules. These stored energy molecules are where animals get their energy.

Energy Usage

Animals have the ability to use food energy immediately. Through a complex version of a combustion reaction, carbohydrates (like glucose) along with proteins and fats can be burned to release the stored energy:

$C_6H_{12}O_6$ (s) +6 O_2 (g) --> 6 CO_2 (g) + 6 H_2O (l) + 2800 kJ (670 Cal)

The energy released by this reaction can be used for any activity in the cells, which allows your organs to function and your muscles to move.

The energy can also be stored for later use.

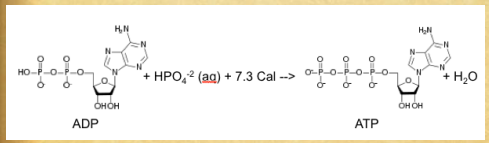
Energy Storage

In cells, the amount of energy needed to perform the various functions is much less than what is provided for by the "burning" of glucose. Plus, you are not eating all of the time, so the energy from the glucose needs to be stored for times when energy is not coming in.

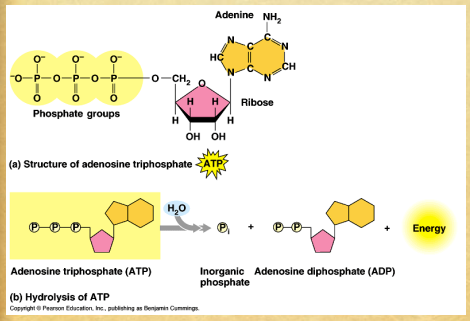
Within the cells are biomolecules called ADP and ATP which store the energy in small amounts to be used by the cell later.

Energy Storage

In this reaction, a small amount of energy is used to attach another phosphate to an adenosine diphosphate molecule, to make adenosine triphosphate. This additional phosphate bond is a high energy bond that can be used later.



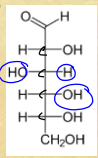
Releasing energy

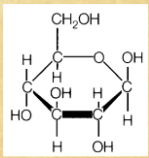


Carbohydrates

Originally, chemists analyzed the structure of sugars and found that the formula was always $C_x(H_2O)_x$. Because it looked like water was attached to carbon, the name carbohydrate was used.

However, later it was determined that the structures for simple sugars looked like the diagram to the right. Obviously, there is no water in the structure.

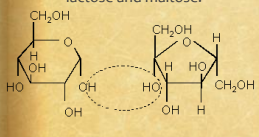




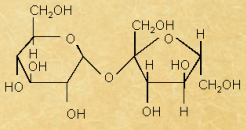
Types of sugars

Monosaccharides - simple sugars, like glucose, that are about 5 to 6 carbons long (or ringed) Examples include glucose, fructose and galactose.

Disaccharides - a combination of two monosaccharides, where water is released in a condensation reaction. Below depicts a common condensation reaction. Examples include sucrose, lactose and maltose.

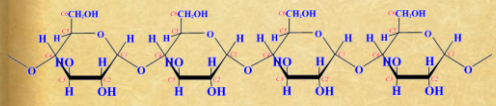

glucose

fructose


sucrose

Types of sugars

Polysaccharides - a polymer version of a sugar. Condensation reactions are repeated over and over again to produce long chains of monosaccharides. Examples include starch, cellulose and glycogen.



Energy from Carbs

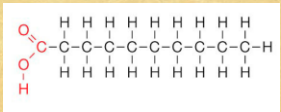
The majority of the energy that humans use from their diets are in the form of sugars, starch and fats. Nutritionists recommend 60% Calories from carbohydrates.

Each gram of a carbohydrate provides about 4 Cal of food energy.

Fats

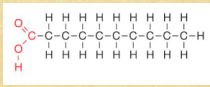
Fats are compounds of C, H and O, but contain fewer oxygen than carbohydrates.

A fat molecule, or fatty acid, is a long chain of hydrocarbons capped on one end with a carboxylic group (-COOH). Fat molecules are largely insoluble in water and have a high energy storing capacity - 9 Cal per gram of fatty acid. A common example is below:

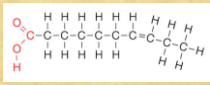


Types of Fats

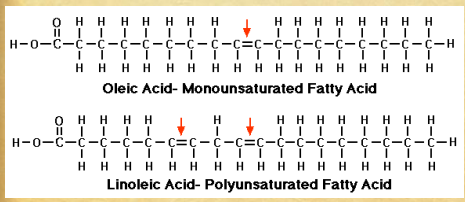
Saturated Fats – a fat molecule in which every carbon is single bonded, maximum saturation of hydrogen



Unsaturated Fats – a fat molecule in which there is at least one double bond between carbons



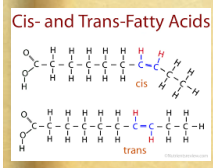
Unsaturated Fats



Oleic Acid- Monounsaturated Fatty Acid

Linoleic Acid- Polyunsaturated Fatty Acid

Cis and Trans Fats



Cis and Trans describe how the hydrogen are bonded on either side of the double bond. Cis means "same" and trans means "opposite".

Trans fats are bad because when incorporated into the cell membrane of a cell, they weaken the barrier and allow more things in, like toxins. Also, they alter the rate of communication between cells, causing metabolic problems.

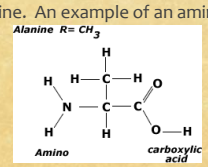
Fats Information

- 1 gram of fat stores 9 Cal of energy, more than twice the amount of carbohydrates.
- After carbs are burned, the next place the body goes to get energy is the fats.
- Saturated fats are more likely to accumulate in the blood stream. However, a certain amount is needed for cells and organs. (about 30% of total fat, 35% from Calories)
- Unsaturated fats are more difficult for the body to break down, but there is little accumulation of these.

Proteins

Proteins are the major structural component of living tissue, such as muscles, cartilage, tendons, ligaments and skin.

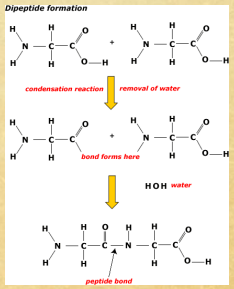
Proteins are polymers built from small molecules called amino acids, which contain a carboxylic acid group and an amine. An example of an amino acid is below.



Protein Synthesis

Proteins are made by the condensation reaction of amino acids. The amino acids are strung together in long polymers to make the protein. Different proteins are made by different combinations of amino acids.

The bond that holds together the amino acids in a protein polymer is called a peptide bond.



Protein Facts

Proteins (in the form of muscle) are burned in the body after carbohydrates and fats. Proteins contain 4 Cal per gram.

Proteins are broken down by the liver into simple amino acids, which can be used to build structural, transport, regulatory or protective proteins.

Your body cannot store amino acids, so a daily requirement of proteins is necessary.

New Food Pyramid

Suggestions (Female)	Suggestions (Male)
Grains – 6 oz	Grains – 7 oz
Vegetables – 2.5 cups	Vegetables – 3 cups
Fruit – 1.5 cups	Fruit – 2 cups
Milk – 3 cups	Milk – 3 cups
Meat & Beans – 5 oz	Meat & Beans – 6 oz
Oils – 5 tsp	Oils - 6 tsp
Discretionary – 200 – 300 Cal	Discretionary – 300 – 500 Cal

Data

	Calories	Carbs	Fat	Protein
Tuesday	1937	279	53	92
Wednesday	1785	346	53	66
Thursday	1502	200	40	56
Total	5224	825	146	219
Average	1741	275	49	73

Diet Suggestions

Girls , age 17, 120 lbs, 5'4"

- 1800 Cal
- 202 g Carbohydrates
- 135 g Proteins
- 50 g Fats

Boys, age 17, 150 lb, 5'8"

- 2300 Cal
- 258 g Carbohydrates
- 172 g Proteins
- 63 g Fat

US Average: 2000 Cal, 250 g Carbs, 125 g Proteins, 55 g Fat

Enzymes

Enzymes are special proteins that act as catalysts that break starch molecules down into simple sugars. Your body cannot burn starches for energy, so these enzymes break the polymer sugars down into burnable sugars.

A catalyst is a substance that speeds up the reaction. Starches will break down on their own, but an enzyme speeds this reaction up.

Amylase is an enzyme present in saliva that breaks down these starches.