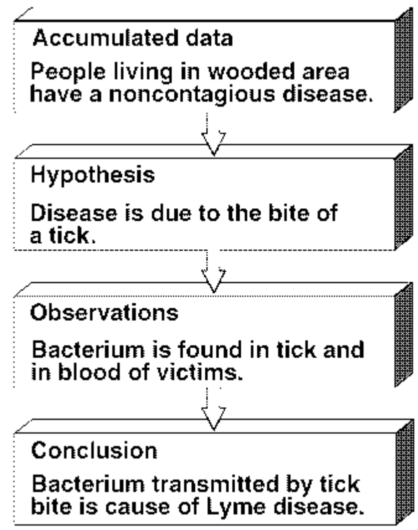
Biology 12 – Biochemistry – Chapter Notes

- *In this chapter, we'll start to look at "**Homeostasis**." We will learn about the molecules that make up living organisms. We will learn what these molecules are made of, how they are formed, and what their functions are in living systems.*
- **Biology is the <u>STUDY of LIFE</u>**. All living things:
  1. are made up of **<u>cells</u>**
  2. **<u>grow</u>** and **maintain** structure by taking in chemicals and energy from their environment
  3. **<u>respond</u>** to the external environment
  4. **<u>reproduce</u>** and pass on their organization (genetic information) to their offspring
  5. at the species level, **<u>evolve</u>/change**, and **<u>adapt</u>** to the environment

- Biologists use the **<u>SCIENTIFIC</u> <u>METHOD</u>**
- *we **ask questions**, **observe** the world, formulate **hypotheses**, test them in **controlled experiments**, **revise**, make **conclusions**.*
- **HYPOTHESIS** - this is a tentative explanation of what you've observed (e.g. "AIDS is caused by a retrovirus"). used to decide the type of experiment needed to test hypotheses. *A hypothesis can be wrong!*
- A hypothesis can be used to propose a logical experiment. *For example: "If green light is the best light for growing tomato plants, then tomatoes grown under green light will be heavier than tomatoes grown under red or blue light.*
- **THEORY** - widely accepted, successful, tested hypothesis accepted around the world. By the time a hypotheses becomes a theory, scientists have the utmost confidence in it. (e.g. Theory of General Relativity).
- Experimental "**<u>CONTROL</u>**": a control is a sample that undergoes all the same steps in the experiment except the one being tested.
  - necessary in order to eliminate other effects that might influence the outcome of the experiment
  - necessary so that scientists may establish a <u>***cause*** and ***effect*** relationship</u>. (want to eliminate, for example, the "placebo effect"). Important for testing new medicines, for example.

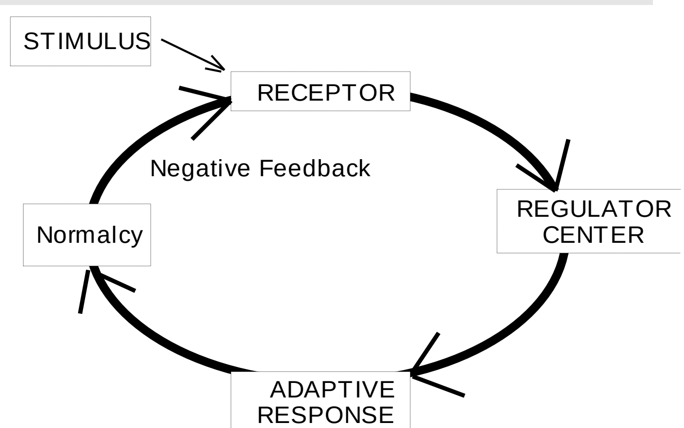


- **HOMEOSTASIS**: all the things living organisms do that cause it to **maintain a relatively constant, stable internal environment** regardless of the external environment. There are countless examples in the human body:

• blood pH =7.4	• body temp. = 37°C
• blood pressure = 120/80	• blood [glucose] = 0.1%

How is homeostasis controlled?
It relies on **<u>FEEDBACK</u> <u>MECHANISMS</u>**.

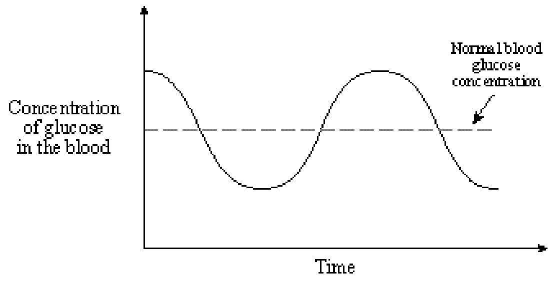
NEGATIVE FEEDBACK: here is a generalized schematic diagram of a negative feedback cycle.

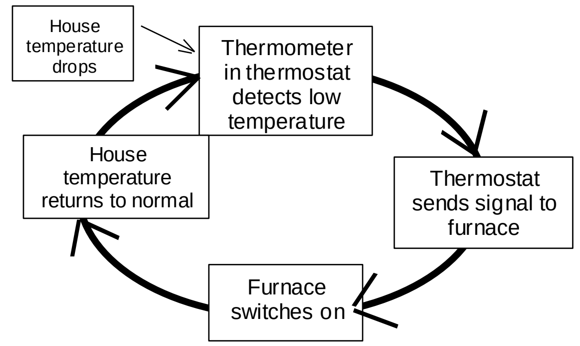


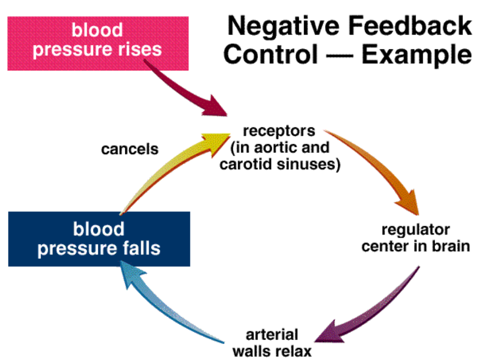
- Brain **<u>control</u> <u>centers</u>** (e.g. in the **hypothalamus**) monitor and control body conditions (e.g. pH, temperature, blood pressure glucose levels)
- **<u>Sensors</u>** all over body **detect unacceptable** levels and signal the appropriate brain center (e.g. temperature sensors in skin stimulate brain if skin gets colder than 37°C).
- **control center directs body** to behave in such a way that **normal state is regained** (e.g. shivering). This is called an adaptive response.
- Once normal state is regained, the **<u>sensor</u> <u>stops</u> <u>signaling</u> <u>the</u> <u>brain</u> <u>center</u>** (this the "*negative feedback part*"), so adaptive response stops.
- results in a **FLUCTUATION** between two levels. e.g. the concentration of glucose in your blood is almost

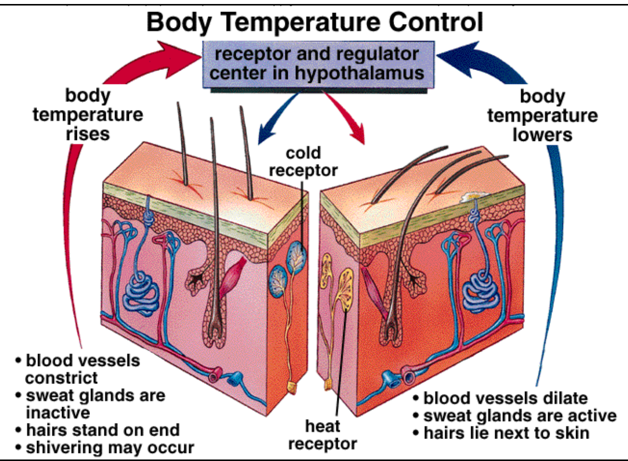
never exactly 0.1%. It's usually a little bit above or a little bit below. Over the course of a day, though, it would average out to be exactly 0.1%.

- Let's look at a classic example of negative feedback: temperature control in your house.









- So it is negative feedback that keeps things constant in your body. There are thousands of these negative feedback cycles known. So what then is *positive feedback?*

- **<u>POSITIVE</u> <u>FEEDBACK</u>** has a number of things in common with negative feedback, such also as requiring receptors and regulatory centers. However, in positive feedback, the stimulus **does not bring about an adaptive response that cancels the stimulus**. Instead, it causes the stimulus to be **<u>increased</u>**. This in turn causes a greater adaptive response, which in turn causes a greater stimulus, and so on. Obviously, this can't go on forever. A positive feedback cycle usually ends up in something being ejected from the body. Because of its nature, positive feedback has a much more limited range of usefulness than negative feedback. Indeed, in Biology 12, there is only ONE specific example of positive feedback that you must know, and that is the positive feedback loop that occurs during **<u>LABOUR</u>** (childbirth) involving the hormone **<u>OXYTOCIN</u>**. Oxytocin is ***<u>made</u>* *<u>in</u>* *<u>the</u>*** **<u>hypothalamus</u>** and **<u>stored</u> <u>in</u> <u>the</u> <u>posterior</u> <u>pituitary</u>**. It causes the uterus to contract.

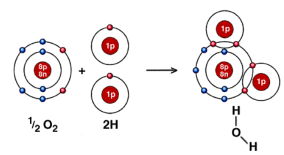
- Just before birth, the growing baby's head exerts pressure against the cervix. This pressure triggers sensory nerves in the cervix to send a nerve signal to the posterior pituitary to release oxytocin. The oxytocin is released into the blood. When it gets to the uterus, it causes **stronger** uterine contractions, which causes greater stimulation of the sensory nerves, which causes more oxytocin to be released, which causes stronger uterine contractions, and so on. The cycle ends when the baby is pushed out of the uterus, stopping the stimulation of sensory nerves to the pituitary.

WATER - Structure, Properties and Importance

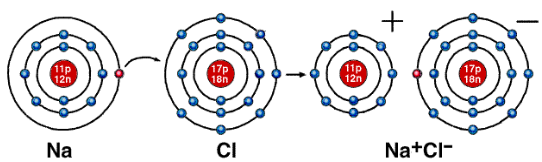
- The first biologically important molecule we need to look at is water. Besides being the most abundant substance on the surface of the planet, it is **absolutely essential to all life** and it is also a very unique molecule.
- **Life began** in water, and all living organisms are "water-based."
- All living organisms have **adaptations for maintaining water levels** (e.g. human skin, plant stomata, bacterial cysts)
- Humans life requires water. But why?
  a) We are mostly made of it! A human body is approximately **60 - 70% water**.
  b) Only **substances dissolved in water** can enter cell membrane of our cells (e.g. glucose, amino acids).
  c) Water **carries away dissolved wastes** from our cells, and wastes excreted in liquid (**sweat**, **urine**)
  d) **Ions** necessary for many body processes (e.g. Ca^{++} for movement, Na^{+}, K^{+} for generation of nerve impulses). Ions are formed when an ionic substance is dissolved in water.
  e) Water and water-based solutions **ACT AS LUBRICANTS**. For example, your **joints are lubricated** by a watery fluid called synovial fluid.
  f) Water **REGULATES TEMPERATURE** in living systems. Compared to most other substances, water doesn't heat up easily or cool down easily (e.g. compare water to metal or sand). Therefore it helps living organisms – since they contain so much water in their tissues and blood, for example, to maintain a relatively constant internal temperature.
  g) Our **brains** partially protected against shock by a watery layer
  h) **Sense organs** require water: **eyes** are filled with thick fluid; **hearing** depends upon a fluid-filled structure (called the cochlea) that detects and transmits vibrations.
  i) **Hydrolytic enzymes:** the chemical reactions that take place in your body rely on chemicals called enzymes. Hydrolytic enzymes are enzymes involved in breaking bonds between molecules. To do this, they require water.

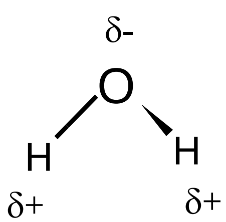
The Chemistry of Water

- Water is **covalently bonded (i.e. bonds formed when atoms share electrons)**. Covalent bonds are strong bonds, compared with the other two types of bonds we'll be talking about: ionic bonds and hydrogen bonds.

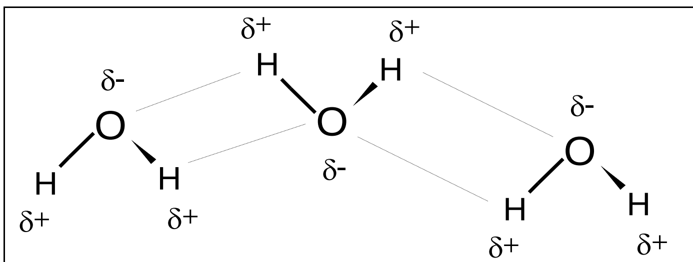


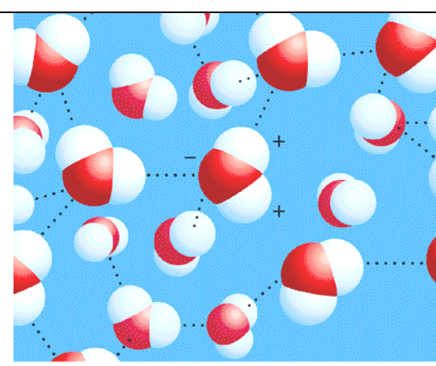
- For example, let's compare this to an ionic bond (a bond in which electron(s) are transferred between atoms.
- Ionic bonds are weaker than covalent bonds.
- So, water is covalently bonded, but it is **POLAR** - the shared electrons spend more "time" circulating the larger oxygen than the smaller hydrogens. Thus, the **oxygen** has a *slight net **negative** charge,* while the **hydrogens** have a *small net **positive** charge*.



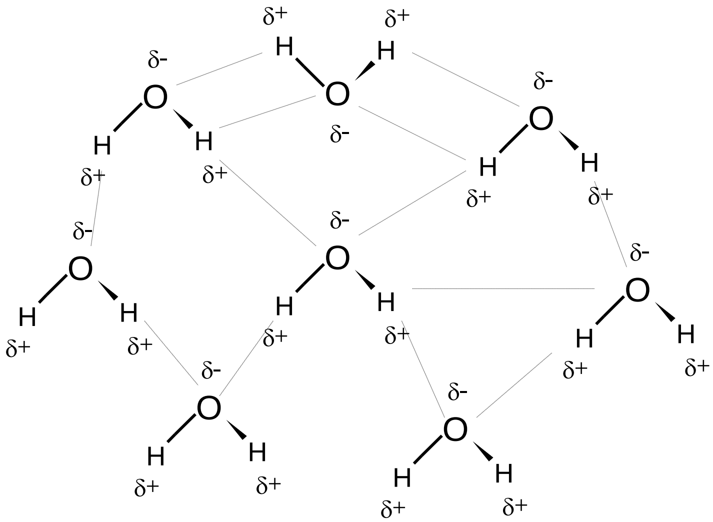


- **Hydrogen Bonds** occurs whenever a **partially positive H is attracted to a partially negative atom** (like oxygen and nitrogen. It is represented by a ***dotted line*** because it is **WEAK** and **fairly easily broken**. *Covalent* and io*nic bonds* are both much stronger.
- However, when you consider the astronomical numbers of water molecules found in living systems, the net effect of all those weak H-bonds, can add up to have a large effect. Indeed, it is the **polar nature of water, which leads to hydrogen bonding**, that gives water its **unique properties**.

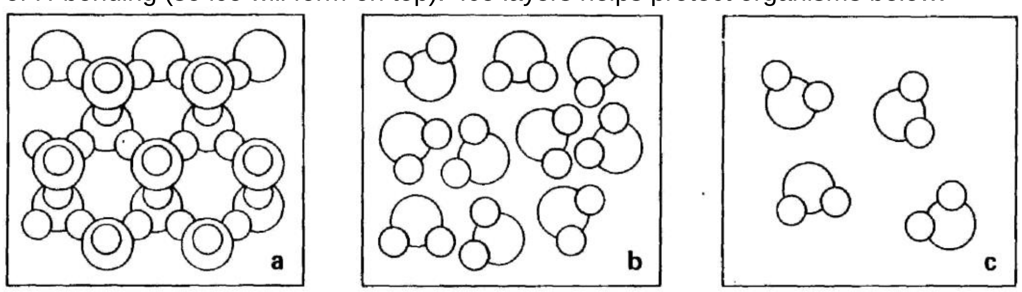




WATER HAS SEVERAL UNIQUE CHARACTERISTICS

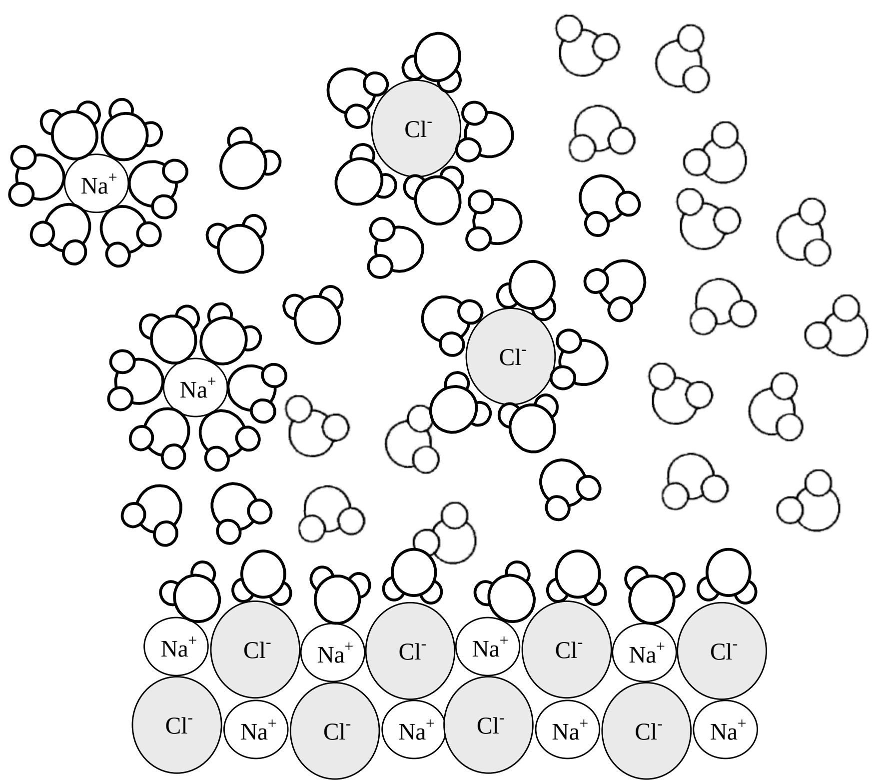


- It is **abundant** throughout biosphere.
- **H-bonding** makes it have a **LOW FREEZING POINT** and a **HIGH BOILING POINT,** so that it is **liquid** at body temperature.
- Water **absorbs much heat before it warms up** or boils, and **gives off much heat before it freezes** (this is why **oceans maintain a basically constant temperature**, and accounts for **cooling effect** of sweating). This is also due to H-bonding.
- Water has high **COHESIVENESS** – Water molecules tend to cling together and draw dissolved substances along with it. This makes it **good for transporting materials** through tubes.
- **Liquid water is more dense than ice** because of H-bonding (so ice will form on top). Ice layers helps protect organisms below.



- Water **DISSOLVES** other **polar molecules** -- is **one of the best solvents known** (--> promotes chem. reactions). Called the "**UNIVERSAL SOLVENT**."

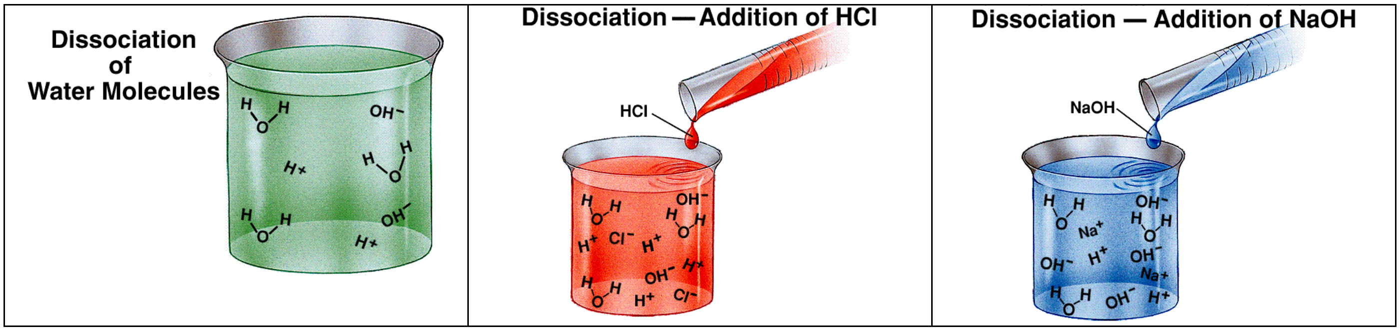
- Now let's look at a couple of important water-based solutions: acids, bases, and buffers.



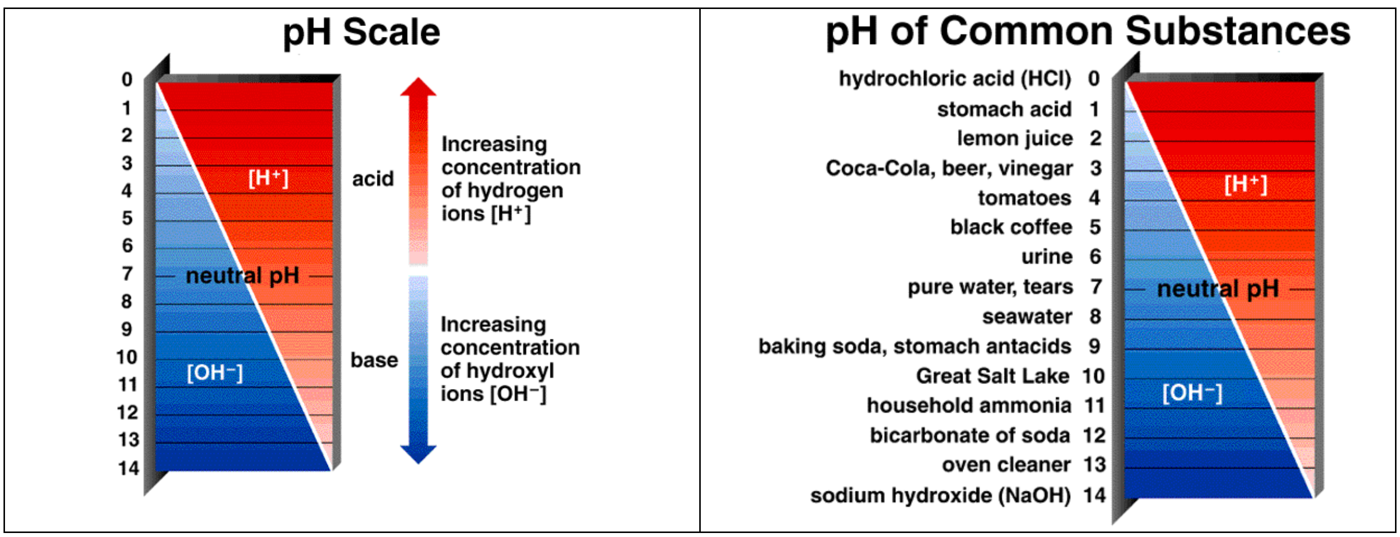
ACIDS, BASES, & BUFFERS

- **ACIDS** are compounds that **dissociate in water** and **release H^+ ions.** e.g. HCl, H_2CO_3, H_2O, CH_3COOH, H_2SO_4

- **BASES** are compounds that dissociate in water and **release OH^- ions**. e.g. NaOH, KOH, H_2O



- **pH** is a measure of the **concentration of hydrogen ions** (how much acid is in a solution) and ranges from 0 to14. The **lower the number**, the more **acidic** the solution. A pH **less than 7.0 is acidic**.
- The **higher** the number, the more **basic** (or "**alkaline**") the solution. A pH more than 7.0 is a **basic** solution.
- A pH of 7 is said to be **neutral**. **Pure water** has a pH of 7.0



- pH can be calculated using the following formula:

$$pH = -\log[H^+]$$

for example, if pH = 3, $[H^+] = 10^{-3}$

- The numbers in the pH scale can seem misleading, because the pH scale is a **logarithmic scale**. That means each number on the pH scale represents a difference in magnitude of **10**.
  - *For example, a pH of 2 is ten times more acidic than a pH of 3.*
  - *A pH of 2 is 100 times more acidic than a pH of 4.*
  - *A pH of 13 is 1000 times more basic than a pH of 10, and so on.*

- An easy way to figure out these sorts of calculations is to do the following:

1. Take the two pH's and **subtract** them. e.g. pH 10 and pH 4

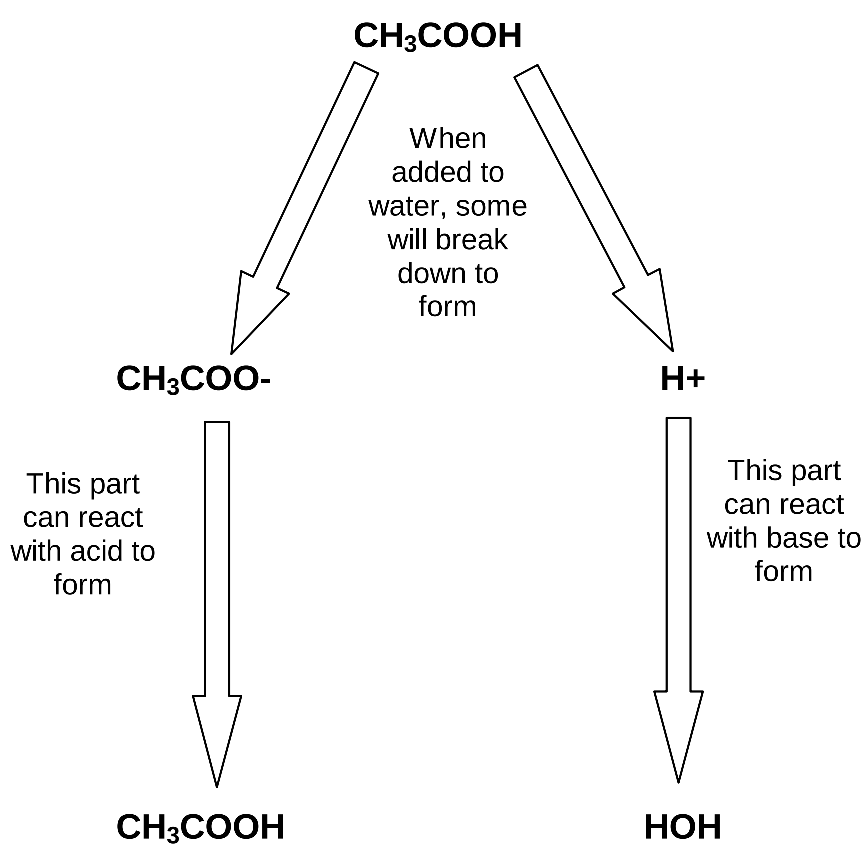
10 - 4 = <u>6</u>

2. Take that number and put that many **zeros** in front of the number one.

1	0	0	0	0	0	0

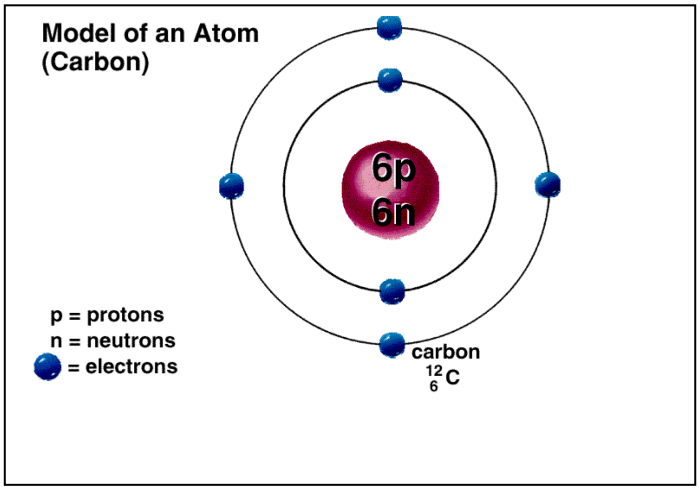
This means that a pH of 10 is **1,000,000 times** more **basic** than a pH of 4. (you could also say it the other way -- a pH of 4 is 1,000,000 times more **acidic** than a pH of 10)

- All **living things need to maintain a constant pH** (e.g. human blood pH = 7.4). ***Why is pH so important?*** If pH changes, it can cause **enzymes** – the chemical helpers that run the chemical reactions essential to life - to "**denature**" (i.e. change shape - more on this later!).
- To keep the pH from changing, livings cells contain **BUFFERS** to keep the pH constant. A **BUFFER** is a **chemical or combination of chemicals** that can take up excess hydrogen ions ***or*** excess hydroxide ions. Buffers ***resist*** changes in pH when acid or base is added. However, buffers can be overwhelmed if acid or base continues to be added.
- Two common buffers in living systems are carbonic acid-bicarbonate ion (H_2CO_3, HCO_3^-) and acetic acid-acetate ion (CH_3COOH, CH_3COO^-). Let's look at how the acetic acid-acetate ion buffer works.

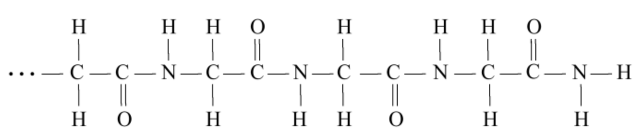
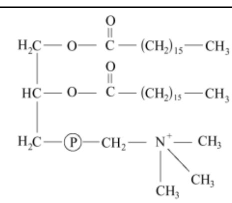
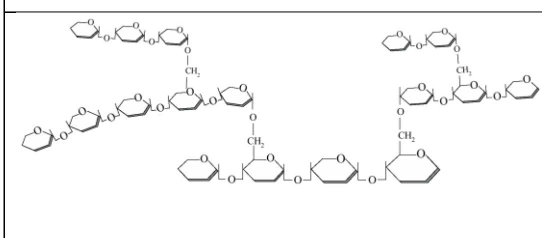
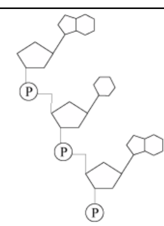


BIOCHEMISTRY & CELL COMPOUNDS

- For the rest of the chapter, we will look at biologically important molecules that are based around carbon atoms. It is said that life on Earth is "Carbon Based..."
- Biochemistry is the chemicals of life and their study. Organic chemistry is the study of carbon compounds. As will see, a lot of biochemistry revolves around organic chemistry.
- Why Carbon?

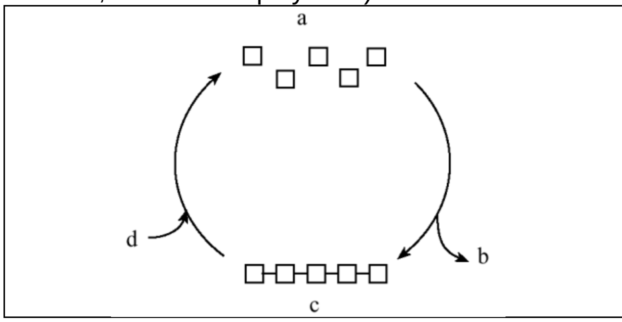


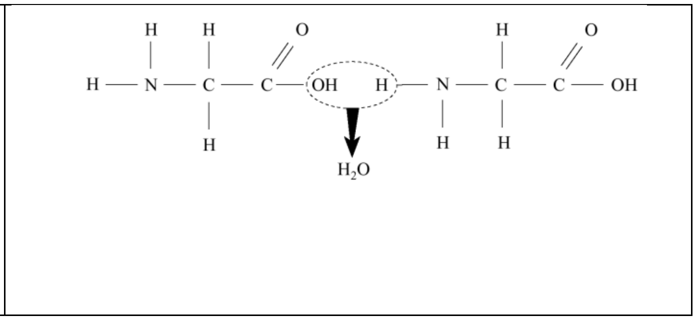
- has four available covalent bonds -- allows for other atoms to bind.
- capable of forming strong bonds with itself
- therefore can form long chains -- can be straight or branched --> great VARIETY of possible combinations.
- carbon atoms in chains can rotate, forming single, double, and multiple ring structures (e.g. glucose, nucleotides, lipids, proteins)

POLYMER FORMATION
Making Big Molecules from Small Molecules!

- a **POLYMER** is a large molecule formed from **repeating subunits** of smaller molecules (e.g. **proteins**, **starch**, **DNA** are all polymers).

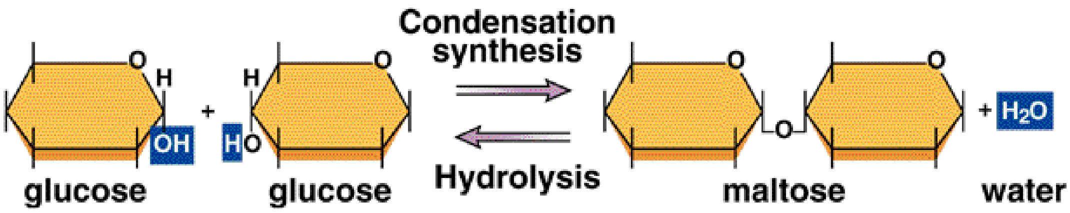




- **DEHYDRATION SYNTHESIS**: **forms large molecules** (**polymers**) **from small molecules**. (Dehydration = to remove water) In the process ***water is produced***. Here is how two amino acids (small molecules) form a dipeptide.

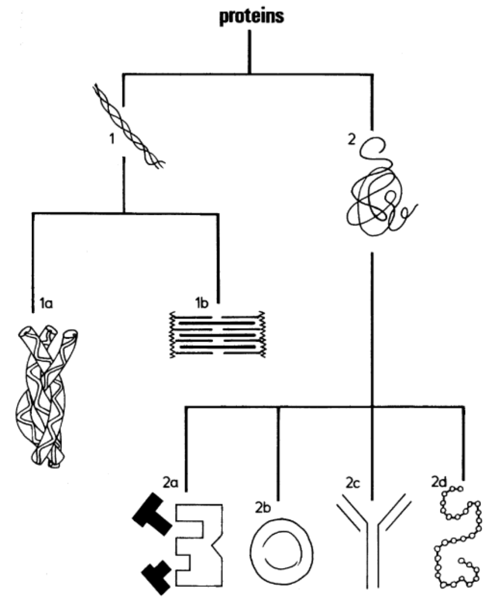
- In synthesis, one molecule **loses an H+**, one molecule **loses an OH-**. In the above example, amino acids can continue to be added to either end of the *dipeptide* to form polypeptides. Large polypetides are called ***proteins***.

- **HYDROLYSIS** (***hydro*** = water, ***lysis*** = to split): is the **opposite reaction**. Water **breaks up another molecule**. The addition of water leads to the disruption of the bonds linking the unit molecules together. **One molecule takes on H+** and the **other takes an OH-**. This also requires the action of helping molecules called **enzymes**. Enzymes that do this are called **hydrolytic enzymes**.



The FOUR MAIN CLASSES of Biologically Significant Molecules:
Proteins, Carbohydrates, Lipids, Nucleic Acids

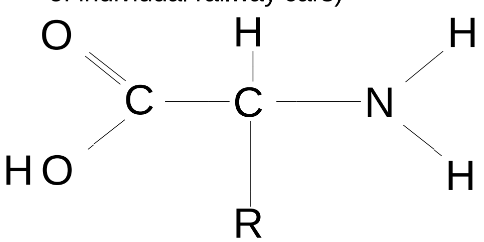
I. PROTEINS



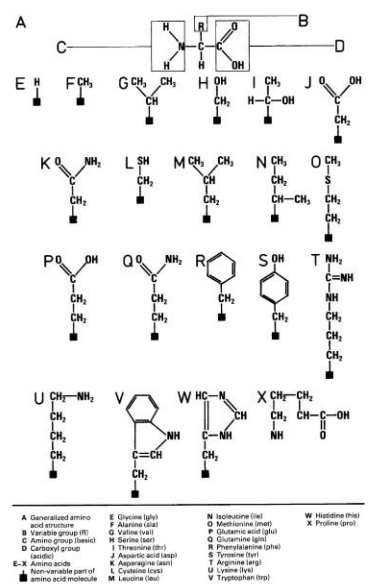
- large, complex organic macromolecules that have three main functions

1) provide **<u>STRUCTURAL</u> <u>SUPPORT</u>** (e.g. **elastin**, **collagen** in cartilage and bone, muscle cells)
2) **<u>MOVEMENT</u>** (actin and myosin etc. in muscle cells)
3) **<u>METABOLIC</u> <u>FUNCTIONS</u>**:

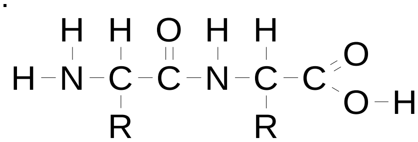
- **<u>ENZYMES</u>** (biochemical catalysts that speed up biochemical reactions). Crucial to life.
- **<u>ANTIBODIES</u>**: proteins of your immune system that fight disease.
- **<u>Transport</u>**: **HEMOGLOBIN** is a protein that transports oxygen in your blood. **Proteins in cell membranes** act as **channels** for molecules entering or leaving the cell.
- **<u>Hormones</u>**: many hormones, like ***insulin***, are proteins. Hormones control many aspects of homeostasis.
- All proteins are composed of **AMINO ACIDS** (like a train is made up of individual railway cars)



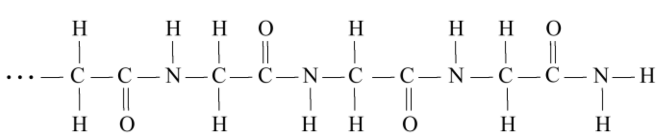
- Note the "**amine**" group on right (ammonia = NH_3), "**acid**" group on the left (COOH = organic acid) of the central carbon. All amino acids have this formula.
- Difference is in "**R**" (= **Remainder**) group -- different for each amino acid.
- There are **20 different amino acids in living things**. Our bodies can make 12 of these. The other 8, which we must get from food, are called "**Essential Amino Acids**."



i. Amino acids join together through dehydration synthesis. The bonds formed are called **PEPTIDE BONDS**. ***Circle the peptide bond*** on the dipeptide below.



- Now, do it for this "polypeptide"



- Peptide bonds are **<u>polar</u> <u>bonds</u>** (this leads to H-Bonding, as we will see).

ii. **<u>Dipeptide</u>**: two amino acids joined together

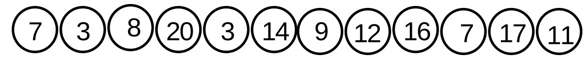
iii. **<u>Polypeptide</u>** (abreviation = ppt): >2 amino acids joined together. Usually short: less than 20 amino acids or so.

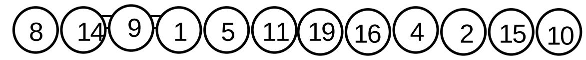
iv. **<u>Protein</u>**: a polypeptide chain is called a protein when it gets large (usually ~75 or more amino acids in length – though there is no absolute rule here)

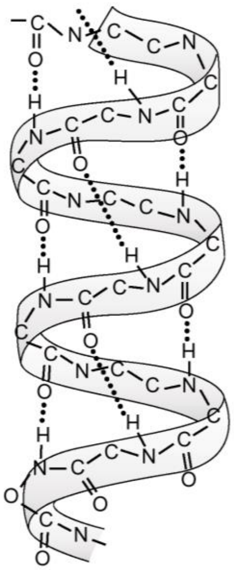
Proteins have 4 levels of organization:

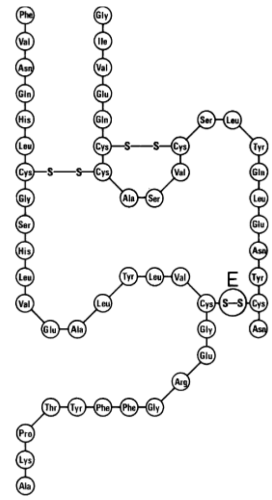
i. **PRIMARY STRUCTURE**: the sequence of a.a.'s joined together in a line. Here are two polypeptide chains that are 12 amino acids long. Note however, that they have different primary structures (different sequences of the 20 amino acids).

- On the right is the entire primary structure for the hormone insulin.

A) 

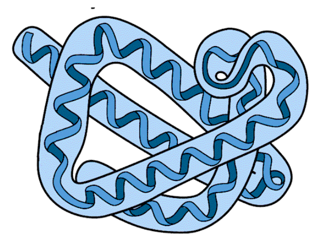
B) 

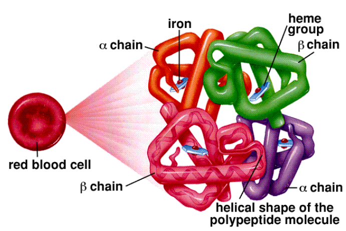




ii. **SECONDARY STRUCTURE**: since peptide bonds are polar, H-Bonding routinely occurs between amino acids in the primary line. Often, this will cause the chain coil up into a shape called an **alpha helix**. Layers called "β-pleated sheets" can also form.

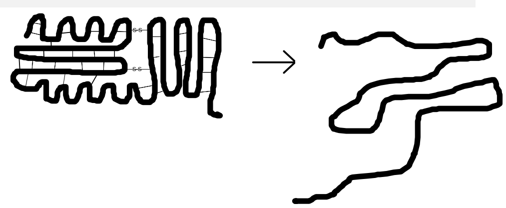
iii. **TERTIARY STRUCTURE**: different types of bonding (covalent, ionic, hydrogen) between -R groups makes the alpha helix bend and turn, forming "globs" of protein of all shapes. This three-dimensional arrangement of the amino acid chain is called the "**tertiary structure**." Although it may look randomly formed, the final 3-D shape is very exact and precise. The shape is due to the **original sequence of amino acids** (the ***primary structure***), as this is what will determine which amino acids in the chain will bind with each other, and in what way.





iv. **QUARTERNARY STRUCTURE**: for proteins with more than one polypeptide chain, the quarternary structure is the **specific arrangement of polypeptide chains** in that protein. (e.g. **hemoglobin**: this is the O_2 carrying protein in blood -- made of four polypeptide chains interlocked in a specific way).

DENATURING PROTEIN



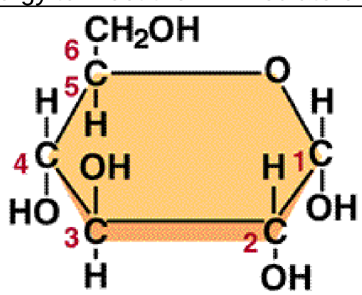
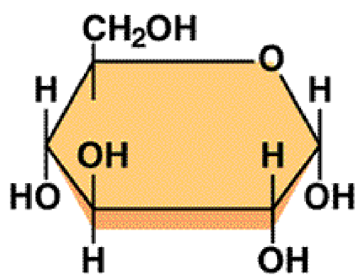
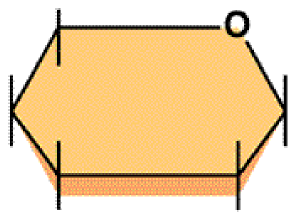
- protein shape is ***critical*** to its function
- changes in **temperature** or **pH**, or the presence of certain chemicals or heavy metals, can **disrupt the bonds** that hold a protein together in its particular shape.

- If a protein is **DENATURED**, it has lost normal structure/shape because **normal bonding between -R groups has been disturbed**.
  - Examples of denaturing include
    - heating an egg white (**raising the temperature above 50°C** will reliably denature most animal enzymes)
    - adding vinegar to milk (this is the same thing as **changing the pH**, since vinegar is an acid)
    - adding **heavy metals** such as lead and mercury also denature proteins.

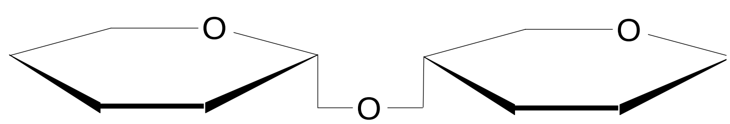
II. CARBOHYDRATES

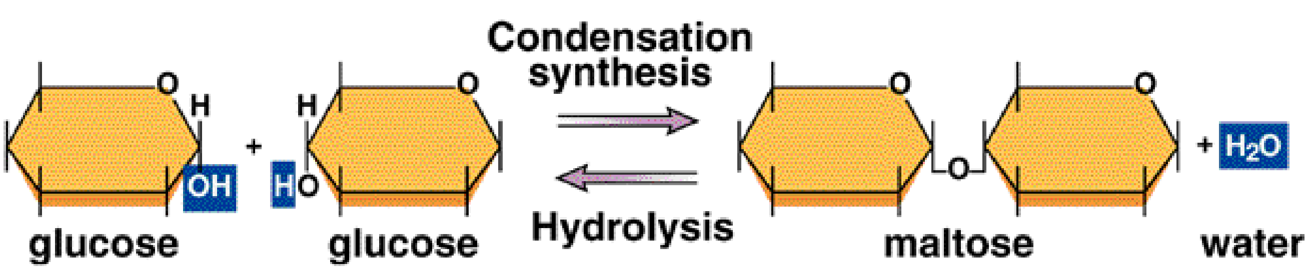
- Carbohydrates are molecules made of Carbon, Hydrogen, and Oxygen
- all carbohydrates have the general formula: $\mathbf{C_n(H_2O)_n}$ - hence the name *"Hydrated Carbon"* or *"Carbo - Hydrate"*
- Different forms used for **ENERGY**, **FOOD STORAGE**, & **STRUCTURAL SUPPORT** in plants and animals. Carbohydrates are very important in living systems for the following functions:
  1. **Short-term energy supply** (e.g. glucose is used by all cells to produce ATP energy)
  2. **Energy storage** (e.g. glycogen is stored in liver and muscles and can be rapidly converted to glucose: starch has a similar role in plants)
  3. As **cell membrane markers** (receptors & “identification tags”)
  4. As **structural material** (e.g. plant cell walls are made of cellulose, insect exoskeletons are make fo the carbohydrate chitin)
- Carbohydrates can be small molecules like glucose, or very large polymers like starch and glycogen.

i. **MONOSACCHARIDES** (e.g. **Glucose**, **ribose**, galactose, fructose)
- simple sugars with only **one unit molecule**
- groups of monsaccharides may be designated by the number of carbons they contain (i.e. "hexose" = 6-C sugar, 5-C sugars = "pentose" sugars). *Note the "..ose" suffix! Most carbohydrates end in “ose.”*
- Probably the most common monosaccharide in living systems is glucose. All cells “burn” glucose to make ATP energy to meet their immediate energy demands.

		
Detailed structure of glucose showing all atoms		Simplified glucose diagram

ii. **DISACCHARIDES** (e.g. maltose, sucrose). At right is **maltose**)
- are formed from **dehydration synthesis reaction** between two monosaccharides.





- maltose = 2 glucose. Table sugar (sucrose) = 1 glucose + 1 fructose)
- Monosaccharides and disaccharides are all water soluble. That means they can be dissolved in water.

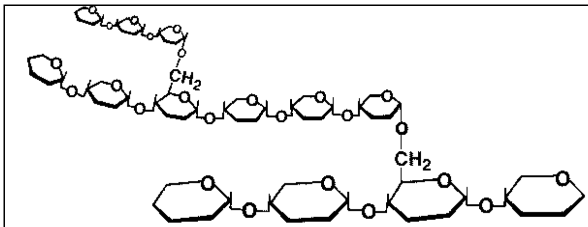
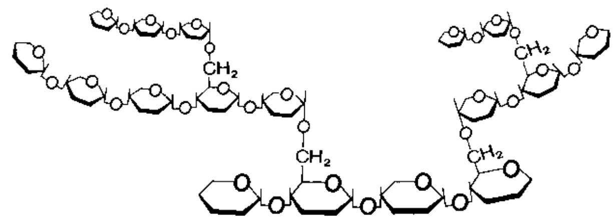
iii. **POLYSACCHARIDES**

- a carbohydrate that contains a **large number of monosaccharide molecules**
- Three main important types in living systems. **All** are made of **<u>repeating</u> <u>glucose</u>** <u>subunits</u>:

1. **<u>STARCH</u>** - the **storage form of glucose in <u>plants</u>**. Made of **<u>fairly</u> <u>straight</u> <u>chains</u>** of glucose, with few side branches off the main chain. Starch forms from dehydration synthesis between many glucose molecules.

synthesis

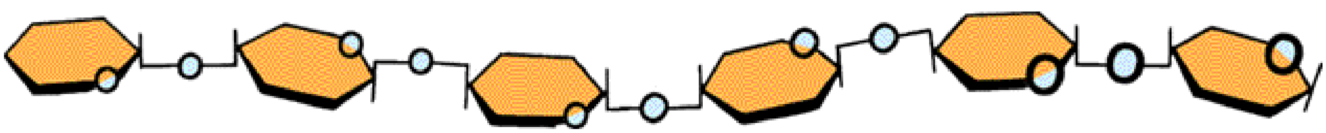
n glucose<=======> starch + (n - 1)H_2O

	
Starch Structure	Glycogen structure – more branching!

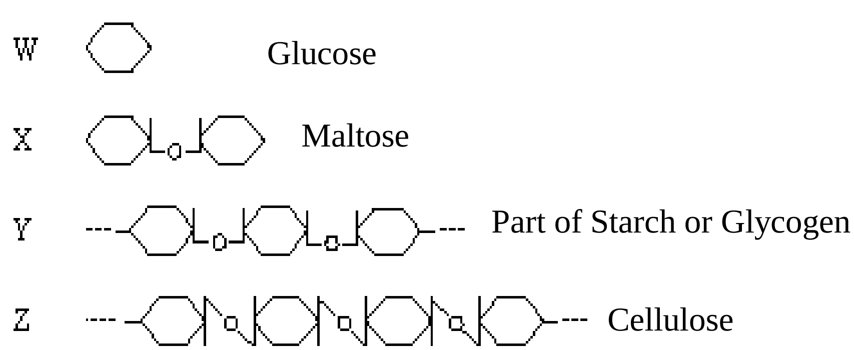
hydolysis

2. **<u>GLYCOGEN</u>** - the storage form of glucose in **<u>animals</u>**. The chains of glucose have **<u>many</u> <u>side</u> <u>chains</u>** compared to starch. In animals, the **<u>liver</u> <u>converts</u> <u>glucose</u> <u>to</u> <u>glycogen</u> <u>for</u> <u>storage</u>**. In between meals, liver releases glucose into blood concentrations remains at 0.1%.

3. **<u>CELLULOSE</u>** - primary **structural component of plant cell walls**. Linkage of glucose subunits different than in starch or glycogen. See the structure below.



- Human digestive system ***can't digest cellulose***, so it passes through the intestines undigested. Other names for the cellulose in plant foods are "**<u>fiber</u>**" or "roughage."
- Dietary fiber is important to health and for the prevention of such things as **colon cancer**.



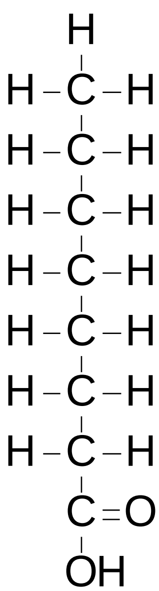
III. LIPIDS

- Lipids are a wide variety of compounds, more frequently known by their **common names**, including ***fats***, ***oils***, ***waxes***.
- are all **insoluble** in water.
- Functions of Lipids include the following:

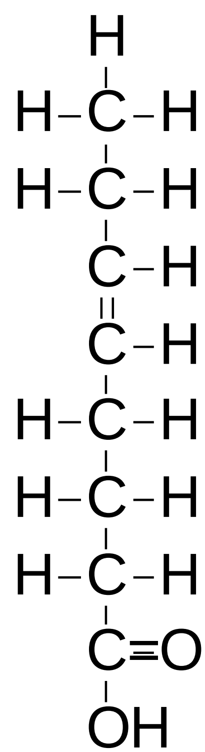
1. **Long-Term Energy storage**:(fat is excellent for storing energy in the **least amount of space**, and packs 9.1 calories of energy per gram, versus 4.4 for carbohydrates and proteins).
2. **Insulation** ("blubber")
3. **Padding** of vital organs
4. **Structural** (e.g.**cell membranes are mostly composed of phospholipids**, white matter of brain contains a high proportion of lipid material)
5. **Chemical messengers** (e.g. steroid hormones like testosterone, estrogen, prostaglandins).

THE MAIN TYPES OF LIPIDS

i. **FATTY ACIDS**: a long chain of carbons with hydrogens attached, ending in an acid group (-COOH). There are two main types:

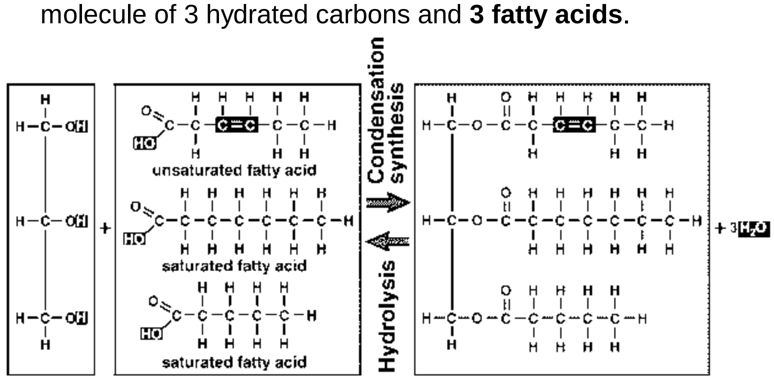


- **Saturated fatty acids - no double bonds** between carbons. All carbons are "saturated" with hydrogens. Saturated fats tend to be **solid** at room temp. These are the "bad" dietary fats (e.g. butter, lard, meat fat), which are known to contribute to **heart disease**, **strokes**, and **cancer**.
- **Unsaturated fatty acids** - have one (monounsaturated) or more (polyunsaturated) **double bonds** between carbons in chain. That means that the carbons are not "saturated" with hydrogens.
- Unsaturated fats tend to be **liquid** at room temperature. e.g. vegetable oils, Omega-3 unsaturated fatty acids. Are thought to be better for your heart than saturated fats.

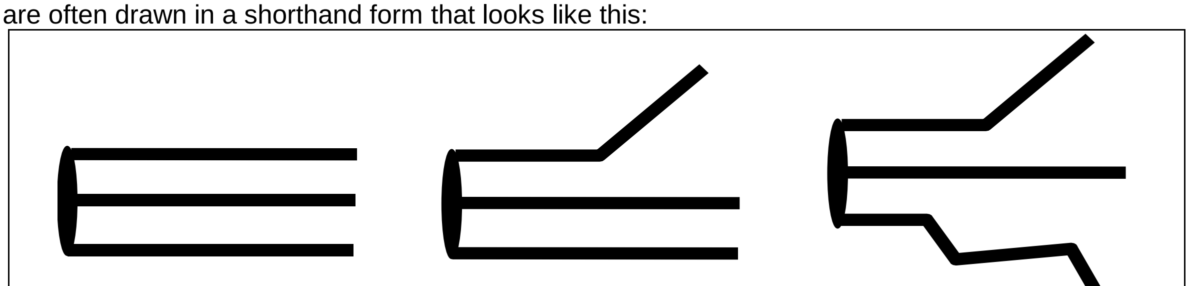


ii. **NEUTRAL FATS**: (also called **TRIGLYCERIDES**)

- formed by dehydration synthesis reaction between **glycerol** (a molecule of 3 hydrated carbons and **3 fatty acids**.

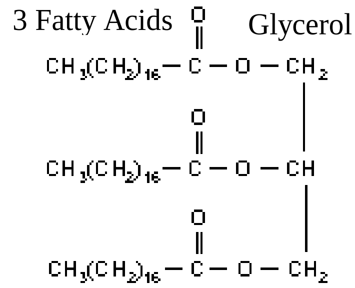


- The fatty acids in a neutral fat can be saturated or unsaturated.
- They are often drawn in a shorthand form that looks like this:



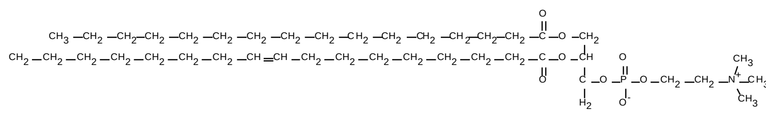
Saturated triglyceride	Monounsaturated triglyceride	Polyunsaturated neutral fat

- All triglycerides are **non-charged**, **non-polar molecules**.
- Neutral fats are also sometimes drawn like this:
- They **do not** mix with water. This property of not mixing with water is called "**<u>hydrophobic</u>**" which literally means "water-fearing." This is the opposite of polar molecules, which mix readily with water and are called "hydrophilic" which means "water-loving."
- **Soap** is made by combining a **base** and a **fatty acid**.
- Soaps are **polar**, will mix with water. Soap molecules surround oil droplets to their polar ends project outwards, causing the oil to **disperse** in water (this process called **EMULSIFICATION**).

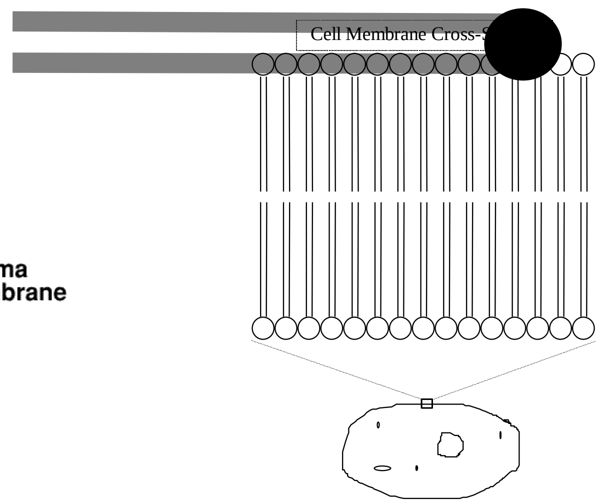


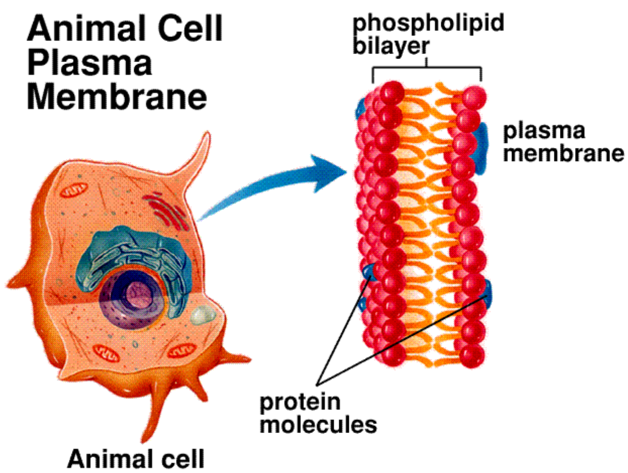
iii. **<u>PHOSPHOLIPIDS</u>**: important components of **cell membranes**

- Phospolipids have the same basic structure as neutral fats **except** that ***one fatty acid is replaced by a phosphate group*** with a charged nitrogen attached.
- phospholipids have a Phosphate-containing "**head**" and two long fatty acid **tails**. Head is **<u>hydrophilic</u>** ("water-loving"), tail is **<u>hydrophobic</u>** ("water-fearing")



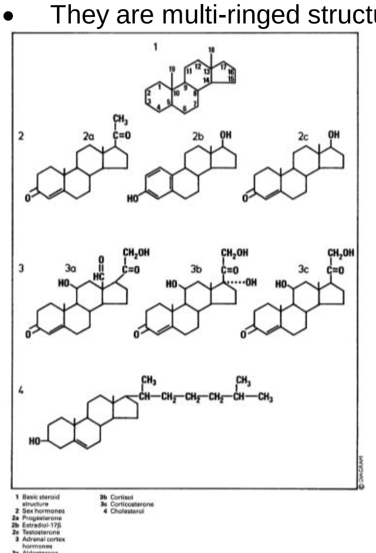
or



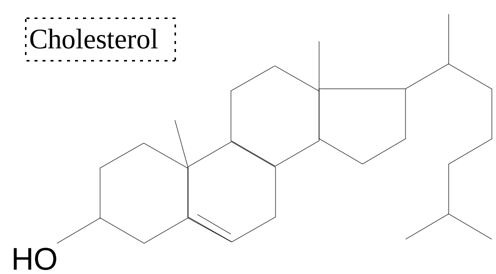


iv. **<u>STEROIDS</u>**: a **different type of lipid**

- They are multi-ringed structures, all derived from **CHOLESTEROL**



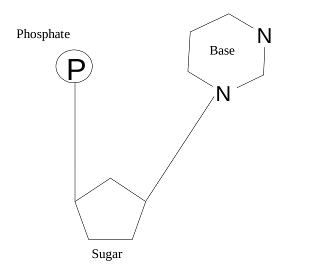
- You've heard many bad things about cholesterol, but it is actually an **essential molecule** found in every cell in your body (it forms parts of cell membranes, for example).
- The problem is that **<u>dietary</u> cholesterol** helps to form **arterial plaques**, which lead to **<u>strokes</u>** and **<u>heart</u> <u>attacks</u>**. Dietary cholesterol only found in **<u>animal products</u>** (meat, fish, poultry, dairy products). There is **no cholesterol in plant foods**. Your blood cholesterol should be no more than 150 mg/dl.
- Steroids can function as **<u>chemical</u> <u>messengers</u>**, and form many important **<u>HORMONES</u>** (e.g. **testosterone**, **estrogen**, **aldosterone**, **cortisol**) that have a wide variety of affects on cells, tissues, and organs (especially sex characteristics, ion balance, and gluconeogenesis).



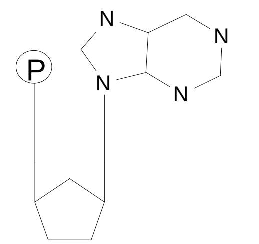
IV. NUCLEIC ACIDS: DNA & RNA

- huge, macromolecular compounds that are **polymers of nucleotides**. There are two types:
  1. **DNA: DEOXYRIBONUCLEIC ACID** - makes up **chromosomes** and **genes**. **Controls all cell activities** including cell division and protein synthesis. DNA also undergoes mutations which are important to the process of **evolution**.
  2. **RNA: RIBONUCLEIC ACID** - works with DNA to direct **protein synthesis**.
- **DNA** and **RNA** are **polymers** of nucleotides that form from the **dehydration synthesis** between **nucleotides**.

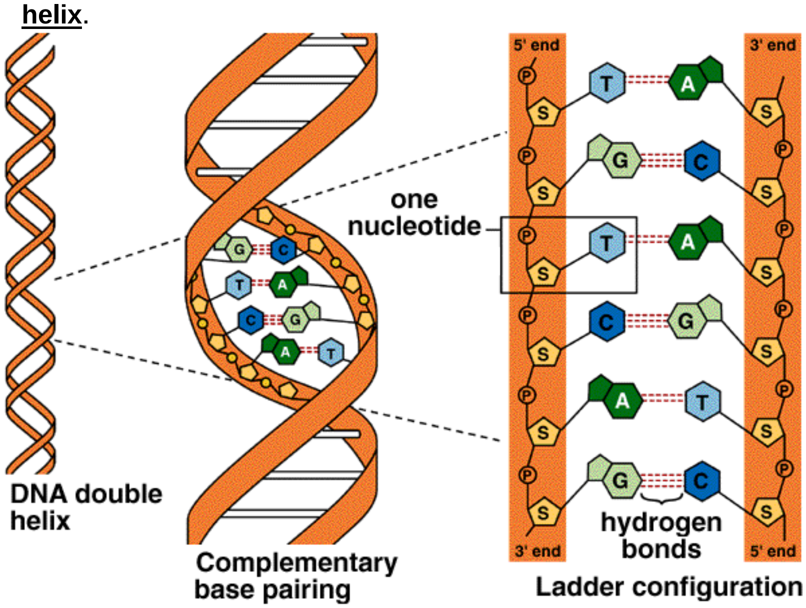
Nucleotide (Pyrimidine (T,C))

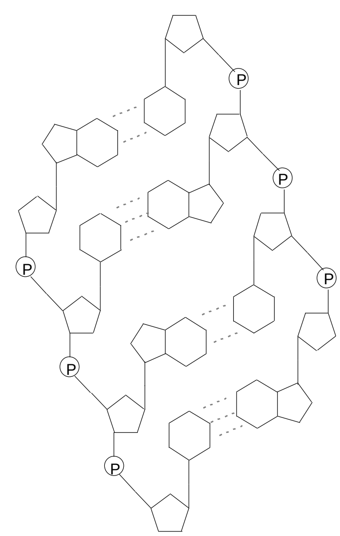


Nucleotide (Purine (A,G))

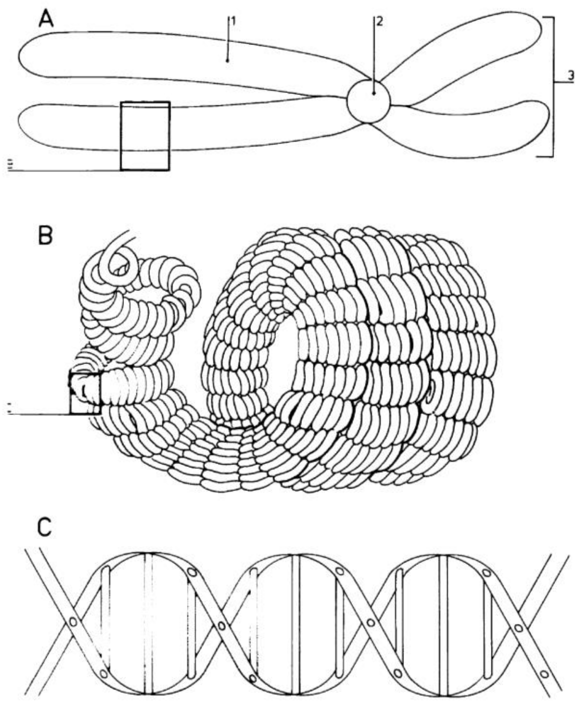


- Nucleotides consist of a **five-carbon sugar** (ribose or deoxyribose), a **phosphate**, and a **nitrogen-containing base** (which may have one or two **rings**). There are **4 different nucleotides in DNA**. The sequence of these nucleotides is the "**Genetic Code**."
- DNA consists of **two antiparallel strands of nucleic acids**. Each strand has a **backbone of the sugars and phosphates of joined nucleotides**. The bases stick out the side and **hydrogen-bond** with the **complementary bases** of the other strand. The two strands wind around each other to form a **double helix**.

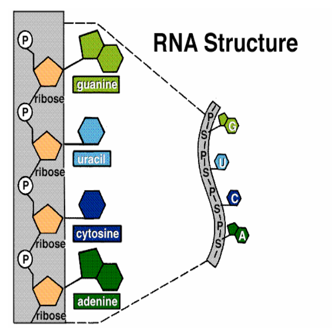




- Sections of DNA form functional units called **GENES**. A gene is one instruction for making one polypeptide, and is about 1000 nucleotides long, on average.
- DNA is packaged into **chromosomes**, and is located in the **nucleus**. You have about **4 billion nucleotide pairs** in each of your cells. Each of your **46 chromosomes** contains one very long **polymer of DNA** around **85,000,000 nucleotides long**!

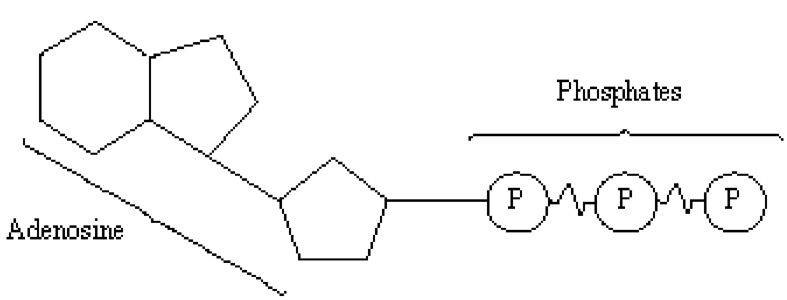


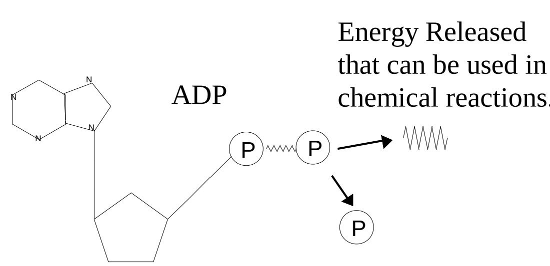
- **RNA** is a **single strand** of nucleic acid, which is **formed off a DNA template** in the nucleus. It migrates to the cytoplasm during **protein synthesis**.



V. ATP - Adenosine Triphosphate - the Molecule of ENERGY

- ATP is a type of **nucleotide** that is used as the **primary CARRIER OF ENERGY** in cells
- Consists of the sugar **Ribose**, the **base Adenine**, and **3 phosphate groups** attached to the ribose.
- The bond between the **outer two phosphates** is **very high in energy**: when it is broken, *much energy is released*, which can be used by the cell (for example, for muscle contraction).
- The bond between the first and second phosphate is also high in energy, but not as high as between the two end phosphates
- ATP is produced mostly produced inside **mitochondria** during the process of **cellular respiration**.





BIOLOGICAL MOLECULE	UNIT MOLECULE (Building Block)	EXAMPLE OF BIOLOGICAL MOLECULE
nucleic acid		
		enzyme
		glycogen
	fatty acid and glycerol	