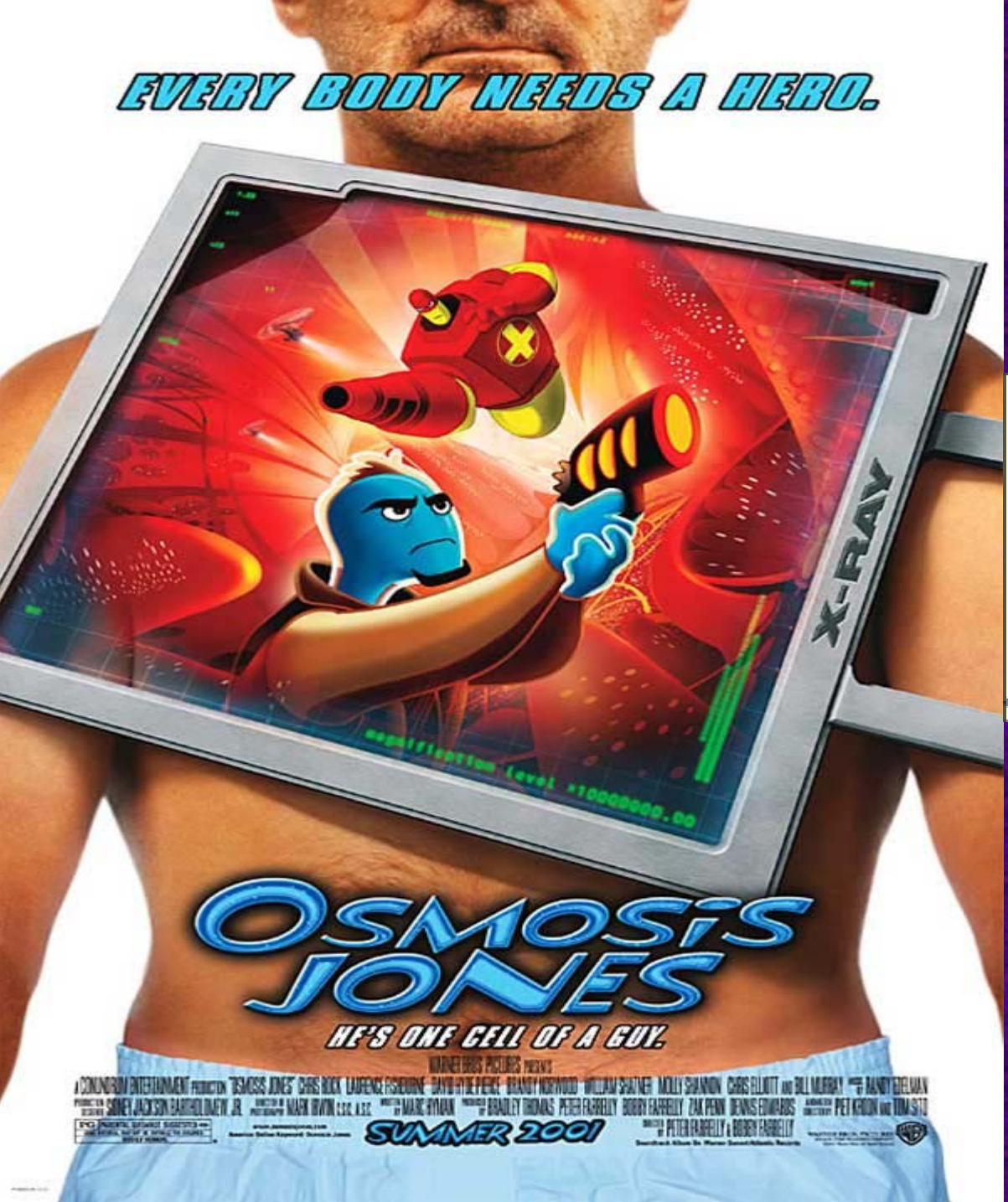
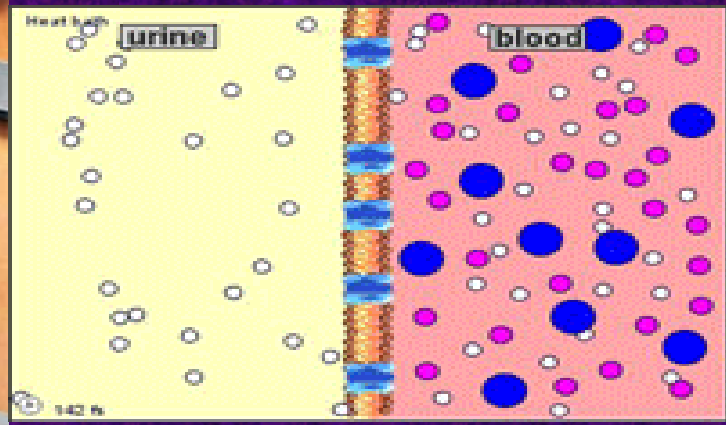


Diffusion and Osmosis

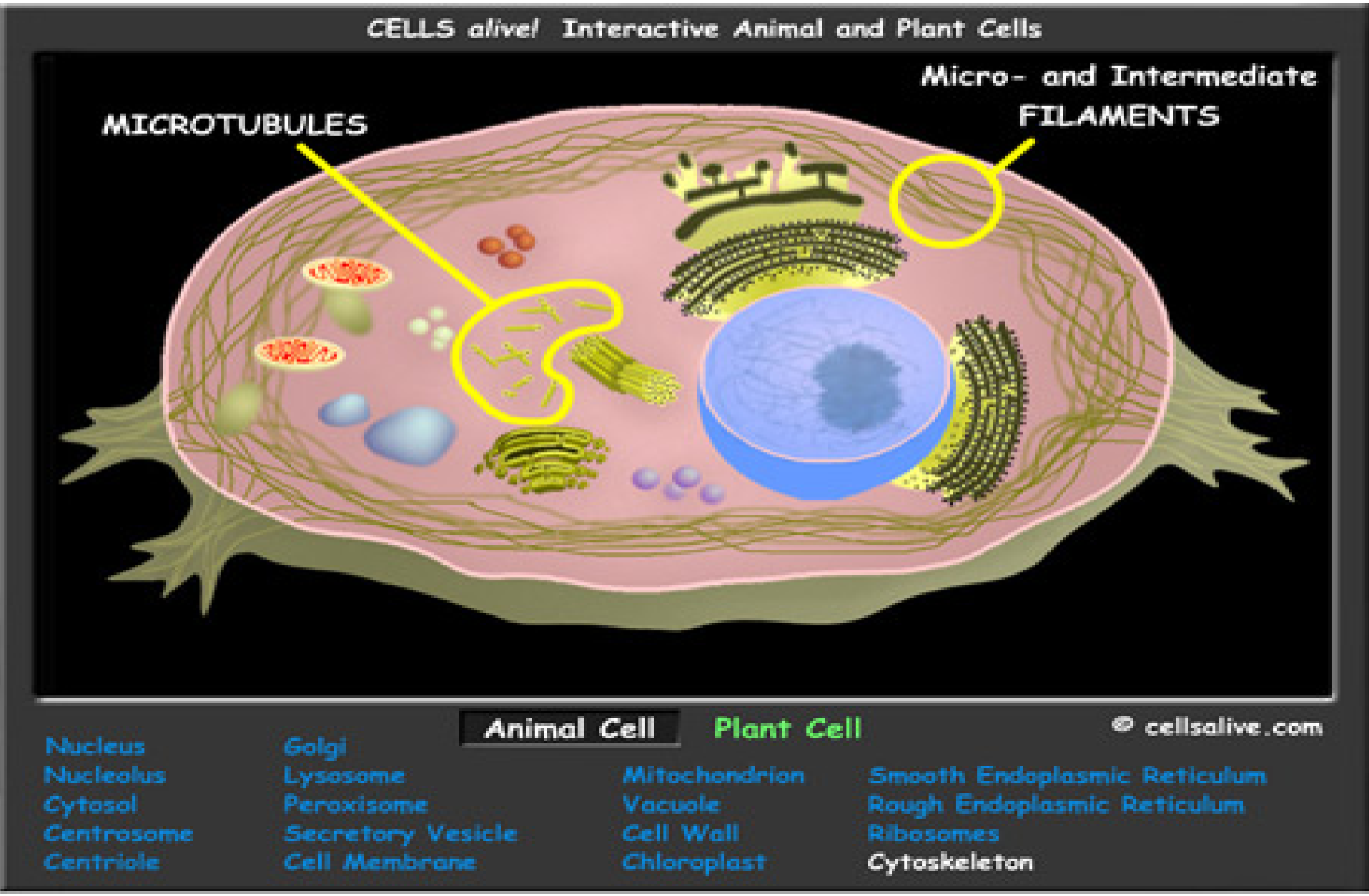


Danil Hammoudi. MD

http://sinoemedicalassociation.org/AP/

•Molecules, the smallest portion of compounded atoms or elements that carries the form's characteristics;
•Cells, the smallest unit of living tissue that can function as an independent entity (form of life);
•Tissues, which are made up of cells and other matter, are what animal and plant organ are made of;
•Organs, a structure of a plant or animal which performs a specific and essential function;
•Organ systems, a group of organs that work together to perform a function, such as the digestive system;
•Organisms, a living thing and/or its structure - a human being is a complex organism, so is a dog, a cat and a tree;
•Populations, the organisms living in a certain group or area, such as a city, a forest or a test tube. The basic disciplines of biology study life at one or more of these levels.

The cells


CELLS alive! Interactive Animal and Plant Cells
MICROTUBULES
Micro- and Intermediate FILAMENTS
Animal Cell
Plant Cell
© cellsalive.com
Nucleus
Nucleolus
Cytosol
Centrosome
Centriole
Golgi
Lysosome
Peroxisome
Secretory Vesicle
Cell Membrane
Mitochondrion
Vacuole
Cell Wall
Chloroplast
Smooth Endoplasmic Reticulum
Rough Endoplasmic Reticulum
Ribosomes
Cytoskeleton

The cells

Latin *cellula*, a small room

- The **cell** is the structural and functional unit of all living organisms, and is sometimes called the "building block of life.

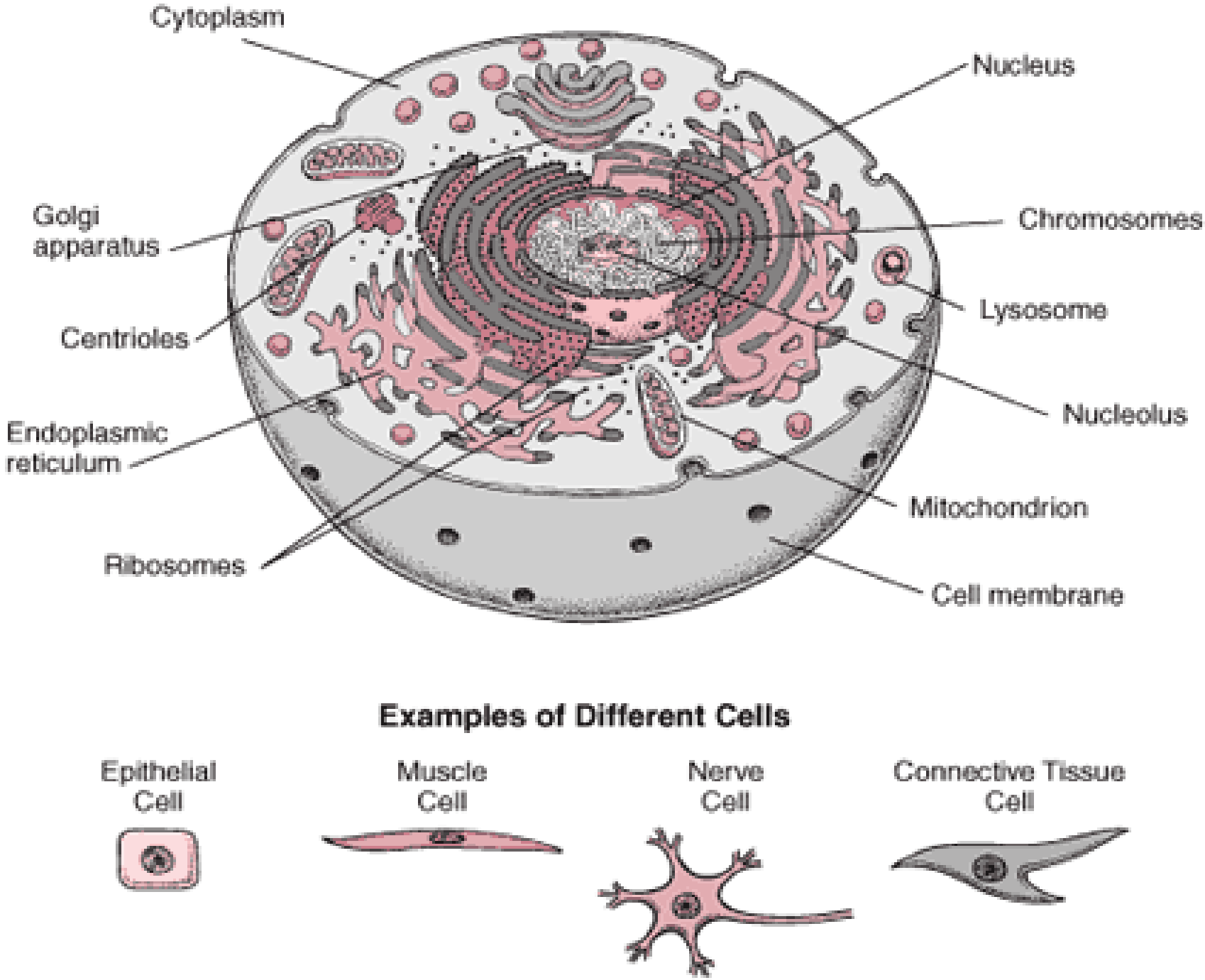
Some organisms, such as bacteria, are **unicellular**, consisting of a single cell.
Other organisms, such as **humans, are multicellular**, (humans have an estimated 100 trillion or 10^{14} cells; a typical cell size is 10 μm, a typical cell mass 1 nanogram).
The largest known cell is an ostrich egg.

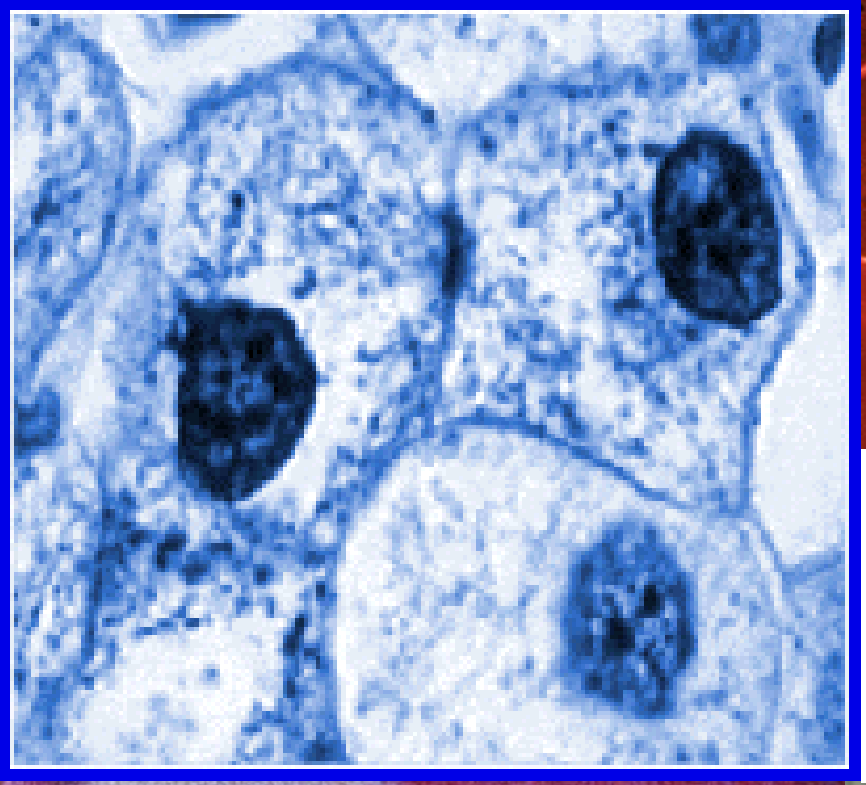
Properties of cells

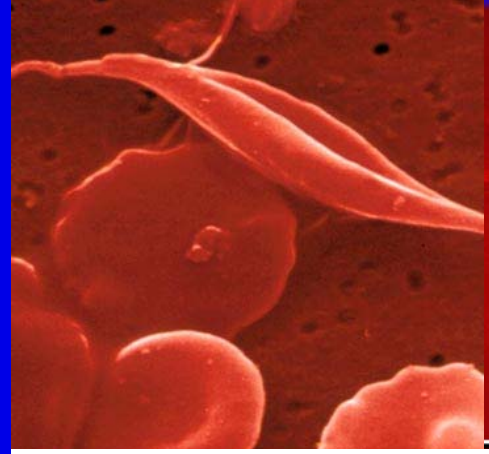
- Each cell is at least somewhat self-contained and self-maintaining: it can take in nutrients, convert these nutrients into energy, carry out specialized functions, and reproduce as necessary. Each cell stores its own set of instructions for carrying out each of these activities.

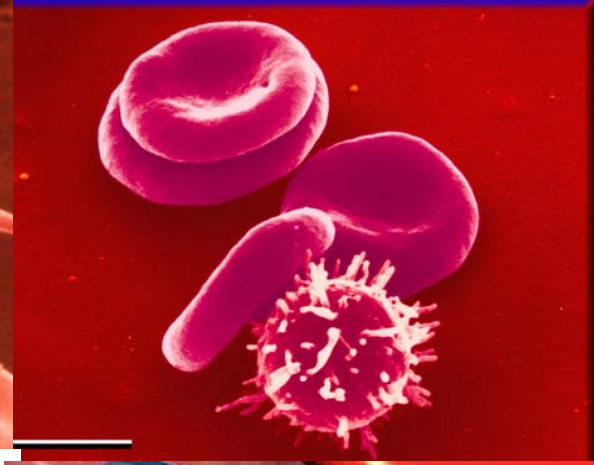
All cells share several abilities:

- **Reproduction** by cell division (binary fission, mitosis or meiosis).
- Use of enzymes and other proteins coded for by DNA genes and made via messenger RNA intermediates and ribosomes.
- **Metabolism,** including taking in raw materials, building cell components, converting energy, molecules and releasing by-products. The functioning of a cell depends upon its ability to extract and use chemical energy stored in organic molecules. This energy is derived from metabolic pathways.
- **Response to external and internal stimuli** such as changes in temperature, pH or nutrient levels.
- Cell contents are contained within a cell surface membrane that contains proteins and a lipid bilayer.
- Some prokaryotic cells contain important internal membrane-bound compartments, but eukaryotic cells have a highly specialized endomembrane system characterized by regulated traffic and transport of vesicles.


Cytoplasm
Nucleus
Golgi apparatus
Chromosomes
Centrioles
Lysosome
Nucleolus
Endoplasmic reticulum
Mitochondrion
Ribosomes
Cell membrane
Examples of Different Cells
Epithelial Cell
Muscle Cell
Nerve Cell
Connective Tissue Cell







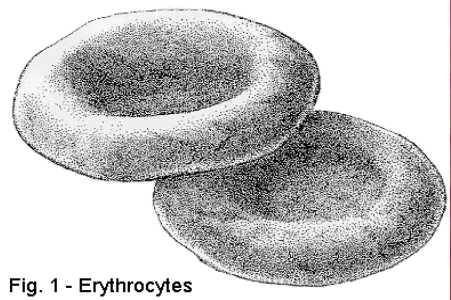
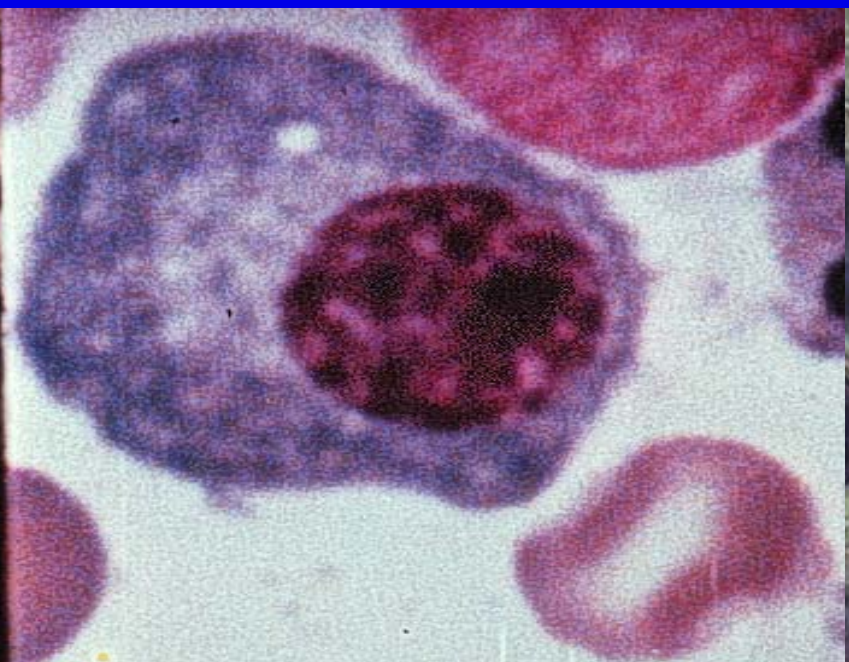
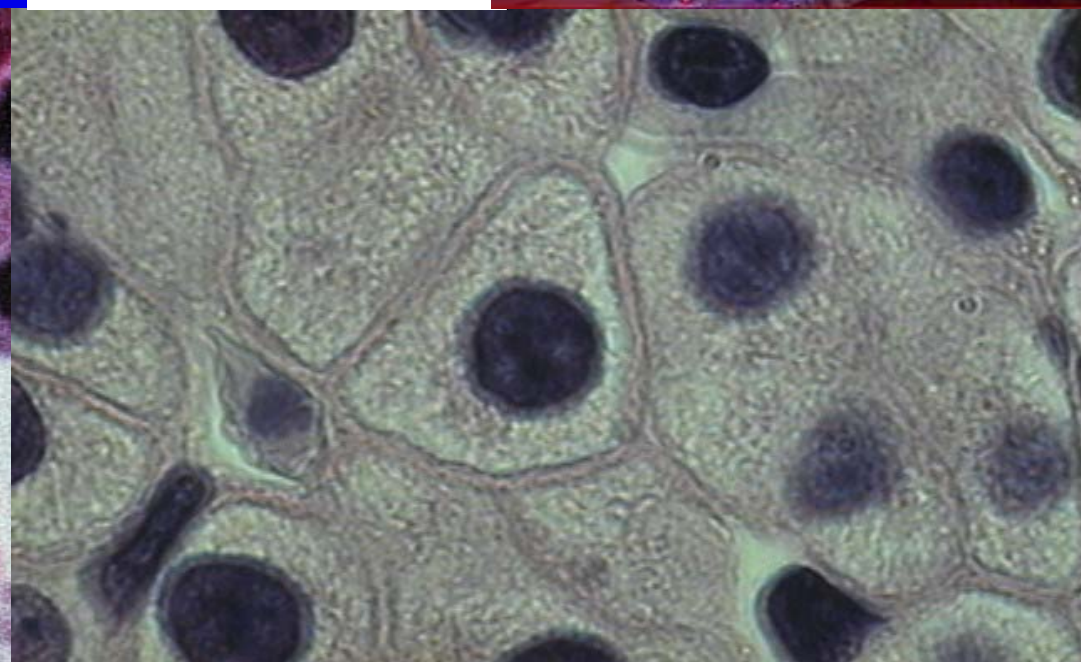
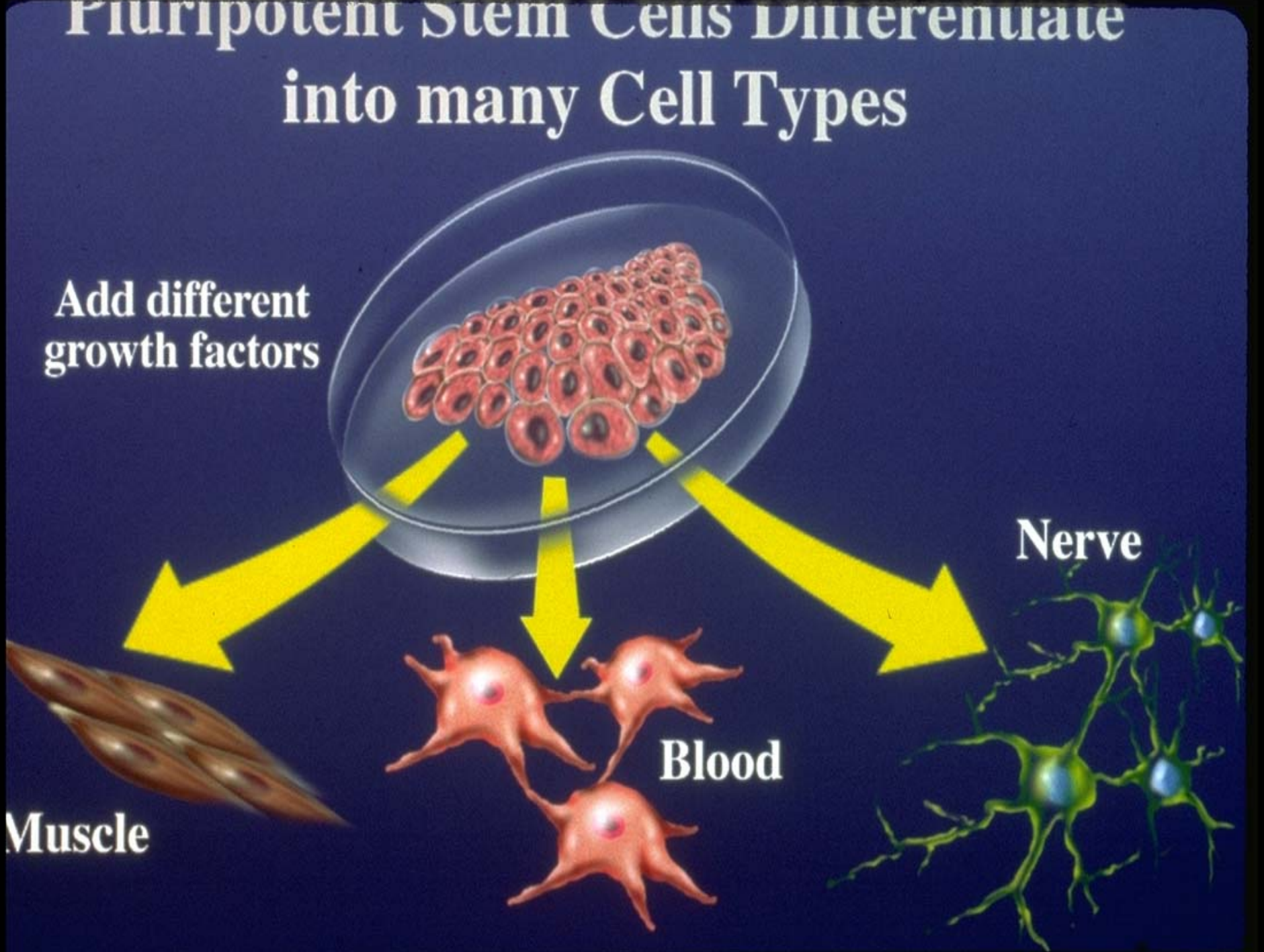


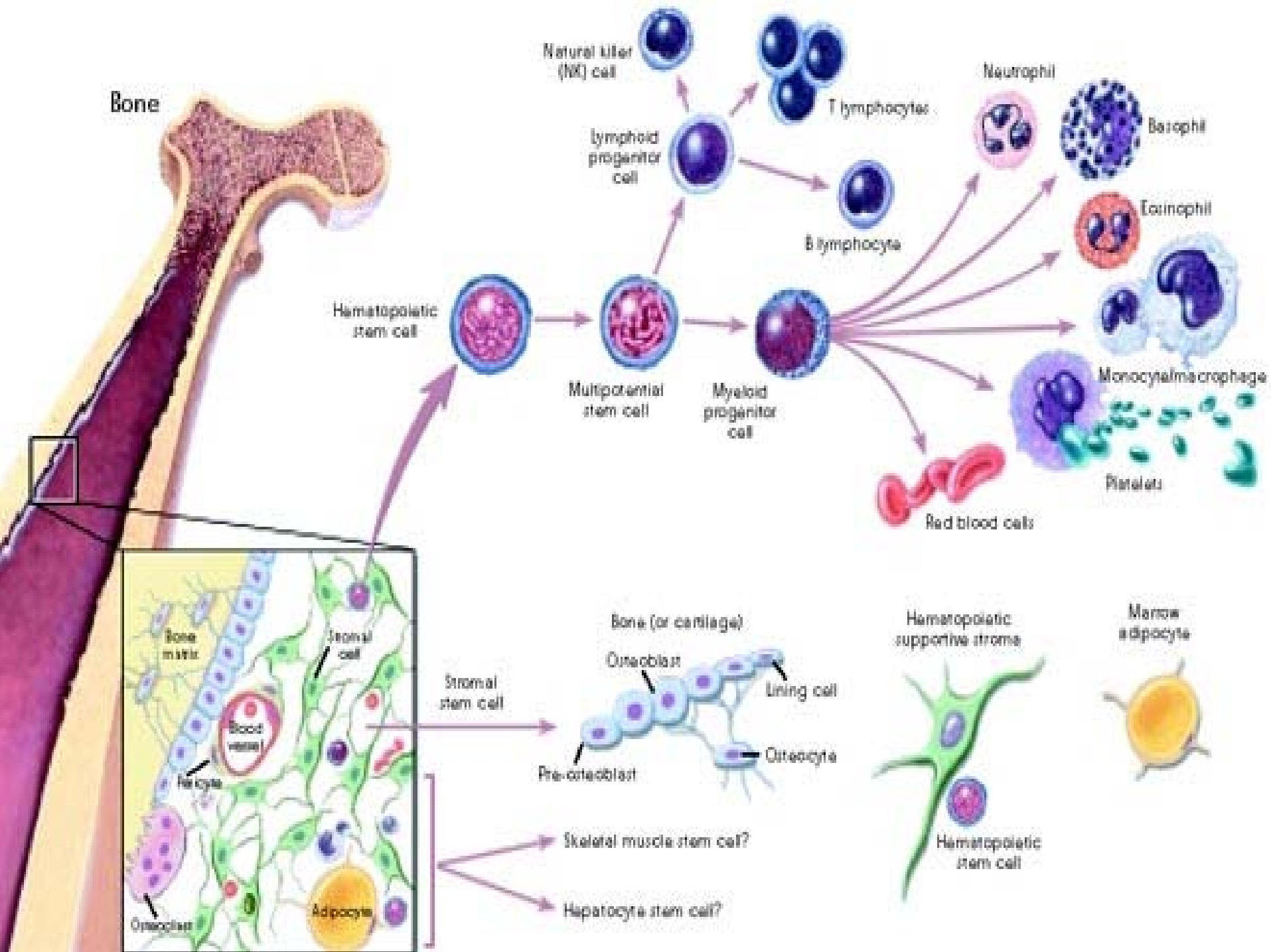
Fig. 1 - Erythrocytes





Pluripotent Stem Cells Differentiate into many Cell Types




Bone
Natural killer (NK) cell
T lymphocytes
Lymphoid progenitor cell
B lymphocyte
Neutrophil
Basophil
Eosinophil
Monocyte/macrophage
Platelets
Red blood cells
Hematopoietic stem cell
Multipotential stem cell
Myeloid progenitor cell
Bone matrix
Stromal cell
Blood vessel
Pericyte
Osteoclast
Adipocyte
Stromal stem cell
Bone (or cartilage)
Osteoblast
Lining cell
Osteocyte
Pre-osteoblast
Skeletal muscle stem cell?
Hepatocyte stem cell?
Hematopoietic supportive stroma
Hematopoietic stem cell
Marrow adipocyte

Cellular transport

Mechanisms by which materials can cross a cellular membrane.

1/ ***A passive transport*** mechanism is one in which

molecules cross the membrane **without requiring the expenditure of energy [ATP] by the cell**.

- Passive transport mechanisms include :

-simple diffusion,

-facilitated transport,

- and osmosis.
- **2/*Active transport*** mechanisms are those that require the cell to expend energy [ATP]to move something across the membrane.

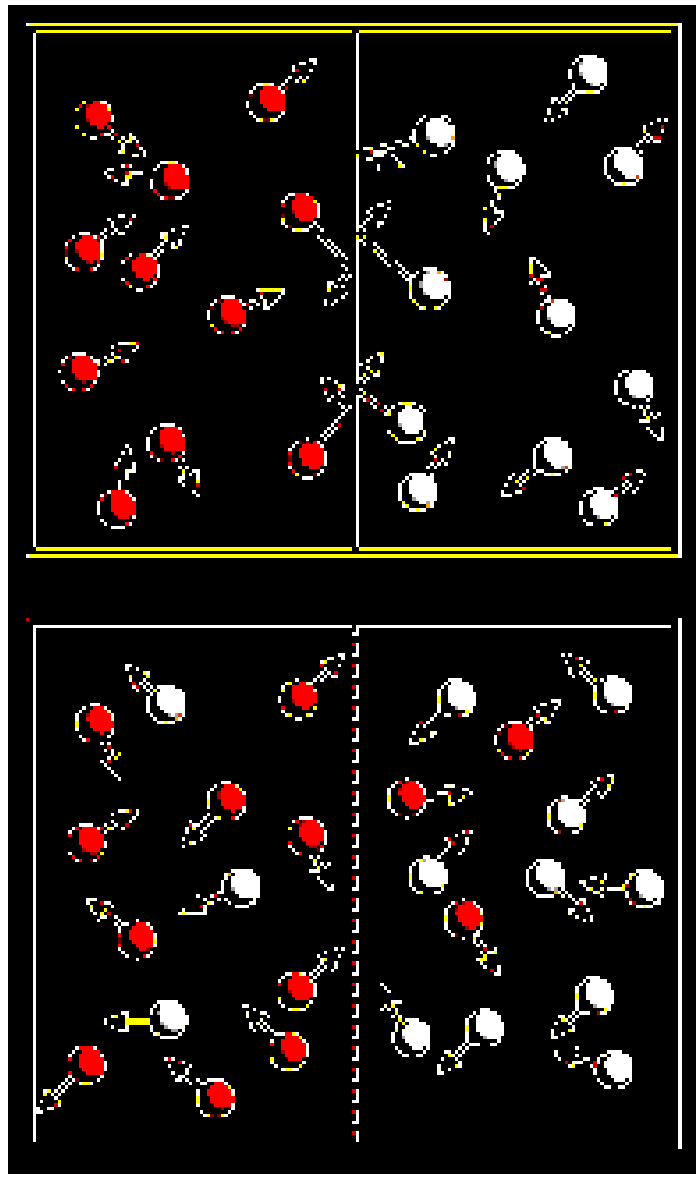
Passive Membrane Transport: Filtration

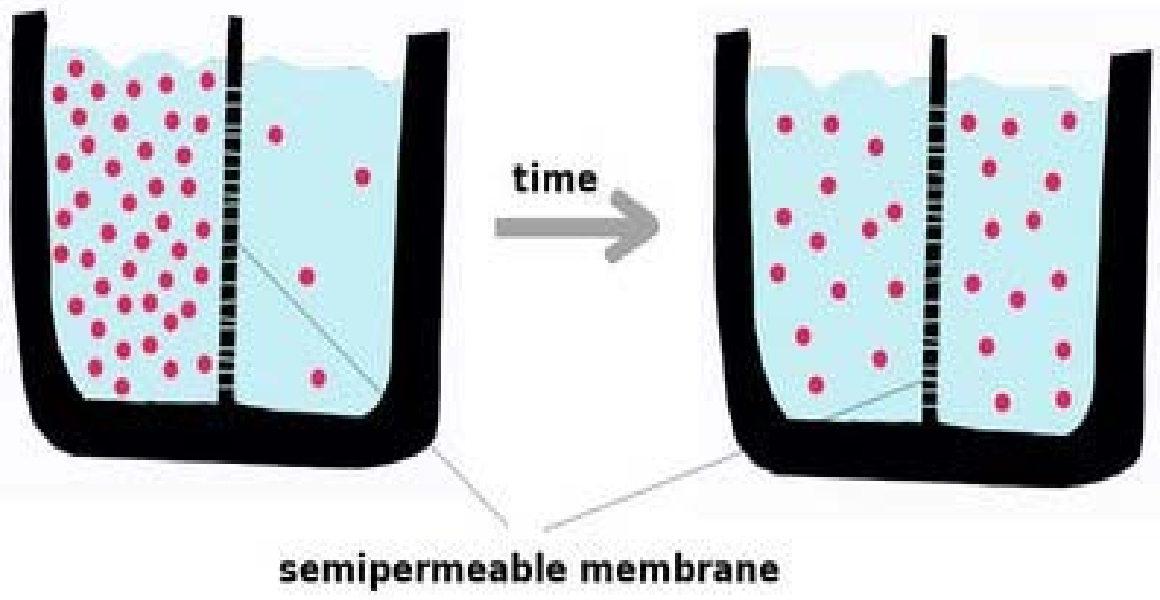
- The passage of water and solutes through a membrane by hydrostatic pressure

- Pressure gradient pushes solute-containing fluid from a higher-pressure area to a lower-pressure area

I. Diffusion

- Key words:
  - **kinetic energy**.
  - **Brownian motion**.
  - **Diffusion**
  - **Concentration gradient**

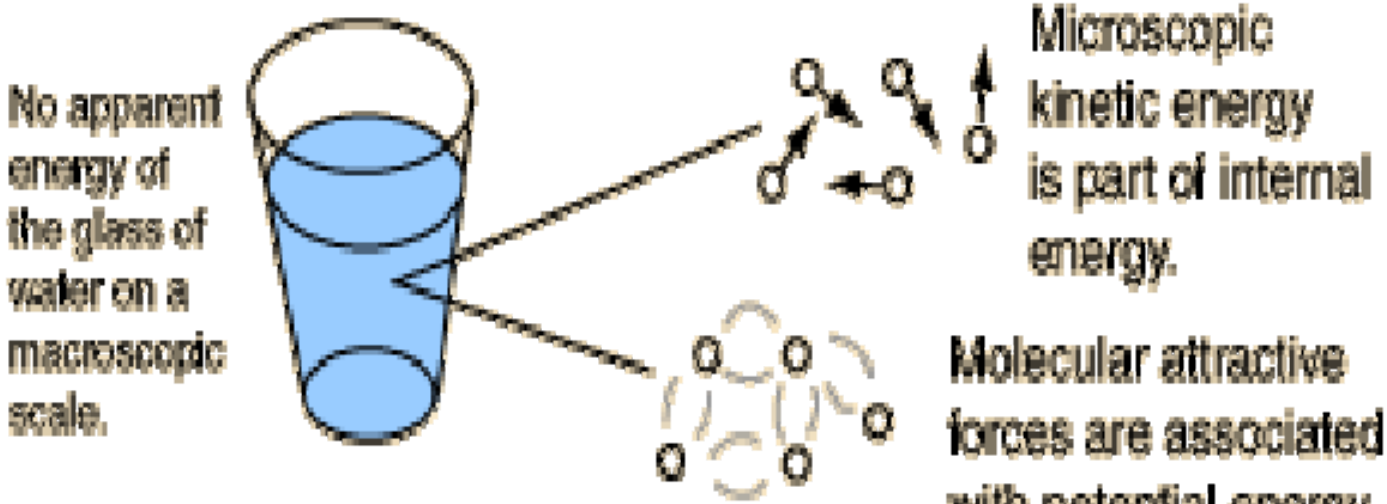




- Diffusion refers to the process by which molecules intermingle as a result of their kinetic energy of random motion.

•Kinetic energy is energy of motion.
•The kinetic energy of an object is the energy it possesses because of its motion.
•The kinetic energy* of a point mass m is given by $\text{Kinetic Energy} = \frac{1}{2}mv^2$

Does a glass of water sitting on a table have any energy?



Type of diffusion

- Gases : example open a bottle of parfume
- Within a liquid : blood in the body
- Through a colloid: example cytoplasm and glucose

Diffusion, being the spontaneous spreading of :

- matter (particles),
- heat,
- or momentum,

is one type of transport phenomenon.

Diffusion is the movement of particles from higher chemical potential to lower chemical potential (chemical potential can in most cases of diffusion be represented by a change in concentration).

It is readily observed, for example, when dried food like spaghetti is cooked; water molecules diffuse into the spaghetti strings, making them thicker and more flexible.

It is a physical process rather than a chemical reaction, which requires no net energy expenditure.

In cell biology, diffusion is often described as a form of passive transport, by which substances cross membranes.

Examples of diffusion

- A balloon filled with helium will deflate a little bit every day, because helium atoms diffuse out of the balloon through its wall. This type of diffusion through small holes is called effusion.

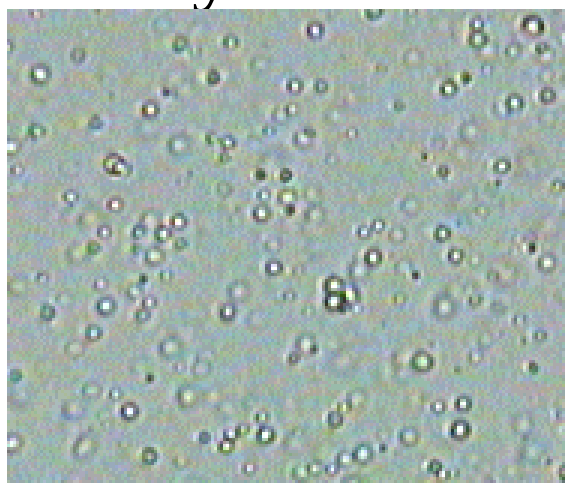
- When spaghetti is cooked, water molecules diffuse into the spaghetti strings, making them thicker and more flexible. Adding salt to the water reduces diffusion by reducing the osmotic pressure.

- Carbon dioxide bubbles in soft drinks start as small nuclei and grow because of the diffusion of carbon dioxide molecules towards them

Diffusion across biological membranes

- Facilitated diffusion
- Ion diffusion through ion channels
- Simple diffusion, not requiring a special protein channel
- Diffusion in the respiratory system - in the alveoli of mammalian lungs, due to differences in partial pressures across the alveolar-capillary membrane, oxygen diffuses into the blood and carbon dioxide diffuses out

- **Brownian motion**. There are two important facts you should remember about Brownian
- motion:
- (1) Brownian motion depends upon the kinetic energy of the water molecules.
- (2) The direction of Brownian motion is random. A particle moving according to Brownian motion does not move in any particular direction.



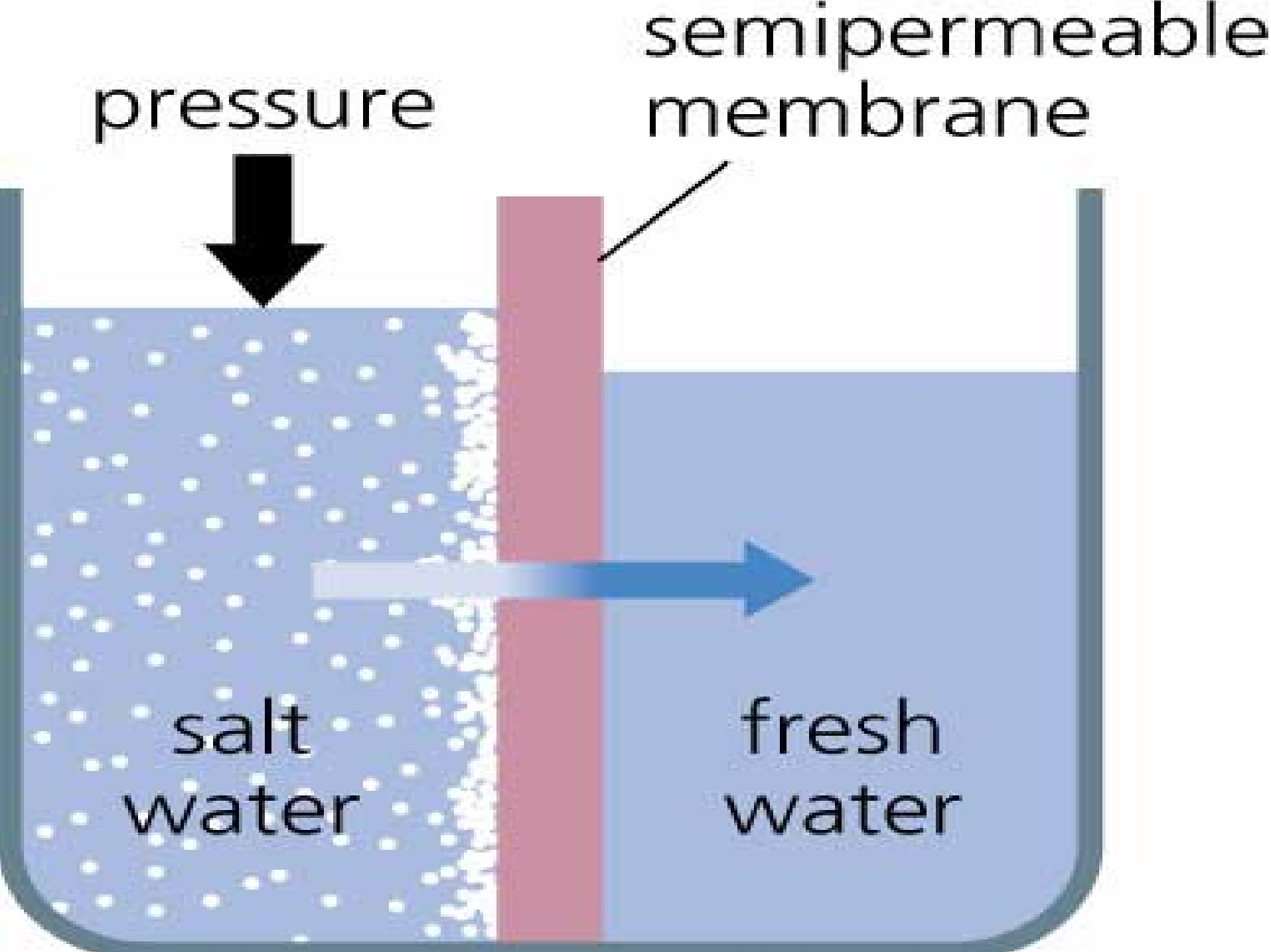
Dialysis

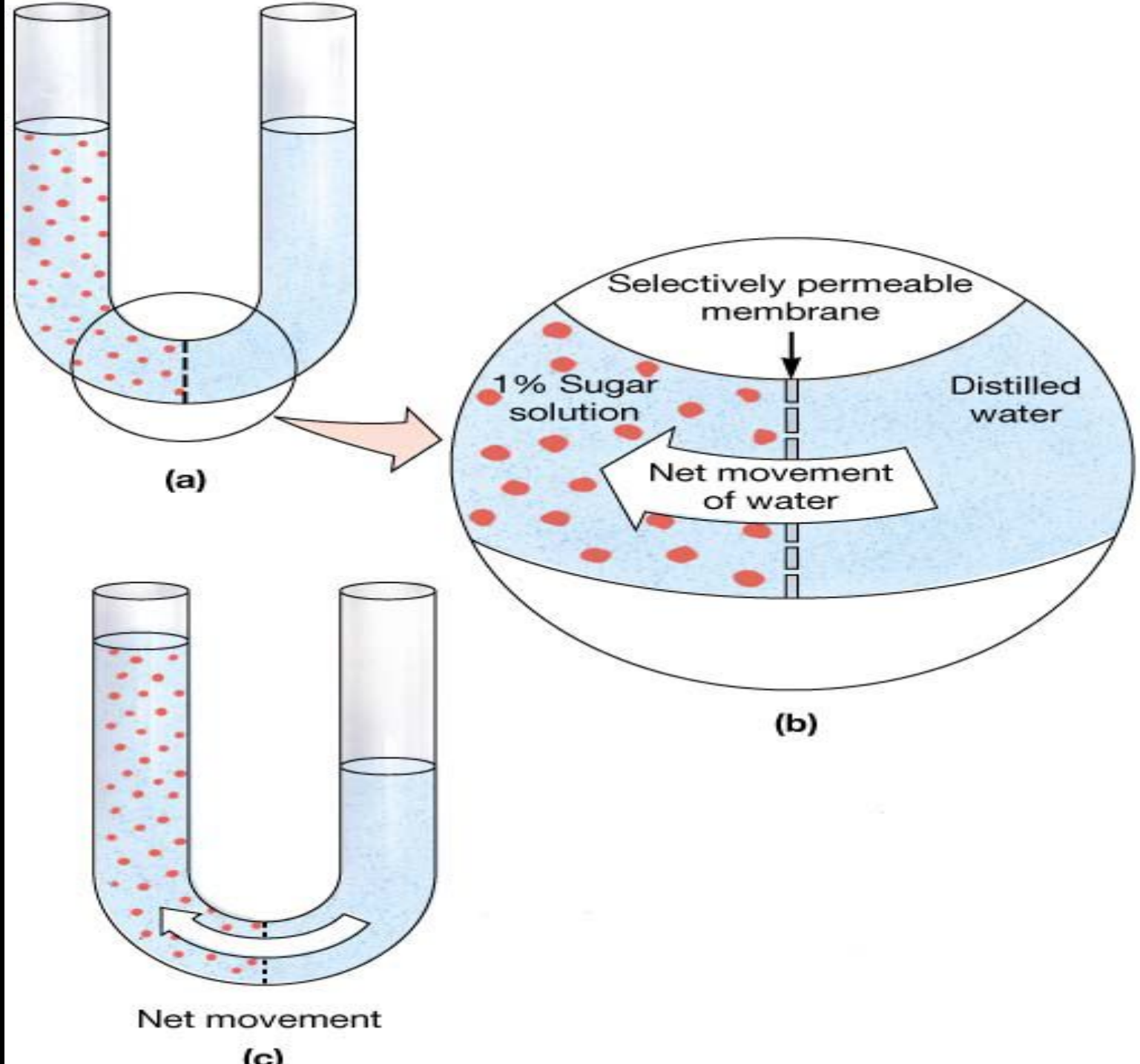
- Separation of crystalloids from colloids through a selectively permeable membrane

- Example: kidneys

Osmosis

- the movement of water molecules from an area of high concentration to an area of low concentration.
- Cell membranes are completely permeable to water, therefore, the environment the cell is exposed to can have a dramatic effect on the cell


semipermeable membrane
pressure
salt water
fresh water


Selectively permeable membrane
1% Sugar solution
Distilled water
Net movement of water
(a)
(b)
Net movement
(c)

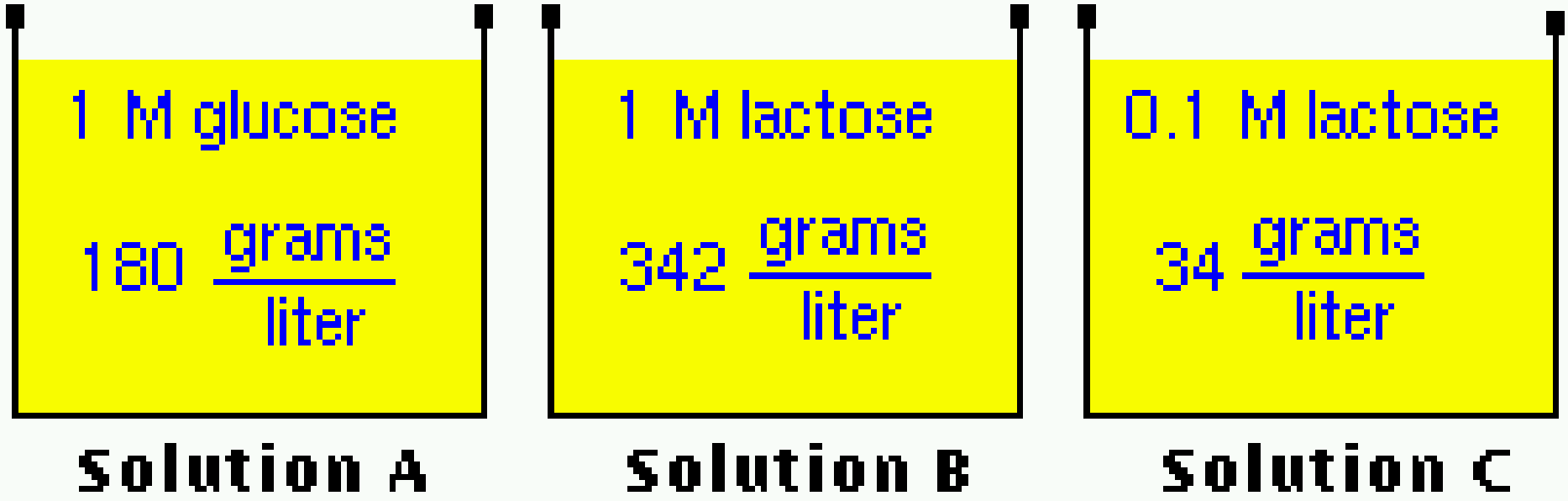
Effects of Solutions of Varying Tonicity

- **Isotonic** – solutions with the same solute concentration as that of the cytosol: (e.g. the cell's cytoplasm). When a cell is placed in an isotonic solution, the water diffuses into and out of the cell at the same rate. The fluid that surrounds the body cells is isotonic.

- **Hypertonic –** solutions having greater solute concentration than that of the cytosol: contain a high concentration of solute relative to another solution (e.g. the cell's cytoplasm). When a cell is placed in a hypertonic solution, the water diffuses out of the cell, causing the cell to shrivel

- **Hypotonic** – solutions having lesser solute concentration than that of the cytosol :contain a low concentration of solute relative to another solution (e.g. the cell's cytoplasm). When a cell is placed in a hypotonic solution, the water diffuses into the cell, causing the cell to swell and possibly explode.

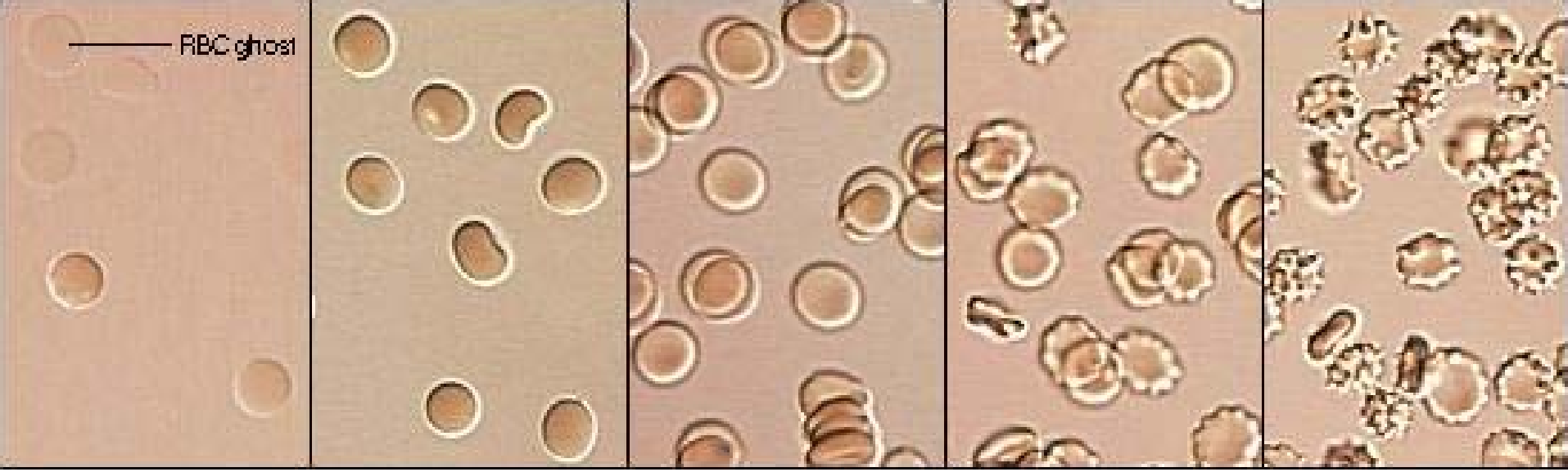
Two containers of equal volume are separated by a membrane that allows free passage of water, but totally restricts passage of solute molecules. Solution A has 3 molecules of the protein albumin (molecular weight 66,000) and Solution B contains 15 molecules of glucose (molecular weight 180). Into which compartment will water flow, or will there be no net movement of water?



Solutions A and B are isotonic (with each other), Solutions A and B are both hypertonic compared to Solution C, and Solution C is hypotonic relative to Solutions A and B.

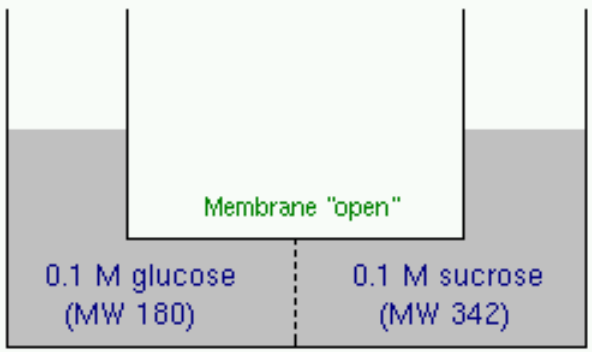
A good link for examples:

http://www.vivo.colostate.edu/hbooks/cmb/cells/pmemb/osmosis_eg.html



100 mOs | 200 mOs | ~300 mOs (In blood serum) | 400 mOs | 500 mOs

Hypotonic ← Isotonic → Hypertonic



There will be NO net movement of water. Both solutions have equivalent molarity of non-dissociating solutes, which means that the concentrations of solute molecules on each side is balanced. The fact that glucose is smaller than sucrose is irrelevant in this example.

Click to Restore

Diffusion of water across a membrane - osmosis - generates a pressure called osmotic pressure.

If the pressure in the compartment into which water is flowing is raised to the equivalent of the osmotic pressure, movement of water will stop.

This pressure is often called **hydrostatic ('water-stopping') pressure**.

The term **osmolarity** is used to describe the number of solute particles in a volume of fluid.
Osmoles are used to describe the concentration in terms of number of particles - a 1 osmolar solution contains 1 mole of osmotically-active particles (molecules and ions) per liter