Homeostasis and Transport

Organisms must maintain internal stability despite a wide range of external conditions, this is homeostasis.
Homeostasis

• **Homeostasis** is the *regulation* of metabolic processes to maintain the constant, stable internal environment required for survival.

• Organisms use feedback mechanisms to respond to changing external/internal conditions to maintain stable internal temperatures, pH levels, and ion concentrations.
Sample Question

Homeostasis is classified under which of the following?

A. cell respiration  
B. photosynthesis  
C. transcription  
D. cell regulation
Answer: D

- Homeostasis describes the process through which a body maintains a stable internal environment. Thus, homeostasis is a form of **cell regulation**.

Without cellular regulation, cells would not be able to control their water concentrations, temperatures, and acidities, and cells would die.
Stable Internal Environment

- **Temperature**
  - Cells rely on enzymes to function, enzymes can only function in a narrow temperature range
  - In cases of exposure to extreme heat/cold, cell death, organ damage, or even death can occur

- **pH Balance**
  - Enzymes also function within a narrow pH range
  - Certain diseases can affect the blood pH, lowering the pH of the blood

- **Solute Concentrations**
  - Organisms must maintain a steady solute concentration to function properly
  - When solutes become imbalanced, diseases, such as diabetes, can result
Sample Question

How is homeostasis important to the survival of organisms?
A. Homeostasis makes all organisms hibernate.
B. Homeostasis allows organisms to regulate their temperature.
C. Homeostasis helps organisms locate food.
D. Homeostasis makes organisms grow bigger and taller.
Homeostasis is the body's ability to regulate its temperature, as well as other internal conditions, even when environmental conditions are changing.

Since an organisms' cells can only function properly in a limited temperature range, homeostasis is important to the survival of all organisms.
Sample Question

Cells can function

A. in a wide range of pHs and temperatures.
B. at any temperature and pH.
C. in rapidly changing temperatures and pHs.
D. only in a narrow range of temperature and pH.
Answer: D

- Cells can only function in a **narrow** range of temperatures and pH.
Mechanisms of Homeostasis

- **Positive Feedback Mechanisms** - interactions that increase or amplify the response of the system

- **Example:**
  Blood clotting - damage to a vessel wall triggers the activation of blood platelets... as platelets accumulate, they send chemical signals to activate more platelets, resulting in a blood clot
Mechanisms of Homeostasis

- **Negative Feedback Mechanisms** - interactions that reduce or dampen the response of the system (work against change), more common of the feedback responses.
Sample Question

When dry environmental conditions exist, guard cells reduce water loss from plants by closing the openings in their leaves. This process is an example of a feedback mechanism that plants use in order to

A. maintain homeostasis.
B. expend their resources.
C. produce more chlorophyll.
D. absorb more solar energy.
Homeostasis refers to an organism's ability to maintain a relatively constant internal environment. In many organisms, **feedback mechanisms** have evolved to help maintain homeostasis.

For example, plants require a certain amount of water for survival. When dry environmental conditions exist, guard cells reduce water loss from plants by closing the openings in their leaves. This feedback mechanism helps plants maintain a relatively constant internal environment.
Cell Structures Involved in Homeostasis

- To maintain homeostasis, cells must be able to sort and send substances to specific locations.
- The **Golgi apparatus** is key in sorting and packaging macromolecules, particularly proteins.
- The **endoplasmic reticulum** is the location for protein (rough ER) and lipid (smooth ER) synthesis and transports proteins within the cell.
Sample Question

The Golgi apparatus helps to maintain cellular homeostasis by
A. controlling which proteins are synthesized during the cell cycle.
B. transforming absorbed light energy to manufacture carbohydrates.
C. synthesizing ATP molecules from glucose during glycolysis.
D. modifying, sorting, and packaging proteins prior to transport.
Answer: D

- The Golgi apparatus helps maintain cellular homeostasis by modifying, sorting, and packaging proteins prior to transport.
Cell Structures Involved in Homeostasis

- The **cell membrane** (or plasma membrane) is a key structure in maintaining homeostasis because the membrane regulates all materials that enter or leave the cell.

- Cell membranes are located inside the cell walls of plant cells, and form the outer cell boundary in animal cells.
Sample Question

Which of the following is a function of the cell membrane of a cell?

A. The production of energy from food molecules using cellular respiration.

B. The transport of molecules into and out of the cell through osmosis and diffusion.

C. The production of genetic material through DNA transcription.

D. The transport of genetic material within the cytoplasm of the cell.
One of the major functions of the cell membrane is the passive transport of molecules into and out of the cell through osmosis and diffusion. The cell membrane also separates the cell's internal environment from the external world.
The cell membrane is formed of a lipid bilayer, this arrangement prevents large molecules and polar molecules from moving through the membrane without assistance from proteins, allowing the membrane to control the movement of substances in and out of the cell.

- **Hydrophilic (“water-loving”) heads**
- **Hydrophobic (“water-fearing”) tails**
Sample Question

The cell membrane, or plasma membrane, is made up of a lipid bilayer in which hydrophilic heads face outward and hydrophobic tails face inward. This arrangement within the cell membrane allows it to

A. fuse with ribosomes during DNA replication.
B. keep out all viral and bacterial infections.
C. absorb water from the cytoplasm whenever necessary.
D. control the movement of substances in and out of the cell.
Answer: D

- All cells have a cell membrane. The cell membrane separates the cell's internal environment from the external world. Cell membranes are constructed of proteins and a lipid bilayer that includes phospholipids. The arrangement of the phospholipids allows the cell membrane to control the movement of substances in and out of the cell.
The Cell Membrane (continued)

- Sometimes the cell needs large or polar molecules, for this purpose the membrane contains proteins for transport
- Therefore, the structure and function of the cell membrane can best be described by the **fluid mosaic model**

The molecules of the membrane can move around the perimeter

Mosaic of different macromolecules, lipids, and proteins
Sample Question

Permeability is the condition of being capable of having materials flow into and out of a membrane. The permeability of a cell membrane is determined by how easily a molecule can diffuse across the membrane. Usually, only molecules that are fat-soluble can permeate across a cell membrane. Why is this the case?

A. Water-soluble molecules are too large.
B. Cell membranes are composed of a lipid bilayer.
C. Cell membranes are composed of cytosol.
D. Water-soluble molecules are nonpolar.
Answer: B

- Cellular fluid (cytosol) and the cell's organelles are contained by the cell's membrane, which is composed of a lipid bilayer. Lipids are a type of fat. Because a cell's membrane is composed of fat, only fat-soluble molecules are able to dissolve through the membrane into the cytosol.
Active & Passive Transport

- In order for cells to function properly, they must be able to transport in materials, such as water and nutrients, and they must be able to transport out materials, such as wastes.

- Materials that cannot move through the lipids must travel through transport proteins (such as carrier proteins, channel proteins, and membrane pumps).
There are two main ways in which molecules are transported into and out of cells - active transport and passive transport. Which of the following statements is true of passive transport?

A. Carrier proteins are sometimes used during passive transport.
B. Molecules move up a concentration gradient during passive transport.
C. Energy, in the form of ATP, is essential for passive transport.
D. Endocytosis and exocytosis are two forms of passive transport.
Answer: A

- There are four main kinds of passive transport: diffusion, facilitated diffusion, filtration, and osmosis. All of these forms involve molecules moving down a concentration gradient (i.e. from a high concentration to a low concentration) and do not require the input of metabolic energy or ATP.

Small molecules such as oxygen, ethanol, and carbon dioxide easily diffuse across membranes. Some larger molecules, such as glucose, require the assistance of a carrier protein. This form of passive transport is known as facilitated diffusion.
Active Transport

- **Active transport** involves the movement of molecules up a concentration gradient, from an area of low concentration to an area of high concentration.
- Since the movement is against the concentration gradient, it requires the input of energy (in the form of ATP).
- Membrane pumps are protein molecules embedded in the cell membrane that assist with active transport.
Examples of Active Transport

- The sodium-potassium pump is an important example of this type of active transport.
Sample Question

Normal homeostatic conditions require potassium concentrations to be about 1000 times higher inside the cell than in the blood. What mechanism does a cell use to move these small potassium molecules into the cell against the concentration gradient?

A. passive transport by osmosis
B. passive transport by diffusion
C. active transport by endocytosis
D. active transport by proteins
Answer: D

Because the concentration of potassium ions is so much higher inside the cell than outside, cells cannot rely on diffusion to move needed potassium into the cell. They instead use active transport to move potassium ions across the cell membrane.

In active transport mechanisms, the cell must expend energy to move molecules into or out of the cell. For potassium, cells have special proteins that form a sodium-potassium pump. This pump moves sodium ions out of the cell while simultaneously moving potassium ions in.
Examples of Active Transport

- Other types of active transport include **endocytosis** and **exocytosis**

- **Endocytosis** is the process in which cells bring large molecules **into** the cell by surrounding them with the cell membrane and forming vesicles

- **Exocytosis** is the process in which cells expel materials from vesicles (often packaged by the Golgi apparatus) **out** of the cell
Sample Question

Exocytosis is the process by which vesicles in the cytoplasm fuse with the cell membrane, releasing their contents into the cell's external environment. This is the form of transport used by a cell to dispose of large molecules. How does exocytosis help a cell maintain its homeostasis?

A. Cells must regularly lose part of their membranes in order to maintain their homeostasis.
B. In order to maintain their homeostasis, cells must release large molecules so that they can replicate themselves.
C. In order to maintain their homeostasis, cells must release the exact same chemicals as they take in.
D. Cells must dispose of wastes in order to maintain their homeostasis.
A cell's metabolic functions produce waste. If these wastes are not removed, they will build up in the cell and disrupt the cell's functions, so exocytosis helps a cell maintain its homeostasis by disposing of these wastes.
Passive Transport

- **Passive transport** involves the movement of molecules down a concentration gradient, from an area of high concentration to an area of low concentration.
- Passive transport does not require energy.
- There are four main types of passive transport: simple diffusion, facilitated diffusion, osmosis, and filtration.
Sample Question

Which of the following types of passive transport involves water molecules moving from a high concentration to a low concentration?

A. facilitated diffusion
B. simple diffusion
C. osmosis
D. filtration
There are four main types of passive transport: simple diffusion, facilitated diffusion, osmosis, and filtration.

Osmosis is a type of diffusion that specifically involves the movement of water.
Filtration involves the movement of water and solute molecules across the cell membrane due to hydrostatic pressure.

Hydrostatic pressure is generated by the cardiovascular system as blood is pumped through the body's blood vessels.

This process frequently occurs in the kidneys.
Diffusion

- **Simple diffusion** is the movement of **small** molecules (such as oxygen, ethanol, and carbon dioxide) across the membrane.

- **Facilitated diffusion** is the movement of **larger** molecules (such as glucose) across the membrane with the assistance of carrier proteins.
Facilitated Diffusion
Sample Question

Which of the following best describes the process of diffusion?
A. Diffusion is the movement of molecules from an area of higher concentration to one of lower concentration by random molecular motion.

B. Diffusion is the movement of molecules from an area of lower concentration to one of higher concentration by random molecular motion.

C. Diffusion is the movement of molecules from an area of higher concentration to one of lower concentration caused by an input of energy to the system.

D. Diffusion is the movement of molecules from an area of lower concentration to one of higher concentration caused by an input of energy to the system.
Answer: A

Diffusion is the movement of molecules from an area of higher concentration to one of lower concentration by random molecular motion. Some of the molecules that may be moved through diffusion include oxygen, carbon dioxide, salts, sugars, and amino acids.

Diffusion results in a gradual mixing of the materials in a system. Diffusion does not require an input of energy into the system because it is caused by random molecular motion.
Osmosis

- The cell membrane is semi-permeable (selectively permeable), only small molecules can pass through unaided, this allows cells to control what enters/leaves the cell
- Water is able to flow into and out of cells freely, but larger molecules and ions (solutess) cannot
- Osmosis is a type of diffusion that specifically involves the movement of water across a semi-permeable membrane
Osmosis

- When solute concentrations become unequal on both sides of a semi-permeable membrane, water flows from areas of lower solute concentration to areas of higher solute concentration.
- Osmosis can also be described as the flow of water from areas of higher water concentration to areas of lower water concentration until equilibrium is achieved.
Sample Question

Osmosis is the diffusion of water across a selectively permeable membrane in which water moves from a solution containing a low concentration of solute to what kind of solution?

A. a solution containing only the solute

B. a solution containing a high concentration of water

C. a solution containing the same amount of solute

D. a solution containing a high concentration of solute
Osmosis is the diffusion of water across a selectively permeable membrane in which water moves from a solution containing a low concentration of solute to a solution containing a high concentration of solute. Solutes are substances, like salt, sugar, or food coloring, that are dissolved into a solvent, like water.

Osmosis plays a role in cell regulation since water molecules constantly relocate themselves to keep the cell at the correct concentration of all of its solutes. If osmosis did not occur, cells could enter a state of having too much water or too little water. This could cause cells to die.
Hypotonic, Isotonic, Hypertonic

Hypotonic = the salt concentration inside the cell is higher than the salt concentration outside the cell, water rushes into the cells and they can burst

Isotonic = the salt concentration inside the cells is the same as the salt concentration outside the cells, net movement of water will be zero

Hypertonic = the salt concentration inside the cells is lower than the salt concentration outside the cells, water will move out of the cells and they will shrivel
Sample Question

Examine the following diagrams of plant cells. Each cell has been placed in a different solution.

The cell in diagram 1 has been placed in a solution that contains _______ the interior of the cell.
A. the same concentration of water as
B. a higher concentration of water than
C. water that is warmer than
D. water that is cooler than
Diagram 1 shows plant cells in a hypotonic solution. This means that the solution has a higher concentration of water than the interior of the cell. In this case, water flows into the cell—causing it to swell and become turgid.