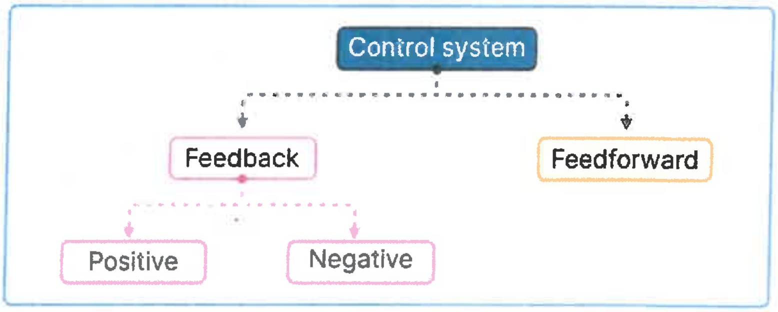
PHYSIOLOGY

1 GENERAL PHYSIOLOGY

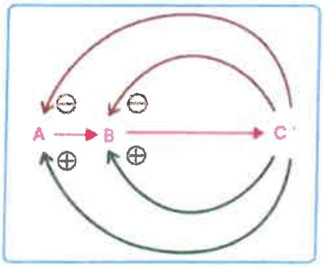
Control System

00:01:12



Feedback Control System

PYQ: INICET 2020 00:01:53



Positive feedback control system	Negative feedback control system
Input returned is of stimulatory type, So, if C is stimulating B and again B will produce C, the pathway will move in the same direction also known as the Vicious Cycle.	In the negative feedback control system, the C will give inhibitory input to B or A.
It destabilizes our control system	It stabilizes our control system

- There are certain conditions where positive control feedback systems are beneficial to the body.

Positive feedback control system 00:03:36

1. Blood clotting
2. A spike in estrogen and LH (LH surge) during the follicular phase of the menstrual cycle causes ovulation
3. Uterine contraction during the process of childbirth (Ferguson reflex)
4. Lactation (suckling of baby)
5. Generation of nerve action potential
6. Release of sarcoplasmic calcium through ryanodine receptors during excitation-contraction coupling in cardiac muscle

Negative Feedback Control System 00:04:57

- **Example:** Hypothalamic Pituitary Thyroid Axis and baroreceptor reflex

The Feedforward Control System

PYQ: AIIMS 2019 00:05:48

- When the control system predicts that some change is going to happen and corrective measures are being taken before the change, that is known as the anticipatory control system.

Examples PYQ: INICET 2021 00:06:42

1. The Thermoregulation System
2. Increase in Heart Rate and Respiratory Rate Even Before the Start of Exercise
   - This is due to psychic stimulation.
3. Cephalic Phase of Gastric Secretion
4. Receptive Relaxation of Stomach
   - Two types of relaxations of the stomach take place
     - Receptive relaxation : Typical of feed forward control system
     - Adaptive relaxation : Not a part of feed forward control system

5. Cerebellum

- Unidirectional output from granular to basket and then to Purkinje, without return of input is an example of the feedforward or anticipatory control system.

Gain of control system

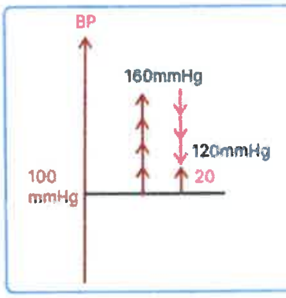
00:08:36

- With a gain of the control system, one understands the effectiveness of the control system.

$$\text{Gain} = \frac{\text{Correction}}{\text{Error}}$$

Example

- In a steady state condition, BP is 100 mm Hg. After a blood infusion, it rose to 160 mm Hg. Baroreceptors reduced it to 120 mm Hg, achieving a correction of 40 mm Hg. However, there remains a 20 mm Hg error compared to the initial state of 100 mm Hg.
- The correction of baroreceptors is in a negative direction; hence the gain of the baroreceptor control system is -2



$$\text{Gain} = \frac{40}{20} = 2 \text{ (negative)}$$

Gain = -2

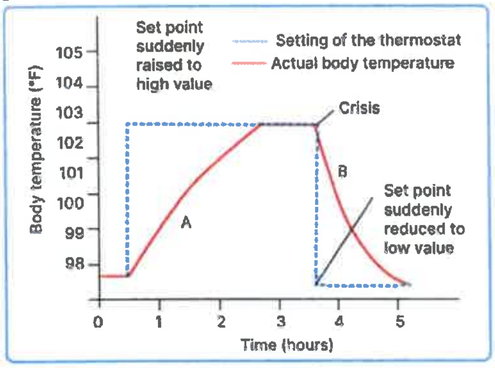
- If there were a condition where the correction is 100 percent and the error is 0, then the gain of the control system is known as infinite gain.

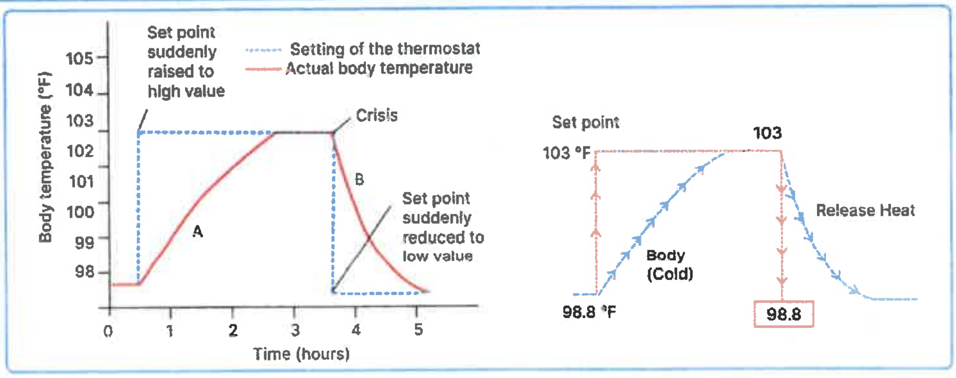
$$\frac{\text{Correction}}{\text{Error}} = \frac{\text{Correction}}{0} = \alpha$$

- An example of such a control system is the Kidney for the regulation of blood pressure and blood volume.

Q. The following diagram shows the change in hypothalamic set points to the body temperature, Which change will be seen at A as compared to B.

A. Sweating
B. Increased blood flow to the skin
C. Shivering
D. Shutdown of chemical thermoregulator.

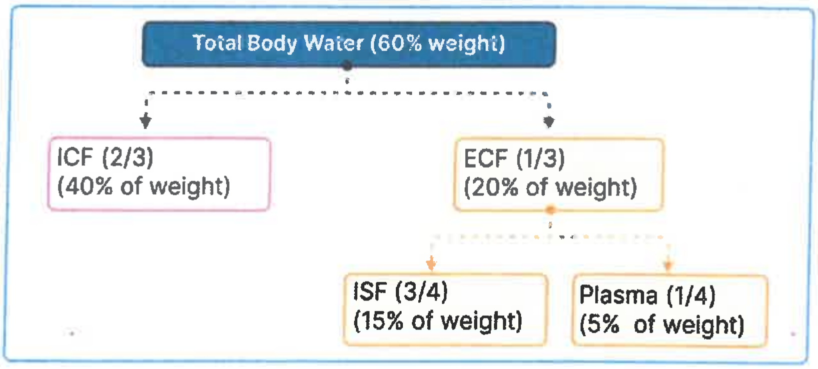




A. Vasoconstriction, Piloerection, epinephrine secretion and shivering
B. Vasodilation and sweating.

Body Water Distribution in the Body

PYQ: AIIMS 2020 PYQ: NEET PG 2021 00:20:30



- Blood makes up to 8% of the body weight, 5% plasma, and 3% of total cell volume (RBC, WBC, and platelets)

MCQ

Q. ECF is -----------% of the body weight.
Ans. ECF is 20% of the body weight.

Q. ECF is -----------% of the total body water.
Ans. As discussed earlier, ECF is 1/3rd of the body water, thus making it 33%.

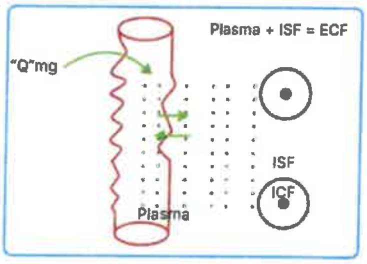
Transcellular Fluid 00:23:47

- The fluid that is present in certain body cavities.
- For example:
  - Cerebrospinal fluid (CSF) : 150 ml.
  - Intrapleural fluid : 10-20 ml.
  - Pericardial fluid : 50 ml.
  - Peritoneal fluid : 10 ml in the case of males and 20 ml in the case of females, particularly in post-ovulatory phases.
  - Synovial fluid: 1 ml/large joint approx.

Measurement of Body Water

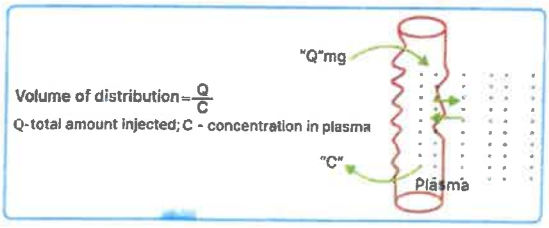
00:24:42

- Approximate calculation of the body water can be estimated according to the body weight.
- To measure the exact amount of body water, the formula of volume of distribution is to be used.



The formula of the volume of distribution concept is integrated with the pharmacology.

- When measuring body water, a substance such as Q mg of inulin is injected into the capillary and evenly distributed in the plasma and ISF.
- After this distribution has reached equilibrium, the concentration of the inulin is measured in the plasma of the person's blood sample by using the formula.
- Inulin is inert, there is little chance of it being metabolized by the body. However, some substances are easily metabolized by the body, in such cases both the metabolism and the excretion of such substances must be taken into consideration. The formula for these cases is modified.



$$\text{Volume} = \frac{Q-e}{c} \quad e \rightarrow \text{excreted or metabolized}$$

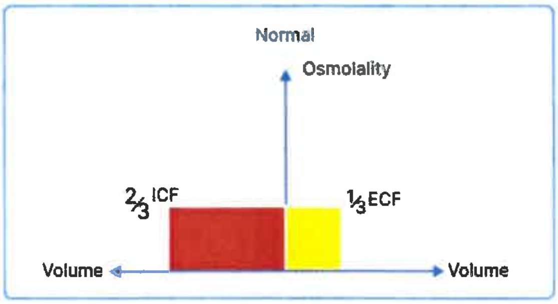
Must Know Topic 00:29:35

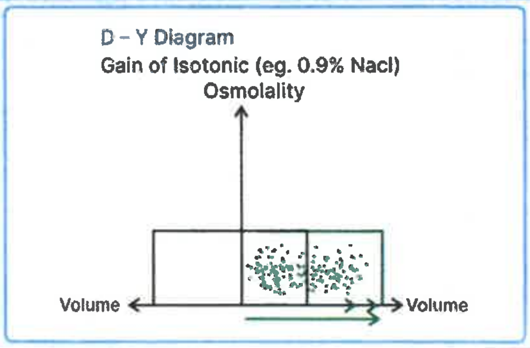
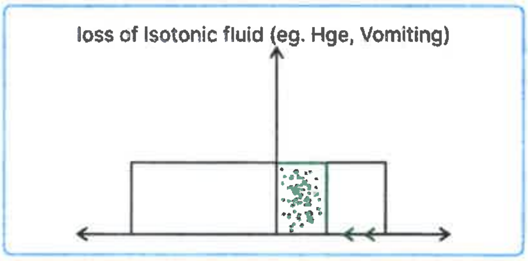
Compartment	Indicator used
Total body water	D_2O, tritium oxide, Antipyrine (freely permeable to capillary and cell membranes)
ECF volume	Inulin (Best), sucrose, ^{22}Na, ^{125}I-iothalamate, mannitol (freely permeable to the capillary and not to the cell membrane)
ICF volume	• ICF volume is measured by determining TBW and ECF and then subtracting ECF from TBW. • ICF volume = (TBW - ECF)
Plasma	Evans' blue, ^{125}I-albumin (Impermeable to capillaries)
ISF (Interstitial fluid)	ISF = (ECF – Plasma volume)
RBC	^{51}Cr, ^{59}Fe tagged RBC

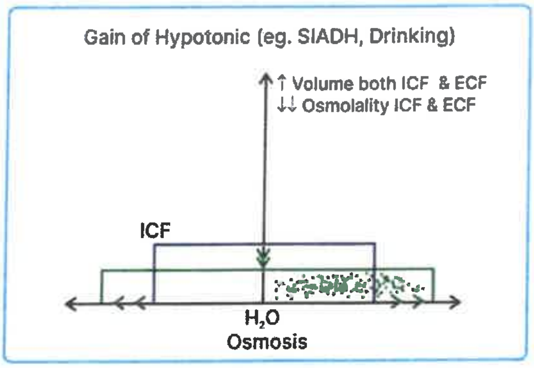
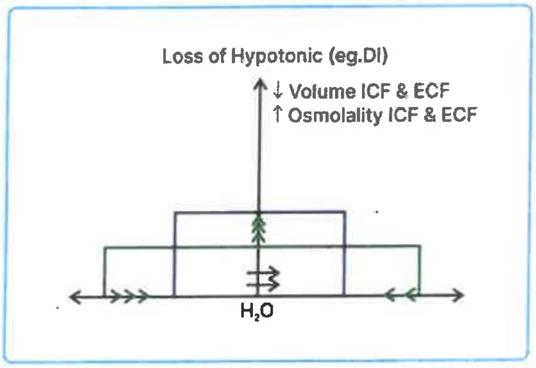
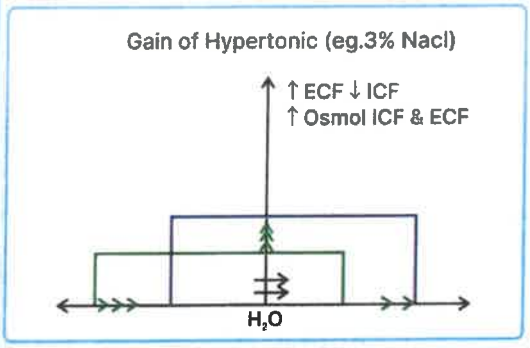
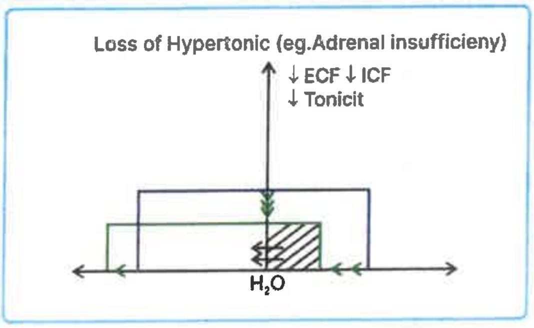
Darrow-Yannet Diagram

PYQ: FMGE 2023 00:30:43

- **Normal**



Gains / Loss of fluids	D-Y Diagram	Explanation
Gain of Isotonic Fluid		• **When the isotonic solution is given,** ECF volume increases without any change in osmolality.
Loss of Isotonic Fluid		• In cases of hemorrhage or vomiting, there is a loss of isotonic fluid from the body which leads to a decrease in the volume of ECF without any change in osmolality.

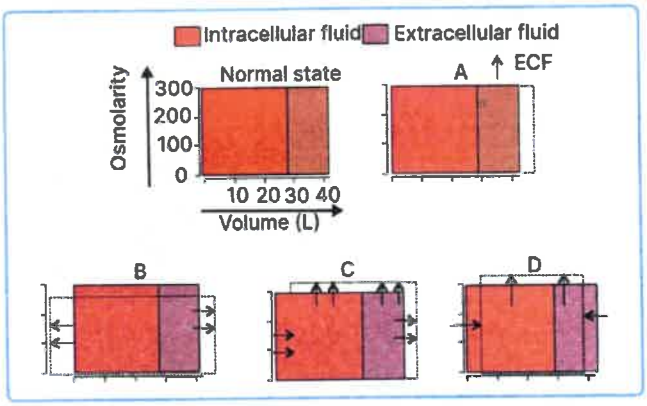
Gain of Hypotonic Fluid		• SIADH causes excess water absorption from the kidneys resulting in hypotonic fluid gain. • Psychogenic polydipsia occurs when one drinks too much water, resulting in hypotonic fluid gain. • There is ECF volume expansion and the ECF osmolality will fall.
Loss of Hypotonic Fluid		• In diabetes insipidus, excess water is excreted due to a lack of ADH. • ECF volume decreases due to the loss of fluid but since only the water is going out and the solute remains, the net osmolality and tonicity of ECF increase, making ECF hypertonic in comparison to ICF.
Gain of Hypertonic Fluid		• Infusing 3% NaCl solution (hypertonic solution) in a patient causes ECF volume to expand and ECF tonicity to increase. • ECF is now hypertonic in comparison to ICF and water will now move out of the cell decreasing ICF volume and increasing ICF tonicity.
Loss of Hypertonic Fluid		• In conditions such as adrenal insufficiency, the solute is lost from the body excess of water. • Water will move from ECF to ICF, leading to a slight increase in cell volume. This will cause a decrease in ECF volume, an increase in ICF volume, and a decrease in the tonicity of both compartments, achieving a new steady-state condition.

MCQ

Q. In each diagram, the normal state(solid line) is superimposed on the abnormal state(dashed lines) to illustrate the shifts in the volume(width of rectangles) and total osmolarity (height of rectangles) of the ECF and ICF Which diagram represents the changes(after osmotic equilibrium) in ECF and ICF volumes and osmolarities after infusion of 3%NaCl?

A. A
B. B
C. C
D. D

00:42:34



Transport Across Cell Membrane

Types of Transport

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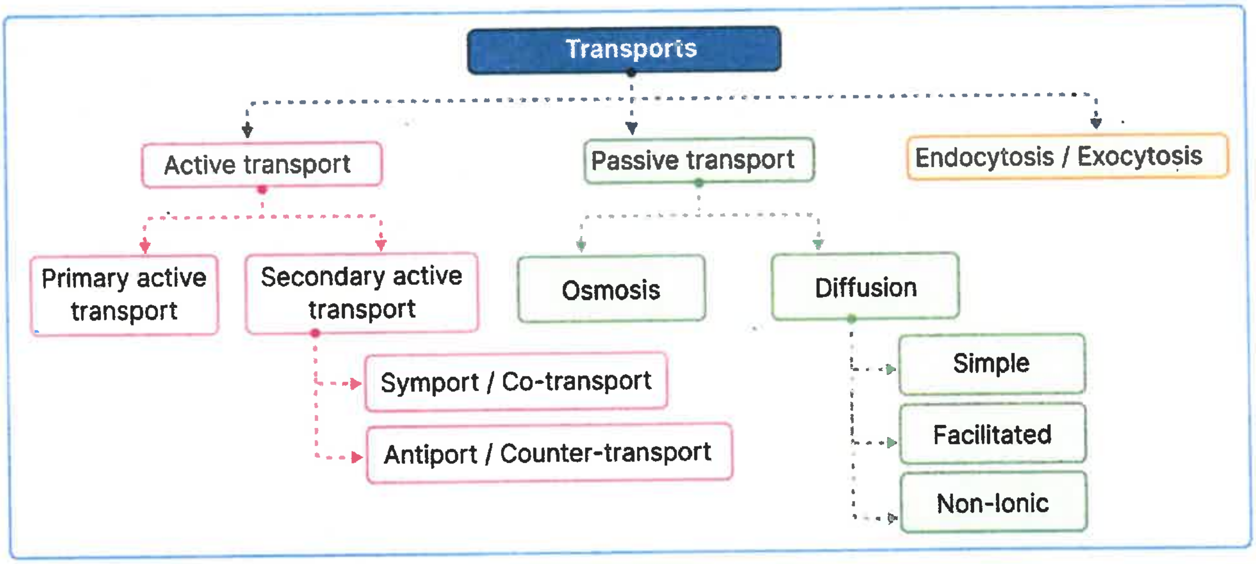


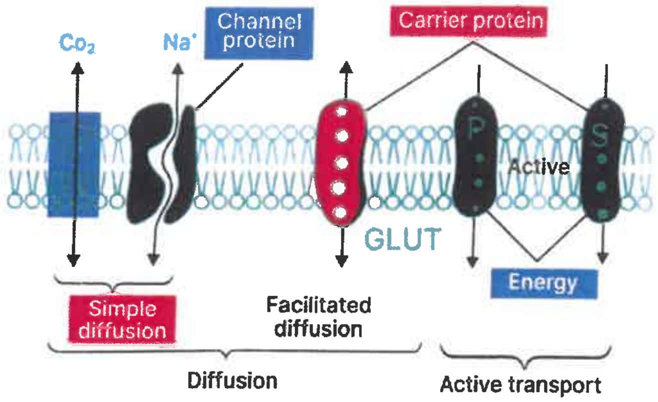
Active transport	Passive transport
• The energy-dependent transport system in the form of ATP • Transportation occurs from low solute concentration to high solute concentration against a concentration gradient known as uphill transport.	• Does not require any energy (ATP) to transport. • Transportation occurs from high solute concentration to low solute concentration. It is also known as downhill transport.

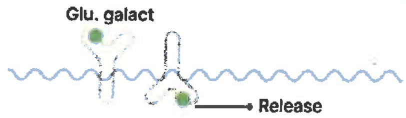
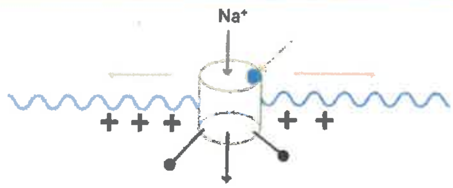
Important Information PYQ: INICET 2018 PYQ: NEET PG 2018

Primary Active Transport	Secondary Active Transport
• Occurs when the energy utilization is direct. • Example: Na-K-ATPase	• Occurs when adenosine triphosphate is used indirectly. • Example: o Symport: SGLT o Antiport: NCX

Transporter Molecules

PYQ: NEET PG 2023 00:46:59



Carrier protein	Channel protein
	
• Binds → change in shape → release • Helps in both active and passive transport	• Does not bind and change its shape • Varieties of channel protein: I. Voltage-gated channel ii. Ligand-gated channel iii. Stretch-sensitive/ Mechanosensitive channel

Diffusion

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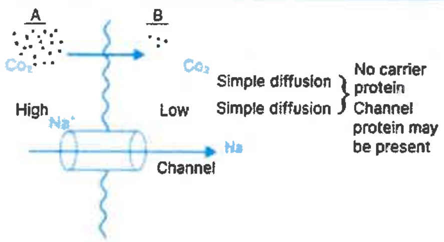
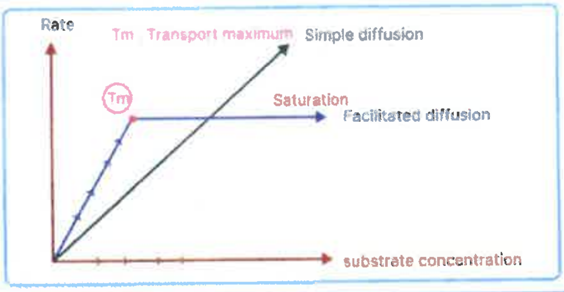
Simple Diffusion	Facilitated diffusion
	• It requires carrier protein. **Example:** • Glucose is transported from high to low concentration by a carrier protein, GLUT.
• If a molecule on side A is nonpolar or very small, it will move from high to low solute concentration (downhill transport) without requiring energy, this is known as simple diffusion. • Simple diffusion does not require carrier protein. However, channel protein may or may not be present in this diffusion. **Example:** • CO_2 is transported from high to low concentration without the help of a carrier or channel protein as it is a gaseous molecule. • Na^+ moves from high to low concentration with the help of a channel protein in simple diffusion.	

00:48:27



- There is no saturation. More concentration will lead to a higher rate of transport.
- According to Fick's law,

  Rate (J) = D.A.ΔC/x

  D - Diffusion constant, A - Surface area of diffusion

  ΔC – Conc. difference between 2 sides of the membrane

  X - Thickness of the membrane through which diffusion occurs.

- In facilitated diffusion, a carrier protein is required, therefore there will be saturation. Initially, the rate of transport increases with the substrate concentration, but after a certain point, there will be a plateau.
- The maximum rate of transport in facilitated diffusion, occurring at the plateau or saturation point, is termed transport maximum (Tm).

SGLT & GLUT PYQ: FMGE 2021 PYQ: NEET PG 2021

Name	Expression Site
SGLT 1	Kidney (PST), Intestinal luminal membrane
SGLT 2	Kidney (PCT)
SGLT 3	Skeletal Muscle, Small intestine (Glucose sensor)
GLUT 1	RBC, BBB, Placenta (Universal GLUT)
GLUT 2	B-cell pancreas, liver, Basolateral membrane of PCT & intestinal epithelial cell
GLUT 3	WBC Neuronal membrane
GLUT 4	Insulin responsive GLUT. Muscle & adipose tissue
GLUT 5	Fructose transporter. Luminal membrane of intestine, sperm

Important Information

There are two types of SGLT:

- SGLT 1
  - GIT - It absorbs 100% of glucose and Na+ from the lumen. On the basolateral aspect, glucose will enter the blood through the GLUT 1 transporter.
  - Kidney (Proximal straight tubule) - absorbs 10% of glucose.
- SGLT 2 is present in the proximal convoluted tubule (PCT) that absorbs 90% of glucose and Na^+ from the kidney. On the basolateral aspect, glucose will enter the blood through the GLUT 2 transporter.

Important GLUTS

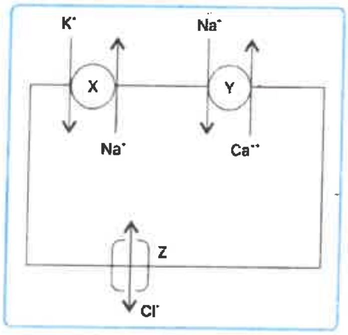
- Insulin responsive GLUT: GLUT 4 and 12
- Insulin responsive GLUT in blastocyst: GLUT 8
- Fructose transporter GLUT: GLUT5 and 11
- GLUT in CNS:

- GLUT1: Endothelial cells (BBB)
- GLUT3: Neurons
- GLUT5: Astrocytes

- Major GLUT in placenta and fetus: GLUT1

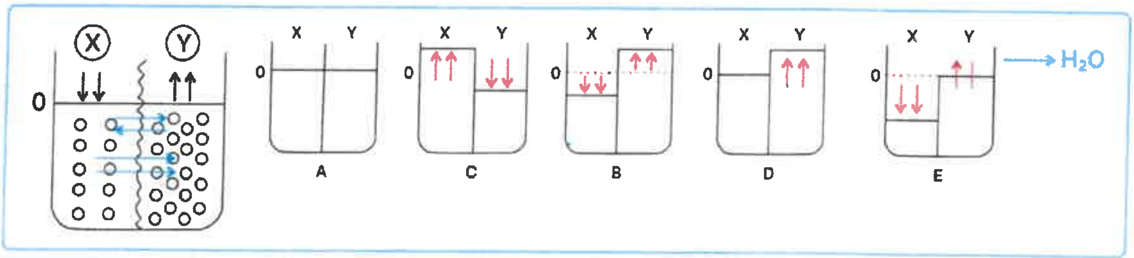
MCQ

Q. A model cell with three different transporters (X, Y and Z) and an RMP of -75mv is shown in the figure below. Consider the intracellular and extracellular concentrations of all three ions to be typical of a normal cell. Which of the following best describes transporter Y?



A. Facilitated diffusion
B. Primary active transport
C. Secondary active transport
D. Simple diffusion

Q. In the figure below, two compartments (X and Y) are separated by a typical biological membrane, The concentrations of glucose in compartments X and Y at time zero are shown below in the first diagram. There are no transporters for glucose in the membrane and the membrane is impermeable to glucose. Which of the below best represents the volumes of compartments X and Y when the system reaches equilibrium?



Ans: B

Cell Cytoskeleton

00:56:53