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“Osmosis is a process by which the molecules of a solvent pass from a solution of low concentration to a solution of high concentration through a semi-permeable membrane.” Osmosis Table of Contents Explanation Solutions Types Effects Osmotic Pressure Significance Examples What is Osmosis? Osmosis is a passive process and happens without any expenditure of energy. It involves the movement of molecules from a region of higher concentration to lower concentration until the concentrations become equal on either side of the membrane. Any solvent can undergo the process of osmosis including gases and supercritical liquids. Let us have a detailed look at the different types and effects of osmosis in detail. Also Refer: Difference between osmosis and diffusion Osmotic Solutions There are three different types of solutions: Isotonic Solution Hypertonic Solution Hypotonic Solution An isotonic solution is one that has the same concentration of solutes both inside and outside the cell. A hypertonic solution is one that has a higher solute concentration outside the cell than inside. A hypotonic solution is one that has a higher solute concentration inside the cell than outside. Types of Osmosis Osmosis is of two types: Endosmosis– When a substance is placed in a hypotonic solution, the solvent molecules move inside the cell and the cell becomes turgid or undergoes deplasmolysis. This is known as endosmosis. Exosmosis– When a substance is placed in a hypertonic solution, the solvent molecules move outside the cell and the cell becomes flaccid or undergoes plasmolysis. This is known as exosmosis. Also Read: Difference between endosmosis and exosmosis Effect of Osmosis on Cells Osmosis affects the cells differently. An animal cell will lyse when placed in a hypotonic solution compared to a plant cell. The plant cell has thick walls and requires more water. The cells will not burst when placed in a hypotonic solution. In fact, a hypotonic solution is ideal for a plant cell. An animal cell survives only in an isotonic solution. In an isotonic solution, the plant cells are no longer turgid and the leaves of the plant droop. The osmotic flow can be stopped or reversed, also called reverse osmosis, by exerting an external pressure to the sides of the solute. The minimum pressure required to stop the solvent transfer is called the osmotic pressure. Osmotic Pressure Osmotic pressure is the pressure required to stop water from diffusing through a membrane by osmosis. It is determined by the concentration of the solute. Water diffuses into the area of higher concentration from the area of lower concentration. When the concentration of the substances in the two areas in contact is different, the substances will diffuse until the concentration is uniform throughout. Osmotic pressure can be calculated using the equation: Π=MRT where Π denotes the osmotic pressure, M is the molar concentration of the solute, R is the gas constant, T is the temperature Significance of Osmosis Osmosis influences the transport of nutrients and the release of metabolic waste products. It is responsible for the absorption of water from the soil and conducting it to the upper parts of the plant through the xylem. It stabilizes the internal environment of a living organism by maintaining the balance between water and intercellular fluid levels. It maintains the turgidity of cells. It is a process by which plants maintain their water content despite the constant water loss due to transpiration. This process controls the cell to cell diffusion of water. Osmosis induces cell turgor which regulates the movement of plants and plant parts. Osmosis also controls the dehiscence of fruits and sporangia. Higher osmotic pressure protects the plants against drought injury. Also Refer: Passive Transport Examples of Osmosis Osmosis has a significant role to play in plants, animals and also in humans. In an animal cell, osmosis helps in absorbing water from the intestines to the blood. Listed below are more examples of Osmosis. The absorption of water from the soil is due to osmosis. The plant roots have a higher concentration than the soil. Therefore, the water flows into the roots. The guard cells of the plants are also affected by osmosis. When the plant cells are filled with water, the guard cells swell up, and the stomata open. If a freshwater or saltwater fish is placed in the water with different salt concentrations, the fish dies due to the entry or exit of water in the cells of the fish. Humans suffering from cholera are also affected by osmosis. The bacteria that overpopulate the intestines reverse the flow of absorption and do not allow water to be absorbed by the intestines, which results in dehydration. When the fingers are placed in water for a longer period of time, they become pruney due to the flow of water inside the cells. Also Read: Reverse Osmosis For more information on osmosis, its definition, types, effects and osmotic pressure, keep visiting BYJU’S Biology website or download the BYJU’S app for further reference. Osmosis is the movement of solvent from a region of lower solute concentration to a region of higher solute concentration through a semi-permeable membrane. The three types of osmotic conditions include- hypertonic, isotonic, and hypotonic. The different types of osmosis include: Endosmosis- when a substance is placed in a hypotonic solution, the solvent molecules move inside the cell and the cell becomes rigid. Exosmosis-when a substance is placed in a hypertonic solution, the solvent molecules move out of the cell and the cell becomes flaccid. Osmosis is important for the cells for many reasons. It helps in the movement of important materials inside and out of the cell. The nutrients, water and other solutes move in and out of the cell by the process of osmosis. Osmosis is a process of movement of solvents through a semi-permeable membrane from a region of lower solute concentration to higher solute concentration. On the contrary, diffusion does not require a semi-permeable membrane to occur and the molecules move from a region of higher concentration to lower concentration. Yes, dead cells also exhibit osmosis. If a dead cell is placed under a hypotonic solution, water moves inside the cell and it bulges. Osmosis helps in stabilizing the internal environment of the organism by balancing the levels of water and intracellular fluids. Also, the nutrients and minerals enter the cell by osmosis which is necessary for the survival of cells. Forward osmosis is a natural phenomenon that occurs around us on a daily basis. It is the type of osmosis that uses a semi-permeable membrane in the separation of water from dissolved solutes. This type of osmosis is widely used in wastewater treatment, osmotic power generation, etc. The real-life examples of osmosis are: Feeling thirsty after having salty food. Dialysis of kidney in the excretory system. Swelling of resins and other seeds when they are soaked in water. Movement of salt-water in the animal cell across our cell membrane. Movement of water and minerals from root nodules to various parts of plants. The factors affecting the rate of osmosis include: Pressure. Temperature. Surface Area. Water Potential. Concentration gradient. Osmotic pressure is defined as the minimum pressure applied to a solution to stop the flow of solvent molecules through a semipermeable membrane. The osmotic pressure of a solution is proportional to the molar concentration of the solute particles in the solution. π = iCRT is the formula used for finding the osmotic pressure of a given solution. The semipermeable membrane is a biological membrane, which functions by permitting the movements of certain molecules or ions to pass through it. Reverse osmosis is a natural phenomenon that occurs in the opposite direction of the natural osmosis. This type of osmosis is used for removing the majority of contaminants from water by pushing the water under pressure through a semi-permeable membrane. The biological importance of osmosis includes: It is essential for the survival of a cell. Osmosis plays a key role during the germination of seeds. Involved in the movement of water molecules between the cell and cell organelles. In plants, it is involved in the movement of water molecules from the soil into the root nodules. The mechanism of stomata is mainly because of the response to the osmotic pressure of the guard cells in relation to the epidermal cells. Osmosis is defined as the spontaneous movement of solvent molecules from a region of low solute concentration to a region of high solute concentration through a semipermeable membrane in order to equalize their concentrations on both sides of the membrane. Osmosis What Causes Osmosis and Why does it Occur When two solutions of different concentration are separated by a semipermeable membrane, the water molecules tend to move from the region of low solute concentration (high water potential) towards high solute concentration (low water potential), to equalize their concentration on both sides of the membrane or attain a state of equilibrium. Osmosis was first thoroughly studied in 1877, by German plant physiologist Wilhelm Pfeffer. The general term ‘osmose’ (now osmosis) was introduced in 1854 by British chemist Thomas Graham. Basic Characteristics of Osmosis Requires a semipermeable membrane A slow and spontaneous process Occurs in liquid medium Requires no energy expenditure and thus also called passive diffusion Movement of water occurs from a region of high water potential to a region of low water potential The process continues until the concentration of the solution becomes even on both the sides of the semipermeable membrane It is an important phenomenon occurring in both plants and animals. Some everyday-life examples of osmosis are: In Plants Roots of plants have a higher solute concentration than the surrounding soil, so water flows into the roots which are absorbed by the plants through osmosis The opening and closing of guard cells, responsible for gas exchange in plants, depends on the absorption of water by osmosis In Animals Human body infected with cholera-causing bacteria perform osmosis to reverse the flow of water absorption in the intestine, causing excess water loss, leading to severe dehydration and sometimes death If a freshwater fish is transferred to saltwater or vice versa, the fish will die of too much osmosis, which will disrupt the balance of salts in its body. Cells take up nutrients and minerals into the cell and also get rid of their waste products by osmosis 1) Temperature – Warmer the temperature, higher is the rate of osmosis. 2) Area of Interaction – More the surface area of interacting molecules, higher is the rate of osmosis. 3) Concentration Gradient or Osmotic Gradient – Greater the difference in concentration gradient between the regions, higher is the rate of diffusion 4) Osmotic Pressure – Higher the hydrostatic pressure exerted by a solution across a semipermeable membrane from a pure solvent, slower is the rate of diffusion The relative concentration of solutes present in the solution is called its tonicity. The tonicity determines the rate and direction of osmosis. Osmotic solutions are classified into the following types: a) Isotonic Solutions: Have the same concentration of solutes both inside and outside the cell. Here there is no net movement of solvents across the membrane as the amount entering and leaving out the cell are equal. b) Hypotonic Solutions: Have a higher concentration of solutes inside the cell than outside. When this occurs, more solvent enters the cell compared to the amount that leaves out, to balance the concentration of solute on both sides of the membrane. c) Hypertonic Solutions: Have a higher concentration of solutes outside the cell than inside it. Here more solvent leaves the cell compared to the amount that enters inside the membrane. Based on the direction of water movement, osmosis is classified into two main types: Endosmosis It is the process by which water moves inside the cell when placed in a hypotonic solution causing them to swell up and become rigid. Endosmosis occurs because the solute concentration of the surrounding solution is less compared to the concentration inside the cell. Exosmosis It is the process by which water moves out the cell when placed in a hypertonic solution causing them to become flaccid. Exosmosis occurs because the solute concentration of the surrounding solution is higher than inside the cytoplasm. In some extreme cases of exosmosis, the cells lose excess water, and the cell membrane separates from the cell wall, a process known as plasmolysis. Article was last reviewed on Friday, February 17, 2023 Osmosis is the movement of water particles from a region of high water concentration to a region of low water concentration through a partially permeable membrane.A diagram showing osmosis and the partially permeable membraneDid you know?Osmosis is a form of diffusionOsmosis is responsible for providing structure to plants so that they stand uprightOsmosis occurs faster when the temperature is warmerOsmosis can lead to the bursting of animal cells but not plant cellsWays to demonstrate osmosisYou can observe osmosis in very simple ways at home with solutions containing different quantities of dissolved salt or sugar. Kitchen items which could be used may include:Naked eggs - eggs with the shells removed using vinegarExpanding raisinsGummy bearsPlace the item in the solution and observe the changes.History of osmosisObservations were documented as far back as 1748 by French abbot Jean-Antoine Nollet. although the term ‘osmosis’ was coined in 1826 by French physician RJH Dutrochet.The study of osmosis was advanced significantly after the development of the semi partially membrane by Moritz Traube in 1867.Water is considered a universal solvent, which means that it carries dissolved substances around within organisms. For example, glucose can be absorbed into the blood in the digestive system and urea can move into the blood from the liver, the blood is circulated around the body.Substances dissolved in water can then be moved into and out of cells via the cell membrane, a selectively permeable membrane surrounding cells. For example, glucose can move into respiring cells from the blood and urea can move into the nephron from the blood in the kidney.Osmosis is responsible for ensuring correct cellular shape which ensures efficiency of cell activity e.g. red blood cells have a biconcave shape which maximises surface area to volume ratio and therefore uptake of oxygenOsmosis is required to provide water to photosynthesising plant cells. Water moves by osmosis into the root hair cells of a plant, driven by the high solute concentration of the cytoplasm within the root cells.Osmosis is covered across many different parts of the GCSE and iGCSE specification, this varies between exam boards, but you will find links to osmosis in topics which cover:Transport across membranes - Osmosis is one of the key processes by which substances more across the cell membrane along with active transport, facilitated diffusion and simple diffusion.Absorption in the intestines - reabsorption of water in the intestine is done by the process of osmosisReabsorption in the kidney - The kidney is responsible for filtering the blood and removing waste as well as excess water and mineral ions.Transpiration in plants - Not all of the transpiration stream uses osmosis, for example, water in the xylem does not move by osmosis as there is no partially permeable membrane for the water to move through. However, the the movement in the xylem is driven by evaporation of water from spongy mesphyll cells and subsequence osmosis of water through the cells in the leaves to replace the water lost.Water and mineral uptake in root hair cells - mineral ions are actively transported into the root cells which results in osmosis of water down the concentration gradient into the cell.Opening and closing of stomata - osmosis of water into guard cells results in the opening of stomata. When the stomata are open, gas exchange occurs as well as transpirationPractical investigations - You may study osmosis through observations made of plant tissue, such as potato, soaked in water of different concentrations. This investigation shows that water moves into the potato cells from solution when the solution has a higher water concentration than the potato cells and out of the potato cells when the solution has a lower water concentration than the cells.These concepts are covered in all Biology specifications, why not take a look at our course-specific revision notes:GCSE Biology RevisionIGCSE Biology RevisionIn addition to the topics covered at GCSE, A Level courses also cover:Translocation in plants - The movement of sugars around the plant is key to ensuring that all cells are provided with glucose for respiration. Osmosis of water from xylem to phloem aids the process of translocation of sucrose.Tissue fluid formation - Tissue fluid is necessary to provide substances to respiring cells and for the removal of waste products. Water is initially forced from the capillaries due to high hydrostatic pressure, however, osmosis is responsible for the movement of water back into the capillaries containing waste products for removal from the body.Urine production and control of blood water potential - water moves by osmosis to and from the filtrate in the kidney. This mechanism ensures that the water potential of the blood is kept within a range which is necessary for the human body cells to function efficiently. Urine volume and concentration is dependent on the water potential of the blood.Practical investigations - similar to the investigations completed at GCSE, but also including the use of water potential calibration curvesThese concepts are covered in all Biology specifications, why not take a look at our course-specific revision notes:Osmosis in ChemistryOsmosis and GCSE ChemistryWhilst osmosis is considered one of the fundamental components of GCSE and Alevel Biology courses, it also appears in Chemistry in a process called reverse osmosis.What is reverse osmosis?Reverse osmosis is a process used to produce drinking water from sea water. The process involves pushing salty water through a membrane to separate the salt molecules from the water. However, the process is called reverse osmosis, because it uses energy to make sure that the water is all extracted, this involves going against the water concentration gradient.You can read more about reverse osmosis in our GCSE Chemistry Revision Notes.Osmosis FAQsIs osmosis active or passive?Osmosis is a passive process because it requires no energy to move the water particles. This is because they move down a concentration gradient.Does osmosis require energy?No, no energy is required for osmosis as it is a passive process.Where does osmosis occur in plants?Osmosis occurs throughout all cells of a plant. From the movement of water into the root hair cells to the movement of water into the spongy mesophyl cells of the leaf where the water evaporates during transpiration. Osmosis is also responsible for the movement of sugars around the plant in the process of mass flow. Remember that all photosynthesising cells require water so water must move into these cells by osmosis.What are the differences between osmosis and diffusion? Osmosis and diffusion are similar in many ways, but the key differences are that osmosis applies to water particles only and requires a partially permeable membrane.Is osmosis a type of active transport or diffusion?Osmosis is a type of diffusion because it is the movement of particles down a concentration gradient without the need for energy. Whereas active transport is the movement of particles against the concentration gradient, this requires energy from ATP.GlossaryWater potentialA measure of the ratio of water particles to solute particles. A higher number of water particles means a higher concentration and therefore higher water potentialConcentration gradientThe difference between two areas, either side of a partially permeable membraneDiffusionMovement of particles from an area of high concentration to an area of low concentration. Osmosis is a type of diffusion which involves water particles only.Partially permeable membraneA membrane which allows some molecules through and not others e.g. large molecules may not fit through the membraneIsotonicAn isotonic solution has the same water potential as another solution e.g. the cytoplasm of a cellHypertonicA hypertonic solution has a higher concentration of solutes or a lower water potential compared to another solution e.g. the cytoplasm of a cellHypotonicA hypotonic solution has a lower concentration of solutes or a higher water potential compared to another solution e.g. the cytoplasm of a cell Osmosis, Greek for push, is the net movement of water across a semipermeable membrane (see Figure. Osmosis).[1][2] Across this membrane, water tends to move from an area of high concentration to an area of low concentration. It is important to emphasize that ideal osmosis requires only the movement of pure water across the membrane without any movement of solute particles across the semipermeable membrane. Osmosis can still occur with some permeability of solute particles, but the osmotic effect becomes reduced with greater solute permeability across the semipermeable membrane. It is also true that, at a specific moment, water molecules can move towards either the higher or lower concentration solutions, but the net movement of water is towards the higher solute concentration. The compartment with the highest solute and lowest water concentration has the greatest osmotic pressure. Osmotic pressure can be calculated using the Van 't Hoff equation, which states that osmotic pressure depends on the number of solute particles, temperature, and how well a solute particle can move across a membrane. Its measured osmolality can describe the osmotic pressure of a solution. The osmolality of a solution describes how many particles are dissolved in the solution. The reflection coefficient of a semipermeable membrane describes how well solutes permeate the membrane. This coefficient ranges from 0 to 1. A reflection coefficient of 1 means a solute is impermeable. A reflection coefficient of 0 means a solute can be freely permeable, and the solute cannot generate osmotic pressure across the membrane.[2] The compartment with the greatest osmotic pressure pulls water in and tends to equalize the solute concentration difference between the compartments. The physical driving force of osmosis is the increase in entropy generated by the movement of free water molecules. It is also thought that the interaction of solute particles with membrane pores generates a negative pressure, which is the osmotic pressure driving the water flow.[3] Reverse osmosis occurs when water is forced to flow in the opposite direction. In reverse osmosis, water flows into the compartment with lower osmotic pressure and higher water concentration. This flow is only possible by applying an external force to the system. Reverse osmosis is commonly used to purify drinking water and requires energy input.[4] The concept of osmosis should not be confused with diffusion. Diffusion is the net movement of particles from an area of high to low concentration. One can think of osmosis as a specific type of diffusion. Both osmosis and diffusion are passive processes and involve the movement of particles from an area of high to low concentration.[2][5]The rate of osmosis always depends on the concentration of solute. The process is illustrated by comparing an environmental or external solution to the internal concentration found in the body. A hypertonic solution is any external solution with a high solute concentration and low water concentration compared to body fluids. In a hypertonic solution, the net movement of water is out of the body and into the solution. A cell placed into a hypertonic solution shrivels and dies by a process known as plasmolysis. An isotonic solution is any external solution with the same solute and water concentrations as body fluids. In an isotonic solution, no net movement of water takes place. A hypotonic tonic solution is any external solution with a low solute concentration and high water concentration compared to body fluids. In hypotonic solutions, there is a net water movement from the solution into the body. A cell placed into a hypotonic solution swells and expands until it eventually bursts through a process known as cytolysis. These three examples of different solute concentrations illustrate the spectrum of water movement based on solute concentration through osmosis. The body, therefore, must regulate solute concentrations to prevent cell damage and control the movement of water where needed. Summary of Red Blood Cell Placed into Hypertonic, Isotonic, and Hypotonic Solutions Hypertonic A hypertonic solution has a higher solute concentration than the intracellular solute concentration. When a red blood cell is placed in any hypertonic solution, free water is moved out of the cell and into the solution. This movement occurs through osmosis because the cell has more free water than the solution. After the solutions are allowed to equilibrate, a cell with a lower overall volume results. The remaining volume inside the cell has a higher solute concentration, and the cell appears shriveled under the microscope. The solution is more dilute than originally. The overall process is known as plasmolysis. Isotonic An isotonic solution has the same solute concentration as the intracellular solute concentration. No net water movement occurs when a red blood cell is placed in an isotonic solution. The concentration of solute and water are equal both intracellularly and extracellularly; therefore, there is no net movement of water towards the solution or the cell. The cell and the environment around it are in equilibrium, and the cell should remain unchanged under the microscope. Hypotonic A hypotonic solution has a lower solute concentration than the intracellular solute concentration. When a red blood cell is placed in a hypotonic solution, free water moves into the cell. This situation results in an increased intracellular volume with a lower intracellular solute concentration. The solution ends up with a higher overall solute concentration. Under the microscope, the cell may appear engorged, and the cell membrane may eventually rupture. This overall process is known as cytolysis. Note that osmosis is a dynamic equilibrium, so, at any given moment, water molecular can momentarily flow toward any direction across the semipermeable membrane, but the overall net movement of all water molecules be from an area of high free water concentration to an area of low free water concentration.[5][6]Water is known as the "universal solvent," and almost all life depends on it for survival. Therefore, though seemingly simple, the principle of osmosis plays a large role in almost all physiological processes. Osmosis is specifically important in maintaining homeostasis, which is the tendency of systems toward a relatively stable dynamic equilibrium. Biological membranes act as semipermeable barriers and allow for the process of osmosis to occur. Osmosis underlies almost all major processes in the body, including digestion, kidney function, nerve conduction, etc. It allows water and nutrient concentrations to be at equilibrium in all the body's cells. The underlying physical process regulates solute concentration in and out of cells and aids in excreting excess water out of the body.[2][7][8][9][10][11]Review QuestionsOsmosis. This figure shows the process of osmosis. Osmosis. BioNinja.com. . Accessed July 29, 2024. 1.Chen J, Sabir S, Al Khalili Y. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): May 1, 2023. Physiology, Osmoregulation and Excretion. [PubMed: 31082152]2.Marbach S, Bocquet L. Osmosis, from molecular insights to large-scale applications. Chem Soc Rev. 2019 Jun 04;48(11):3102-3144. [PubMed: 31114820]3.Kiil F. Molecular mechanisms of osmosis. Am J Physiol. 1989 Apr;256(4 Pt 2):R801-8. [PubMed: 2705569]4.Greenlee LF, Lawler DF, Freeman BD, Marrot B, Moulin P. Reverse osmosis desalination: water sources, technology, and today's challenges. Water Res. 2009 May;43(9):2317-48. [PubMed: 19371922]5.Goodhead LK, MacMillan FM. Measuring osmosis and hemolysis of red blood cells. Adv Physiol Educ. 2017 Jun 01;41(2):298-305. [PubMed: 28526694]6.Maldonado KA, Mohiuddin SS. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Aug 8, 2023. Biochemistry, Hypertonicity. [PubMed: 31082139]7.Kiil F. Mechanism of osmosis. Kidney Int. 1982 Feb;21(2):303-8. [PubMed: 7069994]8.Meir E, Perry J, Stal D, Maruca S, Klopfer E. How effective are simulated molecular-level experiments for teaching diffusion and osmosis? Cell Biol Educ. 2005 Fall;4(3):235-48. [PMC free article: PMC1200778] [PubMed: 16220144]9.Schultz SG. Epithelial water absorption: osmosis or cotransport? Proc Natl Acad Sci U S A. 2001 Mar 27;98(7):3628-30. [PMC free article: PMC33327] [PubMed: 11274376]10.Ogobuiro I, Tuma F. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): Jul 24, 2023. Physiology, Renal. [PubMed: 30855923]11.Trigo D, Smith KJ. Axonal morphological changes following impulse activity in mouse peripheral nerve in vivo: the return pathway for sodium ions. J Physiol. 2015 Feb 15;593(4):987-1002. [PMC free article: PMC4398533] [PubMed: 25524071] Disclosure: Michael Lopez declares no relevant financial relationships with ineligible companies. Disclosure: Carrie Hall declares no relevant financial relationships with ineligible companies. Written by John StaughtonLast Updated On: 2 Jun 2024Published On: 18 Nov 2018 Table of Contents (click to expand) By definition, osmosis is the movement of any solvent through a selectively permeable membrane into an area of higher solute concentration, the result of which will be an equalizing of solute concentration on either side of the membrane. There are many times in life where you have heard someone preach about the importance of balance. As a general concept, keeping things balanced is widely promoted as the best way to increase your health, happiness and attitude. It may seem like an abstract concept, but it is present in so many parts of our daily life, ranging from the balance of foods we eat and the time we spend at the office vs. home, to the political beliefs we hold and our ability to physically stand up straight while walking down the street. Like it or not, finding balance is an important element of survival. As is so often found in this beautiful universe of ours, the microcosm reflects the macrocosm, and balance is just as important on the cellular level as it is in our daily lives. When it comes to the microscopic level, however, finding balance has a great deal to do with solutes and solvents, concentrations of materials inside and outside of cells, which determine the amount of water that needs to move into or out of the cells. Achieving this proper, healthy balance requires a passive, perpetual process, one on which all living cells depend – osmosis! Recommended Video for you:Chugging vs. Sipping: Is It Bad To Chug Water? By definition, osmosis is the movement of any solvent through a selectively permeable membrane into an area of higher solute concentration, the result of which will be an equalizing of solute concentration on either side of the membrane. This equilibrium is important for the efficient and optimized function of cells; as mentioned before, balance is the preferred state in a natural environment. (Photo Credit: LadyofHats/Wikimedia Commons) While any solvent can undergo the process of osmosis, including supercritical liquids and some gases, the majority of discussion surrounding osmosis relates to the movement of water in cells. The regulation of water movement throughout our entire body is done through the manipulation of solute concentrations and osmosis. The absorption or diffusion of water helps to unconsciously provide stability and functionality to every cell, tissue and organ in our body. There are three types of solutions – isotonic, hypertonic and hypotonic solutions – in which osmosis plays a key role and occurs differently; understanding these basic examples is necessary before learning about the cool and more complex details of osmosis, as well as its importance on so many aspects of our survival. Isotonic Solution If you place a cell in an isotonic solution (in relation to the cell), the concentration of solutes is even, meaning that water can move into and out of the cell at an equal rate. Osmosis will occur, but at a balanced pace, meaning that the cell won’t swell or shrink. For example, if both your solvent and your cell’s cytoplasm are composed of 75% water and 25% salt, the concentrations are equal and there is no net movement of water across the selectively permeable membrane. Hypotonic Solution If you place a cell in a hypotonic solution (in relation to the cell), water will flow into the cell in order to equalize the solvent concentration. The best example of this situation is the way your fingers prune after you go swimming. The concentration of salts and other solvents in your skin cells is higher than the water of the lake or pool, so water moves into those cells, causing them to swell and wrinkle. Imagine placing a cell with 60% water and 40% salt into a solution with 80% water and 20% salt. Water would flow from the solution into the cell until a balance of 70% water and 30% salt was achieved. In extreme cases within a cell, when too much water is taken in, it can cause the cell to swell and lyse (burst), causing cell death. Hypertonic Solution When a cell is placed in a hypertonic solution (in a relation to the cell), there will be a higher concentration of solute outside of the cell, so water will diffuse away from the cell, towards the hypertonic solution, in order to balance the solvent concentrations. Essentially, the cell will be sucked dry, and made flaccid, to compensate for the excess solute outside the membrane. In extreme cases, the cell shrivels enough that the cell membrane detaches from the cell wall and becomes plasmolyzed. Without water to move the various molecules in the cell, it will die. Now that you understand the basic processes of osmosis, and what different conditions will cause osmosis to occur, you will be able to see the value of this process in so many areas for every form of life. For plants, osmosis is responsible for the movement of water into the root system, which allows the plant to grow and survive. The root hairs of plants are the key point where minerals and water are taken into the organism. The concentration of water molecules are less in the root hairs than in the soil (hypertonic solution), so water moves into the cells of the root hairs; osmosis continues through numerous layers of cells (cell-to-cell movement) until that water reaches the xylem tubes – equivalent to human veins. On a related note, when water is taken into the cells of plants, the pressure caused by that osmotic movement is called turgidity. When equilibrium is achieved, those plant cells should be full of water, as well as firm and turgid. This prevents leaves from wilting, allowing them to increase their surface area for sunlight capture. Osmosis also helps protect plants against drought and frost damage, as well as in regulating the opening and closing of stomata. For animals (humans), some of the key osmotic functions relate to the balance of water content in the blood versus the surrounding tissues. Similarly, in the kidneys, osmosis controls the amount of waste buildup by increasing fluid flow into that organ. When the solute concentration is higher in the kidney cells (hypertonic solution), water is pulled from the body’s bloodstream into the kidneys (nephrons), which will eventually stimulate the need to urinate in a person/animal, thus eliminating those unwanted waste products. Wherever water is present in the body, which is essentially everywhere, osmosis will be happening. Maintaining the concentration balance of solvents and solutes is a full-time, full-body job. The full extent of osmotic behavior in the body is beyond the scope of this article, but suffice to say that without osmosis, life as we know it wouldn’t be anywhere close to possible! References (click to expand) John Staughton is a traveling writer, editor, publisher and photographer who earned his English and Integrative Biology degrees from the University of Illinois. He is the co-founder of a literary journal, Sheriff Nottingham, and the Content Director for Stain’d Arts, an arts nonprofit based in Denver. On a perpetual journey towards the idea of home, he uses words to educate, inspire, uplift and evolve. Related Videos Osmosis is a type of diffusion that, in biology, is usually related to cells. Diffusion is when molecules or atoms move from an area of high concentration to an area of low concentration. Osmosis is when a substance crosses a semipermeable membrane in order to balance the concentrations of another substance. In biology, this is usually when a solvent such as water flows into or out of a cell depending on the concentration of a solute such as salt. Osmosis happens spontaneously and without any energy on the part of the cell. Osmosis deals with chemical solutions. Solutions have two parts, a solvent and a solute. When solute dissolves in a solvent, the end product is called a solution. Salt water is an example of a solution; salt is the solute, and water is the solvent. In biology, there are three different types of solutions that cells can be in: isotonic, hypotonic, and hypertonic. Different types of solutions have different impacts on cells due to osmosis. An isotonic solution has the same concentration of solutes both inside and outside the cell. For example, a cell with the same concentration of salt inside it as in the surrounding water/fluid would be said to be in an isotonic solution. Under these conditions, there is no net movement of solvent; in this case, the amount of water entering and exiting the cell’s membrane is equal. In a hypotonic solution, there is a higher concentration of solutes inside the cell than outside the cell. When this occurs, more solvent will enter the cell than leave it to balance out the concentration of solute. A hypertonic solution is the opposite of a hypotonic solution; there is more solute outside the cell than inside it. In this type of solution, more solvent will exit the cell than enter it in order to lower the concentration of solute outside the cell. Osmosis affects plant and animal cells differently because plant and animal cells can tolerate different concentrations of water. In a hypotonic solution, an animal cell will fill with too much water and lyse, or burst open. However, plant cells need more water than animal cells, and will not burst in a hypotonic solution due to their thick cell walls; hypotonic solutions are ideal for plant cells. The optimal condition for an animal cell is to be in an isotonic solution, with an equal amount of water and solutes both inside and outside. When a plant cell is in an isotonic solution, its cells are no longer turgid and full of water, and the leaves of the plant will droop. In a hypertonic solution, water will rush out of both animal and plant cells, and the cells will shrivel (in plants, this is called plasmolyzation). This is why slugs and snails shrivel and die when salt is sprinkled onto them; water leaves their cells in order to balance the higher concentration of salt outside the cells. This figure shows the effects of osmosis on red blood cells: Osmosis is how plants are able to absorb water from soil. The roots of the plant have a higher solute concentration than the surrounding soil, so water flows into the roots. In plants, guard cells are also affected by osmosis. These are cells on the underside of leaves that open and close to allow gas exchange. When the plant’s cells are full of water, the guard cells swell and open the stomata, small holes that allow the plant to take in carbon dioxide and release oxygen. Osmosis can have adverse effects on animals such as fish. If freshwater or saltwater fish are put into water that has a different salt concentration than they are used to, they will die from having too much water enter or leave their cells. Osmosis can affect humans as well; in a person infected with cholera, bacteria overpopulate the intestines, leaving the intestines unable to absorb water. The bacteria actually reverse the flow of absorption because osmosis causes water to flow out of the intestinal cells instead of in. This causes severe dehydration and sometimes death. Diffusion – a process by which molecules move from areas of high concentration to areas of low concentration. Osmosis is one type of diffusion. Solution – a mixture made up of two or more substances where one substance, a solute, is dissolved into another substance, a solvent. Semipermeable – also known as selectively permeable, this means that only certain substances can pass through a barrier. Cell membranes are semipermeable. Cell – the smallest unit that makes up a living organism. It includes various different parts called organelles that have functions such as storing genetic material and making proteins and energy. 1. When a cell contains a lower concentration of solute than the solvent surrounding it, that cell is said to be in what kind of solution? A. Hypertonic B. Hypotonic C. Isotonic A is correct. When a solution has a higher concentration of solute than a cell that it surrounds, the solution is hypertonic. When a cell is in a hypertonic solution, osmosis will cause water to flow out of the cell to balance the concentration of solute on either side of the semipermeable membrane. As too much water flows out of the cell, it will shrivel. 2. Isotonic conditions are ideal for which cells? A. Plant cells B. Animal cells C. Both D. Neither B is correct. In isotonic solutions, the net movement of water into and out of the cell is the same, which keeps an animal cell balanced and functioning normally. Plant cells fare better in hypotonic solutions where they can be filled to the max with water. 3. What happens to an animal cell in a hypotonic solution? A. There is no negligible effect, as the concentration of solute on both sides of the membrane is the same. B. Water will rush out of the cell, making it shrivel. C. Water will rush into the cell, and it will become turgid. D. Water will rush into the cell, causing it to lyse (burst). D is correct. When a cell is in a hypotonic solution, the concentration of solute in the cell is higher than the concentration of solute in the water surrounding it. Water will rush into the cell and can cause it to burst. A describes an isotonic solution, B describes a hypertonic solution, and C describes a plant cell in a hypotonic solution. Movement of molecules to lower concentration For other uses, see Osmosis (disambiguation). The process of osmosis over a semipermeable membrane. The blue dots represent particles driving the osmotic gradient. Osmosis (/ɒzˈmoʊsɪs/, US also /ɒs-/)[1] is the spontaneous net movement or diffusion of solvent molecules through a selectively-permeable membrane from a region of high water potential (region of lower solute concentration) to a region of low water potential (region of higher solute concentration),[2] in the direction that tends to equalize the solute concentrations on the two sides.[3][4][5] It may also be used to describe a physical process in which any solvent moves across a selectively permeable membrane (permeable to the solvent, but not the solute) separating two solutions of different concentrations.[6][7] Osmosis can be made to do work.[8] Osmotic pressure is defined as the external pressure required to prevent net movement of solvent across the membrane. Osmotic pressure is a colligative property, meaning that the osmotic pressure depends on the molar concentration of the solute but not on its identity. Osmosis is a vital process in biological systems, as biological membranes are semipermeable. In general, these membranes are impermeable to large and polar molecules, such as ions, proteins, and polysaccharides, while being permeable to non-polar or hydrophobic molecules like lipids as well as to small molecules like oxygen, carbon dioxide, nitrogen, and nitric oxide. Permeability depends on solubility, charge, or chemistry, as well as solute size. Water molecules travel through the plasma membrane, tonoplast membrane (vacuole) or organelle membranes by diffusing across the phospholipid bilayer via aquaporins (small transmembrane proteins similar to those responsible for facilitated diffusion and ion channels). Osmosis provides the primary means by which water is transported into and out of cells. The turgor pressure of a cell is largely maintained by osmosis across the cell membrane between the cell interior and its relatively hypotonic environment. The "endosmometer" invented by Dutrochet Some kinds of osmotic flow have been observed since ancient times, e.g., on the construction of Egyptian pyramids.[9] Jean-Antoine Nollet first documented observation of osmosis in 1748.[10][a] The word "osmosis" descends from the words "endosmose" and "exosmose", which were coined by French physician René Joachim Henri Dutrochet (1776–1847) from the Greek words ἔνδον (éndon "within"), ἔξω (éxō "outer, external"), and ὠσμός (ōsmós "push, impulsion").[n 1] In 1867, Moritz Traube invented highly selective precipitation membranes, advancing the art and technique of measurement of osmotic flow.[9] Osmosis is the movement of a solvent across a semipermeable membrane toward a higher concentration of solute. In biological systems, the solvent is typically water, but osmosis can occur in other liquids, supercritical liquids, and even gases.[11][12] When a cell is submerged in water, the water molecules pass through the cell membrane from an area of low solute concentration to high solute concentration. For example, if the cell is submerged in saltwater, water molecules move out of the cell. If a cell is submerged in freshwater, water molecules move into the cell. Water passing through a semipermeable membrane When the membrane has a volume of pure water on both sides, water molecules pass in and out in each direction at exactly the same rate. There is no net flow of water through the membrane. Osmosis can be demonstrated when potato slices are added to a high salt solution. The water from inside the potato moves out to the solution, causing the potato to shrink and to lose its 'turgor pressure'. The more concentrated the salt solution, the bigger the loss in size and weight of the potato slice. Chemical gardens demonstrate the effect of osmosis in inorganic chemistry. The mechanism responsible for driving osmosis has commonly been represented in biology and chemistry texts as either the dilution of water by solute (resulting in lower concentration of water on the higher solute concentration side of the membrane and therefore a diffusion of water along a concentration gradient) or by a solute's attraction to water (resulting in less free water on the higher solute concentration side of the membrane and therefore net movement of water toward the solute). Both of these notions have been conclusively refuted. The diffusion model of osmosis is rendered untenable by the fact that osmosis can drive water across a membrane toward a higher concentration of water.[13] The "bound water" model is refuted by the fact that osmosis is independent of the size of the solute molecules—a colligative property[14]—or how hydrophilic they are. It is difficult to describe osmosis without a mechanical or thermodynamic explanation, but essentially there is an interaction between the solute and water that counteracts the pressure that otherwise free solute molecules would exert. One fact to take note of is that heat from the surroundings is able to be converted into mechanical energy (water rising). Many thermodynamic explanations go into the concept of chemical potential and how the function of the water on the solution side differs from that of pure water due to the higher pressure and the presence of the solute counteracting such that the chemical potential remains unchanged. The virial theorem demonstrates that attraction between the molecules (water and solute) reduces the pressure, and thus the pressure exerted by water molecules on each other in solution is less than in pure water, allowing pure water to "force" the solution until the pressure reaches equilibrium.[14] Effect of different solutions on blood cellsMicrographs of osmotic pressure on red blood cells (RBC)Plant cell in different environments. Osmotic pressure is the main agent of support in many plants. The osmotic entry of water raises the turgor pressure exerted against the cell wall, until it equals the osmotic pressure, creating a steady state.[15] When a plant cell is placed in a solution that is hypertonic relative to the cytoplasm, water moves out of the cell and the cell shrinks. In doing so, the cell becomes flaccid.