Osmosis Learning Explorable Explanation

Alyxis Burks, Michael Lew, Melody Lee

INTRODUCTION

Osmosis is the shifting of solvent molecules through a semi-permeable membrane from a higher solute concentration to a lower solute concentration until a state of equilibrium is reached.

This problem is worth addressing because osmosis at its core is an easy concept to comprehend if you have the right resources to understand it better. However, the current available resources do not consider the users and the vastness of learning styles. The current resources are typically either all text, or all pictures, and there are few resources that use text alongside pictures and animation to strengthen readers' understanding.

Osmosis relates to our everyday life in almost all aspects around us. For example, saline solutions that we use for medical purposes and contact lenses solution are common applications of osmosis.

Osmosis can be split up into its interactions with three different terms: hypotonic, isotonic, and hypertonic. When the concentration of solute outside of the cell is lower than in the cell, the extracellular fluid is said to be **hypotonic** to the cell. The cells absorb more water, causing the cell to grow. Under ideal circumstances, the osmolarity inside an animal cell is the same as its extracellular fluids. We consider this to be **isotonic**, in which there is no net movement of water in or out of the cell. When the concentration of solute outside of the cell is higher than in the cell, the extracellular fluid is said to be **hypertonic** to the cell. Water in the cell will flow out of the semi-permeable membrane and the cells will shrink until equilibrium is reached.

Without osmosis, our cells would not survive because they would not be able to adjust to different situations. It is important that people understand a vital part of the human anatomy and ecosystem that helps keep all living things properly nourished and surviving.

RELATED WORK

There are currently options to learn about osmosis, but they are either only full text or only visual images to explain the process. These are ineffective because readers who know nothing about osmosis will not be able to fully understand the process using only one source. Pictures and animation alone do not contain enough context to fully understand what is happening in the animation, but it is a powerful way to help readers visualize the process of osmosis. Users currently have to use multiple sources to gain a full understanding of what osmosis is. They will have to first read about the different states of osmosis, then look up a picture or animation that matches the concepts they read.

A member of the group suggested osmosis for the explorable explanation concept. In deciding on whether to pursue osmosis as a concept, the other group members had to look at multiple types of sources to fully understand the concept. After roughly five separate sources, the remaining group members understood the concept.

Many of these options are either too high level of an overview with only pictures, or too technical with only text. Additionally, they lacked real world connections. These three elements - a visual overview, technical details, and real world connections - are all essential for the user to be able to fully grasp the concept. Without a source that covers all of these elements, people have to analyze multiple sources.

We believe that the three classifications of tonicity are especially confusing since they only differ by the prefix (iso/hypo/hyper). Osmosis is commonly learned in introductory high school and college Biology courses, and without understanding what these different prefixes mean, it students can easily get them confused.

In terms of learning styles, some people learn better looking at an animation rather than reading text, and vice versa.

METHODS

To create our explorable explanation, we first did a market analysis of who our users currently are. Our main users are students who are currently trying to learn the process as a part of a current class that they are taking. In our analysis, we learned that to better understand a scientific concept, particularly osmosis, students have to review multiple sources to grasp a firm understanding of what it is, its process, and how they relate to everyday life.

We learned this by using 4 peers from various non-science majors, in which we challenged them to learn about osmosis through internet searches. This process required an average of five to six sources before individuals could properly communicate what osmosis is.

After the market analysis, we decided on the question we would use to guide our explorable explanation. We decided that since our main users are students, our question would be “What exactly is osmosis, and what terms and processes are important to retain?” This question led us to a few goals that we wanted to meet. We wanted our explorable explanation to have a balance of technical and high-level information, and we wanted it to be the "one-stop-shop" way for our users to be able learn about osmosis and be prepared for a concept test.

Once we defined our goals, we drafted out a few designs on how to best show our user this information with a visual and text. After a few iterations we made some important design decisions.

The biggest design decision involves the visualization layout. We originally were going to display one hypertonic, hypotonic or isotonic solution at a time, whereas the user selected next each time, and it would show different osmosis animations. After drawing it out, we realized that having a “next” button would suggest that osmosis was a parallel process, rather than a process that can also be circular and out of order.

We decided that having the text on the left and the photo on the right would support our market analysis by having visual content that directly connects to the text. By having the text on the side they can read the content while also viewing corresponding animations. It also flows with how people naturally view a page, left to right.

We then made a decision about whether our visual should be static, interactive, or animated. We decided that a static image would not as effectively show the different sizes of the cells based on the solution they are in. An interactive display that changes with interaction would not add much value because there are not many variables you can directly manipulate to change the process, and having a large number of controls may be confusing to people who are new to osmosis. We finally settled on an animated display in which the visual automatically animates depending on where you are on the page. This helps users in connecting the visual back to the learnings from the text.

Once we received feedback from peers on the animation, we decided to add arrows that show how the solution is flowing in and out of the cell based on the tonicity of the solution that the cell is in. This gives our users a more explicit presentation of what is happening to the cell in that solution.

After settling on our design, we created the content for the explorable explanation and each solution. We first needed to find the correct balance of technical and high-level information. For the content it meant that they needed to know the definitions of any uncommon words that could be confusing to the user. When explaining the definitions we chose to only use common words so our content is accessible to people without a scientific background. We decided to also connect each solution type to a real-world example in order to make solution types easier to remember.

With our first demo, the feedback we received from our class was that the explorable explanation was not interactive enough. Thus, we brainstormed ways to increase interactivity for our users.

To add more interaction there is a basic content quiz at the end, where students can test their comprehension of the topics. The questions are made to be content based so that the user can directly test what they have learned. If users do not know the content, they can simply scroll back up to review the content. The side animations disappear when the user enters the content quiz section to hide visual helpers from the user. They reappear when exiting the content quiz section. This provides more of a division between the sections.

The final interaction piece we added is a game for the users to play. In this game, the user takes the role of a doctor, and are are shown patients' blood cells that are either too enlarged, too shrunken or a normal size. Players use their newfound knowledge about osmosis to choose between either hypotonic, hypertonic, or isotonic solutions to add to the blood cell in order to return, or keep it to equilibrium. As the user gets answers correct, the user earns points and the game gets faster. The game allows the user to apply the concept to real life situations while improving their retention of the information. This serves as a more interactive tool for people who want to learn in a hands-on way.

With the additions of the quiz and the game, the users will learn technical content about osmosis along with how to apply it.

The final part that was implemented based on user feedback was an introduction section that presented itself when they first land on the page. This introduction section gives a basic overview of what osmosis is and what it does.

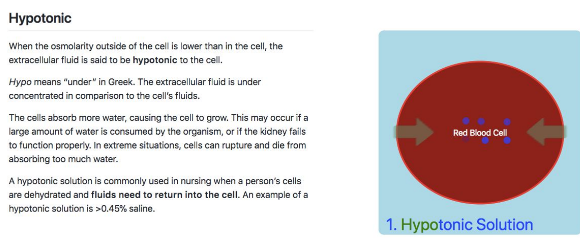
RESULTS

After we completed our research and design process we ended up with our final explorable explanation.

When our users first land on our page they are greeted with an introduction that gives them a basic overview of what osmosis is. Then, they scroll through different states of osmosis based on the tonicity of the extracellular fluids.

The first section shows the cell with hypotonic extracellular fluid. In the content they are told what the greek meaning is behind the words to give the user common words that they can connect the concept with. They are then given a technical description of what the solution does while defining necessary terms. Lastly, the text describes how that solution reacts with the cell and concludes with a real world connection. To the right of the content they can view the animated visual representation of the cell and its interactions with the extracellular fluid.

The same process is repeated for the remaining solutions, “hypertonic” and “isotonic.”



As the different solutions only differ by the root words - hypo, hyper, and iso, the title at the bottom of the visualization highlights these each in a different color which should help associate hypo with the blood cell growing larger, hyper with it getting smaller, and iso with it staying neutral.

The growth or shrinking in size for the hypotonic and hypertonic solutions is also intentionally exaggerated in order to be more memorable for the user, so they do not have to wait for the cell to slowly shrink or expand.

After the content of the solutions, there is a quiz where the users can test what they have learned.

Finally, the user can play the osmosis game where they can further strengthen their knowledge of osmosis through real world applications.

DISCUSSION

After creating our visualization there were also some sub-problems we needed to consider. The main problem we needed to consider was how much information was too much information. Our group reflected on how we learned about osmosis and what level of information was helpful for us. We determined that the text needed to be clearly divided, and that we wanted a high-level but enough detail for application purposes. As a result, when we created the content we give them enough information to grasp the concept and remember it, without creating an information overload.

The hardest design decisions came from trying to accommodate multiple levels of knowledge while also accommodating different ways that our users might learn. To do this we considered a variety of user types to ensure that our designs would be adaptable.

From this explorable explanation we have not only defined what is helpful for our users to learn about osmosis, but how to best to display a scientific process to our users who need a high-level yet technical description and visual to help them better understand what these concepts are for whatever they may need to understand it in. With this technique people will be able to better understand how to help their students understand and remember important concepts.

FUTURE WORK

After our work and research in creating this explorable explanation for osmosis, it would be helpful to conduct more diverse user research to better define a balance between technical and high-level information. We believe we had a good process to balance our content, but would like to do more user research to further refine and validate our process.

Additionally we would like to do more research around the effectiveness of remembering osmosis using our explorable explanation layout and techniques. Our initial thoughts are that this would increase their ability to remember a multi-step/process concept. Along this line we would also like to test the validity and necessity of our explorable explanation for a concept that is not a scientific process.

REFERENCES

"Osmosis." *Scientist Cindy*, www.scientistcindy.com/cell-membranes-and-osmosis.html.

"Osmosis and tonicity." *Khan Academy*, www.khanacademy.org/science/biology/membranes-and-transport/diffusion-and-osmosis/a/osmosis.

Carr, Kevin. "What Happens to an Animal Cell in a Hypotonic Solution?" *Sciencing*, sciencing.com/happens-animal-cell-hypotonic-solution-2607.html.

"Isotonic, Hypotonic & Hypertonic IV Fluid Solution." *Registered Nurse RN*, 22 Oct. 2016, www.registerednursern.com/isotonic-hypotonic-hypertonic-iv-fluid-solution-overview-for-nursing-students-with-quiz/.