You Can't Touch This

A Lesson on Osmosis and Diffusion

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Editor's notes:

Website URLs listed in this resource were current as of publication, but may now be obsolete. If you know of a replacement URL, please suggest it in the resource's "Comments" section http://www.apsarchive.org/resource.cfm?submissionID=3688.

The APS encourages teachers to give students a copy of the "ABC" (Appropriate, Beneficial, Caring) rules for use of animals in the classroom, to discuss the rules, and to ask students to sign the "ABC" rules contract (see References). Also, teachers should have a plan for short term care of the animals (with supporting references for appropriate care guidelines) and for disposal or long-term care of all classroom organisms.

Teachers should carefully review any stimulus or environmental change for an animal being used in experiments or observations before students are allowed to use that stimulus. This is especially important if the stimulus could cause pain or distress to the organism. Teachers may be able to identify a less stressful stimulus for the students to use in their experiment.

Although mammals provide excellent opportunities for observational studies, they require particular care in terms of handling and may cause allergic reactions in some students. The teacher should check local and state guidelines before using mammals in the classroom.

Disclaimer:

This activity was created by the author and reviewed by the American Physiological Society. Any interpretations, statements, or conclusions in this publication are those of the author and do not necessarily represent the views of either the American Physiological Society or the funding agencies supporting the professional development program in which the author participated.

PURPOSE

To illustrate the diffusion of molecules across the cell membrane and the role concentration plays in the movement of water. This lab should be performed as an introduction to the cell unit (i.e., they should not already know about osmosis and diffusion).

OBJECTIVES

Upon completion of this activity, students will be able to:

- develop a hypothesis and design an experiment to test it.
- collect both qualitative and quantitative data and interpret its meaning.
- present their findings in an organized manner to the class.
- explain how diffusion happens using the term concentration gradient.
- state the exact cause of the volume change occurring in the egg.
- apply the concept of diffusion to homeostasis

GRADE LEVEL

This lab is most applicable for an introductory biology course but could be used at any grade level from 6-12.

PRIOR KNOWLEDGE

Students will need to be familiar with the idea of homeostasis. Furthermore, they need to know how to use pipettes and how to determine the approximate volume of a solid. Preferably they have not been introduced to osmosis or diffusion. To meet the given time constraints, students need to be very familiar with web searches (both the hunting and the gathering of information).

TIME REQUIRED

Allow three days for this lab (based on 50 min. class length time). Thursday/Friday/Monday works well, as would Monday/Tuesday/Friday. Be sure to leave 2-3days between the time students set up their experiments and analysis.

INCLUDING ALL STUDENTS

This lesson addresses all modalities of learning: tactile, visual, and auditory. Grouping of students can be random (have students draw cards, etc.) or strategic (pair students willing to help with those who need the help).

QUESTIONS TO ASK ALONG THE WAY

- **Part 1:** When shown the picture, some students will suggest water is going in and others that water is going out. Ask the students why they think as such. Do they notice that this happens other times besides swimming? What about the ocean? During the web quest ask the students to explain what they are learning (to assess their understanding) and also whether the webpage is reliable. Note: If your students have never done a web quest/Internet Treasure Hunt before you will have to teach them how to determine whether or not a site is reliable.
- **Part 2:** When students are formulating their hypotheses and experimental designs, be sure they are heading in the right direction by asking questions rather than saying, "You should do this instead." For example, if the students want to surround the egg in paper towels to try and get it to shrink ask them how they are going to measure the change without touching the egg. Pay careful attention to whether or not they are taking a baseline measurement.
- **Part 3:** During the final discussion have the students come up with the consensus about what is happening rather than giving it to them, then confirm it (see specific questions in procedure section).

NATIONAL SCIENCE EDUCATION STANDARDS

K-12 Unifying Concepts and Processes:
Evidence, models, and explanation
Change, constancy, and measurement
Grades 5-8
Science as Inquiry
Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Life Science
Structure and functions in living systems
Regulation and behavior
History and Nature of Science
Science as a human endeavor
Nature of science
Grades 9-12
Science as Inquiry
Abilities necessary to do scientific inquiry
Understandings about scientific inquiry
Life Science
The cell
History and Nature of Science
Science as a human endeavor
Nature of science

INDIANA STATE SCIENCE EDUCATION STANDARDS

Biology 1
B.1.2: Explain that every cell is covered by a membrane that controls what can enter and leave the cell...
B.1.5: Demonstrate that most cells function best within a narrow range of temperature and acidity...

MATERIALS

Each group will need:
- flat faced container 750-1000ml (check your local craft store for these)
- egg (with shell already removed by vinegar, saves time)
- rulers
- pipettes and bulbs (for removal of original liquid)
- beakers 500ml
- graduated cylinders 250ml
- stirring rods

You will also want to have the following supplies available to all groups:
- salt
- sugar
- vegetable oil
- vinegar
- corn syrup
- distilled water
- tap water

Having one bottle of each of these at each lab station allows students to ponder all possibilities without feeling rushed and also prevents them from milling about the room.

Part 1: Teacher will need vinegar to de-shell the eggs – prepare several extras for accidents! Students will need the Internet Treasure Hunt sheets and access to the Internet
Part 2: Students should work in groups of 2-3. I find pairs work best for computer work but trios for an inquiry lab.
Part 3: Students will need creative supplies (markers, colored pencils, etc.) and large poster-size sticky paper.

SAFETY

As is true with any lab, students should not eat anything, which can be especially tempting with a lab involving actual foods. Those preparing the eggs should wash their hands since they are raw. Also, all students should be sure to wash their hands too.

PREPARATION AND PROCEDURE

Teacher tips: *Students will need to know how to use a pipette for removal of the original solution (an alternative would be to provide them the egg in no solution at all though I find it useful for them to practice their lab skills whenever possible). They also must know how to use the ruler to determine the approximate volume of the egg since they cannot pick it up.*

For greatest success this lab should be performed on a Thursday-Friday-Monday (or the equivalent time period). Each part given corresponds to one day. Part 2 may not take all students an entire day so be prepared – perhaps encourage then to start designing their posters or provide a worksheet for the next topic (cell organelles).

For the sake of time and sanity, have the eggs already de-shelled prior to the start day (have one ready for part 1 as an example – the rest by part 2). This can be done by soaking the egg in vinegar (volume to cover) for eight hours. It is helpful to scrub the egg every hour or so. Make plenty extra just in case – plus my students loved feeling the eggs after they set up their experiments.

On the day your students set up their experiments be sure to remember to set up the samples. Cover one egg completely in corn syrup only (it will shrink tremendously), one in distilled water (it will enlarge), and leave one out in the air.

Part 1

1. The class will be started with a picture of a person that whose hands are all wrinkly (I found a great one at http://www.alaska-in-pictures.com/wrinkled-hands-3546-pictures.htm). Teacher will ask the students if they have had any experiences with this. Then probe them as to why they think this happens. DO NOT provide the answers. Students will then use the Internet to find out why. Two wesites are provided in the worksheet. One focuses more on the anatomy of the skin, while the other poses an idea with the qualifier "no one is really sure." This is a great opportunity to talk about accuracy and usefulness of information. After they complete Internet Treasure Hunt #1, they should turn it in and then be given Internet Treasure Hunt #2 (what is diffusion and osmosis?). This should not take more than 25 min. ***Teacher tip:*** *I have provided websites of treasure hunt #1 and they will be on their own for #2. I would recommend having useful websites for #2 on hand for those who are struggling (see resources).*

2. Then, show the class an egg (de-shelled) in a container. Explain to them that their challenge is to change the volume of the egg without touching it but they can remove the original solution it is in. Have cards that say increase or decrease on them and have each group draw to determine their specific challenge. Depending on the layout of your room you could either send them to their lab stations to see their possible supplies, show them a table, or provide them with a list.

PREPARATION AND PROCEDURE

3. At this time they will formulate their hypothesis and design an experiment to test it. Experimental designs will be submitted at the end of the period for teacher assessment before experiment day. This should take approximately 20 minutes.

Part 2

The next day, students will revise their experimental designs, get final approval from the teacher and enact it. Note: it will take AT LEAST 24 hours to observe any result and 48 or more for an obvious one. Waiting over the weekend (or the equivalent) provides especially remarkable results for eggs placed in corn syrup only but does not add much volume to those in the distilled water. If this lab cannot be performed with a weekend in the middle, continue on with the cell biology unit by covering organelles and come back for the results when ready.

Part 3

1. After observing and measuring their results students will create a poster describing their experiment and results (20 min.) and give a short (2-3) minute presentation to the class.

2. The lab will conclude with a discussion of what happened and why (not lecture – students should come up with the answer on their own!). Ask what worked and what didn't. Were they surprised? Did anyone do similar things and get different results? What problems happened (a few issues I ran into were that students measured after removing the liquid then again during analysis skewing their results due to the magnification of water. Also, a few groups didn't measure the egg at all at first. Let them mess up – it is a great lesson in experimental design)? Why did this egg expand and this one shrink? What exactly moved into and out of the egg (water)? Why did it move? (you may have to give them the term concentration gradient here)? Why is it important for our cells to be able to do this (diffusing things in and out is how cells maintain homeostasis)?

Science Help: *The goal here is for students to realize that is was the water that moved either into or out of the egg. Water always moves to where there is less water in concentration which not necessarily the same as volume. I find it helps to explain it by saying osmosis is like using a dry sponge to clean a small puddle of water. You don't have to put forth any effort to get the water to go into the sponge, it's a natural flow. The reason it works is there is a much lower concentration of water in the sponge than in the puddle so it goes there – hence concentration gradient.*

WHERE TO GO FROM HERE

A good extension for this activity would be to discuss the importance on cells' ability to maintain homeostasis for the human body. Another webquest could be done on diseases that are directly related to problems with cellular diffusion such as Wilson's disease (body cannot properly diffuse copper causing neurological problems) and various lung ailments.

SUGGESTIONS FOR ASSESSMENT

Students will be assessed by their experimental design, their poster, and their presentation. For grading purposes I gave a progress check for the design phase. I looked to see if they wrote down a hypothesis and if it was actually a hypothesis (5 points.), if they measured anything about their egg after prompting (5 points.), then completion of their design (10 points.). If the hypothesis is incorrect tell them so they can adjust the phrasing (not the content!!) for points on the poster. As for the Poster (55 points) and Presentation (25 points) refer to the rubric given in the student section. Students will be assessed for specific content retention upon completion of the chapter.

REFERENCES AND RESOURCES

1. *Diffusion*
http://hyperphysics.phy-astr.gsu.edu/hbase/kinetic/diffus.html
Explanations of diffusion, osmosis and more. The information is accurate though the author is unclear. Accessed on August 2, 2007.

2. *Diffusion, Osmosis, and Cell Membranes*
http://biology.arizona.edu/sciconn/lessons/mccandless/reading.html
Background information of diffusion and including passive and active passport developed by the Department of Biochemistry, University of Arizona. Accessed on July 25, 2007.

3. *Everyday Mysteries*
http://www.loc.gov/rr/scitech/mysteries/wrinkles.html
Searchable website run by the Library of Congress. This link answers the question "why do fingers and toes wrinkle in the bathtub?" Accessed on August 2, 2007.

4. *How do Hypotonic, Hypertonic, and Isotonic Solutions Affect the Water Movement of a Cell?*
http://www.the-aps.org/education/k12curric/activities/pdfs/halverson.pdf
A lab using an egg and various solutions to show the volume change caused by diffusion written by Michael Halverson for the American Physiological Society Frontiers in Physiology Fellowship. Accessed on July 26, 2007.

5. *Investigating Isotonic, Hypotonic, and Hypertonic Solutions*
http://www.accessexcellence.org/AE/ATG/data/released/0487-AltonBiggs/index.html
A lab illustrating diffusion using onions, elodea, salt water, and methylene blue written by Alton Biggs. Accessed on July 25, 2007.

6. *Kids Health for Kids*
http://www.kidshealth.org/kid/talk/qa/wrinkly_fingers.html
A website devoted to providing doctor-approved information on kids health. This link answers the questions "why does my skin get wrinkly in water?" Accessed on August 2, 2007.

REFERENCES AND RESOURCES

7. *Osmosis Tutorial*
http://edtech.clas.pdx.edu/osmosis_tutorial/
This is an online tutorial explaining osmosis and diffusion including discussion of the plasma membrane with e-quiz. It was created by Portland State University. Accessed on August 2, 2007.

8. *Transport In and Out of Cells*
http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBooktransp.html#Cells%20and%20Diffusion
An explanation of osmosis and diffusion with pictures and discussion of hypo- hyper- and isotonic solutions. It is an excerpt from an online biology book facilitated by Estrella Mountain Community College. Accessed on August 2, 2007.

9. *Unit on Cell Function*
http://www.akscience.org/assets/advinstitute/Unit%20on%20Cell%20Function.pdf
A unit including progressive labs illustrating diffusion of molecules including relation to surface area written by Kay Holmes and Cecilia Miller. Accessed on July 25, 2007.

10. *Wrinkled Hands*
http://www.alaska-in-pictures.com/wrinkled-hands-3546-pictures.htm
A website of pictures of Alaskan frontier and wildlife. Accessed on August 2, 2007.

Images on Student Worksheets came from Clip Art files on Microsoft Word Version 2007.

Internet Treasure Hunt Name: _____ Date: _____

I. ENGAGE: Osmosis Simulation Worksheet

This web info search will help you find information about what causes your skin to get wrinkly if you stay in the water for a long time. You will be looking at pre-selected web sites to answer each question. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question 1: Why does your skin get pruny in the water?		
	Site 1 *Everyday Mysteries* http://www.loc.gov/rr/scitech/mysteries/wrinkles.html	**Site 2** *Kids Health For Kids* *http://www.kidshealth.org/kid/talk/qa/wrinkly_fingers.html*
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
What did you learn?		

Internet Treasure Hunt Name: _____ Date: _____

I. ENGAGE: Osmosis Simulation Worksheet

This web info search will help you find information about diffusion and osmosis, which is the cause of wrinkly fingers. You will be looking on your own to find websites that will answer the question. Please reference two sites. It is important to not only find the information at the site, but also to consider who wrote the site, what their purpose is in writing it, and how credible (accurate) you think the information is.

Question 2: What are diffusion and osmosis?		
	Site 1	**Site 2**
Who created this web site (organization, etc.)?		
Why did they create it? (check all that apply)	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure	☐ To provide factual information ☐ To influence the reader's opinion ☐ To sell a product or service ☐ I'm not sure
How credible (accurate) do you think the info is?	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure	☐ Very accurate ☐ Somewhat accurate ☐ Not very accurate ☐ I'm not sure
What did you learn?		

Name: _____ Date: _____

You Can't Touch This

You have been challenged to _____ the volume of your egg.
Remember – you cannot touch your egg at all.
You may only remove the liquid the egg has been provided to you in.

So, what do you do?

First, you and team must form a hypothesis. Write it down on your own paper. Then, you must design an experiment that tests your hypothesis. Write that down step-by-step. Once you get approval from your teacher you may begin.

What happened?

After observing your results, you and your team will create a poster explaining your experiment. Your poster should include your hypothesis, your design, your results, and your best explanation of why what happened. Finally, you will give a brief presentation (2-3 min.) telling the class what you did and what happened. Every member of the group must participate.

How do I get my A?

You will be assessed in four parts. ***First***, your experimental design – don't worry you will have a chance to revise it after I've looked at it. ***Second***, your poster – it should contain all the requested information and be organized and legible. ***Third***, your presentation – did you demonstrate that you knew what you were doing? ***Finally***, as always, there will be points given for general effort and participation in the lab process. For further breakdown of the grading, see the back of this page.

Design Phase		
5	Hypothesis	A predictive statement of what you think will happen - not a question.
5	Measurement	You are not just measuring chemicals here.
10	Completion of design	Step-by-step! What EXACTLY do I do to repeat?
20	**TOTAL**	

Poster		
5	Title	Every good poster has a title and authors.
5	Hypothesis	See above.
5	Design	Include how much of which materials you added, then what did you do? What about the egg was measured?
15	Results	A table!
15	Conclusion	What is your final statement about what happened and how it relates to your hypothesis?
10	Neatness/Effort	Your poster should be easy to read and organized with headings.
55	**TOTAL**	

Presentation		
10	Content	Be sure to discuss all parts of your poster. ADDTIONALLY be prepared to say what you could/should do different next time.
5	Preparedness	As a group, were you ready? Did everyone know who would say which part?
5	Poise	Exhibit proper speaking skills - avoid distracting actions or simply reading the poster.
5	Participation	Everyone talks.
25	**TOTAL**	

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