Name:_____Date:_____Class:_____

Student Worksheet

Can We Absorb Pollution?

Safety

Students MUST have on goggles, latex gloves, and aprons; no open-toed shoes, no shorts, and long hair must be tied back. Razors, scalpels, and dissecting probes are a cutting hazard—use with caution.

Introduction

Many plastics are in our oceans. Sunlight and alkaline ocean water break these plastics down into small particles—many are nanoscale in size. These *nanoparticles* can easily enter our cells. How do these particles cross membranes into cells?

Now that the rains are over, you and your friends go to the beach to swim because the beaches are no longer closed due to pollution. Is this safe? Is the beach really clean, or will you expose yourself to pollution that can be absorbed through your skin?

Demonstration Day Materials

- egg
- plastic container and lid
- tape measure
- pencil or pen
- scale
- labels or masking tape
- marker
- vinegar
- caliper

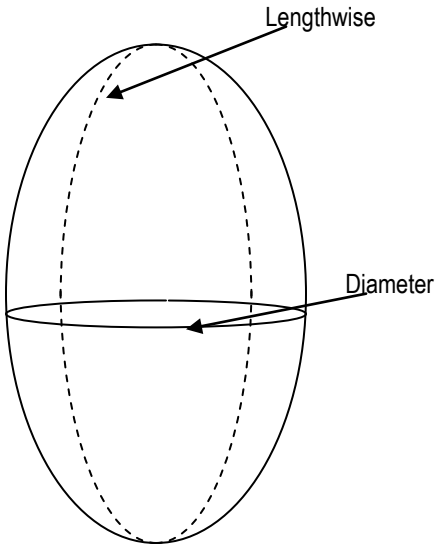
Question: Can tiny (nano-size) pollutants enter a cell?

Make a Prediction

*Example answer: I think that nanoparticle pollutants will enter a cell because they are very small.*_____

Demonstration Day: Procedure

Pre-lab safety checks: Wash your hands.



1. Place the egg onto a lid.
2. Carefully use a tape measure to measure *length and circumference of* the egg, as shown in the diagram to the right. *Be careful not to pop the egg*! Record these measurements in the *Observations* table on page 3 of this worksheet.

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3. Weigh the egg. Record the mass in the table.
4. Notice the color of the egg. Gently rub your finger on the egg and notice its texture (how it feels). Record all observations.
5. Place the egg inside the container. Pour the vinegar over the egg until it covers the egg.
6. Label the container lid with the period, date, group number, and the word "vinegar".
7. Store the egg container in a place where the egg can soak in the vinegar overnight. *Do **not** put the lid on tight.*

Day 1 Materials

- gloves
- goggles
- lab coat or apron
- plastic storage container with egg soaking in vinegar
- tongs
- egg
- plastic squirt bottle of distilled water
- tray
- pencil or pen
- caliper
- tape measure
- scale
- labels or masking tape to label each container
- Sharpie® marker
- corn syrup

Day 1 of Lab: Procedure

Pre-lab safety checks. Wash hands!

8. Using tongs, gently remove the egg from the vinegar in the container you prepared earlier. Pour vinegar down the sink and rinse out container using distilled water. Wearing gloves, use distilled water to carefully rinse the egg over the sink (do not soak the egg). Place the egg into a tray.
9. Use a caliper tool (*careful not to pop the egg*) to measure the length of the egg. Record your measurement in the *Observations* table on the next page.
10. Repeat step 2, but this time, measure the midsection (circumference) of the egg using the tape measure.
11. Weigh the egg. Record the mass in the table.
12. Notice the color of the egg. Gently rub your finger on the egg and notice its texture (how it feels). Record any and all observations in the table.
13. Using the same container (rinsed with water) that was used for the vinegar, create a new label for the container with the period, date, group number, and also write "corn syrup".
14. Place the egg inside the container. Pour the corn syrup over the egg until it covers the egg.
15. Store the egg container in a place where the egg can soak in the corn syrup overnight. *Groups are done for the day at this point. Clean up your area.*
16. Wash your hands with soap and water when done cleaning the lab area.

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Record Your Observations

Egg	Length (cm)	Diameter (cm)	Mass (g)	Color & Observations
Starting	*4*	*3.1*	*103*	*Typical egg. Has shell and shell is hard. Egg looks like a store bought egg.*
After immersion in vinegar	*5.75*	*4*	*113*	*Shell is missing. Egg is rubbery, feels like a plump water balloon. The outside of the egg is cloudy, but the yolk can still be seen.*
After immersion in corn syrup	*3.75*	*2.5*	*88*	*Skin is leathery and egg looks shriveled up. The yolk is very visible. The egg is lighter in weight.*

Day 2 Materials

- gloves
- goggles
- lab aprons
- Glad® storage container with egg soaking in corn syrup
- tongs
- plastic squirt bottle of distilled water
- dissecting tray
- pencil or pen
- caliper
- tape measure
- scale
- Glad® storage container with polluted water sample
- small "Dixie®" cup
- an HMT mercury test kit
- test tube holder
- labels or masking tape
- Sharpie® marker

Day 2 of Lab: Procedure

Pre-lab checks first! Wash hands!

17. Gently remove the egg from the corn syrup using the tongs; place in a gloved hand over the sink and rinse with distilled water into the sink (do not soak the egg). Place the egg into a tray.
18. Measure the length, diameter, and mass of the egg like you did in Day 1 of the lab, and record data and observations in the *Observations* table above.
19. Carefully dry the outside of the egg with a paper towel. *Try not to apply too much pressure or the egg will crack open.*
20. Obtain a Plastic® storage tub containing polluted water sample. Pour about 10 ml of the water from the container into the Dixie® cup. This water is to be tested before the egg is placed in Plastic® storage container.

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21. Use the mercury test kit to test the sample water:
    a. Open up the large clear test tube. The side of the test tube has numbers in milliliters (ml).
    b. Pour 6–7 ml of sample water from the small cup into the clear test tube. Complete 1st column in the Mercury Test table provided on page 6 of this worksheet.
    c. Set in a test tube holder.
    d. Another member of the group should open the vial with the blue cap and carefully pour the contents into the large test tube with the sample water. ***Be careful—this solution is acidic!***
    e. Put the cap back on the test tube with the sample water. Turn it upside down and right side up 3–4 times to mix. There should be no color change.
    f. One other group member should open the vial with the clear cap.
    g. The final member of the group should open the vial that has reddish/brown substance in it.
    h. Pour the solution of the clear cap vial into the tube with the reddish/brown substance.
    i. Place the cap back on tightly. Carefully shake the vial until the reddish/brown substance is dissolved (approximately 2–4 minutes).
    j. *After the substance has dissolved completely,* open the vial. Pour it into the test tube with the water sample and acidic solution. Complete the 2nd and 3rd columns in the Mercury Test table.
    k. Get the box that the mercury test came in. See the color chart on the box? Match the color in the vial to a color on the color chart as best as possible.
    (Hint: If the color stays reddish brown, mercury is present. If it turns light yellow or clear, mercury is not present.) Write the results of your sample water test in the Mercury Test table.

22. Carefully place egg into the plastic storage container containing sample water.
23. Label the container with the period, date, group number, and the words "sample water".
24. Observe any changes in the egg that might or might not occur. Store the egg containers in a place where they can soak in the sample water overnight.
25. Take tested water sample to collection bucket provided by teacher. Wash out plastic storage container that had corn syrup in it with soap and water and leave on lab table. *Groups are done for the day at this point. Clean up your area.*

Day 3 Materials

- gloves
- goggles
- lab aprons
- Plastic storage containers with egg soaking in polluted water sample
- tongs
- tray
- pencil or pen
- measuring tape
- caliper
- scale
- plastic squirt bottle of distilled water
- Exacto® knife or razor
- strainer
- small plastic cup
- an HMT mercury test kit
- test tube holder
- paper towels

Day 3 of Lab: Procedure

Pre-lab and safety checks first!

26. Using the tongs, gently remove egg from the container with the sample water and place in tray.
27. Carefully weigh the egg, measure length and diameter of the egg, and record the measurements in the table on the next page. Copy your measurements from the previous day's table into this table.
28. Pour sample water down the sink. Use distilled water to rinse out the storage container. The rinse water can go down the sink as well.
29. With the tongs, carefully place the egg back into clean, empty container and put the plastic lid over the egg. Do not secure the lid. The lid will act as a shield when the egg is cut during the next step. Be careful—the egg could spurt like a fountain.

30. Carefully make a small incision on the egg and allow the water to drain into the container. Be careful not to break the yolk as the color of the yolk will give different color reading during mercury test.
31. Pour the egg and water into the strainer directly above a small cup. Allow the cup to catch the strained egg whites/water solution.
32. Repeat step 21, a–k, from *Day 2 of the Lab*, but this time test the egg/water solution.
33. Clean up your lab area:
    a. Place cutting instruments into the sharps container at front of the classroom.
    b. Take tested egg/water sample to collection bucket provided by teacher.
    c. Dispose of paper towels and small cups into garbage can. Clean lab area with all-purpose cleaner.

d. Wash out plastic storage container with soap and water and leave on lab table. Wash hands before leaving lab.

Record Your Observations

Egg	Length (cm)	Diameter (cm)	Weight (g)	Color, texture, and other observations
After immersion in vinegar	*5.75*	*4*	*113*	*Shell is missing. Egg is rubbery, feels like a plump water balloon. The outside of the egg is cloudy, but the yolk can still be seen.*
After immersion in corn syrup	*3.75*	*2.5*	*88*	*Skin is leathery and egg looks shriveled up. The yolk is very visible. The egg is lighter in weight.*
After immersion in sample water	*3.5*	*4.1*	*95*	*Skin is tight and rubbery like a water balloon. Egg feels like a water balloon.*

Substance tested with HMT mercury test	Observations before solution added to test tube	Observations after reddish solution added to test tube and flipped upside down	Color inside test tube after 6 minute wait	Concentration of mercury (color closest on chart) (ppm)
Sample of Pollutant Water	*Water is mostly clear with a slight green/brown color; there are some black and green mossy things floating in it.*	*Water is mixing. There are two layers as the 2 solutions slowly mix. The red color is mixing more.*	*The water lightened up but it still has some orange color in it.*	*0.05 ppm*
Egg and Pollutant Water	*Mostly clear, but some blurriness from egg white.*	*Top layer looked like scrambled egg with orange rust color. Bottom layer was still clear—looked like only water.*	*The egg began to look darker yellow and still scrambled.*	*0.025 ppm*

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Analyze the Results

*Mass of egg **after** immersion in vinegar*
*– Mass of egg **before** immersion in vinegar*
Mass of water drawn in from vinegar into the membrane during immersion

*Mass of egg **before** immersion in corn syrup*
*– Mass of egg **after** immersion in corn syrup*
Mass of water that left the egg due to osmosis (negative number since water is leaving egg)

*Mass of egg **after** immersion in pollutant water*
*– Mass of egg **before** immersion in pollutant water*
Mass of water drawn into the egg from osmosis

*Length of egg **after** immersion in vinegar*
*– Length of egg **before** immersion*
Length egg grew due to water uptake inside the membrane during immersion

*Length of egg **before** immersion in corn syrup*
*– Length of egg **after** immersion in corn syrup*
Length showing egg shrinkage due to osmosis (negative number since water is leaving egg)

*Length of egg **after** immersion in pollutant water*
*– Length of egg **before** immersion in pollutant water*
Length of water drawn into the egg from osmosis

*Dia. of egg **after** immersion in vinegar*
*– Diameter of egg **before** immersion*
Diameter egg grew due to water uptake inside the membrane during immersion

*Diameter of egg **before** immersion in corn syrup*
*– Diameter of egg **after** immersion in corn syrup*
Diameter showing egg shrinkage due to osmosis (negative number since water is leaving egg)

*Diameter of egg **before** immersion in pollutant water*
*– Diameter of egg **after** immersion in pollutant water*
Diameter of water drawn into the egg from osmosis

Questions

1. Name three processes that the cellular membrane utilizes for non-energy activation cellular transport.
   a. *osmosis*
   b. *diffusion*
   c. *pino/phagocytosis*

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2. How do these processes regulate what comes into or out of the cell?
   a. *Diffusion is based on size.*
   b. *Osmosis is based on concentration.*
   c. *Pino/phagocytosis is cell membrane pinching off.*
3. What is a nanoparticle?

   A particle that ranges in size from 1–100 nanometers.
4. Do the cell membrane transport methods apply to nanoparticles? Why or why not?

   Yes! Due to the fact that nanoparticles are small enough to bypass a lot of size restricted sites. The nano-sized plastic debris is also lipophilic and is attracted to the cell membrane.
5. What is the reaction that is occurring for this lab?

   $CaCO_3 + 2H^+ \Rightarrow Ca^{+2} + H_2O + CO_2$
6. What is the major function of the endocrine system?

   The endocrine system is a system of glands that involve the release of extracellular signaling molecules known as hormones. The endocrine system is instrumental in regulating metabolism, growth, development and puberty, and tissue function and also plays a part in determining mood.
7. What are some possible complications if the endocrine system is compromised due to toxicity?

   Puberty enhanced/restricted, mood swings, sterility, and a host of other complications.
8. What complications could arise from compromising the neural system?

   Improper neural development, which leads to death, brain damage, and such.

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9. How does osmotic pressure affect the cell membrane's ability to regulate what does come into or out of the cell?

The greater difference of solutes between the inside and outside of the cell membrane will cause water to move more rapidly, and with greater force. A more net amount of water will also be moved.

Terminology comprehension: Now that you've completed the lab, define the following terms:

Phospholipid bilayer: *Cell membrane surrounding the cell. It is a two layer (bi) structure composed of hydrophilic (water loving) heads and hydrophobic (water hating) fatty tails.*

Permeability: *The ability of substances to cross a barrier.*

Nanoscale: *Anything that is 1–100 nanometers in size.*

Homeostasis: *The state at which all metabolic pathways work most efficiently.*

Tissue: *Groups of cells performing a similar function.*

Organ: *Groups of tissues performing a similar function.*

Organ system: *Groups of organs that cooperate to perform a function inside the body.*

Endocrine system: *The system that regulates hormones in glands throughout the body.*

Lipophilic: *Attracted to lipids.*

Osmotic pressure: *The pressure formed from water's attraction to the higher concentration of solutes on the other side of the cell membrane.*

Cell membrane: *The covering double layer of phospholipids surrounding the cell. This regulates what comes into and out of the cell (for the most part).*

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Draw Conclusions

1. How did the mercury enter the cell membrane? (*Hint: discuss nanoparticles*)

   Sample answer: The mercury is lipophilic and binds to nanoparticle plastic debris in the water. The mercury is able to cross the membrane by riding in on the debris. Osmotic pressure also played a key role in "pushing" the mercury past the membrane.

2. What other "banned" and "mandatory" toxins could possibly enter our cells in this manner? Explain.

   Sample answer: PBDEs and PCBs can also enter the cells due to their lipophilic nature and ability to bind with nano sized plastic particles. The lecture will cover the usage of PCBs (banned in 1977) and PBDEs (the mandatory flame retardants used today in our furniture, clothing, etc.).

3. What are some possible consequences of toxins being able to bypass the protective cell membrane phospholipid bilayer? Can you formulate a way we could reduce absorption by the cell?

   Sample answer: It has been found that PCBs and PBDEs have led to some major health and neural development issues. Our endocrine system controls our hormones which in turn control major physiological functions. If we damage the endocrine system, the body will be in poor health or even suffer serious health complications leading to death. Some ways to reduce absorption: reduce exposure by using materials that do not have these toxins in them, find another similar polymer that does not have the attraction to our cells, etc.

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