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iBIO STEM Kit: Solubility of Medicine

iBIO STEM Kit welcomes you to a SCIENTIFIC JOURNEY!

Today, we will be investigating **solubility**. The purpose of this investigation is to challenge you to explore what solubility is and the speed at which chemicals dissolve so that you can design and build a time-released medication tablet. We also challenge you to explore this engineering problem as a scientist would. What does this mean?

Scientific exploration is different than just playing around because it asks you to think about HOW you investigate. This means you need to do your investigation by observing what happens when you change a variable you have carefully chosen. This helps you to understand WHY something happens. Scientific exploration also means that you record WHAT you see or measure and that you record WHY you think it happens. The STEM Kit Notebook that you are holding will help to guide your investigation and give you a place to record your observations, measurements and conclusions.

Follow the QR code at the top of the page for additional resources on this activity. There are many resources for you to use on our website. This type of investigation is associated with some very exciting careers! We hope that you will explore these resources while you are doing your investigation!

Let's Get Started!

FIRST, you will need to prepare your workspace. This can be a very wet and messy investigation, so make sure that you are using a space that will not be easily damaged. A kitchen table will work nicely. To make your clean up easier, you should protect your surface by laying out some used newspaper or opening up a paper grocery bag.

SECOND, you want to lay out your materials. Use the list below to identify which materials are used in each part and organize them in your workspace.

Materials for Part A:
- 3 medicine cups
- Oil
- Bag of M&Ms or Skittles
- 6 inch Foam plate

Materials from Welcome Kit:
- Isopropyl Alcohol

General Supplies:
- Water

Materials for Part B:
- Vitamin C Powder
- Plastic spoon
- 9 oz plastic cup for mixing
- 5 medicine cups
- Antacids in different forms
- pH paper strip
- pH paper scale

Materials from Welcome Kit:
- Ruler
- Pencil

General Supplies:
- Water
- Scissors

Kit Materials for Part C:
- Four color tablets
- Thin water soluble plastic
- Thicker water soluble plastic
- Two non-soluble plastic bags

Materials from Welcome Kit:
- Scotch tape

General Supplies:
- Water
- Scissors

LAST, you need to be prepared for experimenting safely. Always be careful when working with chemicals (even if they do not seem hazardous) to prevent injury. This lab will be working with antacids which are used as medicines. DO NOT eat the antacids.

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Solubility-Chemistry

Adapted from: American Chemical Society- Dissolving M&Ms

Part A: Explore: Do Skittles or M&Ms dissolve in any liquid?

What is solubility?

Solubility is a word that is used to describe when a substance is able to dissolve into a solvent. A solvent is usually a liquid, like water or alcohol or oil. Candy coatings are made of sugar and coloring, which have positive and negative charges on them. Solvents that also have positive and negative charges on them will be able to pull on the sugar and coloring molecules and drag them away from whatever they are attached to. We say that the sugar and coloring **dissolves** in the solvent. In this experiment, you will be testing how well three different solvents can dissolve the sugar and coloring coating on some candies.

Here's what you will need to test solubility:

- 3 medicine cups
- Water
- Isopropyl Alcohol (you will only be using a small amount of this chemical today. You will be saving the rest of this liquid for Wednesday.)
- Oil
- Bag of Skittles or M&Ms

Procedure for testing solubility in different liquids:

1. You will need to start by picking one color candy to test. You will need to test three candies of this color. Put these three candies aside for a moment.
2. Take one medicine cup and find the 5 ml mark on the side. Put 5 ml of **water** in the medicine cup.
3. Take one medicine cup and find the 5 ml mark on the side. Put 5 ml of **isopropyl alcohol** in the medicine cup.
4. Take one medicine cup and find the 5 ml mark on the side. Put 5 ml of **oil** in the medicine cup.
5. Put one of your chosen candies in each of the medicine cups.
6. Swirl each cup for about 20 seconds and see if one liquid is better than another at dissolving the candy coating.
7. Record your observations in Table 1.

Table 1: Observations of the Solubility of the Candies

Liquid	Observations of the Candy *How much of the colored candy coating is gone?*	Observations of the liquid *What color do you see? How much color is in the liquid from the candy?*	Label the liquids as they compare to one another. *Best Solubility* *Medium Solubility* *Worst Solubility*
Water			
Isopropyl Alcohol			
Oil			

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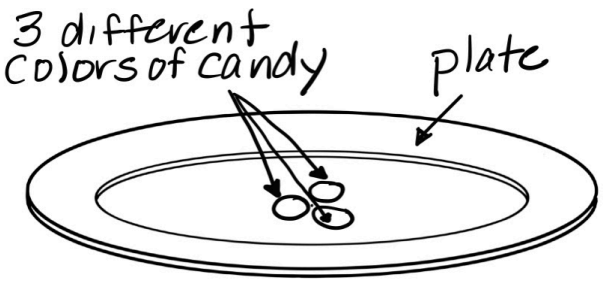

Patterns of Solubility in water:

1. You will need to start by picking three different colors of candy to test. You will need to test three candies of this color. Put these three candies aside for a moment.
2. Put the small plate in front of you. Pour water in the plate until it covers the bottom and is about as deep as the candy.
3. Place three candies near each other in the center of the plate the way it is shown on the diagram. Do not stir the water or bump the plate.
4. Watch for about 1-2 minutes and record your observations in the data table.

Table 2: Observations of Patterns of Solubility

	Draw a picture of the pattern in which the color dissolves into the water.	*Describe the area where the colors meet.*	*Do the colors mix? Why or Why not?*
Candy in water			

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Part B: Test: How does the form of a medicine affect its solubility?

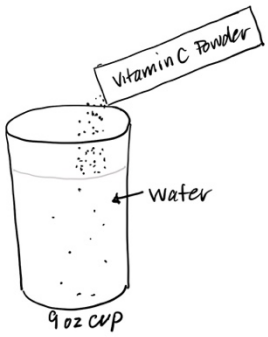
Here's what you will need to test the solubility of different forms of medicine:

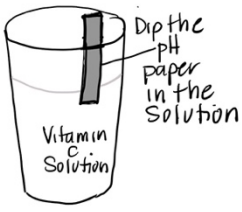
- Vitamin C Powder
- Water
- Plastic spoon
- 9 oz plastic cup for mixing
- 5 medicine cups
- Antacids in different forms
- Ruler
- Pencil
- Scissors
- pH paper strip
- pH paper scale

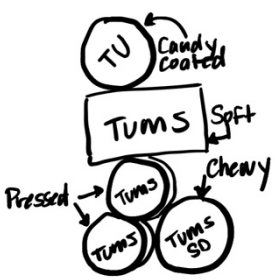
Antacids are a medicine that people take when they produce too much acid in their stomach and it makes them feel sick. Stomach acids have a pH as low as 3 and can damage the inside of our stomach. People use antacids to bring the pH of the stomach back to a pH of 7 which is neutral and harmless.

When you take medicine like an antacid, it needs to dissolve quickly in order to help you to feel better. Medicines come in many delivery method forms: powder, chewable, pressed, coated, and soft. We are going to compare different forms of an antacid to find the delivery method that will work the fastest.

Our solvent for this experiment will be water. Water is the solvent for our digestive system, which is where an antacid does its work. We add vitamin C powder (citric acid) to the water to represent our stomach acid in order to test the different forms of antacid to see which one would work most quickly.







<u>Setting up to test antacid forms:</u>

1. First we will need to cut our pH paper into small pieces that we will be able to use to measure the pH values. Use your ruler to measure 1-cm sections on your pH paper. Mark each cm section with your pencil.
2. Take your scissors and cut the pH paper at your marks. You should have 25 pieces when you finish. Put these pieces aside for now.
3. We will be using a 9 oz plastic cup to do our mixing. Fill the cup almost to the top, leaving about a centimeter of space. This will make it easier to stir without spilling.
4. Open the Vitamin C Powder and add it to the water. Use the plastic spoon to stir the liquid until the Vitamin C powder has dissolved.
5. Take a piece of your pH paper and find your pH color scale. Dip the piece of pH paper into the Vitamin C solution and remove it after 1 second.

Compare the color of the pH paper to the colors on the pH scale. Record your initial pH on the top of Table 3. A pH that is below 7 is an acidic

6. pH.
7. Set out your five medicine cups in front of you on a piece of paper. Pour 15 ml of Vitamin C solution into each medicine cup. Leave them for now.
8. Find the antacids. They should be together in a baggie in your materials. You will see that there are four different forms. 2 pressed tablets, 1 chewable tablet, 1 soft tablet and 1 candy coated tablet.

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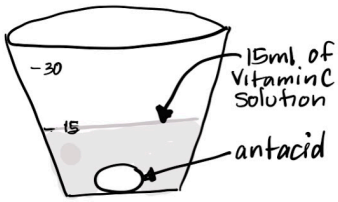
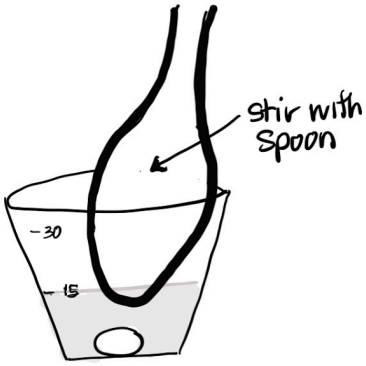
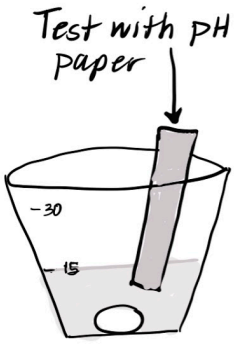
9. The soft tablet will need to be unwrapped. Do this now and place it in front of one of the medicine cups. Write “soft” on the paper to label the cup.
10. Place the chewable tablet in front of a cup. Label the paper “chewable”. Place the candy-coated tablet in front of a cup. Label the paper “coated”. Place one of the pressed tablets in front of a cup. Label the paper “pressed.”
11. The second pressed tablet will need to be broken or crushed into pieces. Place this antacid back into the plastic bag and stomp on it with your shoe. It does not have to be perfect, but it needs to be in pieces when you finish. Leave it in the bag for now. Place it by the final cup. Label the paper “powder”.

Testing the antacid forms:







12. Now we are ready! Set your timer for one minute.
13. Put one of the antacids into its cup. Start the timer.
14. After one minute, gently stir the cup with your spoon.
15. Dip a new piece of pH paper into the Vitamin C solution and remove it after 1 second. Compare the color of the pH paper to the colors on the pH scale. Record this pH in Table 3 for 1 minute.
16. Wait one more minute.
17. After one minute, gently stir the cup with your spoon.
18. Dip a new piece of pH paper into the Vitamin C solution and remove it after 1 second. Compare the color of the pH paper to the colors on the pH scale. Record this pH in Table 3 for 2 minutes.
19. Wait one more minute.
20. After one minute, gently stir the cup with your spoon.
21. Dip a new piece of pH paper into the Vitamin C solution and remove it after 1 second. Compare the color of the pH paper to the colors on the pH scale. Record this pH in Table 3 for 3 minutes.
22. Wait one more minute.
23. After one minute, gently stir the cup with your spoon.
24. Dip a new piece of pH paper into the Vitamin C solution and remove it after 1 second. Compare the color of the pH paper to the colors on the pH scale. Record this pH in Table 3 for 4 minutes.
25. Repeat the experiment for each of the forms of antacid.
26. Once you have finished testing each of the forms, scoop out the remains of the antacids and throw them into the garbage. Rinse out the medicine cups. You will be using these for other experiments this week. Throw the used pH papers into the garbage.
27. Now graph your measurements for each of the tablets. If you are unsure of how to do this, watch the activity video to help you!

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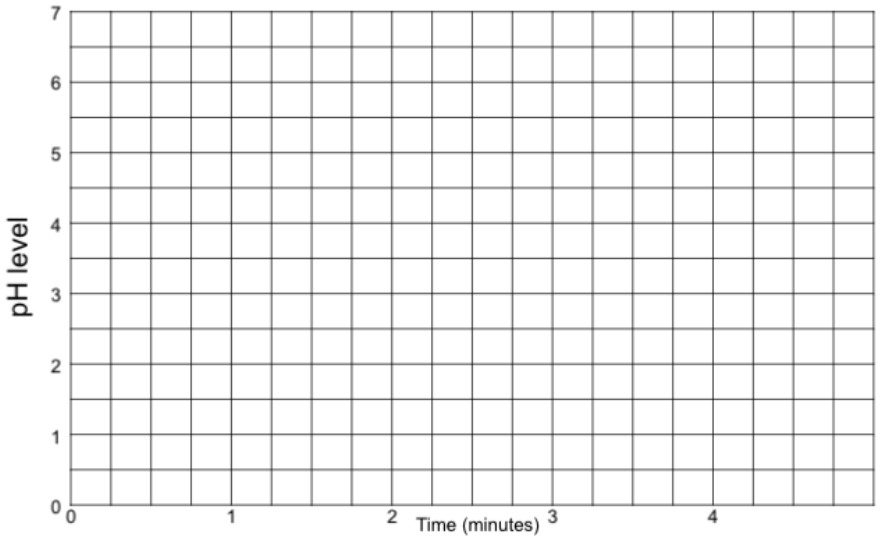
Table 3: pH Measurements				
Initial pH of the Vitamin C solution _____				
Form of antacid	**1 minute**	**2 minutes**	**3 minutes**	**4 minutes**
Powdered				
Pressed				
Chewable				
Coated				
Soft				

Graph:



Which form worked the fastest to change the pH? _____

Which form worked the slowest to change the pH? _____

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Part C: Design Challenge: Design a time-release medicine tablet.

Adapted from: Science Buddies, Design a Delayed Release Tablet

Here's what you will need to make ONE time-release medicine tablet:

- Water
- Two color tablets
- Thin water soluble plastic
- Thicker water soluble plastic
- Two non-soluble plastic bags
- Scotch tape
- Scissors (general supplies)

Additional materials:

- Two extra color tablets
- Scissors (general supplies)

What does it mean when a medicine is "time-release"?

Time-release drugs are designed to **release** small amounts of the **medication** into a person's system over a long period of **time**. This means that the medicine form is designed to dissolve slowly and deliver the medicine at a particular speed.

In this design challenge, you need to deliver two medicines in one "pill". We are representing these medicines with two color tablets.

- You have to use two different color tablets in your "pill"
- The final tablet has to be a single unit (made out of the two different color tablets) and needs to be fully enclosed.
- When submerged in water, their tablet has to release each one of the colors (active ingredients) at a specific target time (First color: 30 seconds, Second color: 3 minutes).

Think about what we have learned about solubility. Some forms dissolve quickly and some forms dissolve slowly. A coating on the outside changes how quickly it will dissolve. A powder dissolves at a different speed than a solid form.

Test your materials:

1. You will want to test out each of your plastics first so that you can see its ability to dissolve in water. Use a very small piece of each of the plastics and test out how long it takes to dissolve and what that looks like. This will help you to decide how you may use it in your design. Record what you observe in your design plan.
2. Test out your scotch tape. Use a small piece and test out how it behaves in water. This will help you to decide how you may use it in your design. Record what you observe in your design plan.
3. You have been given two extra color tablets. Take one of the tablets. Decide how you should test it in water to see how long it takes to dissolve and what that looks like. You might want to alter its form to see how it dissolves. This will help you to decide how you will use it in your design. Record what you observe in your design plan.

Design your Time-Release Tablet:

Now you have some information to work with and you can begin to engineer your plan for your time-release tablet. You only have one set of materials, so you will need to make sure that you plan ahead! Once you are happy with your design, make your tablet! Take a picture of your tablet once you have finished so that you have a record of what it looked like BEFORE you tested it out!

TEST your Time-Release Tablet!

a. Make sure you videotape your test and that you are ready with your timer!
b. Put enough water to cover your tablet into one of the clear plastic 9 oz cups.
c. Have your timer ready. Drop your tablet in the water and observe!

Was your design successful? Post your video so that we can see your creativity and engineering skills!

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DESIGN PLAN for a Time-Released Medicine Tablet

Ask: What is the problem you need to solve?

Imagine: What are your ideas for solving the problem?

1.

2.

3.

Testing your materials: What did you observe?

Plastic 1:

Plastic 2:

Plastic 3:

Scotch Tape:

Color Tablet:

Plan: What will your design look like? Draw a labeled diagram and write down your materials with the amounts you need: