Lesson 6 – Invisible Ink

Overview

This lesson introduces the concept of **hypotheses**. A hypothesis is a prediction or educated guess that is made about how variables relate to each other. There are two important rules when generating a hypothesis: 1) it must be testable and 2) it must be specific. Generating hypotheses about observations is useful because hypotheses provide guidance for designing experiments and testing if ideas about the observations are supported. Scientists generate hypotheses to state their educated guesses before they conduct an experiment. In this way, scientists can confirm or disconfirm their ideas. This process contributes to the accumulation of knowledge in science.

UQUEST scientists will learn to recognize and generate hypotheses. UQUEST scientists will practice generating hypotheses that are relevant to their health. They will also generate hypotheses about which liquid will reveal a secret word written in "invisible ink." After testing the hypothesis with an experiment, the results will be graphed on a bar graph and discussed with the UQUEST scientists.

Science Objectives:

UQUEST scientists will...

- understand that a hypothesis is an educated guess about the relationship between two variables.
- understand that a hypothesis needs to be testable and specific.
- practice generating hypotheses.

Health Messages:

- Citrus fruits are good nutritious snacks that are high in vitamins.
- Brushing your teeth can help protect your teeth from the acid in citrus fruits.

Reinforcement of previous messages:

- Observation (Lesson 1): We can generate hypotheses after observing things that make us wonder.
- Manipulation (Lesson 6): In this experiment we manipulate peeling or not peeling the oranges.
- Experimentation (Lesson 7): Hypotheses can be tested.

Vocabulary

- **Hypothesis**: A prediction we make about how variables are related to each other. Hypotheses are testable and specific.

Materials

- UQUEST kit
- Baking soda
- Lemons
- Blackberries
- Water
- Salt
- Paint brushes
- White paper
- Cotton swabs
- pH test strips
- Napkins
- Spoons
- Cups/containers for liquids
- 2 whiteboards; one per class
- Writing utensils

Preparation

At UM:

- Prepare containers of juice, salt water, and baking soda mixture for each team.
- Cut up lemon slices
- Label pieces of paper (baking soda and salt water)

At OYC:

- Pour liquids in cup for each team
- Set up graph on dry erase board

Introductory Script:

Welcome UQUEST scientists.

Remember the lab notebook is an important tool that scientists use to record their observations and the results of their experiments.

Let's open up your lab notebooks to the second page. Like all scientists, UQUEST scientists pay attention to the world around them. They create an environment that helps them to learn about the world. They listen to each other. They communicate with each other. And they treat each other with respect.

***Let's review the values of a UQUEST scientist. E*ach UQUEST scientist reads OUT LOUD one value.**

1. **Pay attention** when others are talking.
2. **Speak in a low voice**. Do not scream.
3. **Respect each other.** Do not push or shove each other.

****Be sure to praise the students when they do well and tell them why****

Relaxation

Before we begin the lesson, we'd like to start off by doing a relaxation activity. When scientists are relaxed, they do better science.

For today's relaxation activity we will do a visualization exercise.

- Guide the UQUEST scientists through exercise: C*lose your eyes and visualize your favorite place. Maybe the beach, a garden, a park, or anywhere else. Pause. Think of the sights, smells, and noises around you. Open your eyes.*

Instructions for Lesson 6

1. **Question Formulation Technique**
    1. Question focus
        i. *Hi everyone! To start off our Quest for today, we are going to play the question game. The question game has 4 rules. I will say each rule and ask you to repeat after me.*
            1. *First rule is: ask many questions*
                a. *Everyone repeat after me. "Ask many questions."*
            2. *Second: do not discuss or answer questions.*
                a. *Repeat after me: "Do not discuss or answer questions."*
            3. *Third: take turns asking questions*
                a. *Repeat after me: "Take turns asking questions."*
            4. *Fourth: change statements into questions*
                a. *Repeat after me: "Change statements into questions."*
        ii. *Alright, is everyone ready to play?!*
        iii. **Show pH scale image in the lab notebook for 10 seconds.**

1. *I want to know what questions you have about this picture.*
            1. *What are you curious about when you see this picture?*
            2. *What would you like to know?*
            3. *Is there anything confusing you?*
        iv. *Now, I would like to know all of your questions. When you have a question raise your hand and I will call on you. Please state your question slowly so I can write it down exactly how you said it.*
        v. **Set a timer for approximately 5 minutes**
        vi. **REMEMBER the rules for the scribe/guide:**
            1. **Write questions word for word, numbered, and (in discussion only), with scientist initials**
            2. **Monitor student adherence to the process**
            3. **Do not give examples**
            4. **Do not get pulled into group discussion**

5. **Acknowledge all contributions equally: "thank you"**

2. *Thank you for all your questions! We will go back to your questions at the end of the day today. Think if you can answer these questions as we go through the activity.*

2. **Introduction**

1. **Provide background information about pH.**
    a. *Has anybody eaten a lemon before? How do they taste? What's the face you usually make when you taste a lemon? If you do not remember the face you make, you can try one of the lemon slices.*
        i. **Distribute and have each UQUEST scientist try the slice of lemon.**
    b. *Go ahead and try the slice of lemon and remember the face you make when you first taste it!*
        i. *Lemons taste sour because they are acidic, meaning they contain acids.*
    c. *What is an acid?*
        i. *An acid is a chemical that usually tastes sour and is good at dissolving things. In other words, it can break down hard substances like stone or metal, and some acids may be stronger than others.*
2. **Show the class the example pH scale and explain.**
    a. *We have a special kind of ruler, called a pH scale, which tells us how acidic something is.*
        i. *Remember that some acids are stronger than others, so it is important that we have a way to measure and classify them with.*
    b. *If you turn to page 6D of your lab notebook, you can see that the pH scale is labeled from 0-14* **[point to pH scale as you explain the following].**
        i. *The closer to 0, the stronger the acid is. These are red, orange, and yellow.*
        ii. *Some examples of acids are things like citrus fruits, vinegar, and tomatoes.*
        iii. *Between 0-3 are strong acids and between 4-6 are weak acids.*
    c. *On the other end in the green to blue range, things that are not acidic at all are called basic. They range from 8-14.*
        i. *Things that are closer to 14 are stronger bases.*
        ii. *Some examples of things that are basic are baking* soda, dish soap and bleach (cleaning products)
            1. *Then we also have substances that fall somewhere in the middle around 7 on the scale, like water. We call those substances neutral.* **Example: water, human blood**
    d. *What happens when you mix an acid and a base?*
        i. *As scientists, this is something you may be wondering.*
        ii. *When you mix an acid and a base, it causes a chemical reaction.*
3. **Write secret word**
    a. *Have you ever written a secret message to a friend or family member?*
    b. *How do you make sure your word remains a secret? What if someone opens up your letter and reads it?*

c. *Today we're going to go on a quest do discover how we can reveal a secret word written with "invisible ink."*
    i. **Scientists will write a word on a white piece of paper using a baking soda mix and on another piece of paper with a salt water mix (these will be the "invisible inks").**
d. **Distribute two pieces of white paper to each UQUEST scientist.**
e. **Mix 2 tablespoons of baking soda into 1 cup of water**
f. **Mix 2 tablespoons of salt into 1 cup of water**
    i. **Distribute cotton swabs, salt water mixture, baking soda mixture**
g. *First, dip one end of a cotton swab into baking soda mixture and tap off any drips.*
h. *Use the wet cotton swab to write a word on the sheet of paper.*
i. **Repeat above steps with the salt water mixture.**
    i. **Wait ~10 minutes for drying**

4. **Test the pH of different substances.**
    a. **Distribute cups of salt water, baking soda mixture, cotton swabs, and pH test strips**
    b. **Scientists will use pH test strips to find out whether the liquids are an acid or base.**
    c. **Scientists will use cotton swab to dip into liquid and place one drop onto the pH test strip.**
    d. **Observe color change and reference pH scale**
        i. **Example:** *If the baking soda mix turns the paper deep green, that means that it is in the base side of the pH scale.*

3. **Activity**
    5. **Put away materials to limit distractions for next part of lesson.**
        a. *As scientists, we often come up with questions we want to answer with an experiment.*
        b. *When we make an educated guess or prediction about what will happen in an experiment, we call that a* ***hypothesis****.*
    6. *A* ***<u>hypothesis</u>*** *is an educated guess or prediction that we make about the variables in our experiment.*
    7. **2 rules for hypotheses**
        a. **Testable: test hypothesis by doing an experiment.**
        b. **Specific: the instructions for how to do the experiment are stated in detail**
            i. **Example***: If I brush my teeth two times per day, then I will not develop cavities*
            ii. *Why is this hypothesis testable?*
                1. *Because we can brush our teeth twice a day and go to the dentist to see if we have cavities.*
                    a. *We are actually able to test our hypothesis!*
            iii. *Why is this hypothesis specific?*
                1. *Because we gave specific details. For example, we said that we would BRUSH our teeth (not just clean our teeth). We specified brushing TWICE per day. And we specified that we would not develop cavities (not just that our teeth would be healthy).*

1. **Instruct scientists to formulate a hypothesis about which liquid will make our word appear. Ensure hypotheses are testable and specific.**
    i. **Refer to pH scale:** *Blackberries are strong acids. Salt is neutral. Baking soda is a base.*
    ii. *Remember, when you mix an acid and a base, it causes a chemical reaction.*
    iii. *I would like everyone to think about what might happen if I brush a blackberry (strong acid) over the secret word I wrote with my salt water mixture, which is neutral and not a base.*
    iv. *Now think about what might happen if I brush a blackberry (strong acid) over the secret word I wrote with my baking soda mixture, which is a base.*

b. *Which liquid will help reveal your secret word?*
    i. *Make a hypothesis and say it to the team. Please state "my hypothesis is...." and then respond.*
        1. **Example***: My hypothesis is that the blackberry will reveal my secret word written with salt water.*
        2. **Example***: My hypothesis is that the blackberry will reveal my secret word written with baking soda.*
        3. *Why do you think that will happen?*

c. **Instruct scientists to turn to page 6B in lab notebook.**

d. **UQUEST guide reads instructions out loud:** *Please circle if the secret word written with the salt water or baking soda mixture will be revealed by the blackberries.*
    i. *Those are your hypotheses.*

e. **Compare hypotheses with the other UQUEST scientists in the team.**
    i. *There are a couple of possible hypotheses.*
    ii. *Please raise your hand if...Your hypothesis is that the blackberry will reveal the word written with the salt water.*
    iii. *Please raise your hand if... Your hypothesis is that the blackberry will reveal the word written with the baking soda.*
        1. **UQUEST guide totals the number of hands raised for each hypothesis. This information will be used to make the team bar graph.**

2. **Documentation**

a. **UQUEST guide draws graph on white board in real time while explaining the parts of a graph. Do this while waiting for papers to dry.**

b. **UQUEST guide will make bar graph on dry erase board in small teams.**
    i. *First, we are going to set up the bar graph.*
    ii. *Where is the X axis? The X axis is the line on our graph that goes side to side* [**make an x axis**].
    iii. *On our X axis, we will indicate the liquid* [**Write "Mixture" and the two categories are: salt water and baking soda**].
    iv. *The Y axis goes up and down [***draw the Y axis***].*
    v. *And on our Y axis, I will write Number of UQUEST scientists and we will make tick mark labels that say 0, 1, 2, 3, 4, 5 and 6* [**write this**]

vi. *The title of our bar graph says "Hypotheses of whether the word written with the baking soda or the salt water will be revealed by the blackberry"* [**write the title**]

c. *XX of you hypothesized that the blackberry will reveal your secret word written with salt water mixture.* **[make bar on graph]**

d. *XX of you hypothesized that the blackberry will reveal your secret word written with the baking soda mixture* **[make bar on graph]**

e. Instruct scientists to copy graph onto page 6C of lab notebooks

f. **Analyze graph:**

i. *Which bar is taller? What does that mean?*

3. Activity (continued)

a. *Sometimes hypotheses are supported and other times they are not. To find this out, we need to test our hypothesis.*

b. Distribute blackberries.

c. *Take first piece of paper with secret word.*

d. *Gently brush the blackberry over the paper with your salt water word.*

i. *What do you observe? Does your word appear?*

e. *Gently brush the blackberry over the paper with your baking soda word.*

i. *What do you observe? Does your word appear?*

f. *On page 6B of your lab notebook, mark whether the blackberry revealed the word written with the salt water or baking soda mixture.*

g. *Why did the blackberry reveal your secret word written with the baking soda mixture?*

i. *The baking soda is basic. It gets absorbed by the paper and once dried isn't visible anymore (although you might have noticed some baking soda powder residues on the paper, which you can wipe off easily).*

ii. *This changed when you painted the paper with the blackberry. This happens because the acid from the blackberry reacts with the baking soda (which is a base), forming a chemical reaction.*

iii. *When an acid and a base come in contact, it turns it into a different color and your secret word gets revealed!*

h. **Health messages**

i. *It is good to eat citrus fruits because they are high in vitamins, like vitamin C. Vitamin C can help fight off colds.*

ii. *However, the citric acid, found in citrus fruits, can also wear down the enamel, or outer covering, of our teeth over time if we are not careful. What can we do to protect our teeth from this breakdown of our enamel over time?*

1. *We can brush our teeth at least twice a day for two minutes each time. Brushing your teeth will prevent them from breaking down when we eat foods that have citric acid in them.*

4. Discussion

a. *Now that we have finished our activity, we are going to play the question game AGAIN! As a reminder, <u>the question game has 4 rules.</u>*
    i. *First rule is: ask many questions*
    ii. *Second: do not discuss or answer questions.*
    iii. *Third: take turns asking questions*
    iv. *Fourth: change statements into questions*
b. *Alright, is everyone ready to play?! If you had any questions during the activity, now is a great time to raise your hand and ask.*
c. *I want to know what questions you have about today's activity about the pH scale.*
d. *When you have a question <u>raise your hand</u> and I will call on you.*
e. *For every question that you ask, you will get a sticker.*
f. *Let's GO! Question time!*
    i. *REMEMBER the rules* ***show poster of rules**
    ii. REMEMBER YOUR QUESTION WORDS!
        1. WHO, WHAT, WHERE, WHEN, WHY, HOW
        2. You can use these words when you are stuck and don't know what questions to ask?
            a. Encourage questions that are related to the science concept (as opposed to: "why do we have to do this?") -- "could you try to ask a question a little bit more related to the activity or to science?"
        3. **Set a timer for approximately 5 minutes**
            a. **Write questions word for word, numbered, and (in discussion only), with scientist initials**
            b. **Monitor student adherence to the process**
            c. **Do not give examples**
            d. **Do not get pulled into group discussion**
            e. **Acknowledge all contributions equally: "thank you"**
    iii. **NOTE: to keep track of stickers, write the initials of scientist next to the question they posed**
g. **Once the time to produce questions ends, UQUEST Guides will select a few questions from both lists of questions (introduction and discussion) to answer.**
h. **Select questions that you are able to answer and see if they can be answered by the scientists.**

1. **Wrap-up**
    I. *What did you learn today? Write that down on the lines on page 6E.*
    II. *How much did you like today's lesson on scale from strongly agree to strongly disagree.*
    III. **Award prize at the end based on number of stickers.**

Resources

Inspired by:

https://www.generationgenius.com/activities/chemical-vs-physical-changes-activity-for-kids/

https://littlebinsforlittlehands.com/cranberry-secret-messages/

Lesson 6
Invisible Ink

Date: _____

Hypotheses

Instructions: Hypothesize whether the message written with the baking soda or the salt water will be revealed by the blackberry.

Baking Soda Mixture

Salt Water Mixture

Results

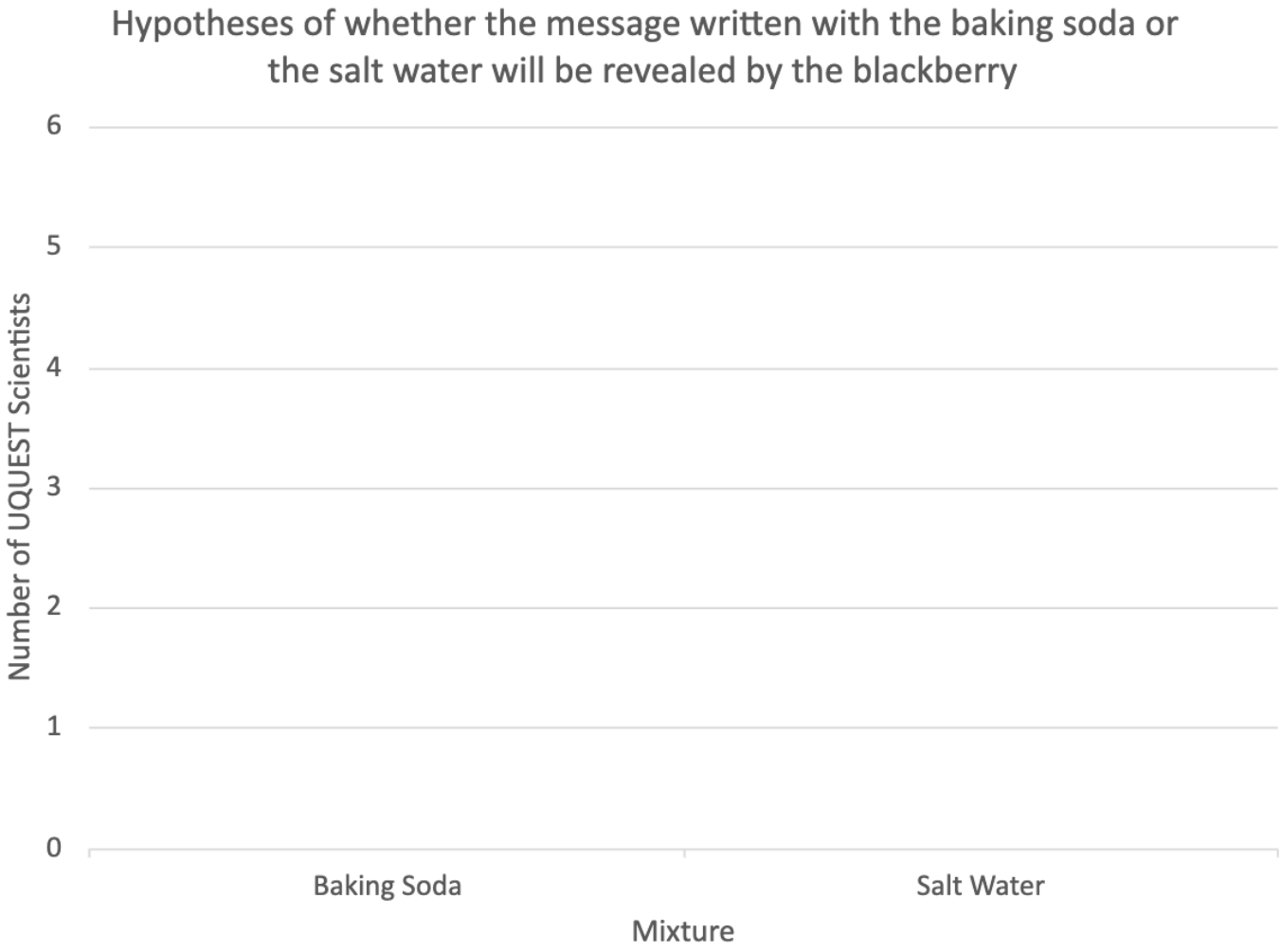
Instructions: Circle whether the message written with the baking soda or the salt water was revealed by the blackberry.

Baking Soda Mixture

Salt Water Mixture

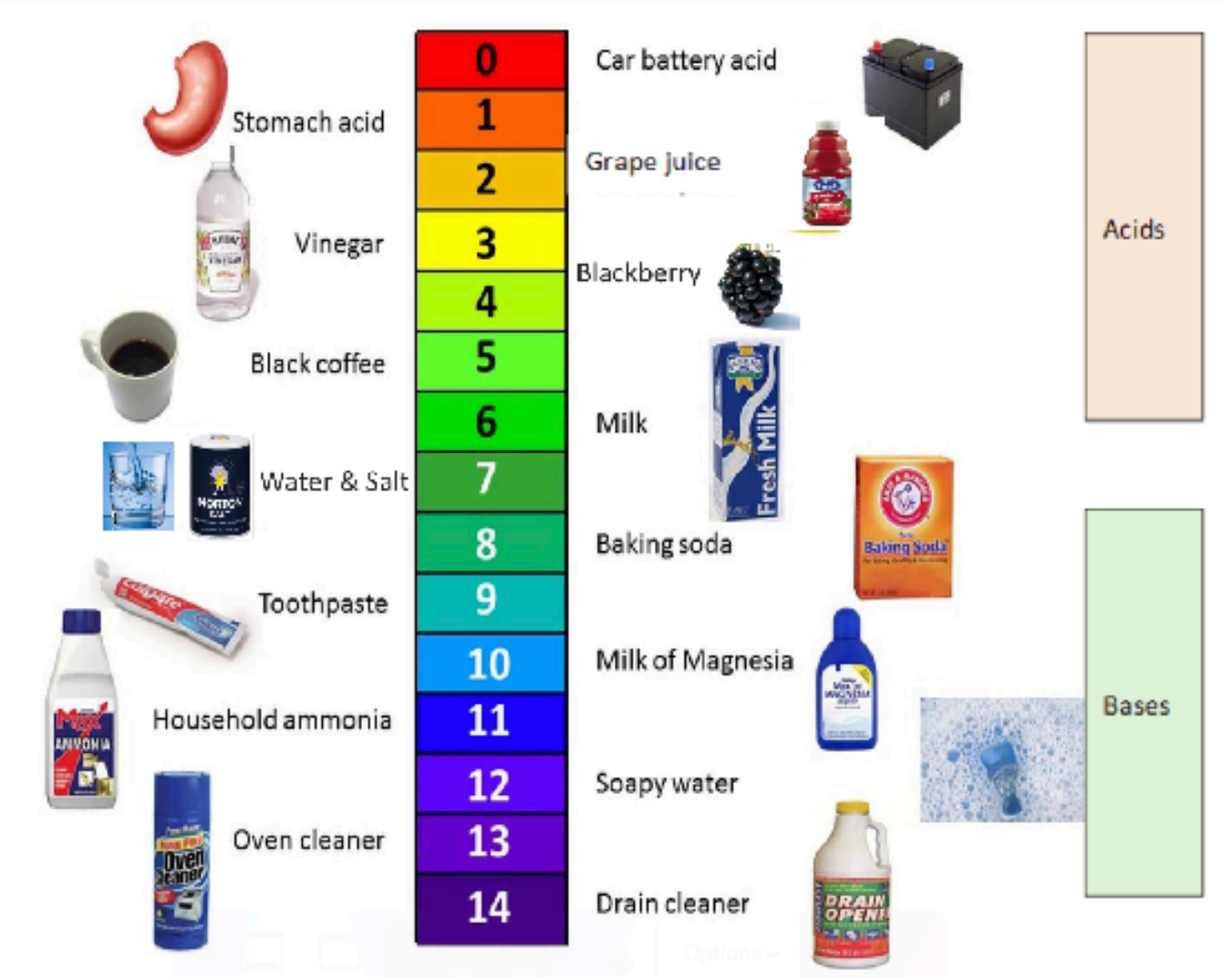
Date: _____

Graphing



Date: _____

pH Scale



Date: _____

Lesson 6

What did I learn today?

_____

_____

_____

I liked this lesson (circle one):

Strongly Agree	Agree	Disagree	Strongly Disagree

Question Game Rules

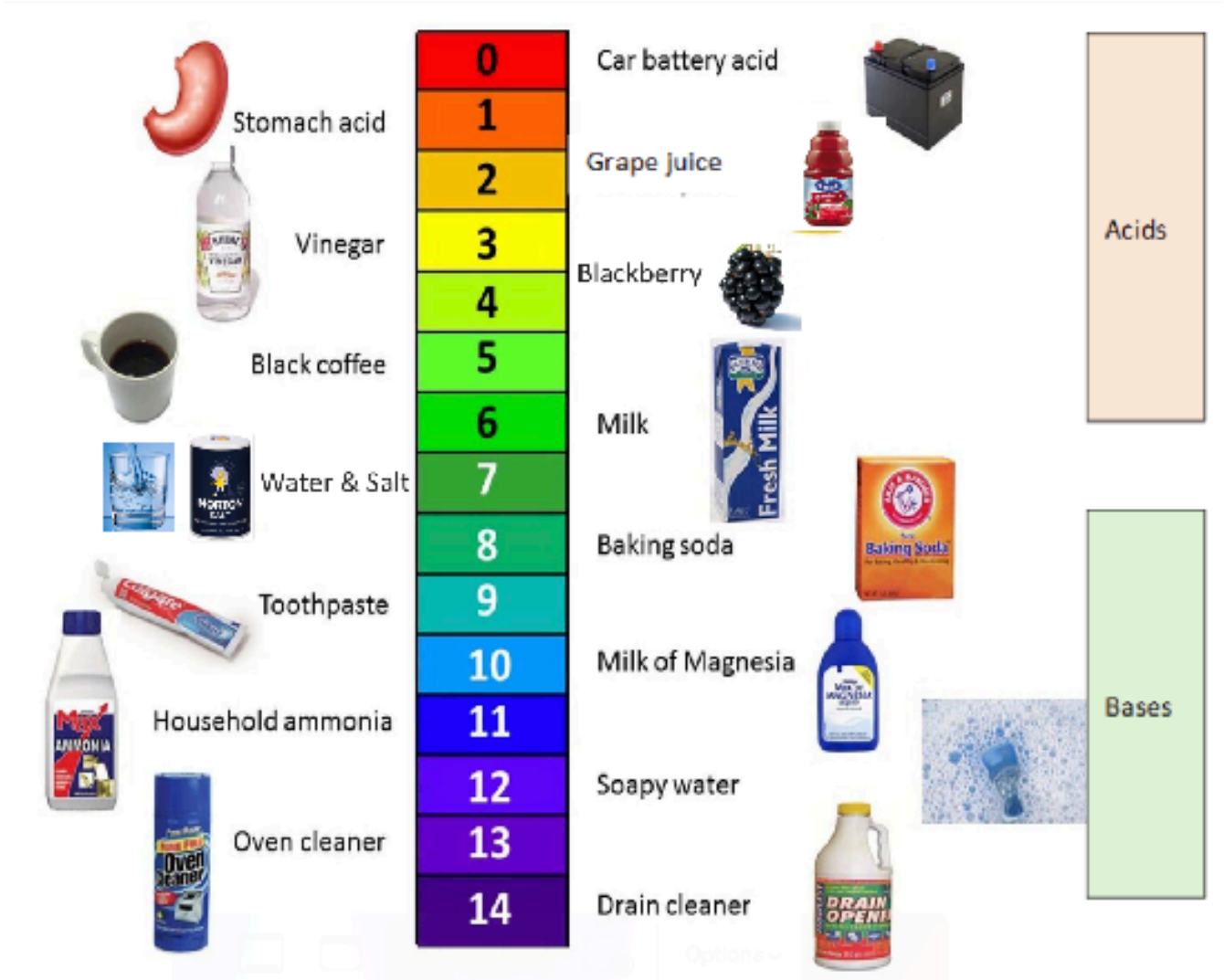
1. Ask many questions about the lesson
2. Do not discuss or answer questions
3. Take turns asking questions
4. Change statements into questions

<u>DON'T FORGET YOUR QUESTION WORDS!</u>

WHO? WHAT? WHERE?

WHEN? WHY? HOW?

pH Scale


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Car battery acid
Stomach acid
Grape juice
Vinegar
Blackberry
Black coffee
Milk
Water & Salt
Baking soda
Toothpaste
Milk of Magnesia
Household ammonia
Soapy water
Oven cleaner
Drain cleaner
Acids
Bases