

# **Rainbow Solutions Module**

## **Team pH**

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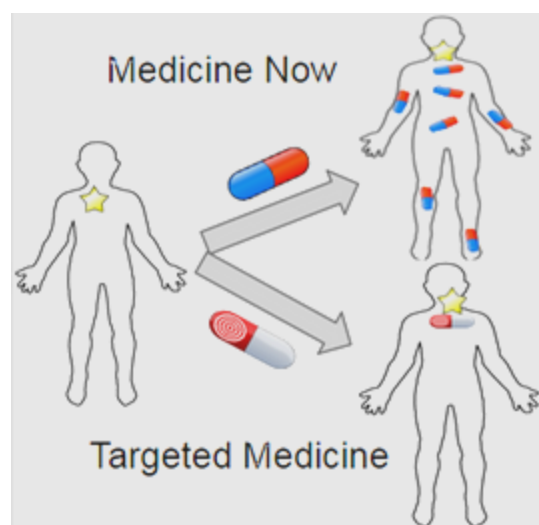
## Rainbow Solutions

### Learning Objectives

By the end of the lesson and experiment, students will have a basic understanding of the meaning and the applications of pH, how medicine works, and how the side effects of today's medicine can be undesirable. The students will also be exposed to laboratory safety and how to apply the scientific method to an experimental question. The students will make predictions and observations, and evaluate those investigations. These learning objectives follow the State of Indiana Science standards for 4th and 5th graders. [1]

### Technical Background

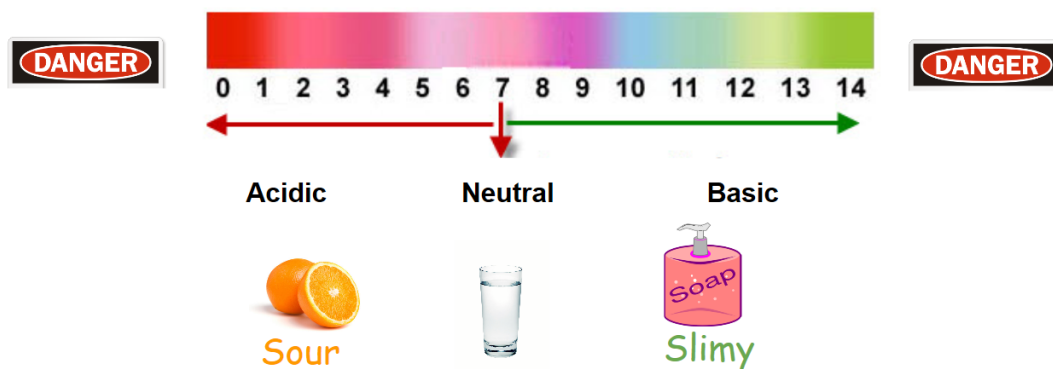
The Grand Challenges of Engineering are a list of the pressing problems that need to be solved in our society. [2] They range from power and energy to computer systems. The Grand Challenge of Engineering Better Medicine addresses the need for targeted medicine. Scientists are using characteristics of diseases and their environments to design medicine that can be localized to the affected area. The challenge is for scientists and engineers to create a device to detect those characteristics and to create medicine that will only work in areas with those characteristics. Currently, most of the medicine that is available for consumption is not targeted. This means that, when a patient takes medicine to treat a specific part of their body (such as a sore throat), the medicine also gets in the blood stream and comes in to contact with most of the rest of the body. (see left) [3] Much of the body is needlessly affected by the medicine and may consequently build up a tolerance to the medicine, which could cause problems in the future. Luckily, there is a simple idea that can be used to help minimize the bad effects that occur when medicine is spread out in the body: pH.



pH is the characteristic of a solution that determines the concentration of protons. This characteristic is used to determine acidity and basicity. Acids and bases are common in everyday life and can be identified by some simple characteristics. Acids are generally sour to the taste and bases have a slimy texture. But, because strong acids and bases are very dangerous, these characteristics are not safe to test on an unknown substance. Thus, scientists use indicators. An indicator is a substance that can be used to determine the pH of a solution, by the color change that occurs when it is mixed

into the environment. A pH scale is used to match colors with their respective pH values, and the pH value is then used to determine if the substance is an acid or a base and how strong it is. Here is an example of the scale used in the original demonstration:

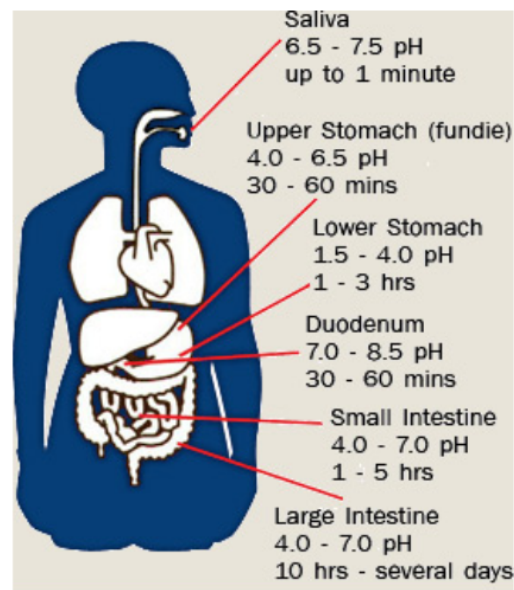
## Red Cabbage pH Scale



[4]

Being able to use an indicator to identify a specific pH is very helpful, especially because indicators work even when there are multiple pH environments.

In the body, there are many different pH environments, as shown in the figure. (see right) [5] This means that pH indicators can be used to target specific areas of the body. For example, when there is an issue with the stomach, current patients generally take oral drugs and wait for them to reach the stomach through digestion. But, using this method, the drugs will also reach the bloodstream and be circulated throughout the body. If this drug is harmful to other parts of the body or can have a tolerance built up to it, there can be many harmful side effects. Now, if the needed drug could have an attachment that only allowed the drug to work in very acidic conditions, the issue is nearly eliminated. By using a type of indicator to target the specific pH of the stomach, the drug can be made to only affect areas with that pH, eliminating the ability of the drug to have those harmful side effects on the rest of the body. Concepts like this can be explained to young students and spark an interest or ideas for how they can be involved in advancing this work.



Getting students interested in the STEM fields (Science, Technology, Engineering, and Mathematics) is one of today's most pressing educational issues. [6] The need for professionals in these career fields is constantly growing because the need of their expertise to solve the growing number of worldwide problems. Thus, it is of utmost importance that students are exposed to these fields of learning at a young age. Increased exposure will lead more students to reach their full potential while also teaching them to work for the greater good. Today's students, boys and girls alike, have the ability to change the world. It is our job as teachers, scientists, and engineers to show them how they can accomplish this and do our part in making the future a better place.

### **Demonstration Materials & Budget**

<b>Materials (Student Demo)</b>	<b>Quantity</b>	<b>Price</b>
Red Cabbages	1	\$2.00
Clear Solo cups	50 cups	\$8.00
Plastic spoons	100 ct	\$3.00
Lemon Juice	1 bottle	\$2.00
Windex®	1 bottle	\$4.00
Milk	1 half-gallon	\$2.00
Soda	1 two-liter	\$2.00
Baking Soda	1 pack	\$1.00
Pitcher	5	\$10.00
Safety Glasses	30	borrowed
<b>Total</b>		<b>\$34.00</b>

## Demonstration Procedure

### Setup - Done by Instructors

#### Cabbage Juice Preparation for 5 sets of experiment (5 groups)

1. Chop one red cabbage in half
2. Chop both red cabbage halves into smaller portions as shown
3. Boil 2 liters of water in a large pot
4. Place chopped red cabbage into the boiling water and continue to boil for 10 minutes
5. Turn off the stove. Let the red cabbage mixture cool.
6. Strain the cabbage and pour the juice into 2 separate containers. Dispose of all the red cabbage solids.
7. Dilute the cabbage juice with water (1:1 ratio of water to cabbage juice) or an amount necessary to achieve the final color shown.
8. Keep the juice refrigerated until use.

#### Sample preparations

1. Obtain the household materials from the list. Only one small container of each should be enough for at least 10 sets of experiment.
2. Label the clear sample cups with letters (A,B,C, etc.). Each letter should correspond to different materials. For example, Mountain Dew is labeled A, Windex in labeled B, etc. until all of the materials are labeled.
3. Pour about half an inch of material into each designated cup. You can adjust the volume of material as you see fit to find the most drastic color change.
4. Divide the students into groups of 2 to 4. Double or triple the setup as needed for more groups.
5. Distribute a set of material samples in the cups to each group.
6. Distribute a container of cabbage juice and a clear plastic cup with a marking at half a cup to each group. This is going to be the cabbage juice measuring cup.



## Conducting Experiment - Done by Students

### **Begin Filling Out The Worksheet** (see Appendix I)

1. Predict whether each material will be an acid or a base
2. Record "Cabbage Juice original color"
3. Fill out the "Sample Letter" and "Material" columns



### **Perform The Experiment**

1. Measure out cabbage juice to the fill line on the measuring cup
2. Pour measured cabbage juice into the first sample cup
3. Mix well with plastic spoon (if necessary)
4. Repeat steps 1-3 for each sample



### **Complete Filling Out The Worksheet**

1. Record each observed sample color in the "Color" column (based on the Red Cabbage pH Scale)

pH	pH less than 7 = Acid			pH more than 7 = Base		
	2	4	6	8	10	12
Colour	Red	Purple	Violet	Blue	Blu-Grn	Grn-Yel

[7]

2. Determine the related pH using the indicator spectrum
3. Record the pH number in the "pH" column

### **Wrap-up**

#### **Reflection**

1. Answer questions at the end of the worksheet
2. Walk around and help answer any questions the students may have
3. Begin open discussion where students can share what they learned

#### **Clean Up**

1. Have each group empty their cups into an appropriate waste container
2. Throw cups and any other trash away into trash receptacle
3. Wipe down surfaces and make sure general area is clean

4. Collect safety glasses
5. Collect writing utensils if distributed

### **Tips and Safety**

The students should be informed of proper lab safety techniques. Safety goggles should be worn at all times and none of the materials should be consumed or directly handled. Paper towels, in case of spills, and writing utensils are recommended as materials provided by the teacher. Instead of students handling the pitchers for pouring the cabbage juice, it is recommended that there are smaller pre-poured containers for the students to measure from. If there is a lesser number of students than expected, each student can complete more of their own experiment with more adult supervision. If there are more than two students per group, colored stickers or labels can be used to help students effectively rotate jobs within the experiment, so that each student has an active role.

### **Engaging Interest**

Fourth and fifth grade students have a variety of learning needs and have a much shorter attention span than the average college student. In order to engage all of the students, the demo is made so that the students are doing most of the hands-on work. This will keep the students busy and actively thinking about the material being discussed. The hands-on work will be especially helpful for kinesthetic learners. Visual learners will be intrigued by the color changes and diagrams used for explanation. Auditory learners will be addressed through the verbal explanations and presenter demonstrations that will walk them through the lesson. Our module is a good introduction into basic concepts of chemistry, experimental design, and the Grand Challenges of Engineering. Teachers may also want to have more related lessons to expand on these ideas. We hope that our presentation will promote interest in the future of engineering and science for both students and teachers.

### **Extra Resources Related To STEM**

Team pH demonstration video

<http://youtu.be/1NyVltr7xOk>

Chem4Kids

[http://www.chem4kids.com/files/react\\_acidbase.html](http://www.chem4kids.com/files/react_acidbase.html)

pH Lessons for Teachers

<http://science.lotsoflessons.com/pHscale.html>

Background Description of pH

[http://water.mecc.edu/exam\\_prep/ph.html](http://water.mecc.edu/exam_prep/ph.html)

Top 10 STEM Resources for Educators

<http://www.nea.org/tools/lessons/stem-resources.html>

Video of Demo for Reference

<https://www.youtube.com/watch?v=ujkuW-0cpNw>

### **Sources**

[1] Indiana's Academic Standards for Science

[2] Engineering Better Medicine. (2012). Retrieved January 14, 2015, from

<http://www.engineeringchallenges.org/cms/8996/9129.aspx>

[3] The Spread of Medicine. Designed January 15, 2015 for the demonstration poster.

[4] The pH Scale. Designed January 15, 2015 for the demonstration poster.

[5] pH of the Body. Retrieved January 15, 2015, from

<http://www.quantumleapwellness.com/images/digestive-ph.jpg>

[6] Why STEM Education is Important for Everyone. Retrieved February 8, 2015, from

<https://www.sciencepioneers.org/parents/why-stem-is-important-to-everyone>

[7] Red Cabbage Color Indicator Chart. Retrieved January 15, 2015, from

<http://4.bp.blogspot.com/-UJOL0fv8WIM/TzgVaLpNecl/AAAAAAAAAo8/LhKlu87FZ1Y/s640/red+cabbage+indicator.jpg>



## Appendix I

## Rainbow Solutions – pH of Acids and Bases

Predict whether you think these materials will be an acid or a base.

Windex \_\_\_\_\_

Lemon Juice \_\_\_\_\_

Milk \_\_\_\_\_

Baking Soda \_\_\_\_\_

Soda \_\_\_\_\_

Procedure:

1. Pour the cabbage juice to the line on the measuring cup
2. Pour measured cabbage juice into first sample cup
3. Record observations
4. Repeat steps 1-3 with each sample

Observations:

Cabbage Juice original color \_\_\_\_\_

## Red Cabbage Indicator Colour Chart

pH	pH less than 7 = Acid			pH more than 7 = Base		
	2	4	6	8	10	12
Colour	Red	Purple	Violet	Blue	Blu-Grn	Grn-Yel

Sample Letter	Material	Color	pH

### Conclusions

1. Based on the pH results you observed, which materials were acids and which materials were bases?

2. Explain how your experimental observations compare to your predictions.

3. If you are given a clear, colorless liquid, explain how you would safely determine whether it is an acid or a base. What safety precautions would you follow?