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|  | **Activity 1 – What’s the Right Dose?** |  |

**Teacher Instructions**

Instructions for this activity can be found here: <https://www.pbs.org/wgbh/nova/teachers/activities/2805_cancer.html>

This activity simulates a clinical trial to determine the “right” dose of a substance. The students are put into groups and each group tests adding different amount of a salt solution to a sample of liver. The liver sample is then transferred to a test tube and treated with hydrogen peroxide. A balloon is placed over the test tube with the liver and hydrogen peroxide. The balloon catches any gas that is produced. The more gas produced, the less effective the liver sample is in deactivating and eliminating the toxic hydrogen peroxide. Questions are asked to prompt the students to form conclusions from the observation and analysis of the data.

**Objective**

After this activity, students should be able to determine the toxicity of salt to an intracellular liver process using a dose response curve.

**Materials**

* copy of "What's the Right Dose?" student handout
* dropper bottle of .17 fluid ounce (5 ml) of liver cell homogenate
* dropper bottle of .17 fluid ounce (5 ml) of 2 percent salt solution
* test tube and test tube rack
* spot plate
* balloons
* watch showing seconds plastic pipette
* graduated cylinder (.34-.85 fluid ounces; 10-25 ml)
* 1.0-1.35 fluid ounces (30-40 ml) of 3 percent hydrogen peroxide
* safety glasses

**Procedure from:** <https://www.pbs.org/wgbh/nova/teachers/activities/2805_cancer.html>



1. Gather the materials listed above and in **Materials Preparation** below.
2. Organize students into teams of two and provide each team with a copy of What's the Right Dose? activity page and a set of materials.
3. Explain to students that they will be determining how different salt concentrations affect the liver's ability to break down toxic hydrogen peroxide.
4. Students will conduct the experiment three times. Discuss with them why it is important to conduct more than one trial at each dose and report the average. Remind students to note sources of error as they conduct each trial. Assign one group to do the experiment as the control group, i.e., the liver cells that get no dosages of salt.
5. Assign each team a number of drops to experiment with, from 0 (control group) to 12. Have students begin, allowing a full four minutes for the salt to "act" upon the liver cells. When they are ready, students can start their three trials using the instructions on the student activity page.
6. Once students have recorded their results, have them determine the average of the three trials. Include each team's average on a class data table indicating: Team, Dosage of Salt (# of drops), and Average Response Time (# of seconds).
7. Have students graph the data by putting Dosage of Salt (# of drops) on the X-axis and Degree of Inhibition (# of seconds) on the Y-axis. You can establish degree of inhibition values together as a class or use the Sample Test Results values in the [Activity Answer](https://www.pbs.org/wgbh/nova/teachers/activities/2805_cancer.html#answer).
8. To complete the lesson, discuss with students the four phases of clinical trials (see [Activity Answer](https://www.pbs.org/wgbh/nova/teachers/activities/2805_cancer.html#answer) for more information).

**Materials Preparation**
Liver cell homogenate: Blend 1/4 pound (113.4 g) of fresh beef liver with 13.5 fluid ounces (400 ml) of water in a blender. If possible, strain homogenate through a cheese cloth. Keep in refrigerator until 20 minutes prior to use. Put into dropper bottles for each team.

2 percent salt solution: Add .07 ounces (2 g) of table salt to 6.8 fluid ounces (200 ml) of tap water. This will yield an approximately 2 percent salt solution. Put into dropper bottles for each team.

3 percent hydrogen peroxide solution: This can be purchased in any pharmacy. Do not use a higher percent hydrogen peroxide solution. Make sure you check the expiration date. Provide 1.7 fluid ounces (50 ml) available to each team.

Balloons: Choosing the right size is critical. If too small, the balloons will fill up too fast; if too big, they will fill up too slowly.



Clinical trials are used to determine the efficacy and safety of new drugs or treatments. According to National Institutes of Health, there are four phases in clinical trials:

**Phase I:** The drug is tested on humans for first time, usually on between 20 and 80 people. Researchers begin to evaluate the drug's overall safety, its safe dosage range, and any side effects it produces.

**Phase II:** In this phase, the drug is further evaluated with testing on a larger group of people (100 to 300).

**Phase III:** The drug is administered to large groups of people (1,000 to 3,000) to confirm its effectiveness, monitor its side effects, and compare it to commonly used treatments.

**Phase IV:** After the drug has been marketed, testing is continued to monitor how the drug reacts in various populations and determine the consequences of long-term use.

This activity models part of a Phase I clinical trial—investigating safe dosages. Students plot and use a dose response curve to determine the toxicity of salt on an intracellular liver process. The role of healthy liver cells is to deactivate and eliminate a wide variety of toxic molecules in the body, including hydrogen peroxide—H2O2—which can damage cells and tissues. Since hydrogen peroxide is broken down into two harmless substances, water and oxygen, the rate at which oxygen gas is produced can reveal whether liver cells are functioning normally. Salt inhibits the ability of liver cells to change hydrogen peroxide into water and oxygen.

Breaking down hydrogen peroxide into water and oxygen is a two-step process. During this process, free radicals are formed, which have the ability to create havoc within the cell. If the liver is unable to deactivate and eliminate hydrogen peroxide, cells and body tissues may be harmed or poisoned, and thus be unable to carry out their vital cell processes.

**Sample Test Results**



**Student or Group Name:**  **Date:**

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|  | **Activity 1-****What’s the Right Dose?**  |   |

From: <https://www.pbs.org/wgbh/nova/teachers/activities/2805_cancer.html>

When developing new medicines and cancer treatments, researchers must first determine important properties of the drugs at certain doses, including efficacy, toxicity level, the biological effects in cells, and the drugs' side effects. Only in this way can scientists determine which dose will maximize the desired effect while causing the fewest side effects. In this activity, you will determine a dose response curve for the effect of salt on a vital intracellular process in liver cells.

**Procedure**

1. Copy down this data table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial #** | **Drops of LiverCell Homogenate** | **Dosage of Salt(# of drops)** | **Response Time(# of seconds)** |
| 1 | 15 drops |   |   |
| 2 | 15 drops |   |   |
| 3 | 15 drops |   |   |

1. Add 15 drops of liver cell homogenate to three different wells in the spot plate. You will be conducting three dosage trials and determining their average.
2. Add the prescribed dose (# of drops) of salt solution that has been assigned by your teacher to each well.
3. Wait four minutes for the salt to "act" on the liver cells. While waiting, prepare a test tube with .34 fluid ounces (10 ml) of 3 percent hydrogen peroxide. Prepare your balloon and decide who will be the time-keeper.
4. Begin Trial #1: Use a pipette to add 3 drops of the liver cell/salt mixture directly to the hydrogen peroxide. Immediately place the balloon on the test tube and start tracking time. Avoid shaking or tapping the test tube because this will release too many oxygen gas bubbles too quickly and bias the readings.



1. When the balloon is filled with enough oxygen gas, it will stand up straight. Stop the watch and record the time.
2. Repeat the above procedure for Trials #2 and #3. Make sure you use .34 fluid ounces (10 ml) of fresh hydrogen peroxide each time and that you squeeze any gas out of the balloon.
3. Average your results for the three trials and provide this figure for the class data table.

**Questions**
Write your answers on a separate sheet of paper.

1. According to the graph, what does salt do to intracellular processes in liver cells? Explain your reasoning.
2. What might happen to cells and tissues of the body if the liver is unable to deactivate and eliminate hydrogen peroxide?
3. Based on the class data table, what do you think are acceptable doses of salt? What doses do you think might be too toxic? Why?

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|  | **Activity 2 –** **Kidney Filtering** |  |

**Teacher Instructions**

This activity can be found on: <https://www.teachengineering.org/activities/view/cub_human_lesson08_activity1>

Students filter different substances through a plastic window screen, different sized hardware cloth and poultry netting. Their models show how the thickness of a filter in the kidney is imperative in determining what is filtered out and what stays in the blood stream.

This includes a very detailed activity plan with pictures of the set up and pictures of the activity in progress. Answer keys are also provided.

**Objective**

After this activity and accompanying worksheet, students should be able to:

* Explain the role of the kidney as a filtering system for blood.
* Describe the by-products of the excretory system.
* Model the filtering function of a kidney on a larger scale.
* Give examples of filters designed by engineers, such as dialysis machines.

**Materials**

Each group needs:

* 6-inch square pieces of each of the following:
1. plastic window screening
2. hardware cloth (½" mesh)
3. hardware cloth (¼" mesh)
4. hardware cloth (1/8" mesh)
5. poultry netting (1" holes)
* 1-2 sheets of newspaper (to cover desk)
* 2 measuring cups or bowls (about 4 cups each)
* large funnel (large enough to have large pebble flow through the neck)
* ½ cup sand
* ½ cup small pebbles in various sizes from 1/8" to >1"
* ½ cup water
* Filtering System Journal, 4 copies
* Filtering Worksheet, 4 copies

To bind the screens for safety:

* duct tape

Optional materials:

* (optional) round coffee filter
* (optional) 2 tbsp. flour (only needed if using a coffee filter)

**Worksheets and Attachments**

[**Filtering System Journal (pdf)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_journal.pdf)

[**Filtering System Journal (doc)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_journal.doc)

[**Filtering Worksheet (pdf)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_worksheet.pdf)

[**Filtering Worksheet (doc)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_worksheet.doc)

[**Filtering Worksheet Answers (pdf)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_worksheet_answers.pdf)

[**Filtering Worksheet Answers (doc)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_worksheet_answers.doc)

[**Excretory System Overhead (pdf)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_overhead.pdf)

[**Excretory System Overhead (doc)**](https://www.teachengineering.org/content/cub_/activities/cub_human/cub_human_lesson08_activity1_overhead.doc)

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|  | **Activity 3– Kidney Dissection** |  |

**Teacher Instructions**

This activity is a dissection that allows students to examine the structure of a kidney.

**Objective**

After this activity, students should be able to:

* Identify external and internal structures of the kidney

**Materials**

Each group needs:

* A copy of the student activity sheet for each student
* Beef or sheep kidney fresh from grocery store or preserved from science supply store
* Goggles
* Gloves
* Apron
* Dissection tray
* Scalpel
* Blunt probe
* Forceps
* Scissors
* Dissecting pins with different colored heads

Note: beef kidneys are lobed, but contain the same internal structures.

**Student or Group Name:**  **Date:**

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|  | **Activity 3-****Kidney Dissection**  |   |

**Safety: Goggles, Gloves, Apron optional**

**Materials: Dissection tray, one sheep kidney, scalpel, blunt probe, forceps, small scissors, several pins with different colored heads.**

**Procedure:**

1. Observe the renal capsule. This structure is made up of dense irregular connective tissue and provides protection as well as helps maintain shape. Remove any adipose tissue that may be attached to the capsule.
2. Locate the hilus. This is an indentation where the ureter and blood vessels enter and exit the kidney. Place a blue pin in the hilus. Remove the excess adipose tissue and locate the renal artery and place a red pin in the artery. Locate the renal vein and place a white pin in the vein. Have instructor check off these structures.
3. Make a frontal structure through the kidney. Locate the cortex, which lies below the cortex and place a yellow pin in the cortex. Locate the medulla and place a red pin in the medulla. Have instructor check off these structures.
4. The medulla consists of numerous conical structures called renal pyramids. The base of each pyramid lies next to the cortex, while the tip forms a renal papilla. Each papilla projects into the renal sinus. Locate the renal pyramid and mark with a red pin, the renal papilla and mark with a white pin, the renal sinus and mark with a green pin. Have your instructor check off these structures.
5. Renal pyramids are separated by bands of tissue called renal columns. Each column begins in the cortex and extends through the medulla. Examine the texture of this tissue. Columns have a granular texture similar to that of the cortex.
6. Each renal pyramid and adjacent cortical region make up a renal lobe. Urine production occurs in the renal lobes. Each renal papilla discharges urine into a cup shaped minor calyx. Four or five minor calyces merge to form a major calyx. Major calyces merge to for the renal pelvis. Using a probe, trace the path of urine from the renal pyramids to the renal pelvis. Have instructor check off this procedure.
7. Examine the renal pelvis. It is formed by a wall of thick fibrous tissue and forms the expanded end of the ureter. Using a scalpel, carefully cut one wall of the ureter and extend the incision into the hilus. The ureter is continuous with the renal pelvis. Observe the fine ridges on the endothelial lining of the ureter and renal pelvis.
8. Once you have observed all structures of the kidney and your instructor has completed your check list you may dispose of your kidney and clean up all equipment and your lab area.

 **Kidney Diagram Drawing**

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| **Check Off List** | Image result for check mark |
| **Renal Sinus****(Hilus)** |  |
| **Ureter** |  |
| **Renal Artery** |  |
| **Renal Vein** |  |
| **Cortex** |  |
| **Medulla** |  |
| **Renal Pyramids** |  |
| **Renal Papilla** |  |
| **Minor Calyx** |  |
| **Major****Calyx** |  |
| **Renal** **Pelvis** |  |
| **Renal Capsule** |  |
| **Renal** **Columns** |  |

**Questions**

1. In the space next to your list, draw a frontal section of a kidney. Label and color code each structure that is on your list.

1. What are the differences between the renal cortex and the renal medulla?
2. Describe the general function of each of the following:
* Kidney:
* Ureter:
* Urinary Bladder
* Urethra
1. Describe the location of the kidneys in the body. (Use landmarks and anatomical directions)
2. What is the structural and functional unit of the kidney?