Homeostasis

Overview

This activity introduces students to the concept of homeostasis by asking them to maintain a system within specified limits in the face of perturbations.

Background

Homeostasis is from the Greek meaning "to stand equal." This term refers to the ability of organisms to maintain constant internal conditions relative to changing external factors. Humans are an amazing amalgam of systems designed to maintain a balance and "keep it between the ditches," so to speak. Commonly known examples of this are body temperature control and the regulation of blood glucose. Mechanistically, homeostasis relies on some receptor that measures a variable. This receptor sends signals (for example, a hormone secreted into the blood stream) to a control center, reporting on the levels of the variable. The control center determines an appropriate response and in turn sends signals (another hormone in the blood) to an effector, which takes the appropriate action. This sets up systems of feed back loops designed to control a variable within certain set points.

Materials

Materials for the whole class

- Water supply
- Hot water
- Cold water
- Standard Colored Solution
- Timer
- Overheads for graphs

Materials for small groups

- 1 plastic cup, 3.5 oz, with label
- 1 plastic cup, 3.5 oz, no label
- 1 color comparator strip
- 2 Styrofoam cups (one for hot and one for cold water)
- 1 plastic dropper with red dye
- 1 plastic cup, 9 oz, for mixing
- 1 digital thermometer
- 1 dump bucket
- 1 syringe
- 1 plastic dropper
- 1 ruler
- Colored pencils

Materials for individual students

- 1 Homeostasis Data Table
- Graph paper

Preparation

- Prepare a class supply of Standard Colored Solution by adding 10 drops of red dye to a half gallon of room temperature water.

Procedure

- Start by explaining to the students that they will be given the challenge of maintaining a cup with colored water in its original condition with regard to volume, color, and temperature in the face of certain perturbations.
- Ask the students to attach the scale sticker on a 3.5 oz cup. Orient the label with the bottom edge of the label (the end with -3 is the bottom) aligned with the bottom ridge of the cup.
- Pass out the Standard Colored Solution to each pair of students. It may save time to have the solution poured into a plain 3.5 oz cup. Ask the students to fill their scale cup with the solution to the 0 mark on the label and to be as exact as possible. Ask them to keep any remaining standard solution in the plain 3.5 oz cup as a control for color.
- Pass out the data collection sheet and the thermometer and walk the students through collecting the starting point data. They may need to practice reading the thermometers. They will need to record these starting values:
    1. The temperature, using the thermometer
    2. The color, using the color comparison chart
    3. The volume, using the label on the cup
- Pass out Styrofoam cups with hot and cold water, dump buckets, an empty 9 oz plastic cup, a syringe, and a color comparator strip. It may be helpful to have these items ready to go on the paper trays that are provided in the kit to ease the hand out procedure.
- Explain that one person will act to disturb the system and record data (Disturber) and the other person will work to get the cup back to its starting values (Maintainer). The Maintainer will have two one-minute work sessions to get the cup back to the original condition. The Disturber will measure and record the data at each minute break.
- The Instructor will be the official timekeeper. The Instructor will also inform the students when to disturb the system and orchestrate refilling of any solutions.
- Start by instructing the Disturber to add <u>20 ml of cold water</u>, using the syringe, to the standard solution cup with the label.
- The disturber should then measure and record these values:
    1. The temperature, using the thermometer
    2. The color, using the color comparison chart
    3. The volume, using the label on the cup
- The Instructor should be sure that everyone has measured and recorded the original data on the data sheet and then call “start.” The Maintainers then go to work to get the cup back to its original values. One rule is that the cup volume is never allowed to go below -3. In other words, the Maintainer is not allowed to dump out the cup and start over.
- The Instructor should count down the last 10 seconds before the1 minute measurement. The Maintainers must stop working at 1 minute, and the Disturbers

should then measure the three values and record them on the data sheet. The Maintainers should not be allowed to start work until the Instructor calls "start" again. This will allow time for refilling of maintenance supplies needed by the Maintainer.

- After another minute the Instructor counts down from 10 seconds and calls time and all work must stop. The Disturber will then gather and record the data on the three parameters again.
- The Instructor will then call on the Disturber to add 20ml of cold water and 1 drop of red dye to the labeled cup. The Disturber should then record the new values of temperature, color, and volume.
- The class then proceeds as before. The Maintainers try to get the cup back to its original values. The Instructor counts down the last 10 seconds before each of the minute readings. The Disturber measures and records the values.
- The third disturbance is to add 4 drops of red dye.
- After the two one-minute work sessions by the Maintainer on this disturbance, there is no fourth treatment, and the Maintainers have an extra minute to work on getting back to the original values.
- Final data are collected, solutions are refilled, and the Disturber and Maintainer trade roles for another round with the same sequence of disturbances.
- After the second run-through, students should graph their data on graph paper (see examples below). Students may need some help with the axes and scale, but it is good to let them work and struggle a bit. It is easiest to start with volume or color. Add 2 "death lines," as shown on the example graphs, running parallel to the x-axis at a value of 1.5 and -1.5. Tell the students that if they were beyond the death line for two consecutive readings, then the system did not maintain homeostasis and their organism died. Ask the students to make graphs for each of the measured parameters using their own data.

Reflection/Discussion

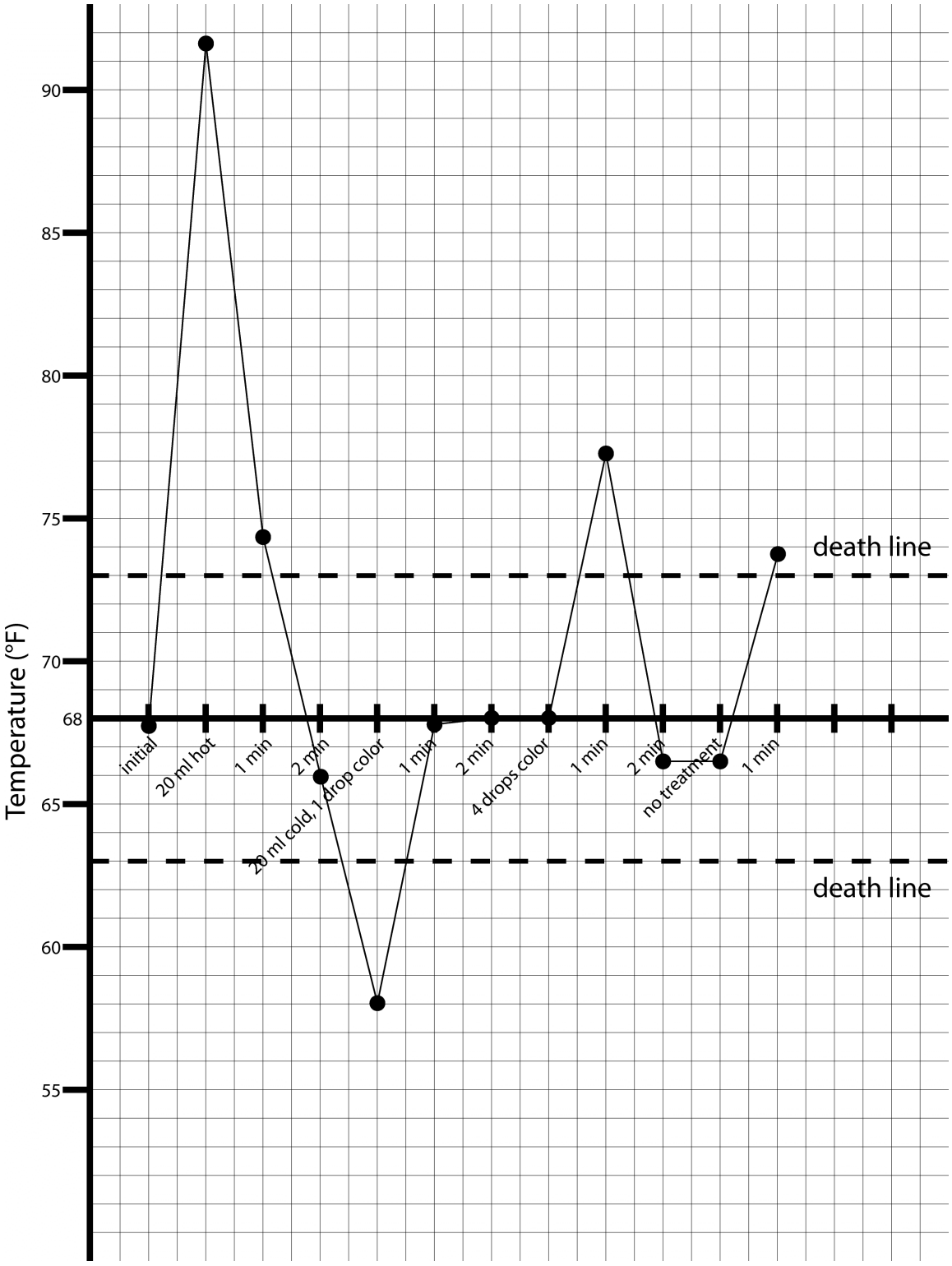
Engage the students in a discussion about the problems they had maintaining homeostasis. How did they know what to do to fix the situation? Ask them to compare this activity to any of the systems in their body that serve to maintain a certain value.

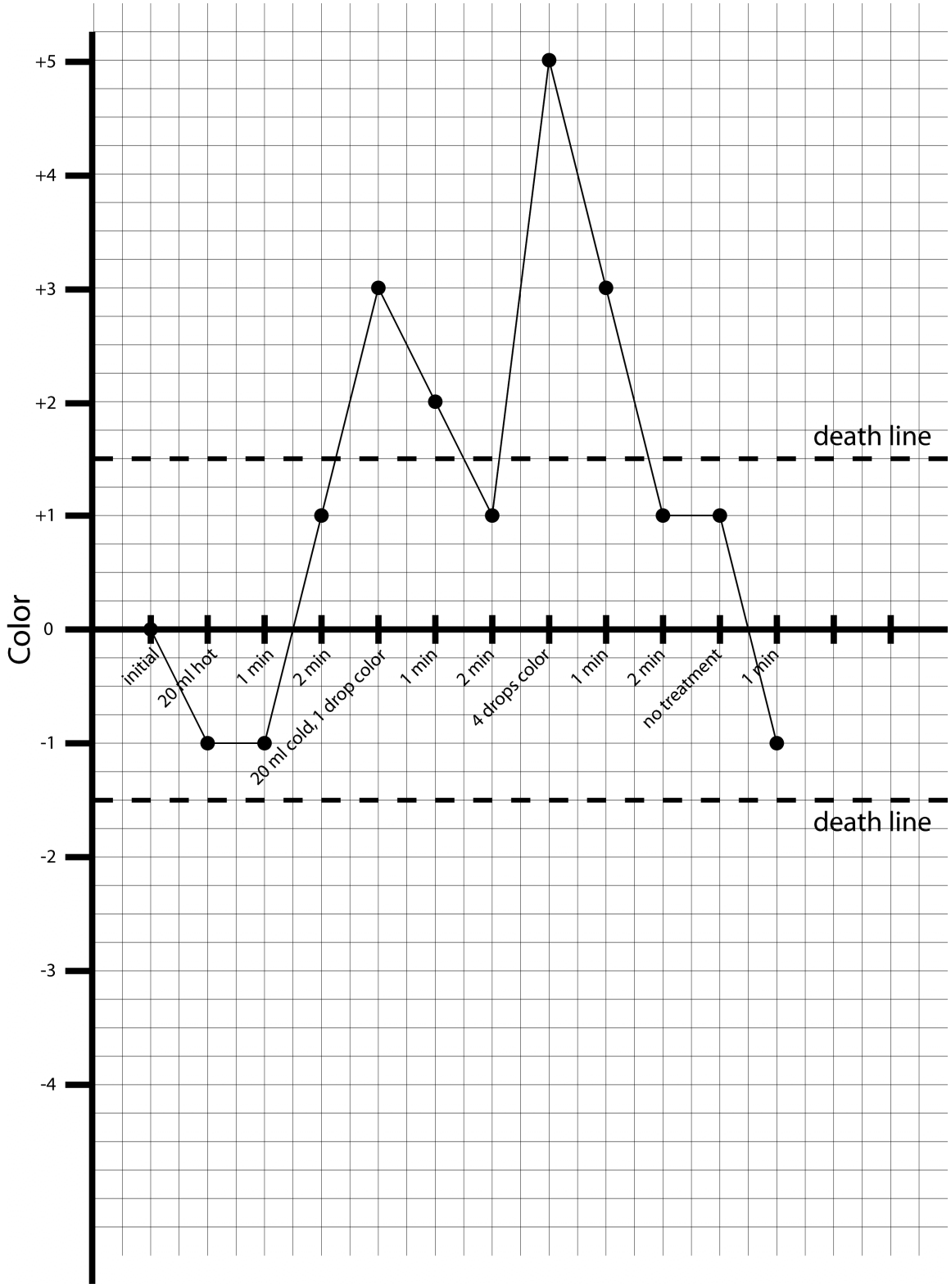
Assessment

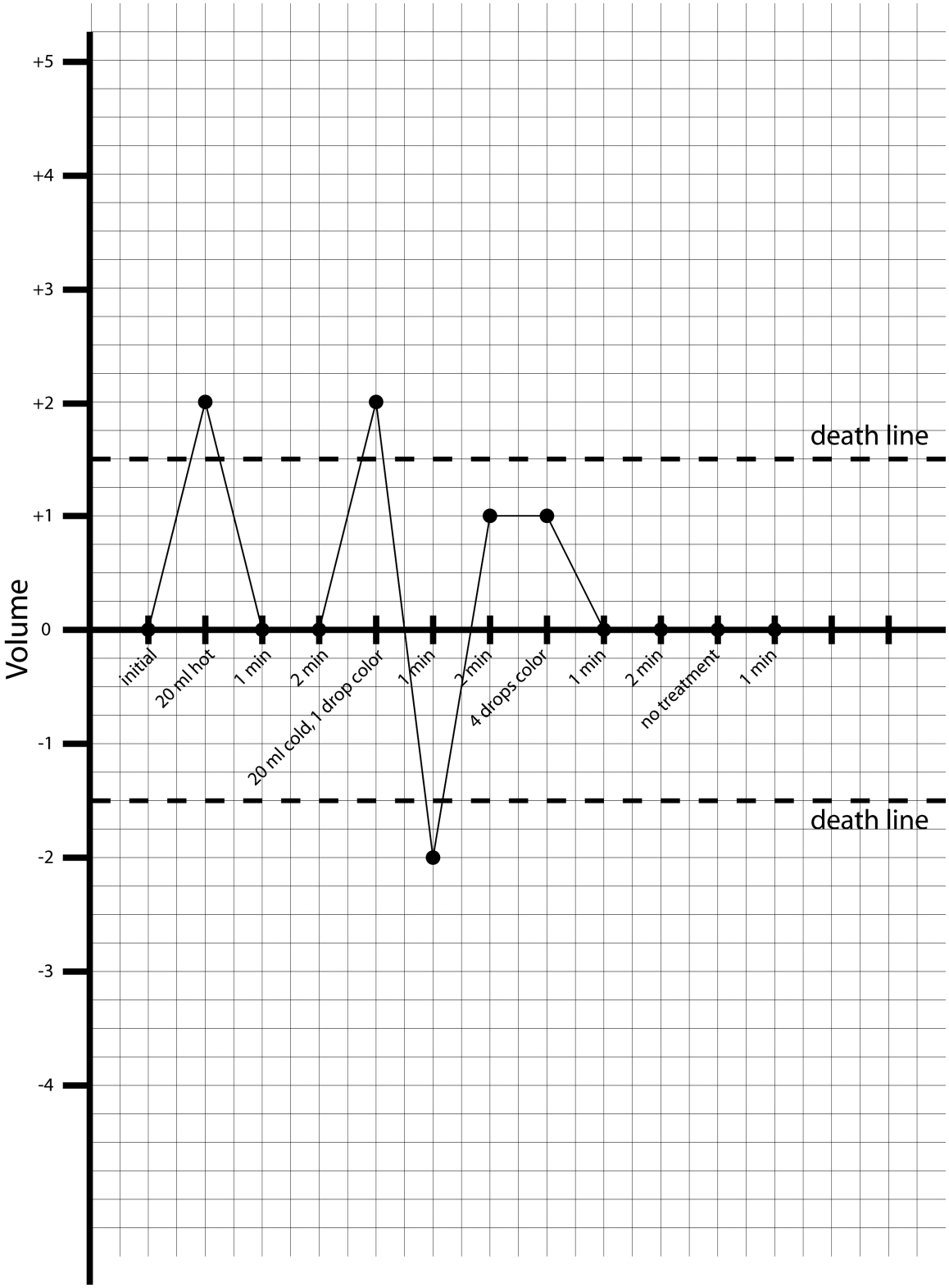
Ask students to describe in detail what the body does to maintain homeostasis when they run 100 yards to catch the bus, hop up the bus stairs, and quickly sit in a seat on a hot summer day in August.

Homeostasis Data Table

Reading	Temperature	Color	Volume
Initial			
20 ml Hot water			
1 minute			
2 minute			
20 ml Cold water **1 drop color**			
1 minute			
2 minute			
4 drops color			
1 minute			
2 minute			
No treatment			
1 minute			


Temperature (°F)
90
85
80
75
70
68
65
60
55
death line
death line
initial
20 ml hot
1 min
2 min
20 ml cold, 1 drop color
1 min
2 min
4 drops color
1 min
2 min
no treatment
1 min


+5
+4
+3
+2
+1
0
-1
-2
-3
-4
Color
death line
death line
initial
20 ml hot
1 min
20 ml cold, 1 drop color
2 min
1 min
2 min
4 drops color
1 min
2 min
no treatment
1 min


Volume
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
death line
death line
initial
20 ml hot
1 min
2 min
20 ml cold, 1 drop color
1 min
2 min
4 drops color
1 min
2 min
no treatment
1 min