Hormone signaling pong

NATURE Sunday Academy

Project Description:

The proposed lesson will examine important endocrinology concepts including hormone signaling and homeostasis and allow students to predict and explore how changes in hormone signaling can lead to pathology.

Project Objectives:

1. Understand components of endocrine communication (e.g., the hormone is released by a gland, travels through the blood and must bind to a hormone receptor in a target tissue to cause a biological action).

2. Predict biological effects when different components of the endocrine system including the hormone and hormone receptor change.

3. Apply these concepts to the example of insulin signaling, glucose regulation, and Type 1 and Type II Diabetes.

Session Organization:

11:00 – 11:30 am

1. Cultural Connection
2. We will begin by using the telephone game to define what a hormone is and to demonstrate that unlike the telephone game, hormones are capable of accurately carrying signals over long distances.
3. Provide students with key terms for insulin signaling and ask them to create a box and arrow diagram using these terms to establish prior knowledge.
4. Provide a brief introduction of endocrine communication.

11:30 am – 12:00 pm

5. Activity 1 - Hormone signaling game I. There will be hormone molecules (orange ping pong balls) and hormone receptors (solo cups), and when they combine, they will cause a biological action (pieces of candy will be transferred from the blood bucket to the cell bucket).

   Round 1: Players will work in teams. The orange ping pong balls will represent hormone molecules. The solo cups will represent the receptors. One student will stand at one end of the table and throw the orange ping pong balls and try to get them to land in the solo cups. Another student will stand at the other end of the table and every time a ping pong ball lands in a solo cup the student will transfer one piece of candy from the blood bucket to the muscle cell bucket). Each team will have at least two students and mid-way through we will pause and ask the students to switch rolls. We will have each group graph the number of candy pieces that they were able to transfer in 5 minutes on the board.

Round 2: Now we will reduce the number of solo cups on the table to simulate a reduction in the number of receptors. We will then have students predict how the results of this round might differ from the previous round. We will again run the activity for 5 minutes and have students graph their new data on the board.

Round 3: Next we will reduce the number of balls that they have to throw to simulate a reduction in hormone production. We will then have the students predict how the results of this round might differ from the previous rounds. We will then run the game for 5 minutes and have them graph their new data on the board.

We will then bring everyone together for a group discussion about how changes in hormone levels and receptor densities impacts endocrine signaling.

12:00- 12:45 pm Lunch

1:00 – 1:45 pm

6. Activity II – At the beginning of this session, half of the students will use the glucose test strips and record their data. The other half of the students will wait and use the test strips at the end of Activity IV (see below).
7. We will now provide a brief introduction to insulin signaling. Then we will ask the students to reflect on the game we played and identify which aspects of insulin signaling the different game elements represent (i.e., the ping pong thrower in the pancreas cells, the ping pong balls are insulin molecules, the solo cups are insulin receptors, the candy is glucose, and the bucket is liver cells).
8. We will then ask the students to look at the box and arrow diagrams they constructed and the beginning of the lesson and modify them according to their new understanding.
9. Students will then make a prediction about the glucose test strip results collected at the beginning and end of Activity II.
10. Students will then compare the results of the glucose test strips collected at the beginning and end of Activity II and discuss the whether the results match their predictions.

11. Activity III - Students will work in small groups on a medical case study to determine whether the patient has Type 1 or Type 2 Diabetes.
12. Brief discussion of Diabetes Type 1 and Type 2.
13. Students work together in groups.

1:45 – 2:30 pm

14. Activity IV - Hormone signaling game II. Blood sugar levels must be carefully regulated within the body, and this is done by two hormones, insulin takes the glucose out of the blood and puts it into cells so that it can be used. But if you have not eaten for a while blood sugar levels can also

get too low and another hormone, glucagon helps to pull glucose out of storage. (Discussion 10 mins).

15. We will briefly discuss how insulin and glucagon work together to regulate blood glucose levels.

16. Round 1: We will now create teams with at least 4 people per team. One person will throw orange ping pong balls (insulin) into red solo cups (insulin receptors). The other person will stand at the opposite end of the table and throw white ping pong balls (glucagon) into clear solo cups (glucagon receptors). A third person will stand in the middle. Every time an orange ping pong ball lands in a red solo cup, this person will transfer one piece of candy from the blood bucket into the liver cell bucket and every time a white ping pong ball lands in a clear cup, this person will transfer a piece of candy from the liver cell bucket into the blood bucket. The blood bucket will be marked with an acceptable glucose line. The fourth person will monitor the blood bucket and each time the candy gets above or below this line, the person will make a tick and tell the people to either speed up or slow down. Midway through we will ask the students to switch roles.

17. We will discuss how the two hormones work together to maintain homeostasis.

18. Now we will stop to introduce scenarios that would alter blood glucose levels, go for a run, now move 10 candies from the blood bucket to the muscle bucket, eat a large meal, move 10 candies into the blood bucket, etc. Ask the mediator (central nervous system) what we need to do to bring glucose levels back to an acceptable level in the blood.

19. Ask the students to add terms for glucagon signaling to their box arrow diagrams.

20. Ask the students to make predictions about blood glucose levels for a normal mouse, a diabetic mouse, and a house sparrow. Discuss hypotheses for why birds might have very high blood glucose levels but are not diabetic.

2:30-3:00 pm

21. Closing discussion, including generating ideas for how to maintain good blood sugar levels.

ND State Science Standards:

MS-LS1-1, MS-LS1-2, MS-LS1-3, MS-LS1-7, HS -LS1-2, and HS-LS1-3.

Materials and Equipment:

All materials necessary for the lessons will be provided by the visiting faculty. We will use ping pong balls (two colors), solo cups (two colors), ice cream buckets, paper, pencils, glucose test strips, and dry erase markers, and data sheets.