HOW TO DO IT

Easy, Cheap, & Fun: Role-play on Endocrine Regulation & Negative Feedback

NABT BioClub RECOMMENDATION

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ABSTRACT

This simple role-play exercise involves the whole class in learning about the function of hormones in promoting homeostasis and the value of negative feedback, using the example of regulation of calcium ions by parathyroid hormone.

Key Words: *Endocrine; role-play; negative feedback.*

Active involvement promotes learning and retention (Michael & Modell, 2003; Cherney, 2008). A major goal for promoting students' engagement in their studies is to foster actively collaborative learning (Zepke & Leach, 2010). This role-play activity is flexible enough to involve everyone in classes of different sizes, promotes cooperation among students, and provides them with opportunities to observe, interpret evidence, and form and test their predictions. I have used simple role-play exercises in teaching anatomy and physiology for many years (Hudson, 2003), and students and colleagues consistently tell me that these exercises help in learning and are fun. Students refer directly to this exercise in review sessions or on exams when describing actions of parathyroid hormone or how negative feedback works. In this exercise, some students play the role of drops of blood carrying ions and hormone molecules, and others play the roles of different organs that participate in use and regulation of calcium in the body. You can adapt the exercise in a variety of ways to suit yourself and your class. The objective is to illustrate the value of regulation within normal limits, the role of hormone in regulation, and negative feedback. The hormone used is parathormone (parathyroid hormone), and the substance regulated is calcium ion concentration in the blood.

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Materials

- Small squares of paper with "Ca^{++}" written on them to symbolize calcium ions
- Poker chips to symbolize hormone molecules
- Signs (Kidney, Bone, Small intestine) to hang on the wall or around the neck of the person playing the role, and a badge saying "Parathyroid gland" for that person
  - One side of the small intestine sign says "Dairy products and broccoli on board, calcium available," and the other side says "Sorry, no calcium available at this time. Check back later."
  - The sign at the kidney says "I'm just doing my balancing act."
  - One side of the sign at the bone says "I'm building bone, so give me calcium." Other side: "Calcium bank. Short-term loans available."
- 3 × 5 cards with job descriptions for bone, kidney, small intestine, and parathyroid
- Concentrated (~50 g/500 mL water) aqueous solutions of calcium chloride and potassium phosphate (K_2HPO_4) in labeled clear bottles
- Four clear 50-mL or 100-mL beakers or glasses
- One person each to play the four organs and 15 or more to be drops of blood

People playing the kidney, bone, and small intestine take their places in the room, at sides or back. I give them each their sign and a 3 × 5 card outlining their duties (described below). People playing the blood are each given a calcium ion and count off by 3's, remembering their numbers. They line up around the room so that they can follow each other single file past the organs. For the first two rounds of circulation, the parathyroid gland is omitted. Figure 1 shows the general layout in the rooms I use.

Trip 1

What can affect the concentration of calcium ions in the blood? Some interactions between the blood and the organs. (We leave the parathyroid gland out for this trip.)

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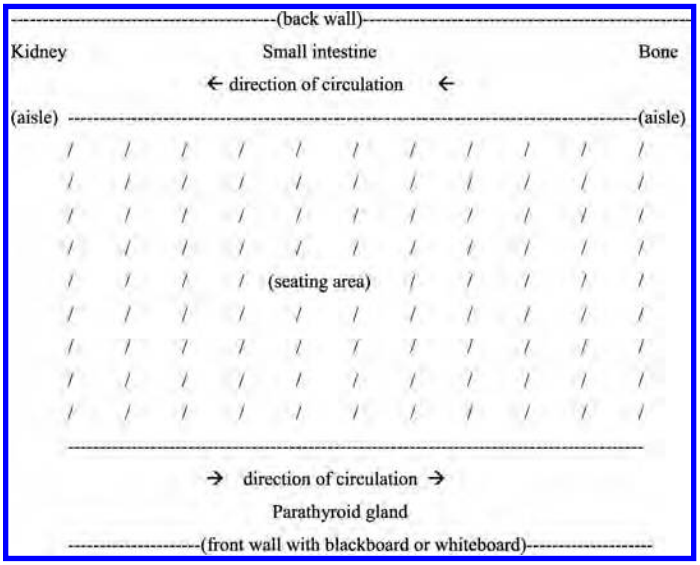

Figure 1. Layout for the activity in the author's classroom.

Give the person at the small intestine some calcium ions (maybe 50 for a class of 24 students), and set the sign to "Dairy products available." Set the bone sign to "Building bone."

Start the blood circulating, and according to what number each person has:

1 – Go to the kidney, where the kidney removes a calcium ion from every other person (calcium being lost in the urine).

2 – Go to the small intestine, where the intestine gives 4–6 calcium ions to each person (calcium being absorbed into the blood).

3 – Go to the bone, where the bone removes a calcium ion from every other person (calcium building bone strength).

I write these on the board so that everyone can see and check if needed:

1 → Kidney

2 → Small intestine

3 → Bone

For each subsequent trip, I just switch the numbers so that the groups visit different organs.

Have the students circulate for two or three rounds. Ask the blood drops to share if a neighbor has no calcium. Ask: How many students have four or more calcium ions? How many have three? Two? One? None? Has the calcium ion concentration increased? Decreased? Stayed the same? (After one round, some students may notice that the blood calcium level is rising, and after two or three rounds it should be obvious to everyone.) Ask the students to predict what would happen to the calcium ion concentration in the blood if they took another trip around the circulation like the one they just took. (Run this to check predictions, if you like.)

Could an increase in blood calcium become a problem?
Demonstration: Pour 20–30 mL of concentrated calcium chloride solution into a beaker or clear glass and ask a nearby student to tell you what the solution looks like. Pour another 20–30 mL of concentrated potassium phosphate solution into another beaker or clear glass and ask another student to tell you what that solution looks like. (They should both look clear, like water.) Ask if they think it would be hard or easy for such solutions to flow through tubes the size of blood capillaries. Then hold up the beakers and pour the two solutions together so they can see what is happening and ask again – How would this flow through narrow tubes? (The solutions when mixed will immediately make a whitish sludge that would be a great part of bone matrix but bad about blocking blood flow.) Pass the beaker around so that everyone can see it.

Conclusion: it would be good to keep the blood calcium ion concentration from getting too high. Could ask: What other problems might result from high blood calcium?

○ Trip 2

What if there is no calcium coming in from the diet?
Start the blood out with one calcium ion per person again.

The small intestine sign says "Sorry, no calcium." The bone sign says "I'm building."

On this trip,

1 → Small intestine, where there is no calcium available from the diet, so that the small intestine person can say "Hi" but can't give calcium.

2 → Bone, where the bone removes a calcium ion from every other person; this calcium ion would go into the bone structure for what? (Ask the students, if they would be expected to know at this point in the course. Answer: to provide hardness and resistance to compression).

3 → Kidney, where the kidney removes a calcium ion from every other person; this calcium would be discarded in the urine.

After this trip, count how many calcium ions are still in circulation. If students are expected to know by this time in the class, ask: What would be some problems if blood calcium concentration drops too low? (slow blood clotting, muscle and nerve irritability)

Conclusion: it would be good to keep the blood calcium ion concentration from getting too low. It looks as if we could be at the mercy of our diet!

○ Trip 3

If different organs may have different needs for calcium ions at different times, and dietary calcium intake isn't steady throughout the day, how can the blood calcium concentration be kept from getting too high or too low?

Now put in the parathyroid gland at the front of the room. Give the poker chips to the person playing this part. Confirm with the "organs" what their job will be now in responding to hormone (I write this on the bottom of their 3 × 5 card), and give them each a handful of calcium ions (maybe 50). Make sure the parathyroid gland knows that his/her job is to keep the blood calcium ion concentration steady at (for this exercise) one calcium ion per "drop" of blood.

Start again with one calcium ion per "drop" of blood, but let's say the person has eaten food with calcium in it ("Calcium available" at the small intestine). The person playing the part of the parathyroid

gland gives every other person in the blood a poker chip (hormone molecule).

On this trip,

1 → Bone, where a hormone (poker chip) can be traded for a calcium ion. If there is no hormone, the bone takes one calcium ion.

2 → Kidney, where if the person presents one calcium ion and one hormone (poker chip), the kidney takes the hormone but does not take the calcium ion. If there is no hormone, the kidney takes away one calcium ion.

3 → Small intestine where a hormone (poker chip) is traded for two calcium ions.

After this trip, have the blood redistribute the calcium evenly and flow past the parathyroid gland, which considers how much calcium each person has. If the homeostatic goal is to have, on average, one calcium ion per "drop" of blood, does the gland need to pass out more, or fewer, hormone molecules for another round of circulation? Do another few trips while the parathyroid gland works to adjust calcium levels under these conditions. Typically the person playing this role feels a little stressed at first and may need some encouragement or coaching, but as she or he keeps working with the blood coming by, there is a moment when this person breaks into a smile and says "I've got it!"

Ask: How does the parathyroid gland know how much hormone to give out? Parathyroid gland, do you need to see what the bone is doing? What the kidney or small intestine is doing? Note: this is negative feedback in action!

Question for the class:

Using this hormone, could we keep the blood calcium concentration normal even if there were no calcium ions coming in from the diet? If so, how? You can run another round of circulation to test whether that might work.

Conclusion

This activity as presented takes about 15 or 20 minutes, depending on questions and student interest in checking hypotheses. Using badges and signs for people with specific jobs and a reference card spelling out their duties helps in recruiting volunteers and helps them to get into their roles. I also coach and encourage the participants particularly as they start out, and lead a good round of applause for everyone when finished. When I presented this activity at the NABT meeting in Atlanta in 2007, people began thinking right away about ways in which they could adapt it for their students. I am always glad to exchange ideas about ways to help students learn.

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