Discussion Leader Activity:

What's in the Box?

Practical application of negative/positive controls and technology

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Created for: D140: How to Read a Science Paper (applicable to any science class that discusses experimental data)

Activity Type: Small group activity

Time Needed in Discussion : 15 minutes *(minimum, 20 minutes if time allows for discussion)*

Purpose

- To engage students in the process of experimentation and demonstrate the use of positive/negative controls and technology
- To give students a common experience that can be referred to later in the course

Abstract

0. Pre-class prep: Distribute sealed boxes	~2 min
1. Prompt students to determine what is in sealed box	2 min
2. Give students negative control (empty box)	2 min
3. Give students positive controls (bag of possible items)	5 min
4. Give students "advance technology" (magnet)	2 min
5. Open sealed boxes and discuss what the students learned from activity	4 min
Total in class time	15 min

Supplies

- Box set (1 set/ group of 2-4 students):
    - 1 empty box (have found microscope slide boxes work best)
    - 1 tape-sealed box with 1-3 items inside
    - 1 bag of possible items

      Suggested items:
        - 1 item that rolls (marble)
        - 1 item that is magnetic (screw/nut)
        - 1 item that can damper/hinder movement of the other items
        - 1 item that can change conformation (binder clip)
        - 2 items of similar sizes/shapes
        - 2 items that can 'interact' (screw+nut)
    - 1 magnet (different strengths)

- *Optional: Prizes for groups that correctly determine item(s) in box*

Pre-class prep

- Place sealed box on desk of each group

In Class

1. (2 min) Prompt students to examine their sealed box and try to guess what is inside the box

Say, "think of the box as a cell, and there is a protein you are trying to identify inside without opening the box.
At this point, the groups will start shaking their boxes to figure out what is inside.

After the groups have tried to guess for ~2 minutes, ask what could help their investigation. Often, a student will ask if they could get an empty box. If no one asks, then suggest it.

2. (2 min) Give students negative (vehicle) control (empty box)

Tell the students to use the empty box as a "negative control" to help determine what is in the sealed box.

At this point, the students will mostly try to see a weight difference between empty box and the sealed box.

Ask if the empty box helps. Ask for a few guesses. Some students will say "marble" or "screw." Then ask if getting these items would help their investigation.

3. (5 min) Give students positive controls (bag of possible items)

Say that you have done background research for possible/known items in the box and compiled a set of possible "negative controls."

Now, the real experimentation will begin. The groups will start putting the items inside the empty box and compare with sealed box. Walk around and talk with the groups, comment on the various methods used. Some groups will test each box sequentially. Some will do it concurrently.

After ~5 mins of experimentation. Ask students what kind of properties do they think their item/protein has. What can they be made of? A student with a screw with say "metal." Say "how could we test for this." A student will say "magnet" (These are predicted events, if the students do not give these responses, you can say them yourself).

4. (2 min) Give students "advance technology (magnet)

A technology has been developed to investigate the magenetic properties of items in the box.

At this point, the groups will use the magnets to try to see if they can isolate their item in the box. Comment on how if the magnet is weaker, could you get false negatives. If the screw is magnetic, but it is not strong enough to hold the screw in place, you may falsely assume that it is not magnetic.

(Optional 2-5 min additional) scale if available

This can activity can be expanded to include a scale if readily available and time permits. Once given the access to the scale, the students can weight their sealed box, empty box and items. Point out whether they believe the weights will match exactly or do they expect variability. A smart student will point out the lack of tape.

5. (4 min) Open sealed boxes and discuss what the students learned

a. (1 min) Final hypothesis
Say "ok, every group, make your final hypothesis. Place your guesses in your empty box"

b. (1 min) Open sealed boxes to determine if hypothesis is correct
Say, "now you can open your sealed boxes." Allow for response time (*oh man, I knew it, that's what it was*)

c. (2 min) Discuss what students learned from activity
What worked, what didn't work? Where did they go wrong? What helped?
How does it apply to what they have done in lab, read in papers, examples of empty boxes (vehicles (buffers, water, DMSO, BSA)) – Note time for this portion can be increased to allow for more discussion if time permits.

Things to Ask or Emphasize

All points, if possible and time permits, let the students say with your gentle nudging.

- Real examples of the process and tools used in the activity.
    - Sealed box with mystery item = cell with protein of interest
    - Empty box = just the cell
- How the accuracy of guess what is in the box is increased with each step (that is why you need a negative control, this is what you can learn with a positive control)
- How technology can cause variability in results and generate false negatives (positive result with strong magnent, negative result with weak magnet)
- Interaction of items in the box, proteins in cells, screw/nut together, mesh dampering others, some proteins we discover indirectly rather than directly based on their effect on other proteins.

Comments

- The success of the activity is greatly increased with teacher interaction. It is best done with multiple moderators that can interact with many groups at the same time. Pay attention to variability of methodologies between groups and bring interesting or innovative methods to the attention of the entire class
- This activity is highly flexible and can be modified to emphasize different points. Every time I have done this activity, I have found some other component that can be added to emphasize different points. Different strength magnets can generate false negatives. Different size/type boxes can give different experimental data (studying the same protein in different cells/organisms give conflicting results), protein/protein interactions.