USING BALLOONS TO TEACH IMMUNOLOGY

Purpose

This demonstration is designed to show what an antibody is and how antibodies combine with foreign materials to help eliminate them from the body.

Immunology provides lessons for many of the principals of biology and medicine, as well as chemistry. Students are readily interested in this field because of the common basic knowledge about vaccinations and infectious diseases. Several principals of immunology can be taught in a relatively simple exercise involving active participation using two sets of colored balloons. A beginning lesson of immunology would include the mention of the word "antibody" and that these molecules are made in your body to help protect against infection and eliminate the invading organism. The purpose of this participatory demonstration is to show what antibodies look like and how they combine with foreign materials in order to eliminate them from the body.

Set-Up

The students for which this demonstration is directed can be from elementary to middle to high school; this exercise can also be modified for use in undergraduate classes with additional levels of sophistication. The underlined words are definitions that can be learned through this exercise at higher grade levels; they need not be memorized. As background, however, all students should have been introduced to the immune system at a basic level to understand its function to protect us from infection, for example. They will need to know that antibodies are materials (proteins called "immunoglobulins") that circulate in the blood and are designed to combine with, attack, and eliminate these invading organisms. Depending on the age group, the students should realize that an antibody has the potential to combine with two antigens and that the shape of an antibody molecule is similar to the letter "Y". Students are encouraged to form the letter "Y" with the trunk of their body and hands (students can even be reminded of the Village People's song "YMCA"). The invading organisms **(antigens)** in this demonstration are represented by balloons of two different colors. In this demonstration we will use black and purple balloons to represent different pathogens

Materials

- Gloves – 6 purple, 2 black
- Balloons – 6 purple, 2 black, 1 red
- Garbage bag
- Toothpick/Tack

Demonstration: How Antibodies Work

Three student volunteers are requested to step forward. One is given purple gloves, one is given black gloves, and one has no gloves (or gloves of a different color not matching any of the balloons). Volunteers are asked to show everyone what an antibody molecule looks like. That is, they are to hold their arms out and make the shape of the letter "Y". They are informed that antibody can grab onto (have **affinity** for) certain foreign materials. The "grabbers" are their hands. The teacher then brings out a trash bag full of six purple balloons and two black balloons and literally shakes them out over the students, who are instructed to grab as many balloons as they can. Remember, they are acting as antibody molecules. Depending on the age group, there usually is a flurry of activity in which students try to collect as many different colored balloons as possible. At this point, the instructor examines what has occurred and points out the following:

1) Antibodies can only combine with two antigens since they have a **valence** of two, that is, two combining sites (see next item). Each hand represents a binding site so an antibody can bind only two antigens (balloons). Therefore, all students who are holding more than two balloons (under their arms, between their legs, *etc*.) are instructed to let go of them.

2) Students are reminded that their hands represent the antibody-combining region, and so they must only hold onto the appropriate balloons with their hands. For example, students can be informed that an antibody molecule might also be represented by a lobster with the combining sites represented by the claws. So students may not be holding balloons between legs, under arms, etc.

3) Students are reminded that antibodies have **specificity**. Students holding different colored balloons are then asked whether this is possible. The teacher and/or audience should inform the students that an antibody combines with two antigens, but they are both identical (same color) and must match the color of their gloves. An exchange of balloons can then occur at this point. Therefore, purple gloves match purple balloons and black-black. Have the others drop the balloons. (Volunteers with no gloves will not be able to match any of the balloons.)

4) Note that at this point there are two purple balloons bound and two black balloons bound by antibodies. If you started with six purple balloons there should be four lying on the floor. Point out to the students that in this example there are more pathogens than there are antibodies to neutralize it. What happens to those pathogens? Potentially they could make us sick if they were left unchecked. How will our body deal with those? We need to make more B-cells, and thus antibodies, specific to the purple pathogen. We will learn more about how this works and continue with part two of the demonstration later on in the lesson.

Demonstration: Clonal Expansion

Bring the volunteers with the purple and black gloves back up. Have them bind the two black and two purple balloons. We have learned about Clonal Expansion as a way our body makes more B-cells that produce antibodies specific for a certain invading pathogen. Ask for two new volunteers. Give these volunteers purple gloves. Now ask them to bind antigens. At this point the antibodies will have bound all of the pathogens, thus neutralizing the infection!

But what happens to pathogens? The antibodies have just bound them, not necessarily killed them. Other immune cells in our body recognize antibodies that have bound pathogens. Earlier we learned about neutrophils and macrophages; two cell types that can "eat" or **phagocytose** pathogens and degrade them. Neutrophils can also release toxic molecules that can kill pathogens. In this way, these balloon "invaders" can be eliminated from the body. It is convenient at this point to have a toothpick hidden in the palm of your hand. As theatrically as you may wish to do so, start punching holes in the balloons to show how the body also has components (called complement), which can directly lyse (literally poke holes in) antibody-coated invaders to eventually lead to their destruction and elimination. Also, you can use your trash bag to "capture" the antibody-coated balloons to mimic phagocytosis by macrophages or neutrophils, which destroy the invaders. (This is also a convenient way to recollect the balloons!)

But pathogens can adapt too! By changing their own DNA, antigens displayed by pathogens can change such that our immune system can no longer recognize them. Show the students a red balloon. There is no existing immunity to the red pathogen, which could then replicate. This will become important when we talk about the flu.

Adapted from "Using Balloons to Teach Immunology" demonstration by: David W. Scott, Ph.D.