The Use of Manipulatives for Microbiology and Immunology Students

Resource Type: Curriculum: Classroom

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Abstract

Implementing manipulatives into the classroom to help explain different laboratory testing procedures and their applications can be a useful tool. Using manipulatives is a very time efficient and cost effective method for engaging students in active learning either as an individual activity or a group experience. The use of manipulatives encourages free exploration and discussion in either setting by being a “hands-on” activity for students. At the completion of each manipulatives session, students will be able to review and discuss the principles and procedures, including quality control issues, for selected tests used in microbiological testing.

Activity

Invitation for User Feedback. If you have used the activity and would like to provide feedback, please send an e-mail to MicrobeLibrary@asmusa.org. Feedback can include ideas which complement the activity and new approaches for implementing the activity. Your comments will be added to the activity under a separate section labeled "Feedback." Comments may be edited.

INTRODUCTION

Learning Objectives.
At the completion of each manipulatives session, students will be able to review and discuss the principles and procedures, including quality control issues, for selected tests used in microbiological testing.

Background.
Using manipulatives as a tool for introducing laboratory testing methodologies is **not** intended to replace a traditional laboratory experience. Successful use of the manipulatives requires that students have a basic understanding of antigen-antibody reactions and understand the importance of quality control issues as they learn more about microbiology and laboratory testing.

PROCEDURE

Materials.

- Colored poster board cut into different shapes, add magnets to the backs for display on white boards if appropriate
- Large white sheets of paper for white background, if using manipulatives on a table top, or to write special instructions
- Answer key placed between two sheets of non-see-through paper, stapled on one edge so students can open like a book and compare their completed answer with the correct answer

Student Version.

1. Appropriate lecture material, such as the testing methodologies used in identifying infectious diseases, is delivered in a traditional classroom setting using a PowerPoint presentation, notes on the board, or depictions on an overhead projector. Individual students or groups of students are asked to describe the testing methods that were just presented using manipulatives in their explanation. Students can do this activity either individually, if the class is small, in groups (three to four per group), or as an entire class discussion if the class is very large. This can be done by inviting students to come to the board (if it is magnetized) and arrange the pieces with the help of their peers in the audience or by having groups (three to four) students work together to complete the process. The individual manipulative components used in the testing methodology are selected from an inventory of different manipulative pieces.
2. As a resource, the correct answers are available for students as they work through this process, either directly from the instructor or via a printed sheet with all the correct information. This is dependent upon the size of the class and the number of test methods being discussed.
3. Each student or group of students describes the principle and the procedure of the test during or after they have placed the manipulatives in the correct sequence for the specific test methodology. Students are required to use the correct terminology for the different components of the tests in their verbal explanation. Quality control issues can also be discussed using manipulatives to reinforce the information.
4. Review sessions can be included in subsequent sessions.

Instructor Version.
Class time required for a manipulatives activity involving several methodologies is approximately 30 minutes. Review sessions can be infused in subsequent class sessions and can cover one or more testing methods taking approximately 5 minutes per test.

1. Cut out several manipulatives representing the various components of the testing methodologies and store in a drawer organizer or other type of organizer. Make sure you have many of the more frequently used structures such as antigens and antibodies. This work can be done by students but is **not** a good "fit" for a traditional 50-minute class period. It is also easier to make uniform pieces when just one person is making them.
2. It is important to have adequate manipulatives for students or groups of students. The number of pieces required can be determined by going through the various testing methodologies and determining how many and what kind of pieces are needed. Usually no more than five individual tests are being depicted at any one time if the students are working in groups. In a class of twenty students, the following inventory was adequate for group discussions with three to four students per group: ~70 antibodies (6 inches tall), ~50 antigens (2 inches tall), ~20 enzymes (3 inches tall), ~15 washes (3 inches), and ~15 substrates (3 inches). The specific shapes can be seen in the photographs in the appendices. This inventory was made and stockpiled over one semester by the instructor. If the manipulatives are made from poster board or foam-backed poster board and cut with an Exacto knife, it will take much longer to make them than if they are made out of construction paper. Either paper or poster board shapes can be magnetized by gluing magnets on the back or adding magnetic strips for use on most white boards found in the classroom.
3. After discussing a certain laboratory testing method, such as latex agglutination, in the traditional lecture setting usually in identifying infectious diseases, invite the students to select appropriate manipulatives and explain the principle and the procedure through the use of manipulatives either on a magnetized board or on a tabletop. Make sure the correct answers are available, either directly from the instructor(s) or on a printed sheet with all the correct information, as students work through the process.
4. Encourage students to work in groups and arrange the manipulatives to explain a variety of tests and discuss the quality control needed for each test.
5. Assist students as needed but encourage them to use their critical thinking skills before you help them with the answers.
6. Implementing timed competitive challenges among the groups of students to describe different test methods is a popular way to use manipulatives. The instructor can pick a piece of paper out of a bowl or hat with the name of a testing methodology written on it, announce the name of the test to all of the groups who have equal numbers of manipulatives to use, and start a stop watch. The groups work to correctly describe the methodology using the manipulatives. The winners are then asked to explain the steps to the other groups. Students enjoy these challenges particularly after they have become very familiar with the manipulatives. This is a good way to end a lecture class on a positive note.
7. Make sure the correct answers are nearby for students to compare their results. As they progress and become comfortable with the manipulatives, the correct answers can be depicted on a sheet of paper and placed between two other sheets of paper so students cannot see the answer as they are working. Stapling the one edge and having them open the correct answer like a book is a good way to accomplish this. This is an excellent resource for review at different times during the semester or from one semester to another.

ASSESSMENT and OUTCOMES

Suggestions for Assessment.

1. Exam questions can cover the test methods that were discussed by the students during the manipulatives exercises.
2. The instructor can use manipulatives to design a test methodology with an error and then challenge students to identify the error and correct it. More than one of these can be included on an exam or made available for extra-credit points throughout the semester.

Field Testing.
Undergraduate students in a medical microbiology class (75 minutes) were given the assignment of constructing different manipulatives and then depicting laboratory testing methods. Each testing method had been discussed in class before the assignment was given. The students were divided into groups of three and were allowed to use their books. Each group completed their specific assignment and then explained it to their peers. The groups were then reconfigured to allow for diversity in the knowledge of the various testing methods. They were then given problems to solve using the manipulatives to help explain their answers. Students in the new groups were also challenged with one quality control issue for a specific test method and asked to solve the problem.

Student Data.
Data is taken from standard classroom evaluations received at the end of the semester.

- Students found that using manipulatives to identify testing methods was a positive experience, as indicated on 75% of the student evaluations for the junior-level medical microbiology course.
- Students were able to solve problem scenarios without asssistance from the instructor 80% of the time.
- Students were able to correctly answer exam questions which had been reinforced by manipulative demonstrations over 80% of the time.
- Students enjoyed the timed challenges and working in teams to answer the questions using manipulatives.
- Manipulatives can be helpful in bridging a gap for students that struggle with theory and need to see a more visual example before the laboratory experience.
- Students interacted with their classmates during the manipulatives exercises.

SUPPLEMENTARY MATERIALS

Possible Modifications.

1. Construction paper and regular poster board **do not withstand the test of time**. Foam-backed poster board is very durable and an excellent choice if the manipulatives are to be used frequently. An Exacto knife cuts the thicker

foam-back poster board without any problems.
2. Limit the number of test methods to the major ones used in the microbiology laboratory. Too many choices tend to confuse students especially in the beginning. Build from the simplest such as precipitation and continue to the more complex, as the students become more familiar with the process. Students can become overwhelmed by too much information disseminated too quickly.
3. Continually review the students' work and make sure the correct answers are available for the students to review. It is easy for students to make an error and not detect it or pass it on to another student when they are discussing the different testing methods. This is especially true for students who attend study groups outside of class.
4. Student participation in constructing the manipulatives can be very time consuming and many times the product is not acceptable for more than one use. It is more time efficient for the instructor and/or graduate assistants to actually construct the manipulatives.

References.

1. **Angelo, T. A., and K. P. Cross.** 1993. Classroom assessment techniques. Jossey-Bass, San Francisco, Calif.
2. **Hentzen, A. E.** 2000. Manipulatives help teach molecular diagnostic concepts. Lab. Med. **31**(9)**:**513–517.
3. **Levinson, W., and E. Jawetz.** 2002. Medical microbiology and immunology: examination and board review, 6th ed., p. 384–393. McGraw-Hill, New York, N.Y.
4. **Stevens, C. D.** 1996. Basic immunologic procedures, p.109-158. *In* Clinical immunology and serology. F. A. Davis Company, Philadelphia, Pa.

Appendices.

Examples of some of the manipulatives designed and implemented in the classroom experience are provided. In the photographs, the manipulative examples have magnets attached and are on a standard white board. The camera flash reflection is not part of the example and should be ignored.

Appendix 1 - Basic Shapes
Appendix 2 - Example of a test method - Enzyme Immunoassay—Direct Method (sandwich)
Appendix 3 - Example of a test method - Noncompetitive Enzyme-Linked Immunosorbent Assay (frequently used method)
Appendix 4 - Example of a test method - Indirect Enzyme Immunoassay (Monoclonal antibody pairs)

Other successful manipulative exercises include:

- Latex agglutination testing
- Fluorescent antibody testing
- Complement fixation testing
- Diffusion testing

Examples of questions:

1. In a precipitation test, explain where the largest amount of precipitate is found, and why this occurs at this point in the process.
2. Explain the difference between the direct enzyme immunoassay and the indirect immunoassay.
3. In the direct enzyme immunoassay, explain the need for the wash phase between each step. If a wash phase was not completed after the first step in the test, explain how that would affect the results of the assay?

Questions can be very simple or more complex depending upon the level of the students and intended outcomes of the course. Repetition of the basic principles throughout the semester reinforces the more complex testing issues.

Curriculum Resources

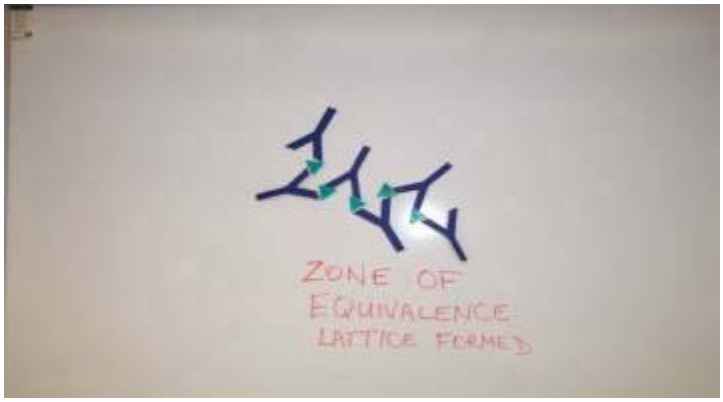
Basic Shapes

These shapes are attached to a standard white board using magnets. Fluorescent (F) and enzyme tags (E) can be added as needed.

Antibodies

Antigens

Prozone reaction. Too many antibodies for precipitation reaction to occur.



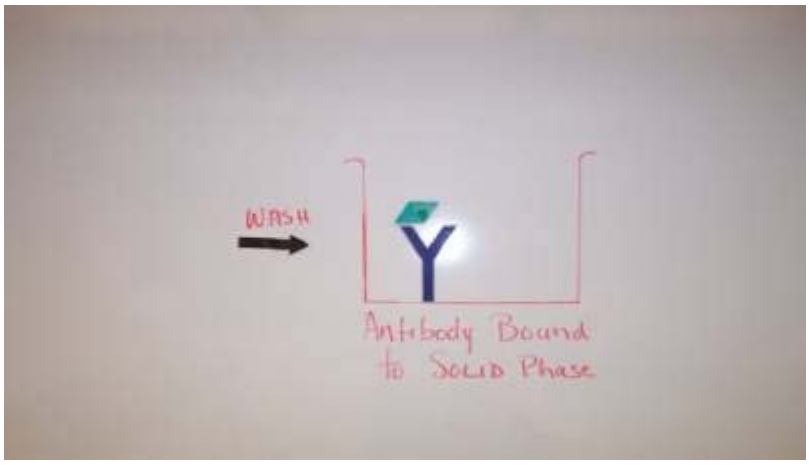
Zone of equivalence. Lattice formed

Post zone reaction. Too much antigen for precipitation to occur.

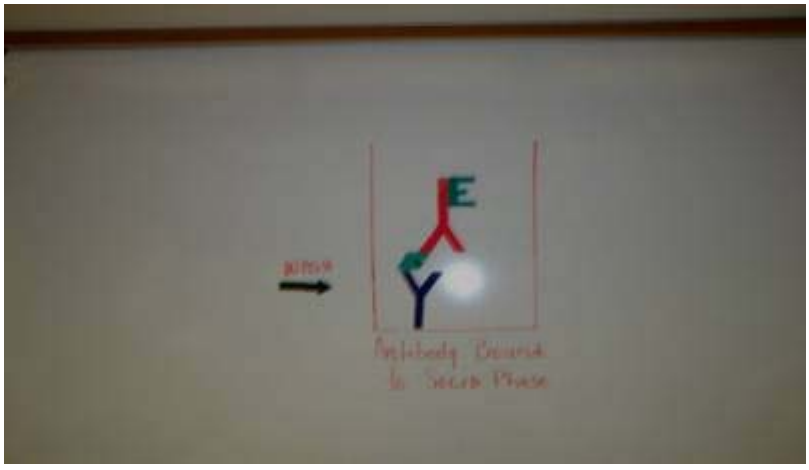
Curriculum Resources

Example of a test method: Enzyme Immunoassay—Direct Method (sandwich)

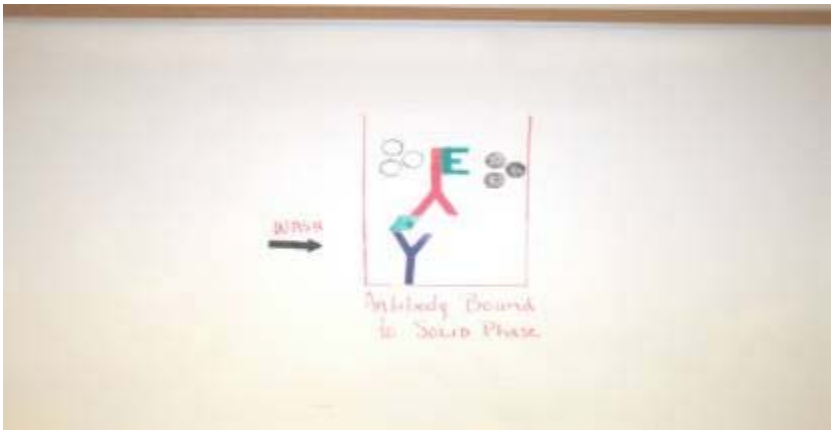
1) Specific antibody bound to solid phase.



2) Each black arrow à indicates wash phase. Antigen attaches to antibody.



3) Each black arrow à indicates wash phase. Enzyme-linked antibody is added. The antigen is "sandwiched" between two antibodies.

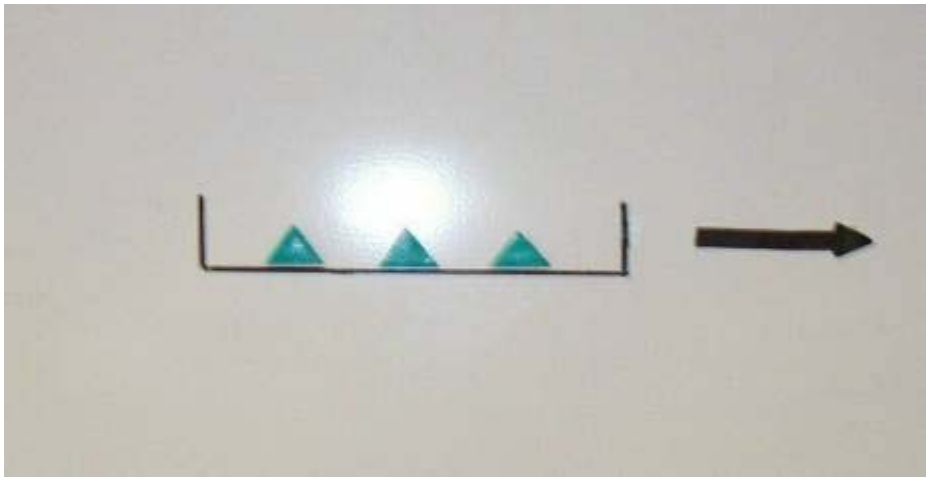


4) Each black arrow à indicates wash phase.

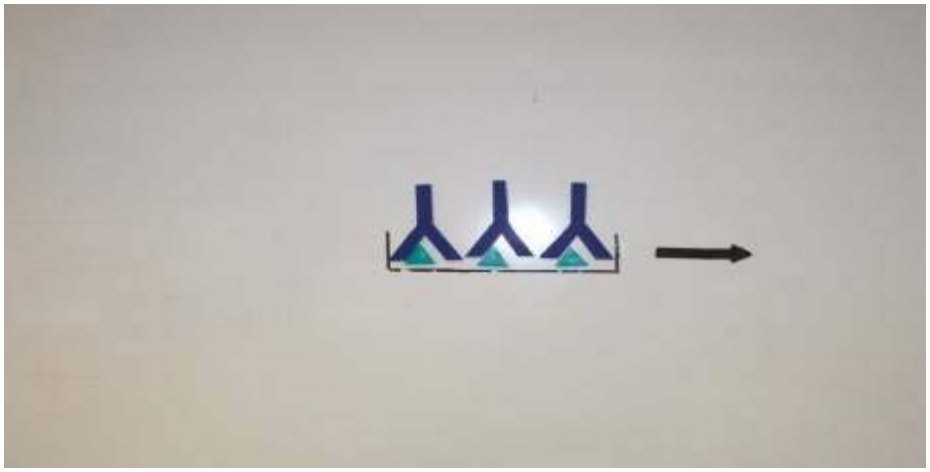
Enzyme substrate added. Before reaction takes place substrate is indicated as "ooo"; after reaction takes place measurable product is indicated as "•••."

Curriculum Resources

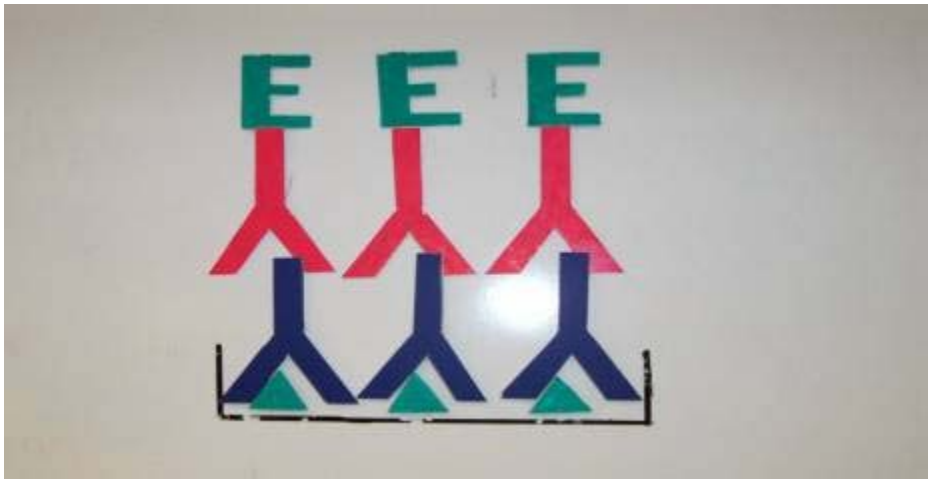
Noncompetitive Enzyme-Linked Immunosorbent Assay (frequently used method)



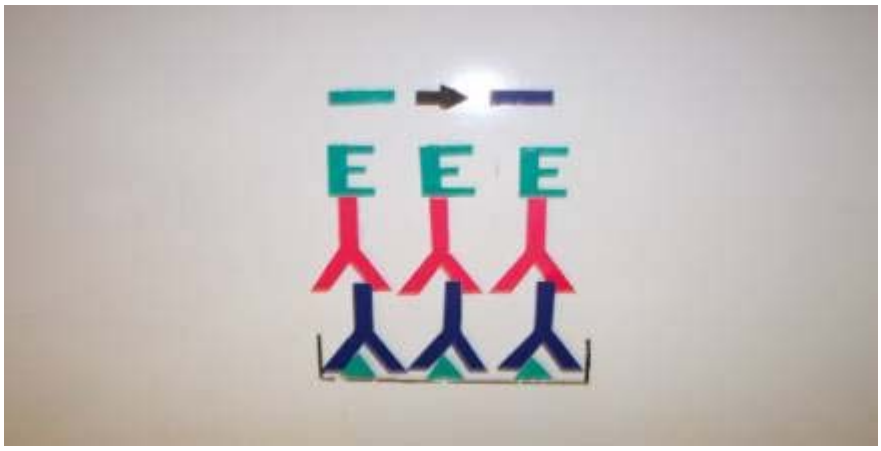
1) Antigen is attached to bottom of polystyrene wellà wash**.**



2) Antibody in patient's serum attaches to antigenà wash**.**



3) Antibody to human IgG (which is enzyme linked) attaches to patient's IgG**.**

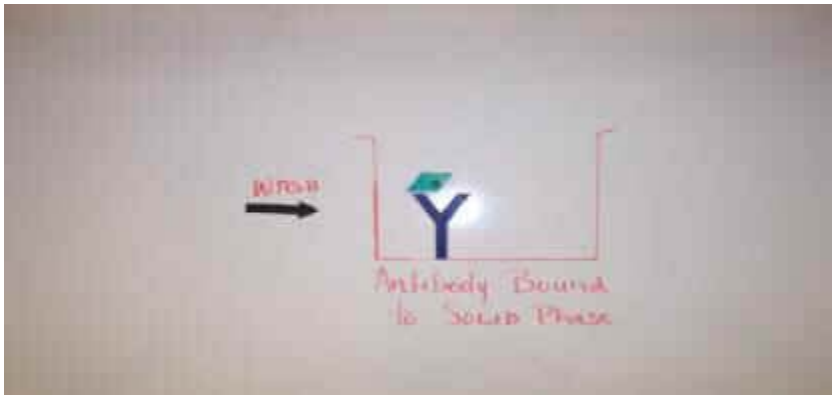


4) Substrate for the enzyme is added with a color change when acted upon by the enzyme—color development is directly proportional to the amount of patient antibody present**.**

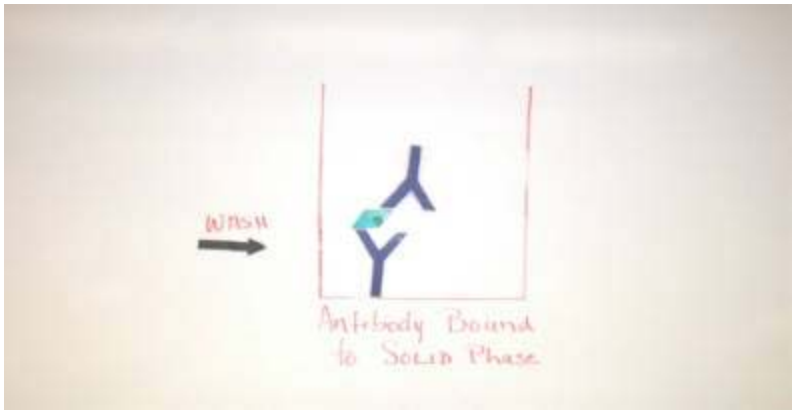
Curriculum Resources

Indirect Enzyme Immunoassay (Monoclonal antibody pairs)

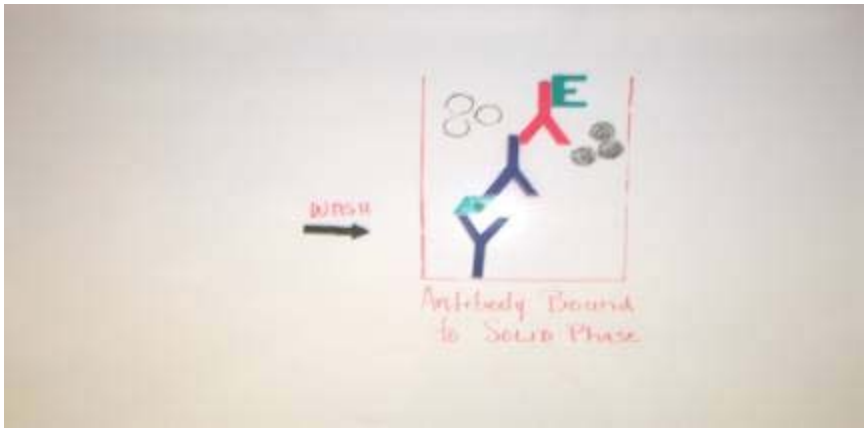
1) Specific antibody bound to solid phase.



2) Each black arrow **à** indicates wash phase. Antigen attaches to antibody.



3) Each black arrowà indicates wash phase. After wash another antibody is added and attaches to another antigenic binding site creating a “sandwich.”



4) Each black arrow à indicates wash phase. Enzyme-linked antibody is added. Enzyme substrate added, before reaction takes place substrate depicted as "ooo." After reaction takes place measurable product is depicted as "•••."