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Chemistry 504: Biochemistry and Molecular Biology

Lesson Plan 2: Antibodies

Grade Level: 11th grade Honors Chemistry Class

Time duration: 60 minutes lesson

Introduction: (5 minutes)

The body is constantly under the threat of invasion by pathogenic organisms such as bacteria and viruses. The immune system is the main protection against this. An impaired immune system due to genetic defects or to infection by the AIDS virus could be lethal. Proteins are the most important class of macromolecules that the immune system responds to. The human body has thousands of proteins differing from foreign proteins only by their amino acid sequence, yet it can distinguish between “self” and foreign proteins, an error could result in an autoimmune disease such as, the weakening of heart valves and insulin-dependent diabetes (1)

There are two protective mechanisms in the immune system; the first is the humoral immunity which involves the production of antibodies (soluble proteins) which combine with the antigens. The second is the cell-mediated immunity, where the cytotoxic or special killer cells recognize and kill abnormal cells.(2)

Antibodies are produced by plasma cells (one type of white cells) when B cells are stimulated. The cytotoxic cells or the T lymphocytes (helper T cells) are produced continuously in bone marrow (or liver in the fetus). The B cells activated by helper T cells multiply and mature into a clone of antibody-secreting B cells known as plasma cells. The immune system is distributed roughly as 30% in the spleen, 20% in the lymph nodes, 40% in the intestinal and mucosal lymphoid tissue, and 10% in the blood and lymph circulation (3)

Students background knowledge:

- The primary, secondary and tertiary structures of proteins
- White blood cells in the blood provide a defense mechanism for the body
- Immunization against certain diseases
- How to construct a concept map

Enduring Understandings:

- The structure and function of the IgG molecule
- The different classes of antibodies and their functions
- How antibody diversity is achieved
- The role of the helper T cells

Lesson Objectives:

By the end of the lesson, the learners should be able to:

- Draw and label a diagram of the immunoglobulin (IgG) molecule
- Describe the functions of the different parts of the IgG
- Name the different classes of antibodies and state their functions
- The mechanisms of immunity-B cells, helper T cells, and the production of antibodies
- How antibody diversity is achieved

Pre-class activity: (10 Minutes)

You may refer to you text book or do a search on the internet

A. List five diseases, against which babies' require immunization.

1. _____
2. _____
3. _____
4. _____
5. _____

B: Refer to your textbooks or use on line sources to define the following key terms:

Key terms:

- Antibodies
- Immunoglobulin
- Heavy chain
- Light chain
- Variable region
- Constant region
- Complimentary-determining region (CDR)
- Antigens
- Epitope
- Humeral immunity
- Cytotoxic
- Plasma cells
- B cells
- T helper cells
- Lymphocytes
- Different classes of antibodies(IgM, IgG, IgA, IgE, IgD)
- Memory cells

Class Notes: (Refer to the power point slide below)- 15 minutes

A) Immunoglobulins are a major class of antibody molecules found circulating in the bloodstream. There are different classes of immunoglobulins, such as IgM, IgA, IgE, and IgD. The immunoglobulin IgG is the one that is produced in the largest amounts.

An IgG antibody molecule is bivalent (see diagram below) the two identical binding sites can bind to the same epitope on separate antigen molecules.

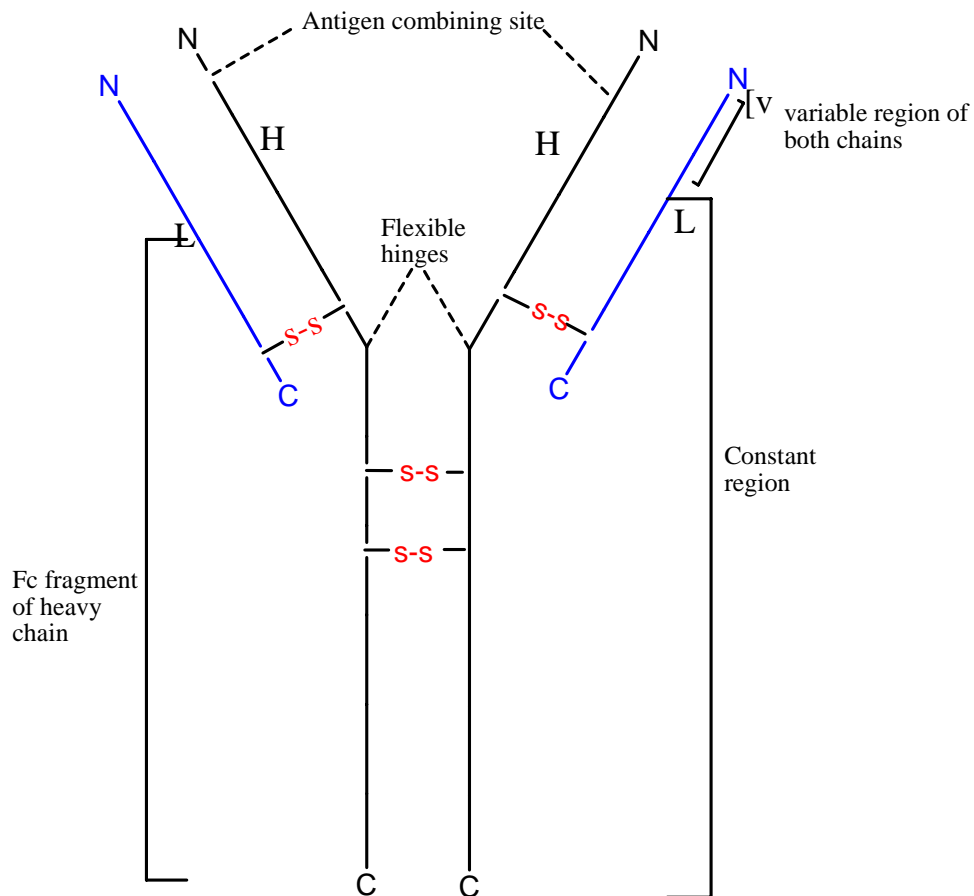
B) Show a power point presentation

Visit the websites below to view molecular pictures of the IgG molecule.

ghr.nlm.nih.gov/handbook/illustrations/igg

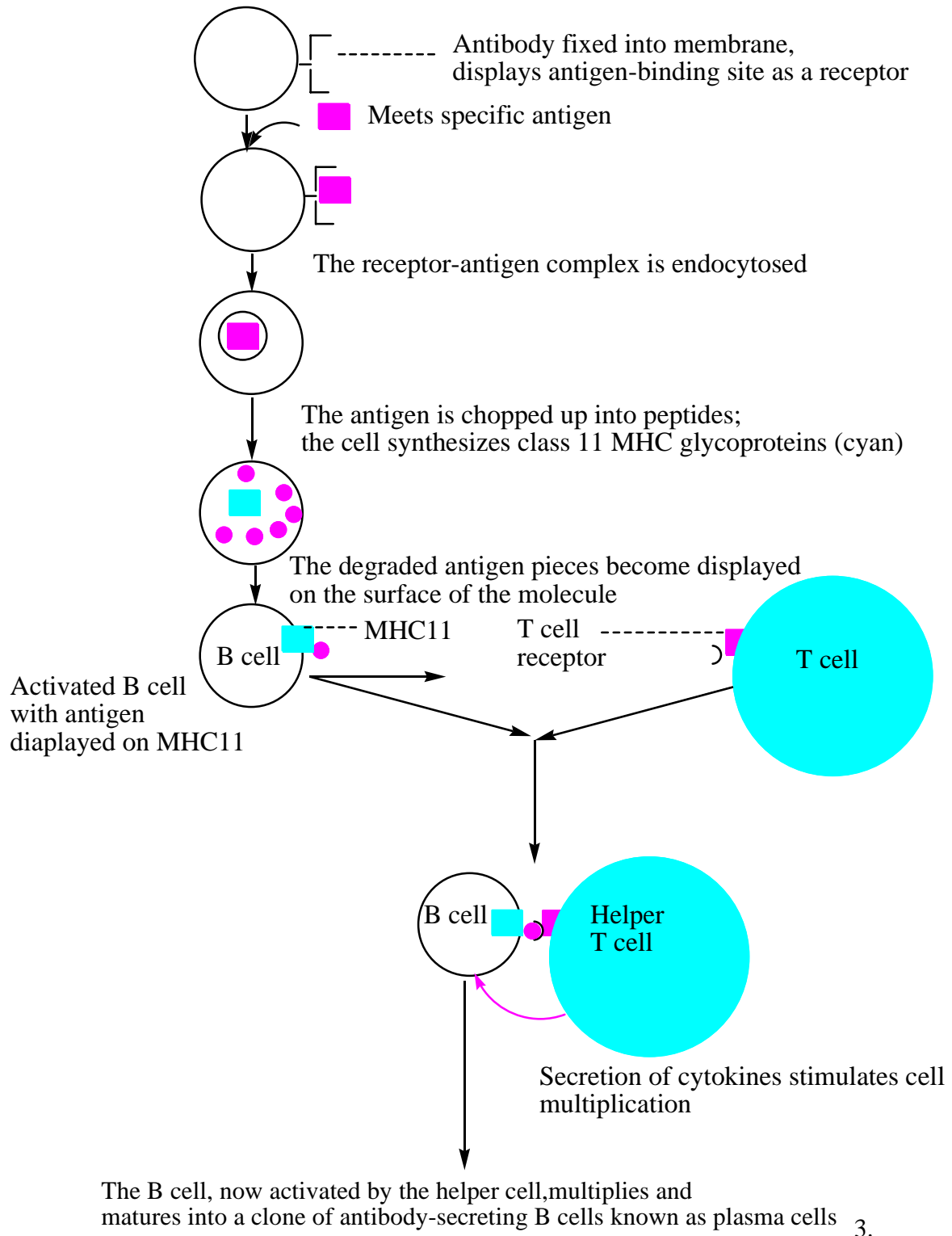
www.alerchek.com/IgG.htm

Structure of Antibodies- The Immunoglobulin molecule (IgG)



An antibody is a naturally occurring protein used by the immune system to identify and neutralize foreign objects. All antibodies share the same basic Y-shaped structure consisting of 2 heavy chains and 2 light chains. Each chain contains constant domains, which identify the antibody as part of a given class, and variable domains, which determine its binding specificity to a given antigen (2)

A schematic diagram showing the function of antibodies and the role of the helper T cells in activating B cells to secrete antibodies (Humeralimmunity)



Group Work: Constructing a concept map on Antibodies

Requirements for each group: (30 minute)

1. Construction paper(different colors)
2. Ruler
3. Pencil
4. Color pens
5. Scissors

Procedure:

1. Work in groups of four's
2. Write all the key terms on the construction papers (you may use different colors)
3. Using your scissors cut out the key terms in any shape you like (circle, oval etc)
4. Organize the key terms into a concept map on antibodies.
Show how the key terms are related to each other. You may use lines, arrows and a few descriptive words. **Concept maps may vary**

Homework:

1. Describe the structure of an IgG Molecule
2. Describe briefly how the IgG molecule works
3. List the different class of Lymphocyte and state function
4. What is an antigen-presenting cell?
5. Briefly, explain the clonal selection theory

Group Activity Worksheet-Concept Map

Name _____ Class _____ Date _____

Group members _____, _____, _____

Answer Key:

Pre-class activity:

List five diseases, against which babies' require immunization.(Any 5 answers)

- Chicken pox
- Diphtheria, tetanus and pertussis
- Measles, mumps and rubella
- Polio
- Haemophilus Type b Influenzae
- Hepatitis B

B: Refer to your textbooks and define the following key terms: (Definitions may vary)

- Antibodies

Molecules in the blood or secretory fluids that tag, destroy, or neutralize bacteria, viruses, or other harmful toxins (see Antigens). They are members of a class of proteins known as immunoglobulins, which are produced and secreted by B lymphocytes in response to stimulation by antigens. An antibody is specific to an antigen. (4)

- Immunoglobulin

Immunoglobulins (antibodies) are proteins produced by plasma cells. They are designed to control the body's immune response by binding to substances in the body that are recognized as foreign antigens (often proteins on the surface of bacteria or viruses.) Antibodies are diverse, with more than 10¹⁰ possible variations, yet each antibody is designed to recognize only a specific antigen.(4)

- Complimentary-determining region (CDR)

The complimentary determining regions (CDR) of the antibody are the sites in closest contact between the antibody and antigen. (4)

- Antigens

An antigen is any substance that stimulates the immune system. Antigens are often foreign substances such as bacteria or viruses that invade the body.(4)

- Epitope

A localized region on the surface of an antigen that is capable of eliciting an immune response and of combining with a specific.(4)

- Humeral immunity

The component of the immune system involving antibodies that are secreted by B cells and circulates as soluble proteins in blood.(4)

- Cytotoxic antibody

This is any specific antibody directed against cellular antigens that, when bound to the antigen, activates the complement pathway or activates killer cells, resulting in cell lysis (death).(4)

- Plasma cells

Any of the antibody-secreting cells found in lymphoid tissue and derived from B cells upon lymphokine stimulation and reaction with a specific antigen. Also called *plasmacyte*(4)

- B cells

B cells are a type of white blood cell (called a b-lymphocyte) that produces antibodies. B cells develop from stem cells in the bone marrow (4)

- T helper cells

T cells are white blood cells, derived from the thymus gland, that participate in a variety of cell-mediated immune reactions. Three fundamentally different types of T cells are recognized(4).

- Lymphocytes

Any of the nearly colorless cells found in the blood, lymph, and lymphoid tissues, constituting approximately 25 percent of white blood cells and including B cells, which function in humoral immunity, and T cells, which function in cellular immunity.

- Memory cells

A cell in the immune system that, when exposed to an invading pathogen, replicates itself and remains in the lymph nodes searching for the same antigen, resulting in a more efficient and rapid response to any subsequent attack(4).

- Different classes of antibodies

I gG- is the most abundant class of antibodies found in blood serum and lymph. **IgG** antibodies work to fight against bacteria, fungi, viruses **etc (4)**

IgM, - Immunoglobulin M is a major class of immunoglobulins. IgM includes the antibodies that are usually produced first in an immune response and are later replaced by other types of antibodies.(4)

IgA,- Immunoglobulin A, a major class of immunoglobulins found in serum and external body secretions such as saliva, tears, and sweat as well as in the gastrointestinal, respiratory, and genitourinary tracts.(4)

IgE,- Immunoglobulin E, a class of immunoglobulins that includes the antibodies elicited by an allergic substance (allergen). A person who has an allergy usually has elevated blood levels of IgE. IgE antibodies attack and engage the invading army of allergens.(4)

IgD

Immunoglobulin D, a class of immunoglobulins found as antibodies on the surface of

B cells (B lymphocytes). Almost nothing is known about the normal function of IgD.(4)

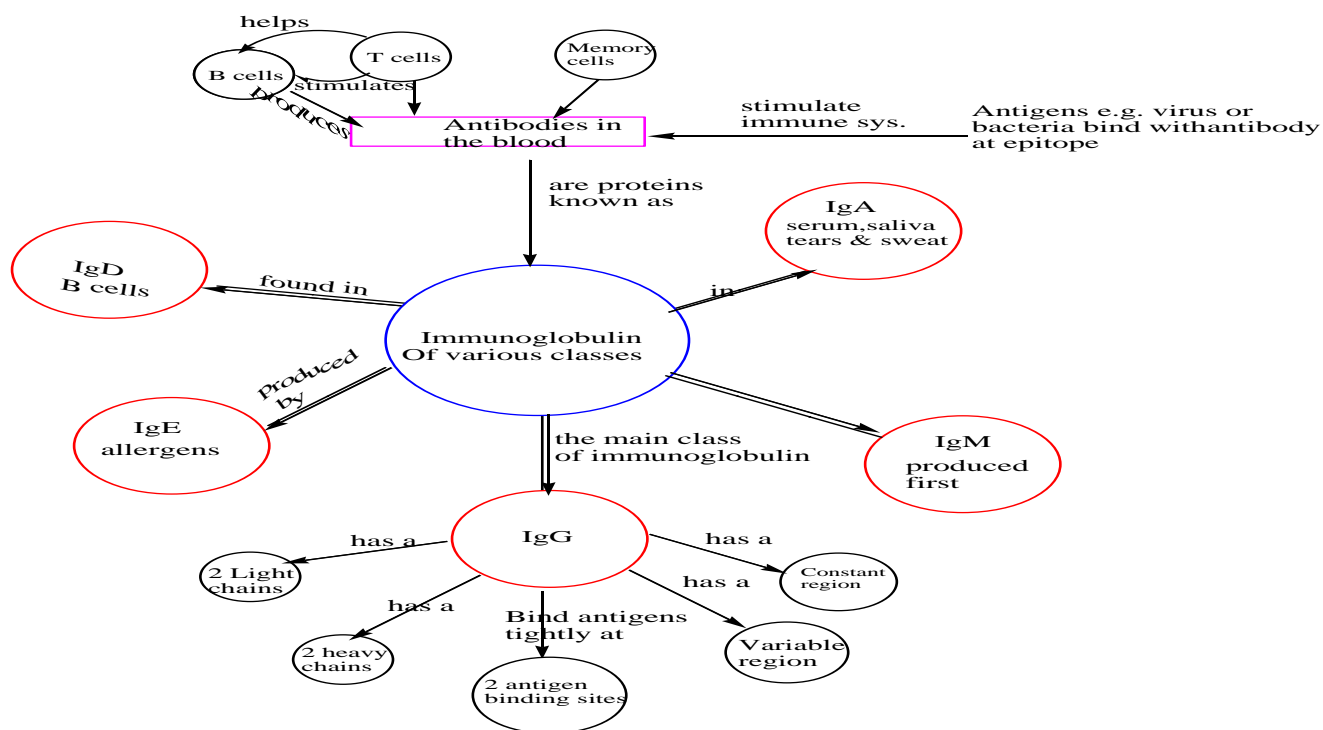
Closure: (5 minutes)

Review the major concepts learned from the concept map activity
each group to hang their concept map on the wall
Answer any questions students may have regarding the homework

Homework:

1. Describe the structure of an IgG Molecule (**Refer to diagram on the slide above**)
2. Describe briefly how the IgG molecule works(**It presents an antibody site that combines to an antigen**)
3. List the different class of Lymphocyte and state function (refer to the definitions of IgM, IgA, IgE,IgD, IgG above
4. What is an antigen-presenting cell?
A cell, originating in the bone marrow and subsequently found as a dendritic cell in various locations, that facilitates the immune response by holding antigens on its surface and presenting them to lymphocytes (4)
5. Briefly, explain the clonal selection theory-
(Immunology) Theory to explain the specificity of the adaptive immune response according to which there is a large pool of lymphocytes, each having genetically predetermined specificity for only one of a vast array of possible antigens. Upon encountering an antigen, the lymphocytes sensitive to it reproduce much more rapidly than the others, thus leading to a build-up of antigen-specific cells large enough to mount the response (4)

Concept Map -On Antibodies



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