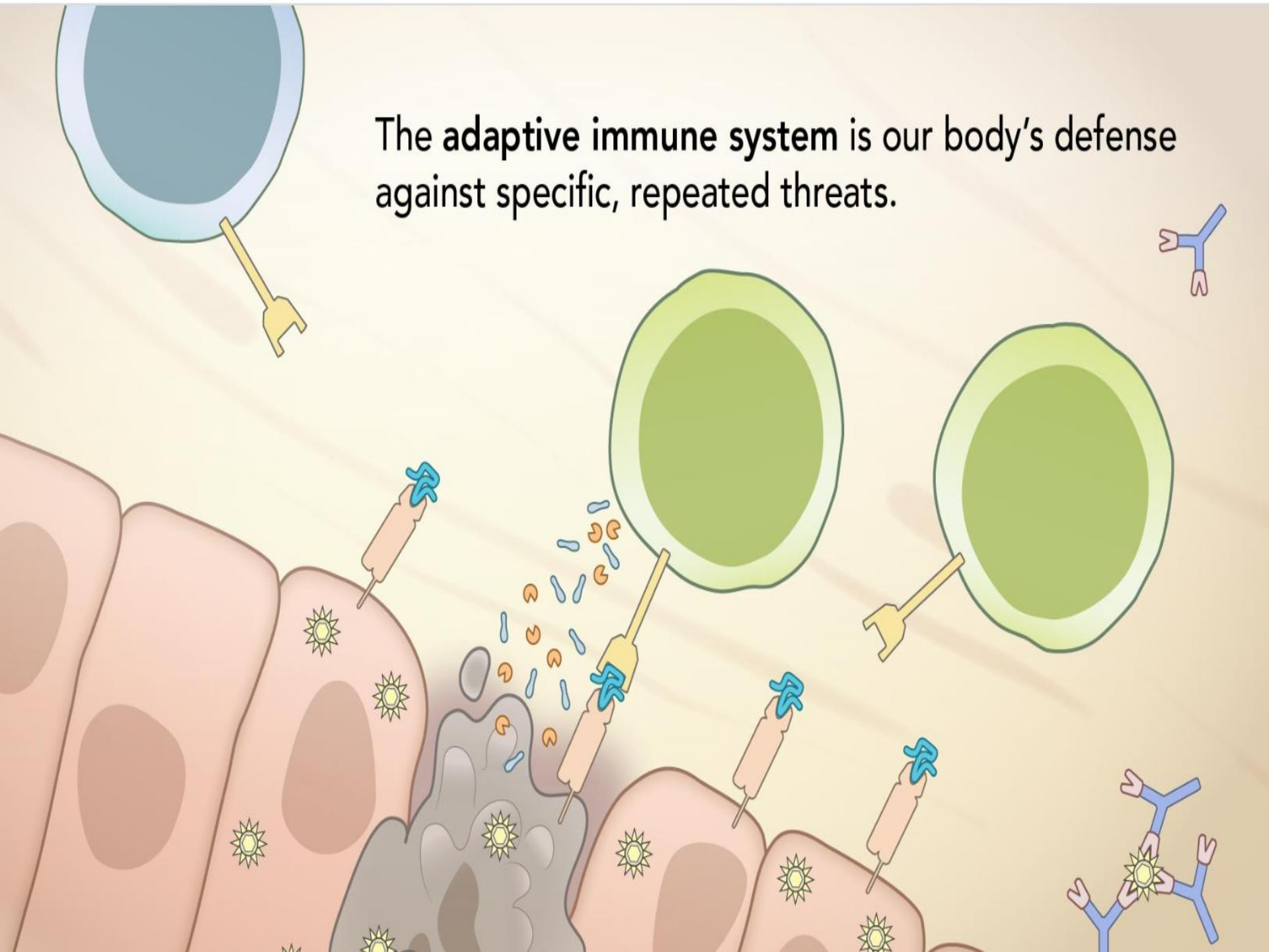
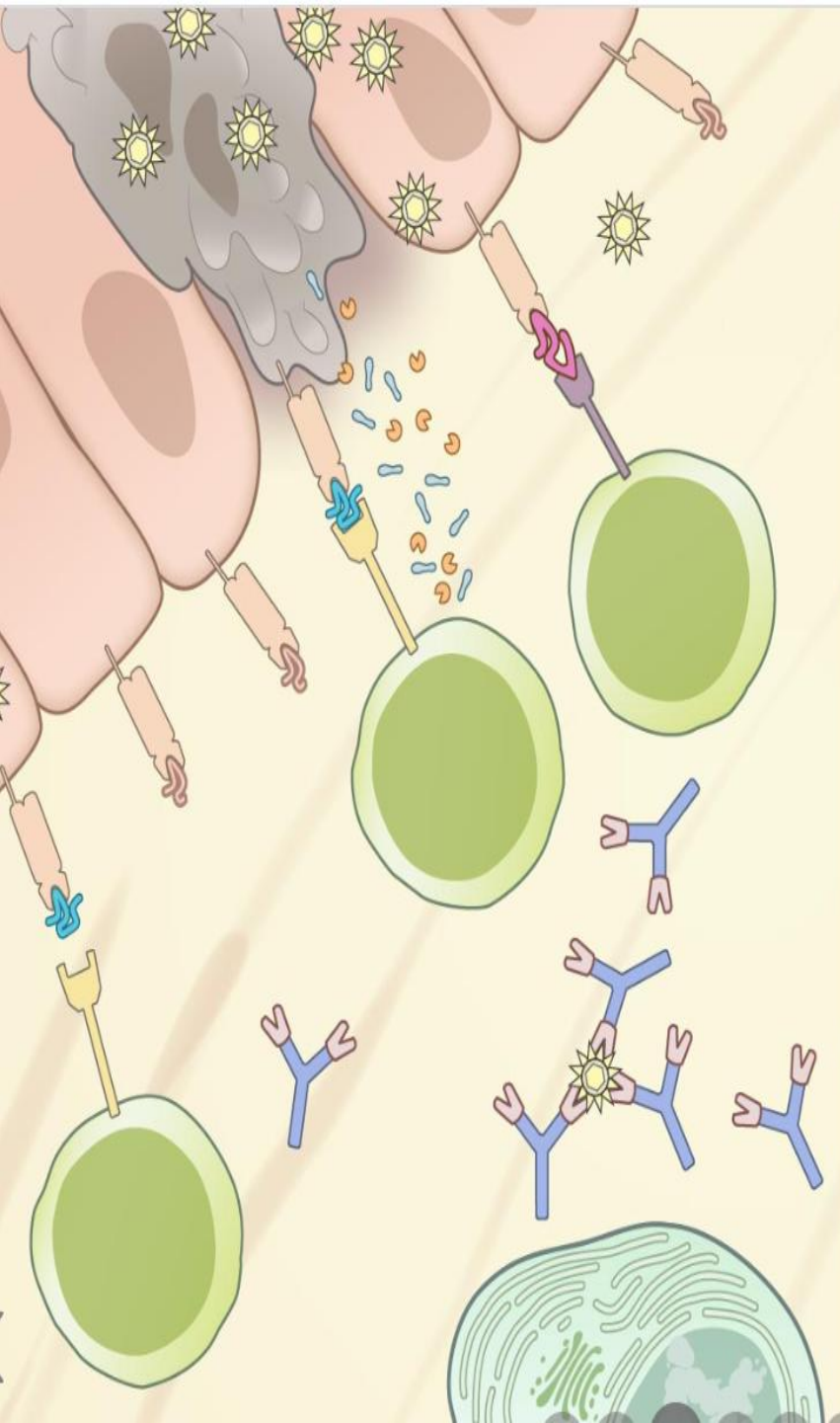
Adaptive immune system : B cells


The **adaptive immune system** is our body's defense against specific, repeated threats.



The adaptive immune system has...

Specificity

The adaptive immune system responds in a targeted way to specific antigens rather than general categories of pathogens.

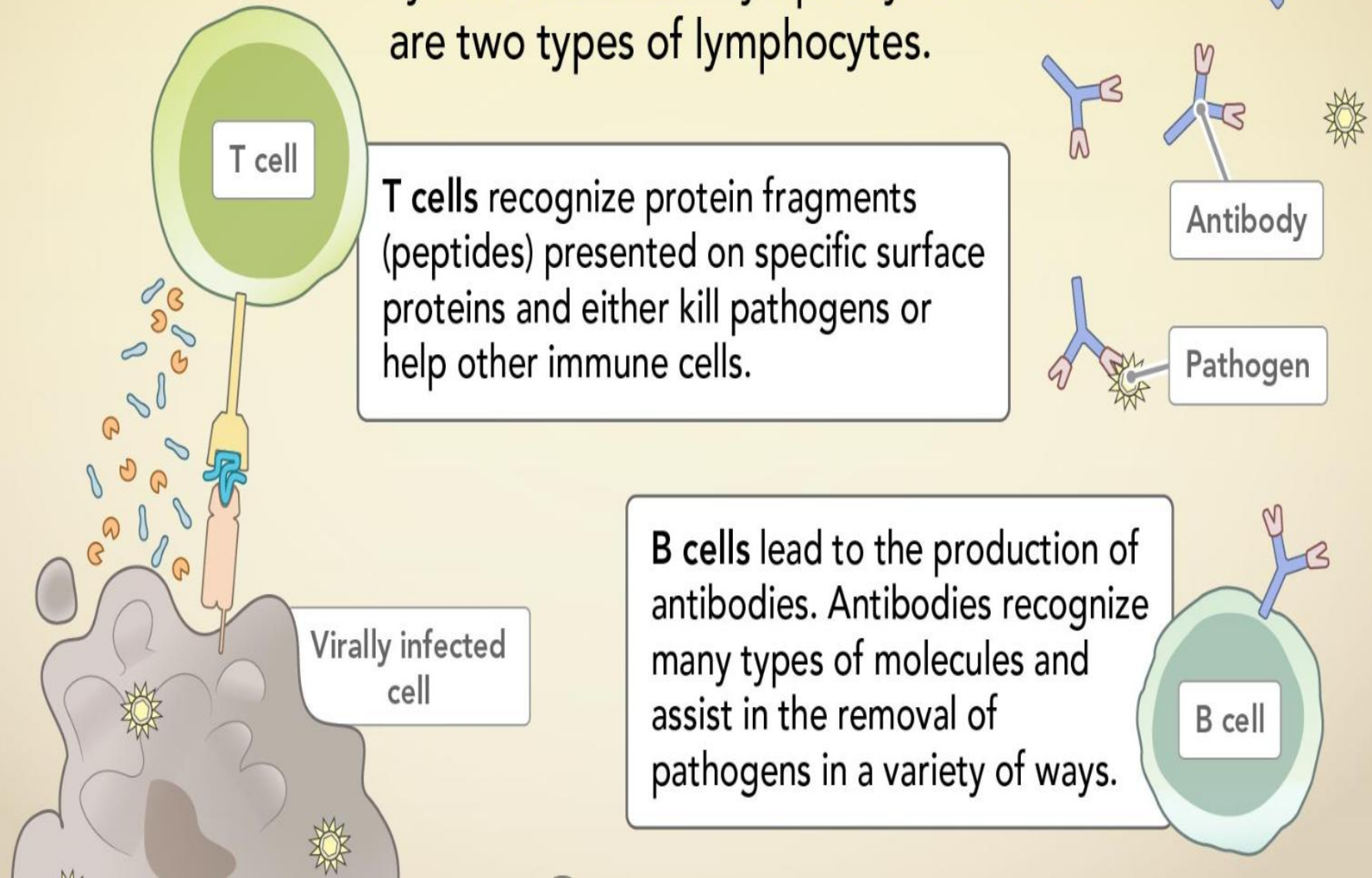
Recognition of self

The adaptive immune system can identify and respond to dangerous foreign molecules while ignoring harmless foreign molecules and molecules produced by our own body.

Memory

After the adaptive immune system has responded to a threat, it will be able to do so more quickly and robustly in the future.

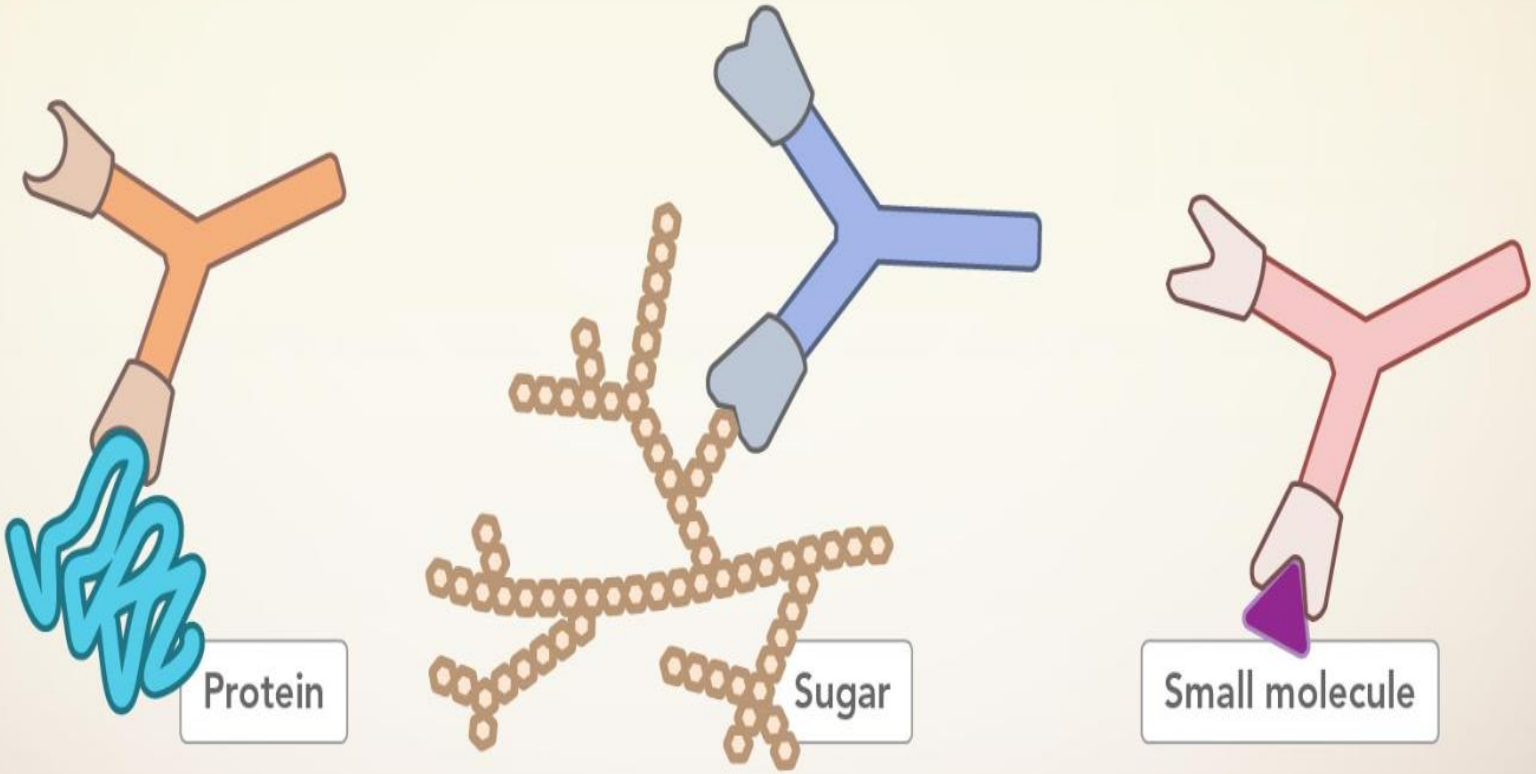
The unique cells of the adaptive immune system are called "lymphocytes." There are two types of lymphocytes.



T cells recognize protein fragments (peptides) presented on specific surface proteins and either kill pathogens or help other immune cells.

B cells lead to the production of antibodies. Antibodies recognize many types of molecules and assist in the removal of pathogens in a variety of ways.

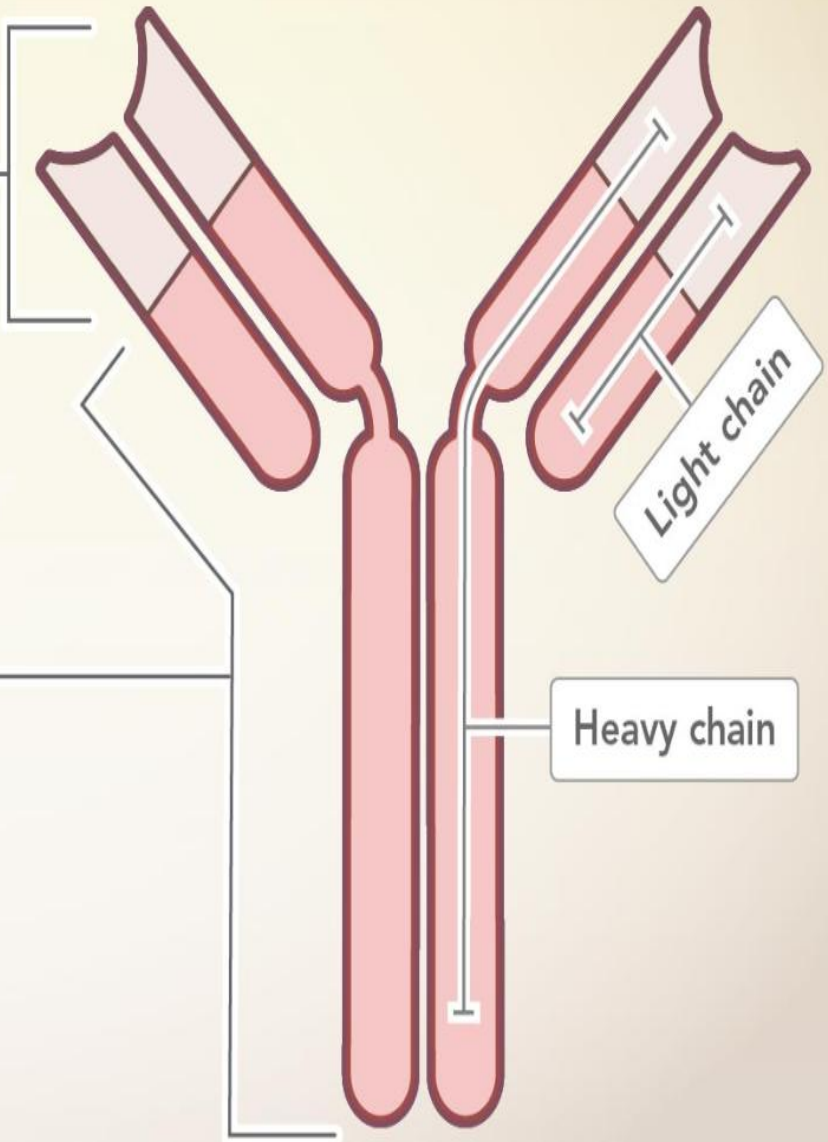
The main function of B cells is to produce **antibodies**, specialized proteins that can bind to many different kinds of antigens.

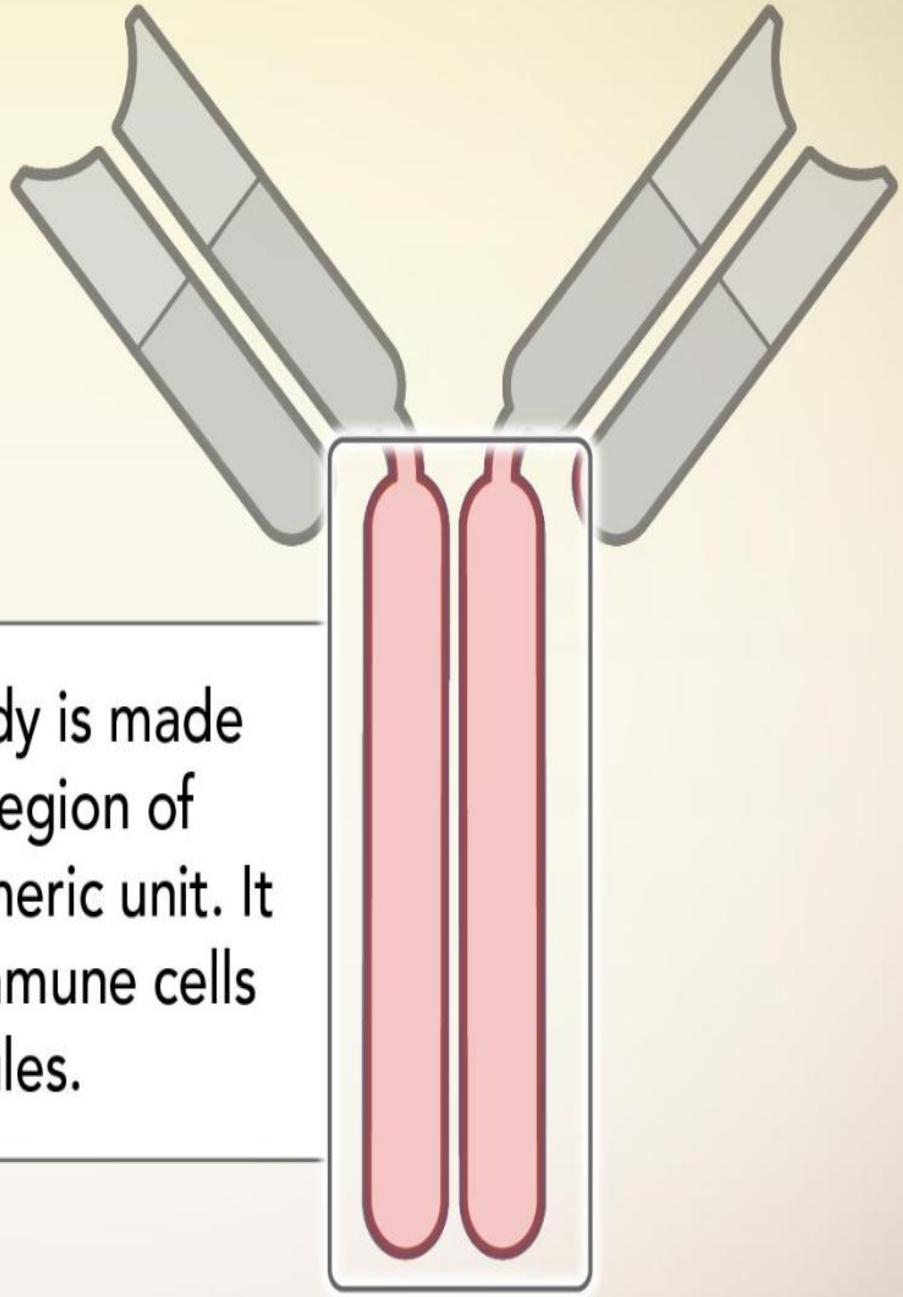


All antibodies have the same basic structural components.

The **antigen recognition site** is highly variable from one B cell clone to another, and binds to antigens.

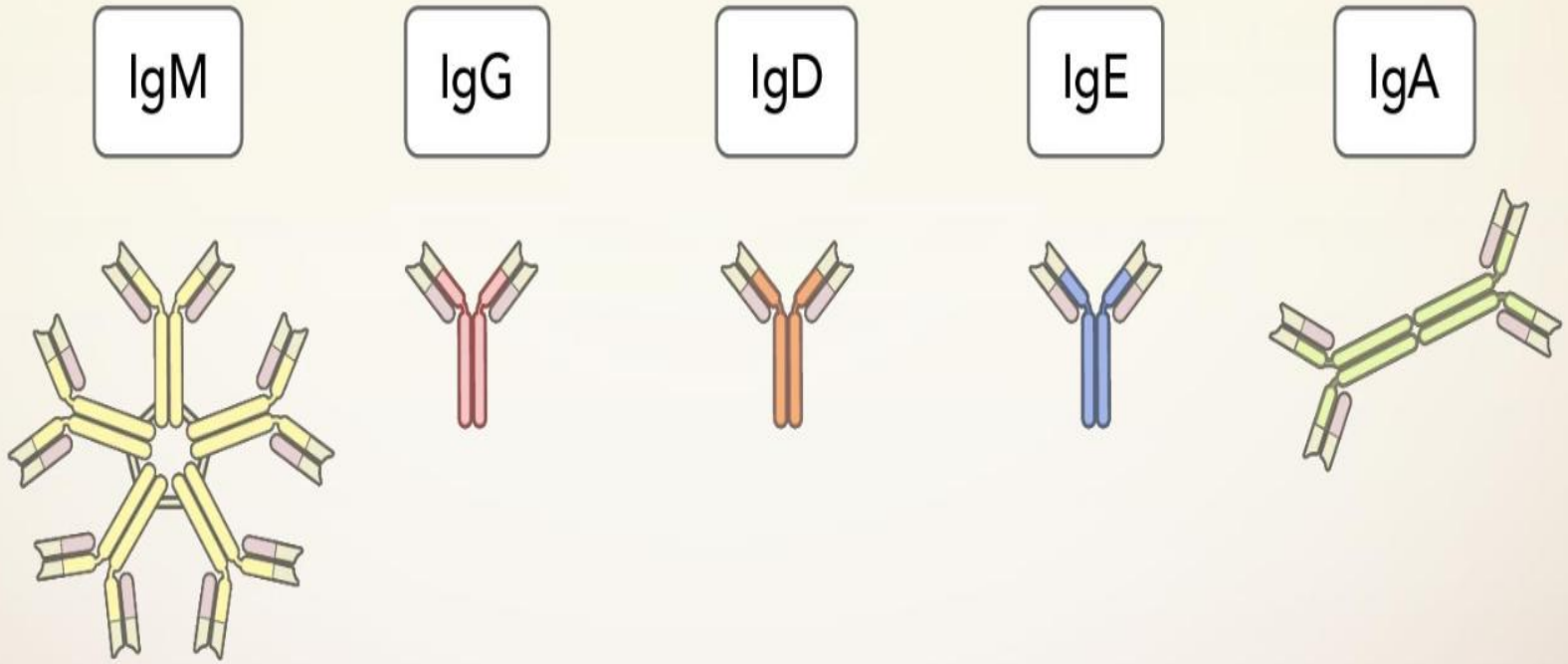
The **constant region** of an antibody is different for each of the different isotypes (including IgG, IgA, IgM, IgD, or IgE).



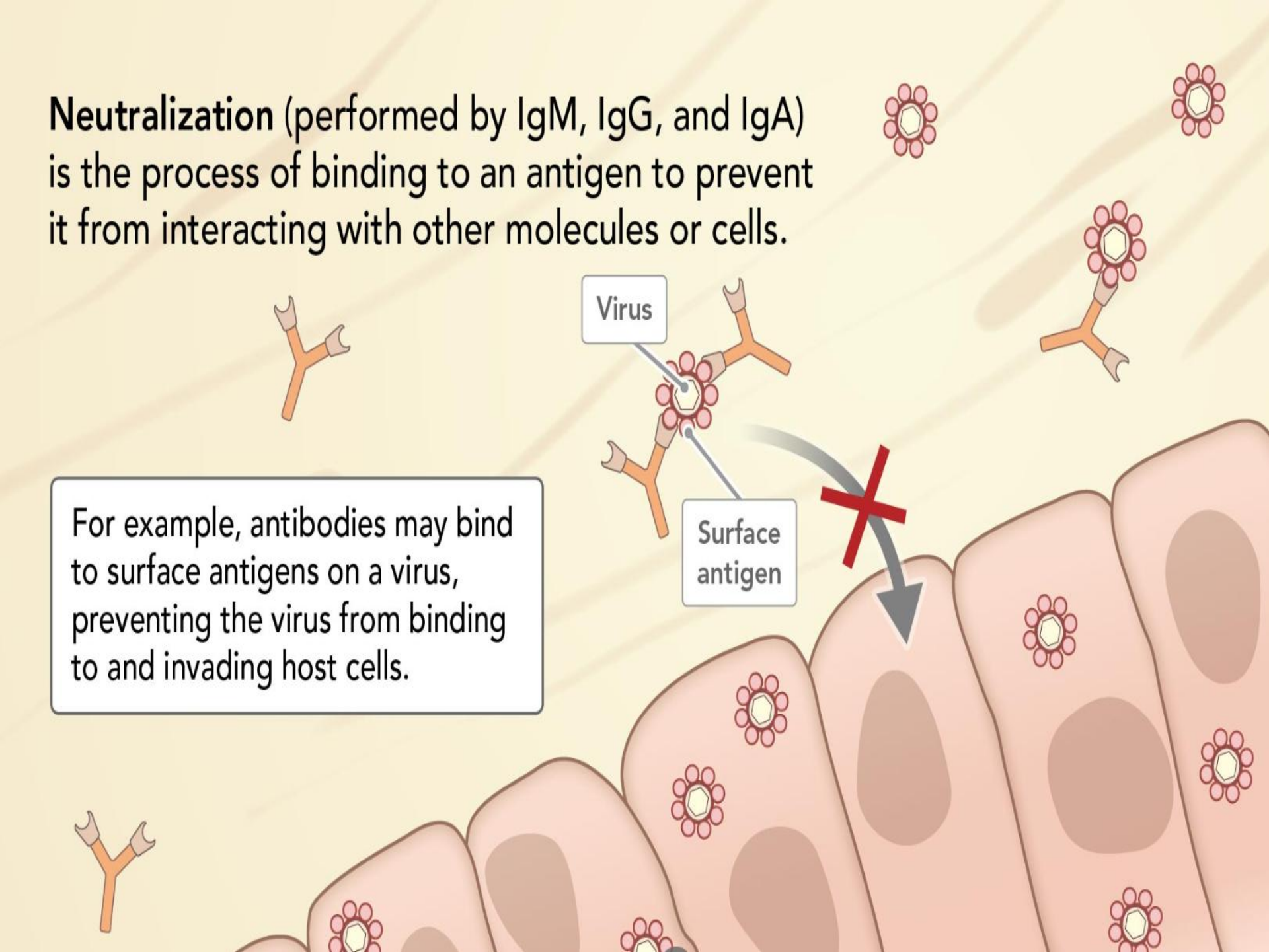


The **Fc region** of an antibody is made up of part of the constant region of each Ig heavy chain in a dimeric unit. It binds to Fc receptors on immune cells and to complement molecules.

There are 5 major types of heavy chain constant regions which determine the isotype of the antibody. Antibodies perform several different functions which vary between isotypes.



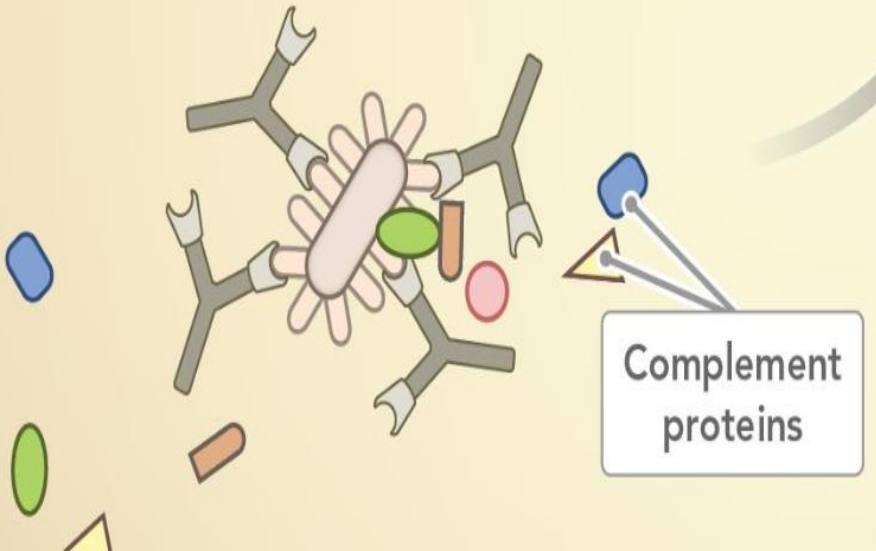
Neutralization (performed by IgM, IgG, and IgA) is the process of binding to an antigen to prevent it from interacting with other molecules or cells.

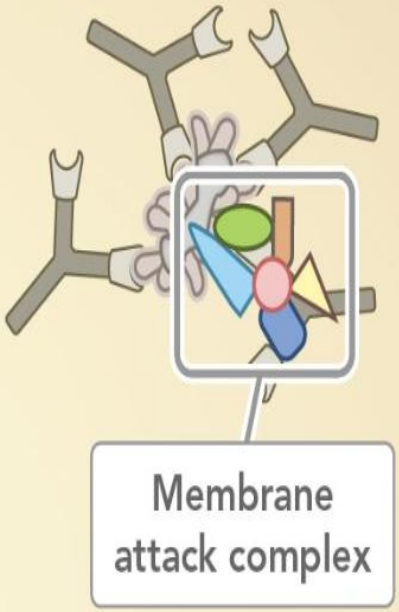


For example, antibodies may bind to surface antigens on a virus, preventing the virus from binding to and invading host cells.

Complement fixation (performed by IgG and IgM) refers to the ability of antibodies to activate the complement system.

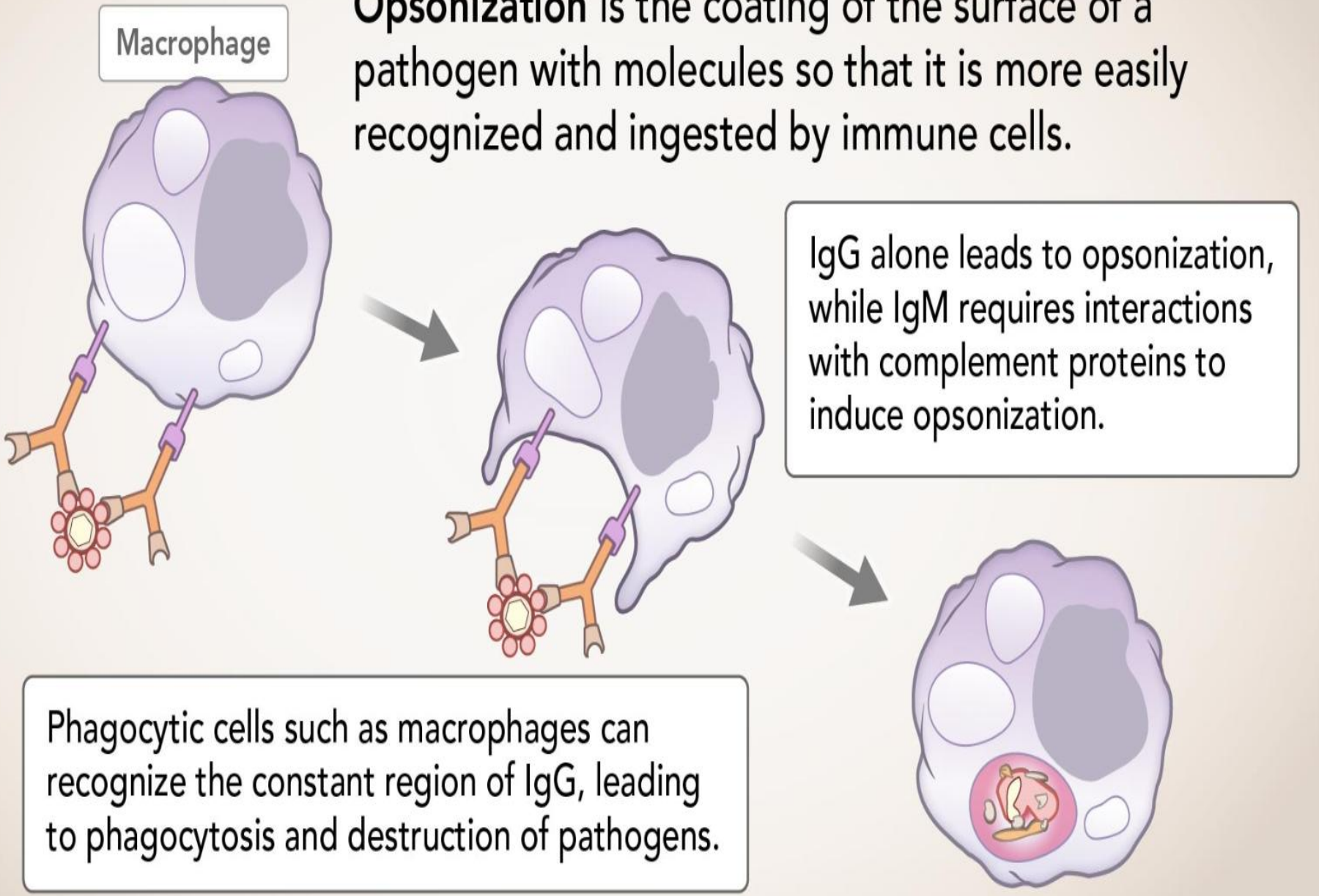
Antibodies help initiate binding of complement proteins to the surface of a pathogen. This can help with opsonization by complement receptors.





The complement cascade also leads to the formation of the membrane attack complex, which leads to cell lysis.

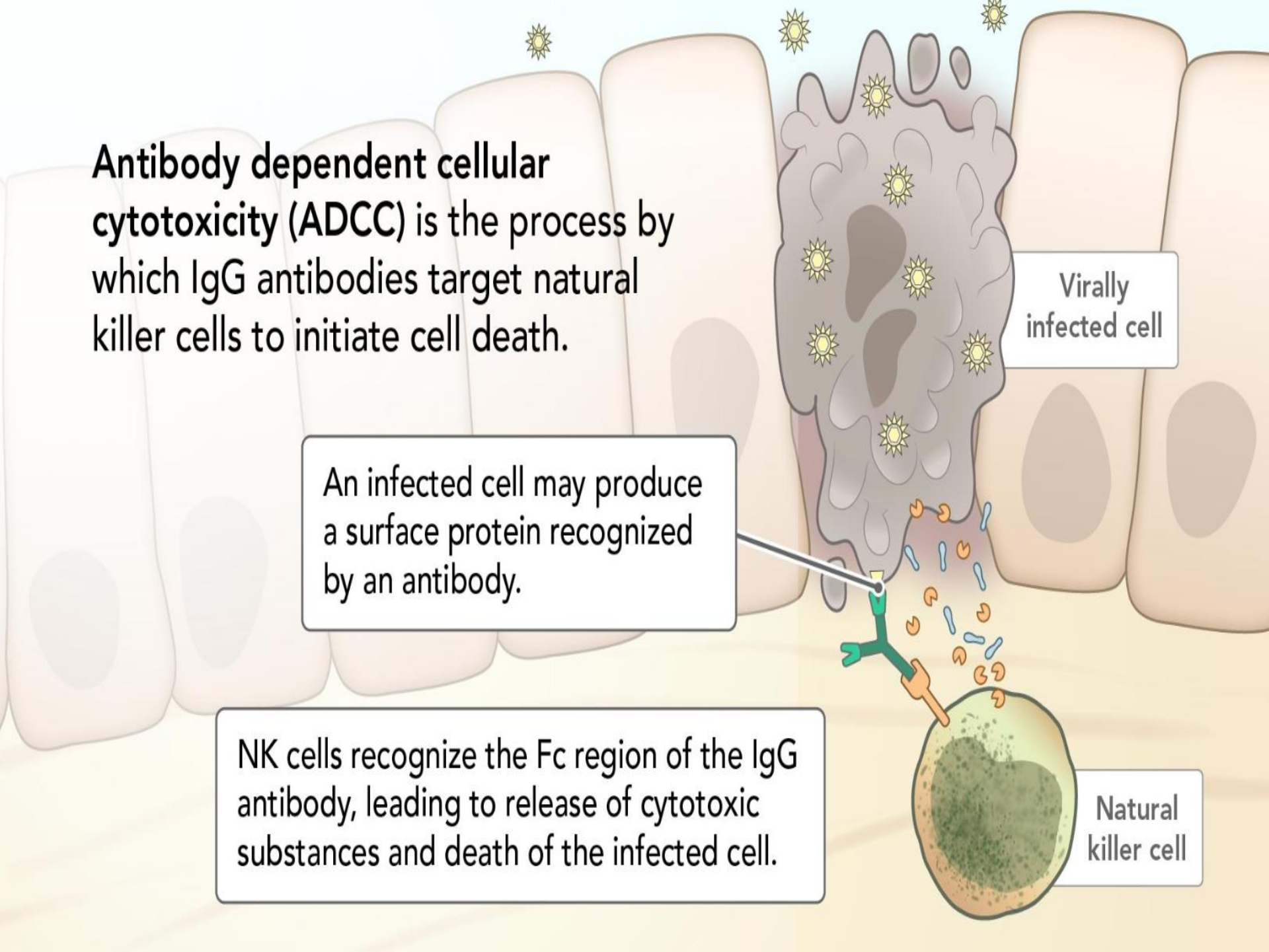
Opsonization is the coating of the surface of a pathogen with molecules so that it is more easily recognized and ingested by immune cells.



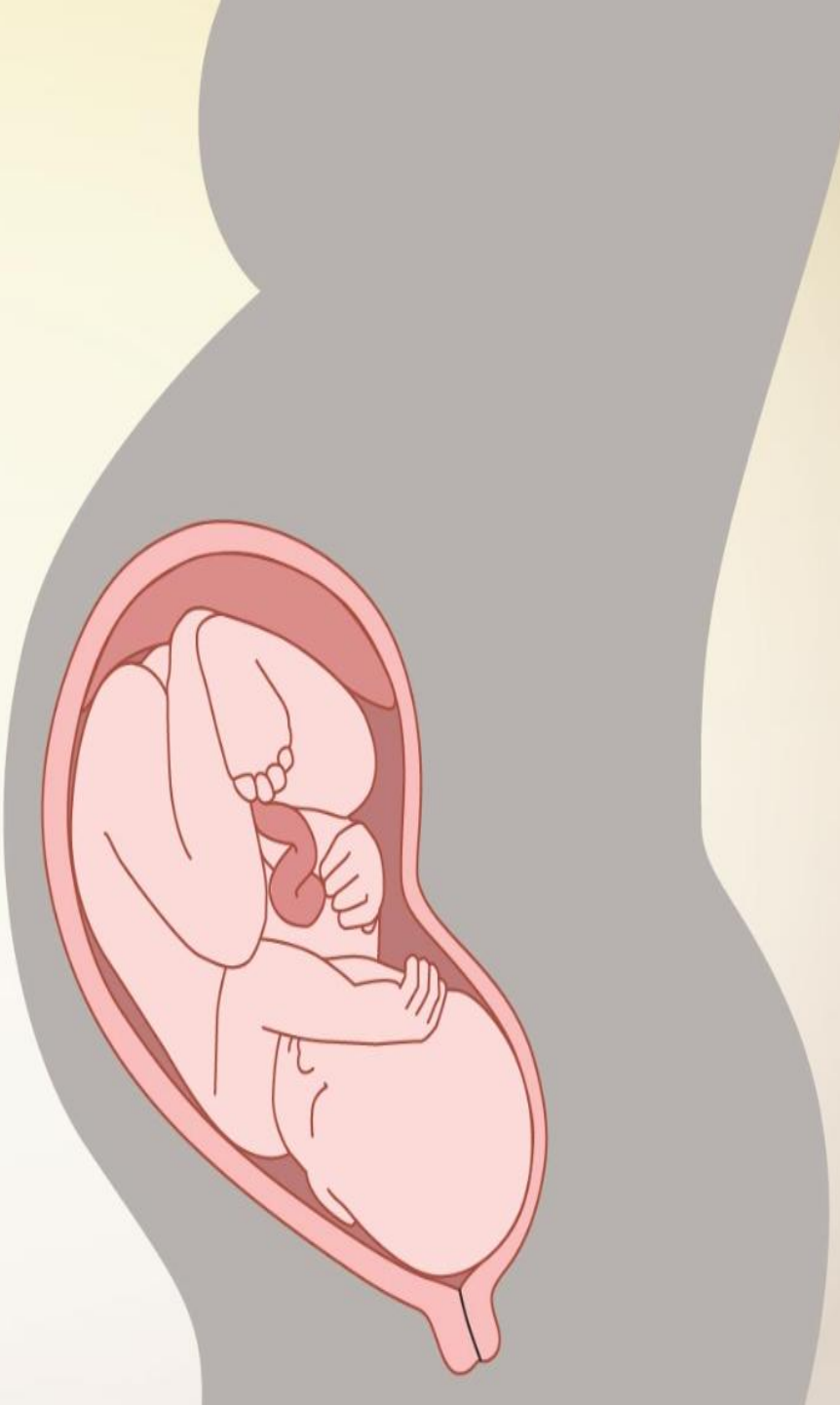
IgG alone leads to opsonization, while IgM requires interactions with complement proteins to induce opsonization.

Phagocytic cells such as macrophages can recognize the constant region of IgG, leading to phagocytosis and destruction of pathogens.

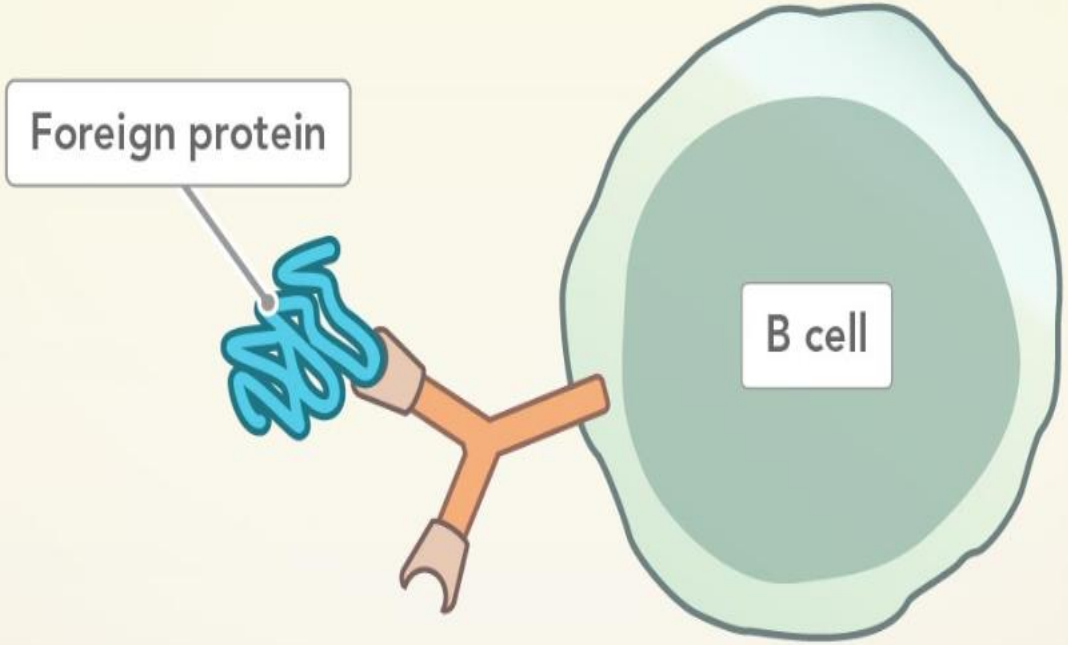
Antibody dependent cellular cytotoxicity (ADCC) is the process by which IgG antibodies target natural killer cells to initiate cell death.



Antibodies also mediate **neonatal immunity.** Maternal IgG transported through the placenta to the fetus protects babies from infections for about 6 months after birth.

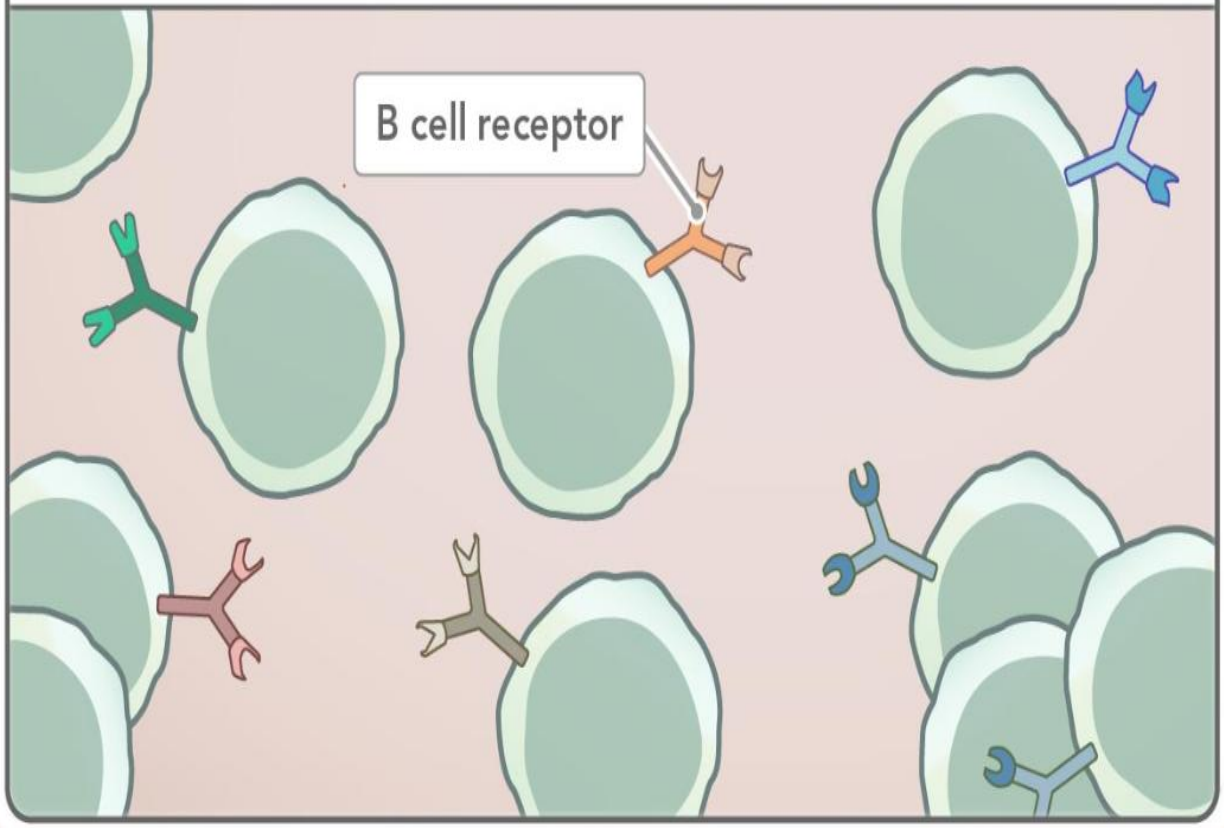


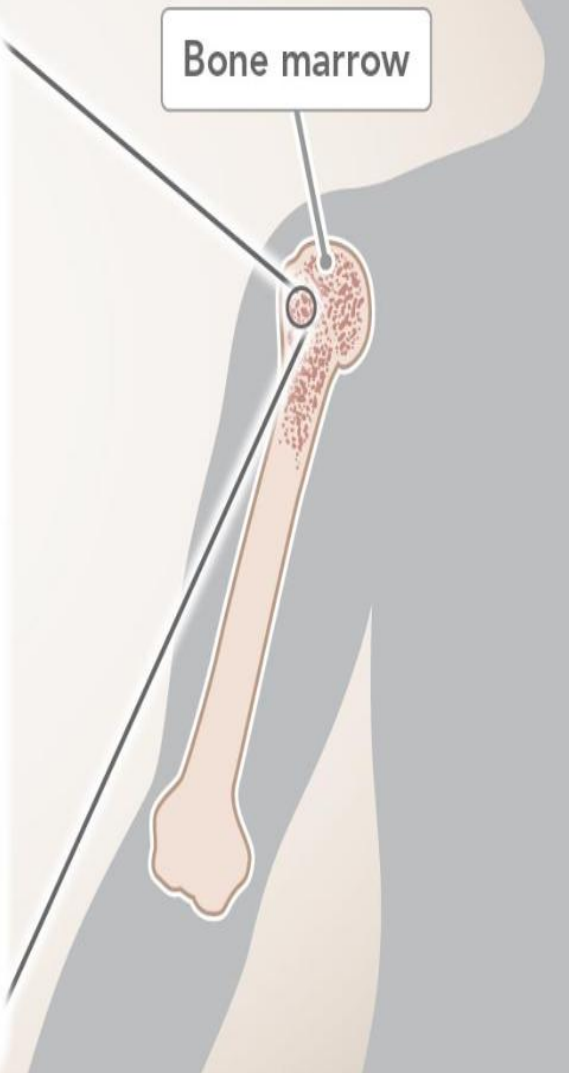
To understand how B cells produce antibodies for specific antigens, let's follow an example of antibodies being produced in response to a foreign protein.



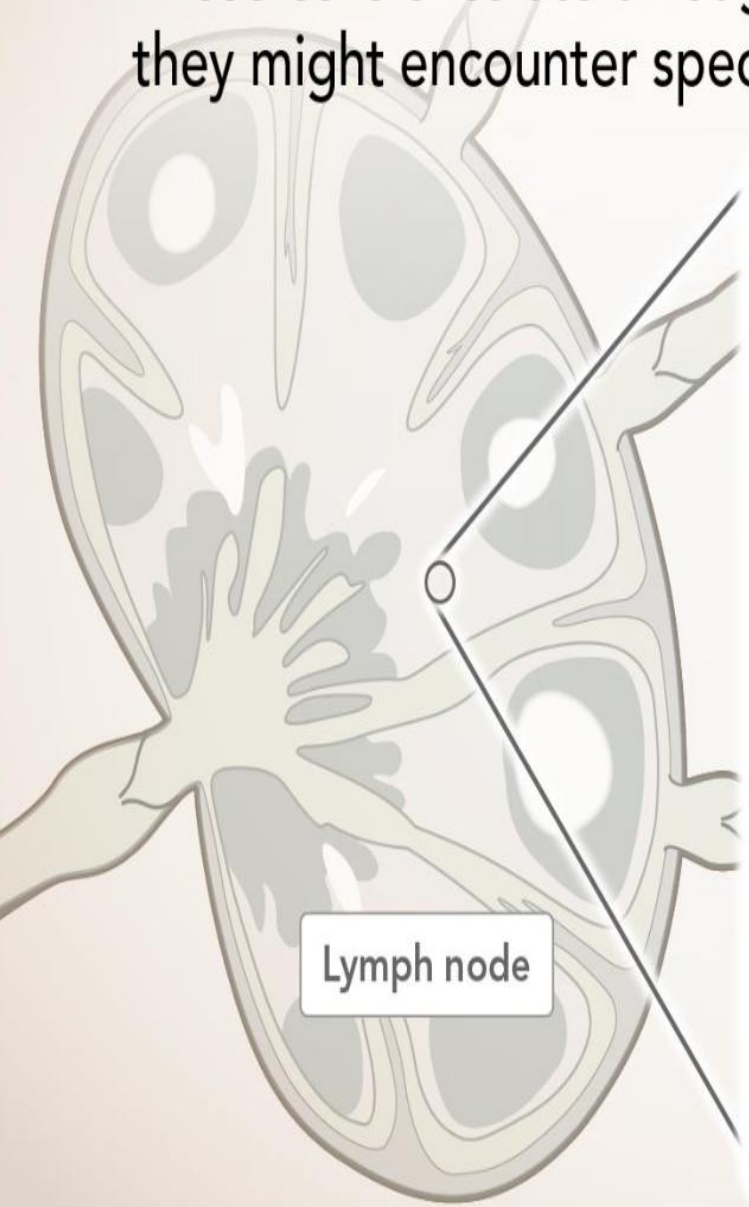
B cells develop in the bone marrow. Each immature B cell expresses a B cell receptor with a random, unique specificity.

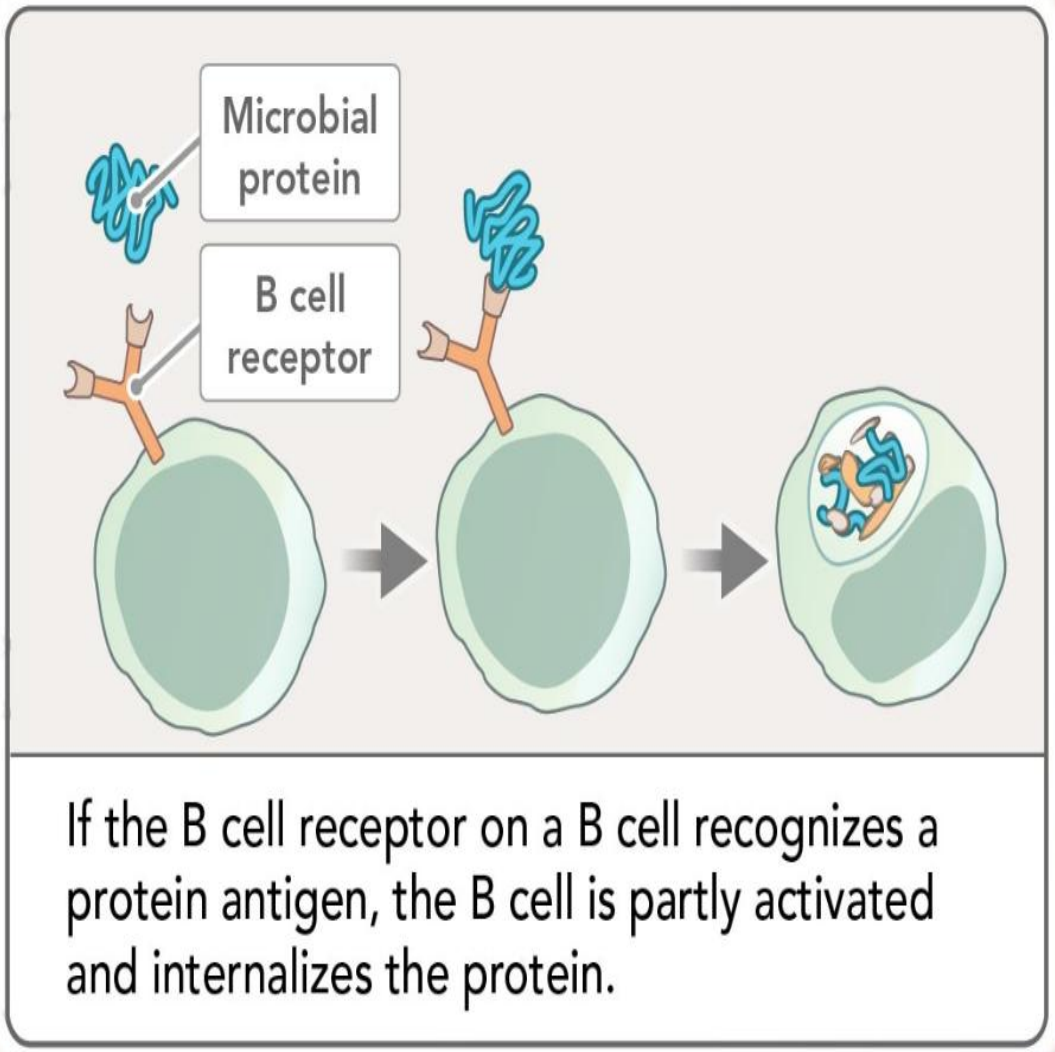
The B cell receptor on each cell is a membrane bound form of antibody and will recognize a specific antigen.





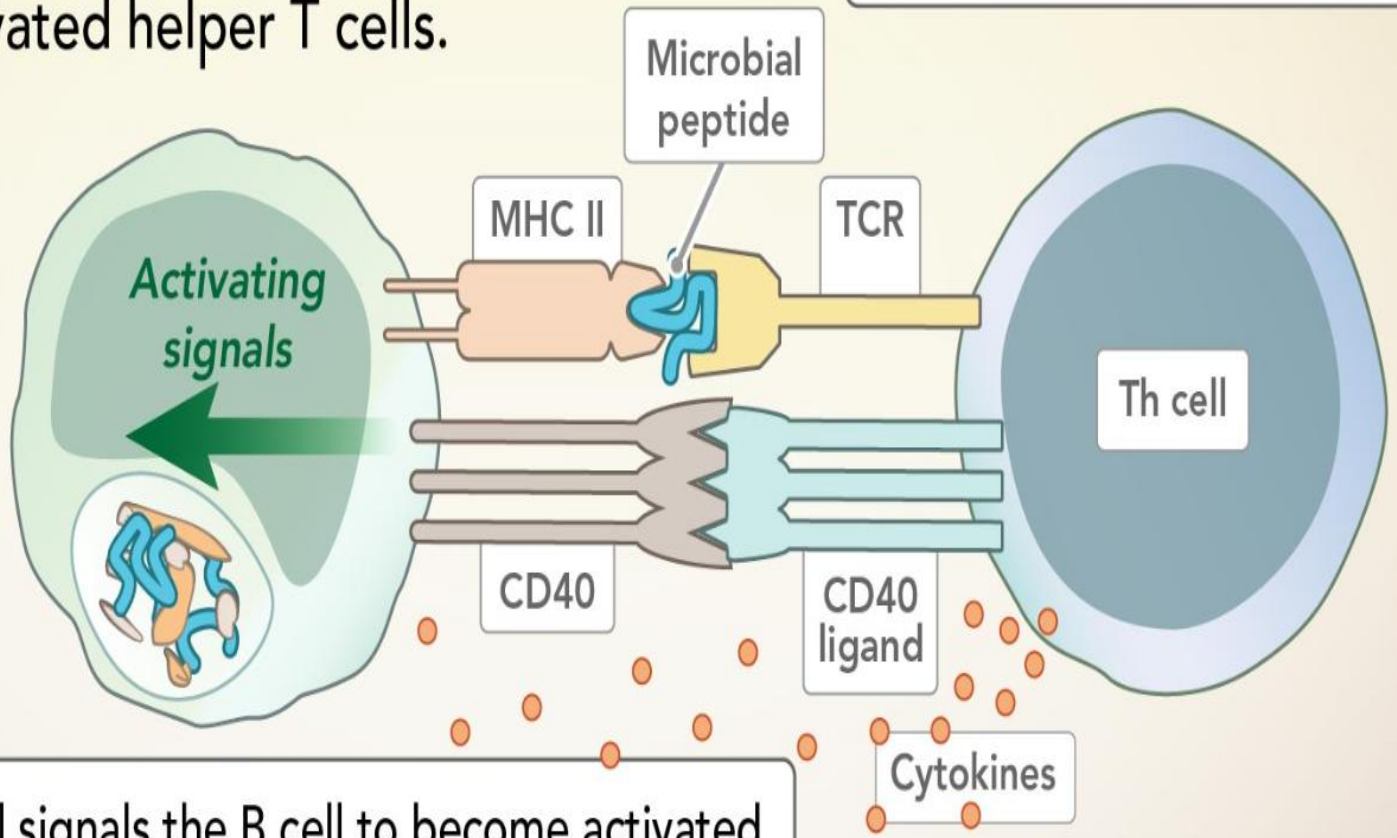
These cells circulate through secondary lymphoid organs, where they might encounter specific microbial molecules or antigens.





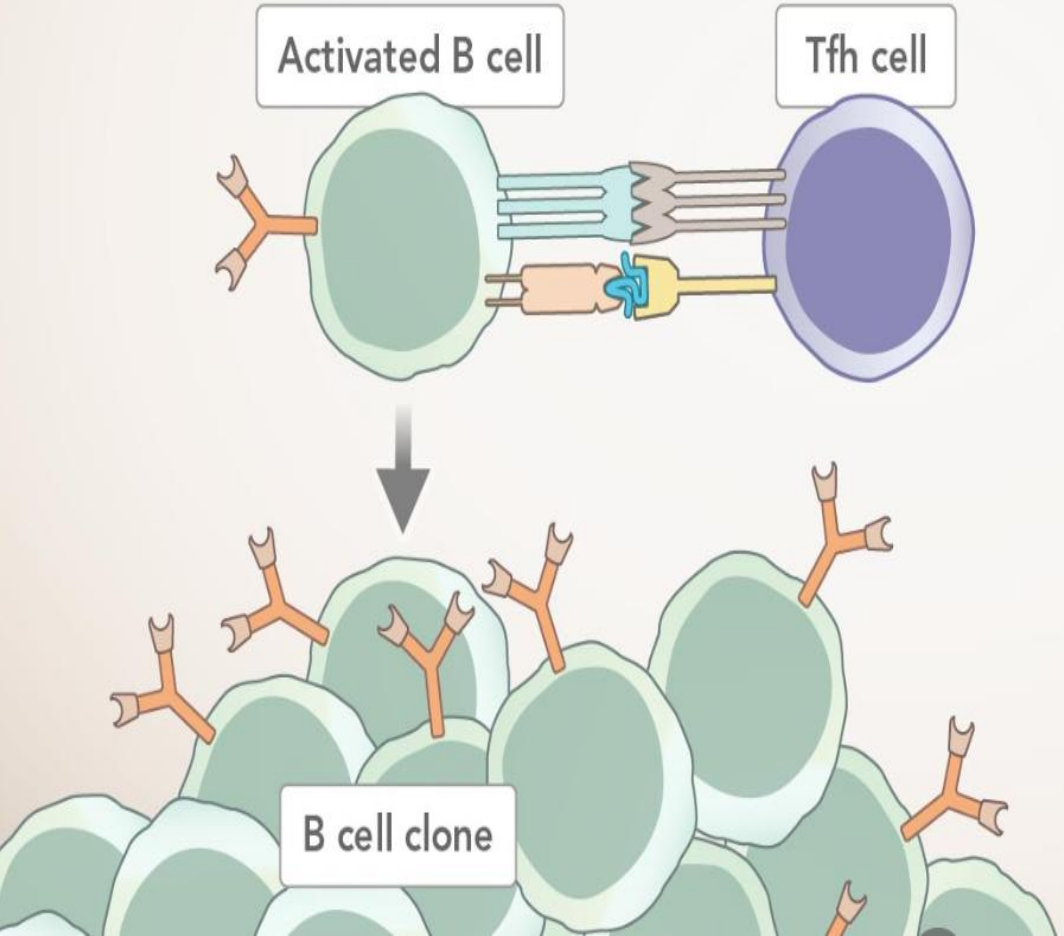
The B cell presents processed peptides from the protein antigen on MHC II, allowing interaction with activated helper T cells.

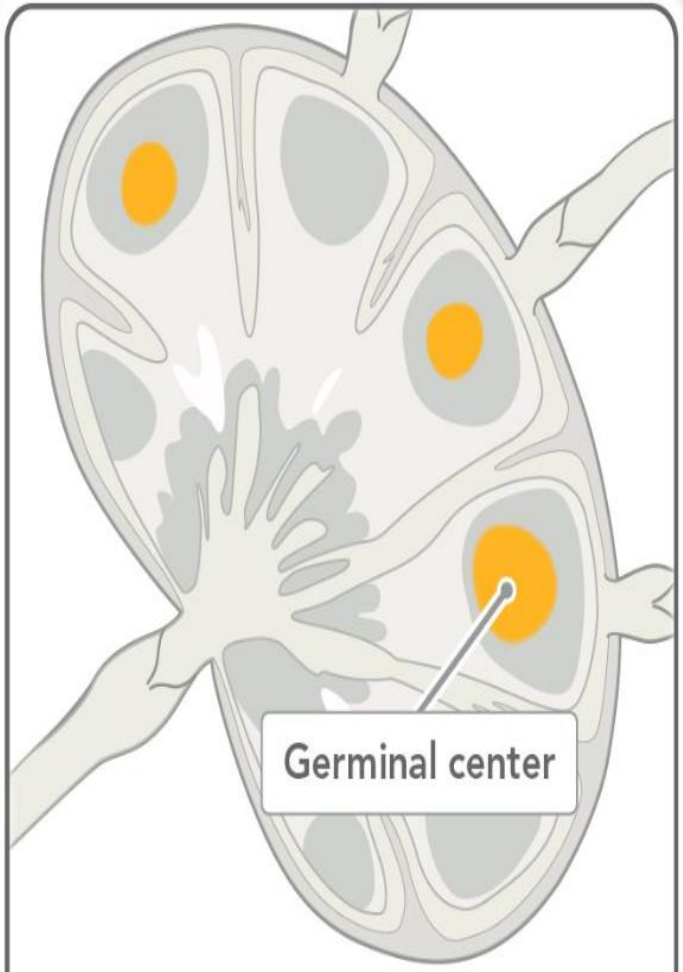
Helper T cells that recognize the peptide bind to the peptide/MHC II complex.



The T cell signals the B cell to become activated using CD40 ligand and secreted cytokines.

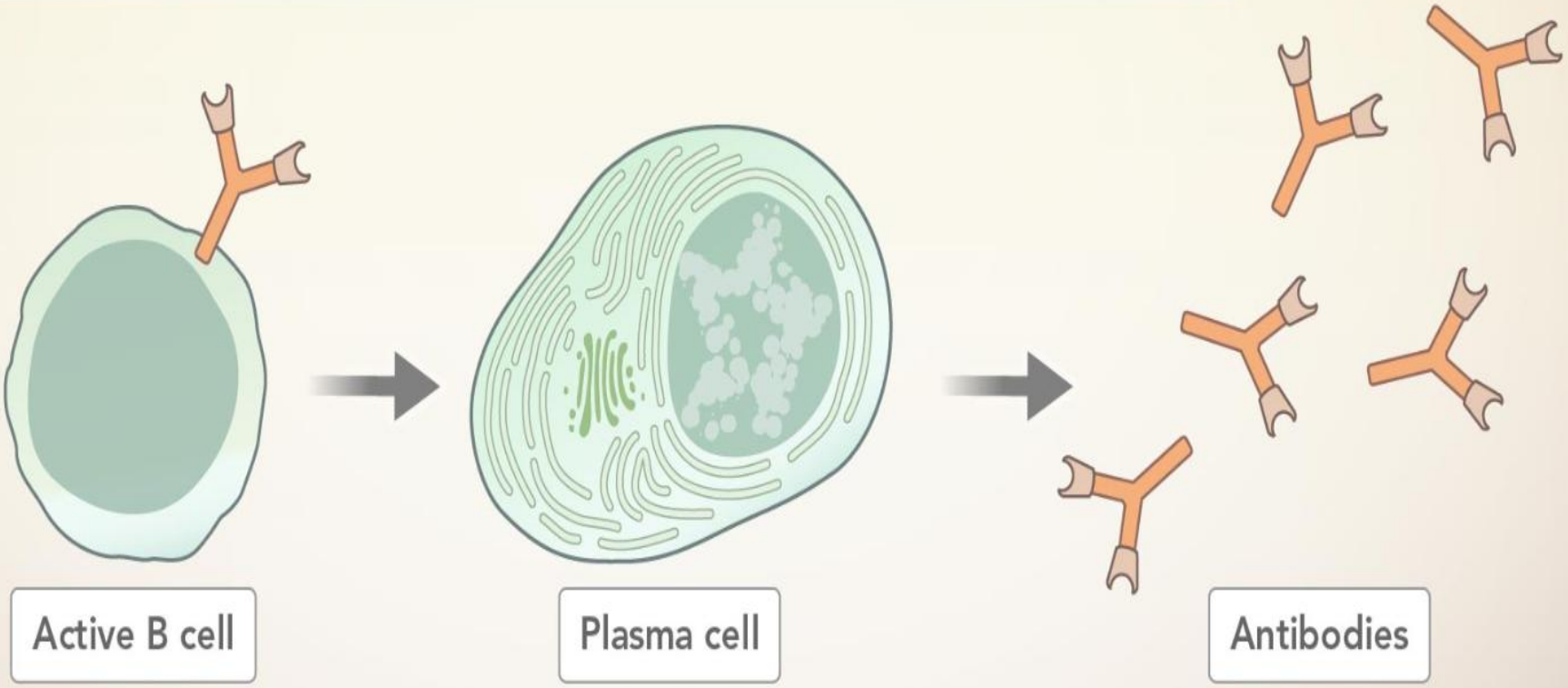
With help from follicular helper T cells, the activated B cell undergoes **clonal expansion**, creating many B cells with B cell receptors specific for the protein.



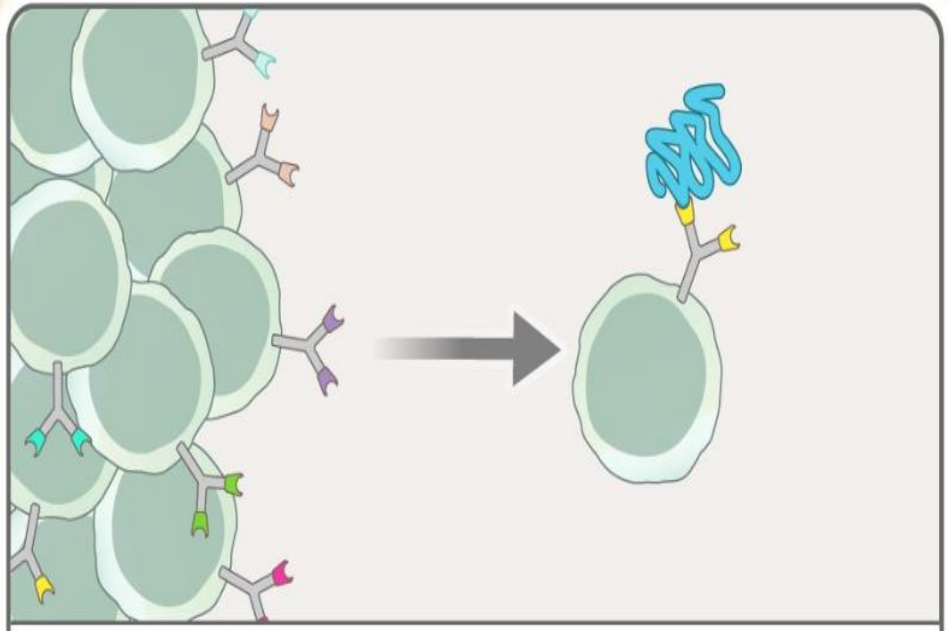


The area of the lymph node where the B cells expand becomes a **germinal center.**

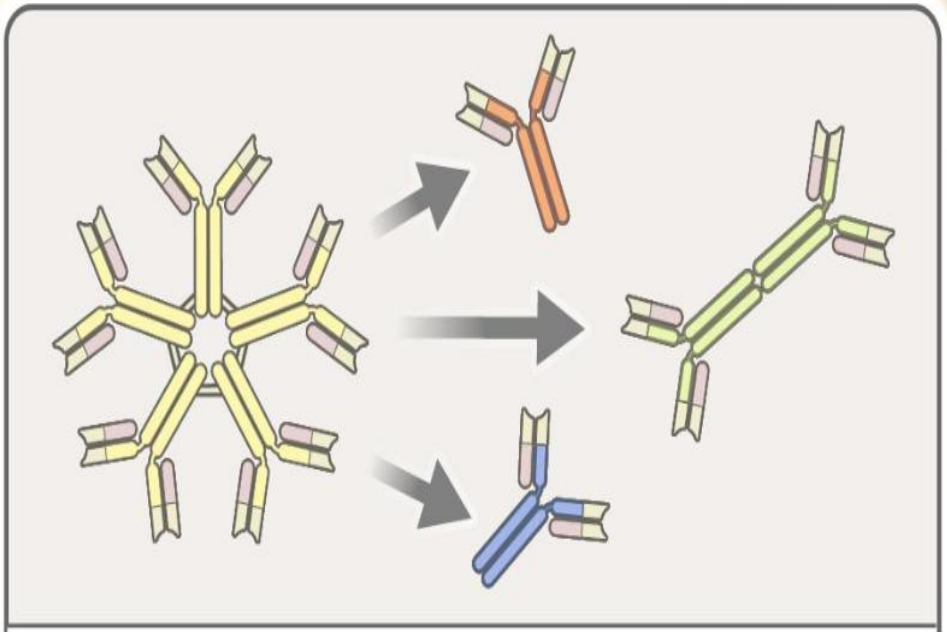
These activated B cells can then differentiate into **plasma cells**, which produce antibodies with the same antigen-binding site as the original B cell receptor.



Germinal centers are sites at which dividing B cells undergo affinity maturation and isotype switching.



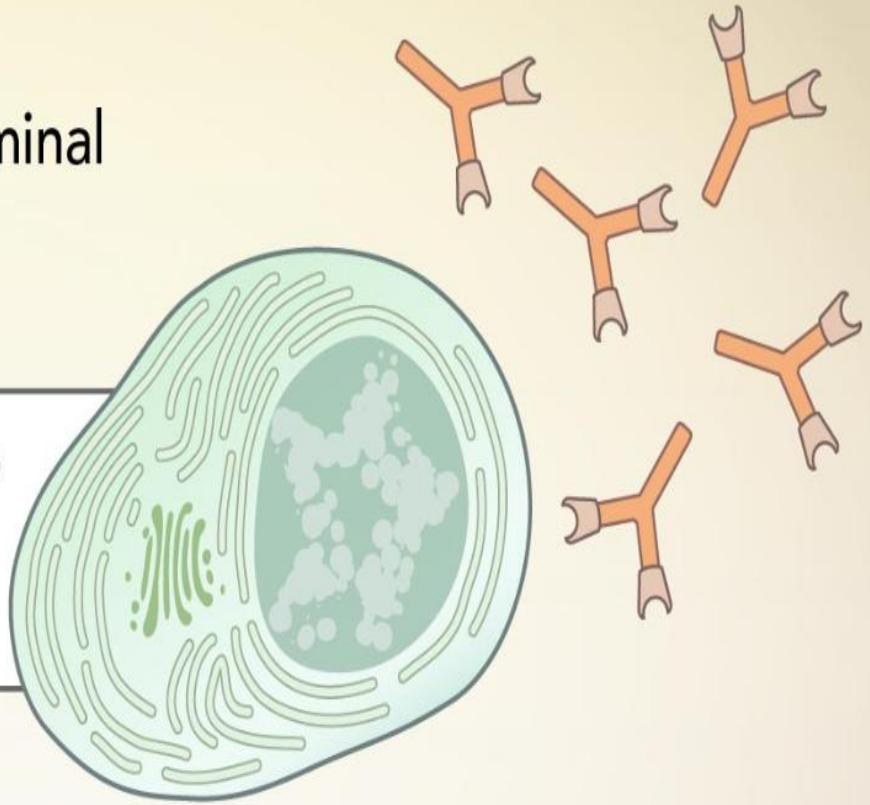
Affinity maturation: B cell receptors are mutated in the germinal center (somatic hypermutation) and the highest affinity B cells are selected to become memory B cells and long-lived plasma cells.

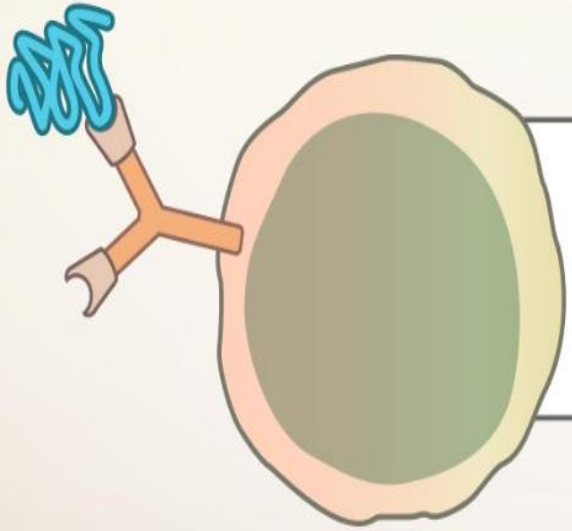


Isotype switching: The heavy chains of B cell receptors are changed so that different antibody isotypes can be produced, creating a more robust immune response.

High affinity B cells selected in the germinal center give rise to...

Long-lived plasma cells. These cells produce high affinity antibodies that will circulate in the body even after the infection is cleared.





Memory B cells. These will become re-activated and produce more plasma cells if re-exposed to the antigen in the future.

After the initial B cell response, circulating antibodies provide protection and memory B cells allow the body to react much more quickly to subsequent exposure to the same antigen.