



Antibody Production

Topic 11.1



Understandings

- Every organism has unique molecules on the surface of its cells
- Pathogens can be species-specific although others can cross species barriers
- B lymphocytes are activated by T lymphocytes in mammals
- Activated B cells multiply to form clones of plasma cells and memory cells
- Plasma cells secrete antibodies
- Antibodies aid the destruction of pathogens
- White blood cells release histamine in response to allergens
- Histamine causes allergic symptoms
- Immunity depends on the persistence of memory cells
- Vaccines contain antigens that trigger immunity but do not cause the disease
- Fusion of a tumor cell with an antibody-producing cell creates a hybridoma cell
- Monoclonal antibodies are produced by hybridoma cells

The Immune System Review

- Defends the body from infections through a network of proteins and cells
- Keeps a record of infections that have been defeated before so that it has the “instructions” to easily get rid of them again



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IMMUNITY

INNATE IMMUNITY

Physical Barriers



Chemical Barriers

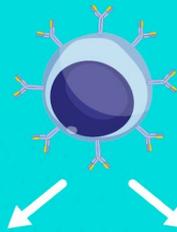


Cellular Defences



ADAPTIVE IMMUNITY

Active Immunity



Natural



Vaccination



Passive Immunity



Maternal



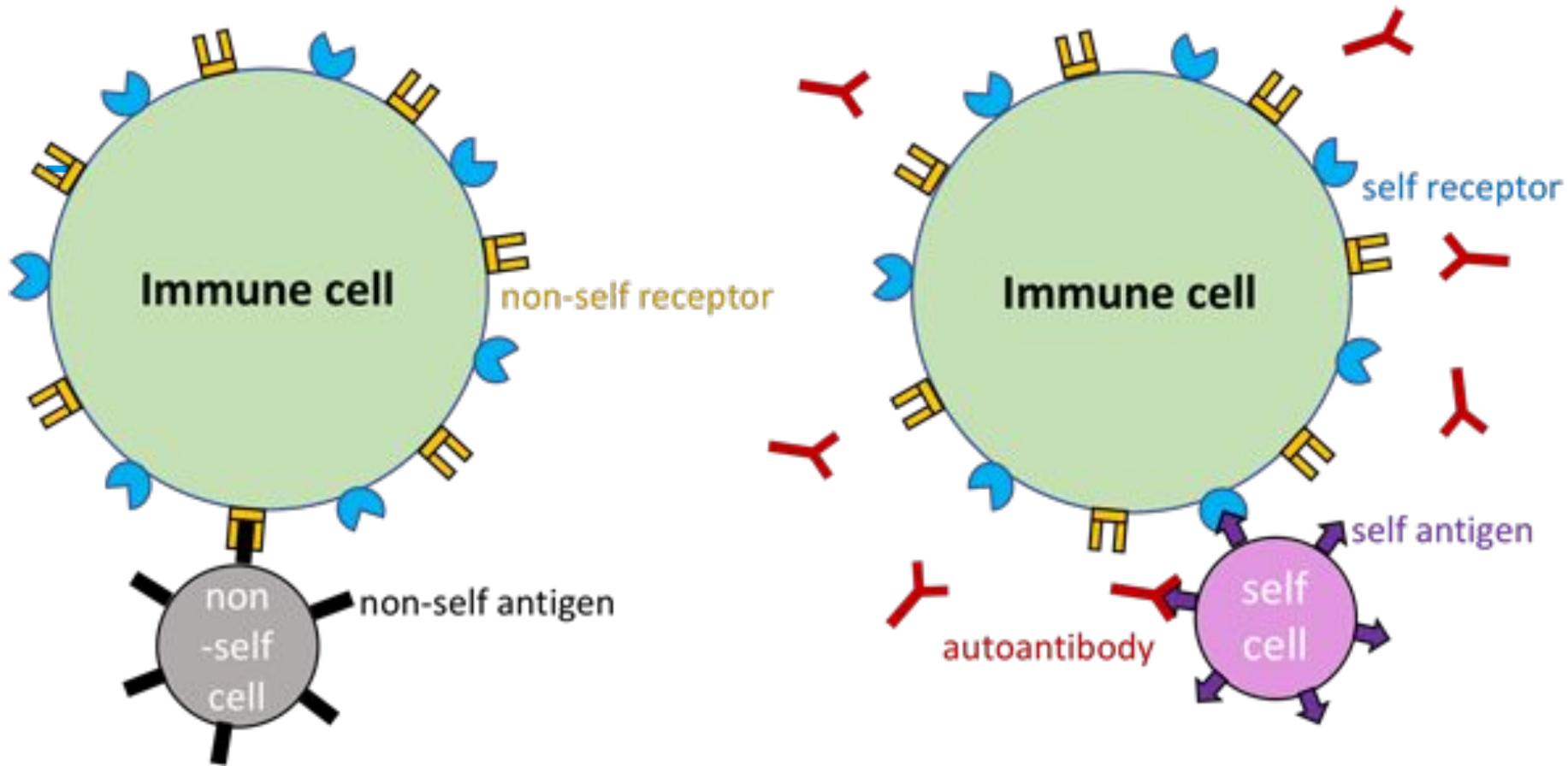
Artificial



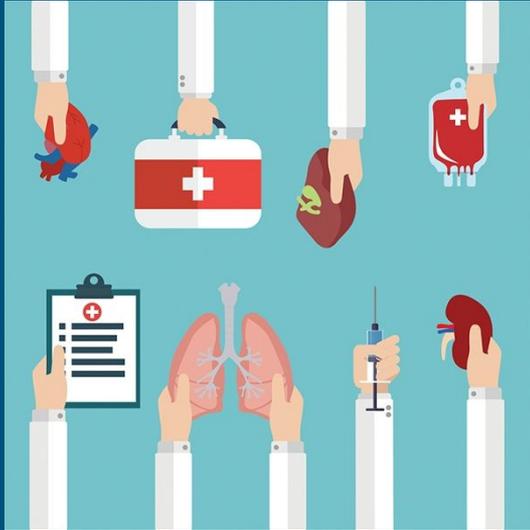
Self or Non-self

- The immune system only recognizes what is coming from the body and what is foreign
- Ex: pathogens vs. virus
- How does the immune system differentiate between self and non-self?
 - Our body cells all have the same DNA
 - Same DNA produces the same membrane proteins (antigens)
 - Our immune cells recognize that different cells have different membrane proteins (antigens)
 - ***Remember, one of the functions of the cell membrane is RECOGNITION

Foreign Antigen: The membrane protein/marker on any non-self substance in the body. Triggers an immune response

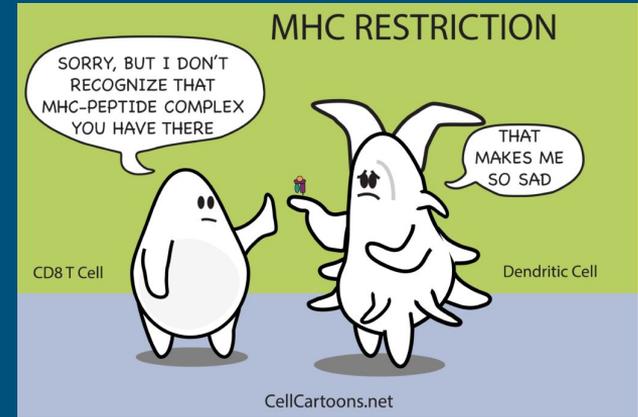


Marker Proteins



- Major Histocompatibility Complex Molecules (MHC class 1) on all nucleated cells (not blood cells)
- They are like ID cards on a cell

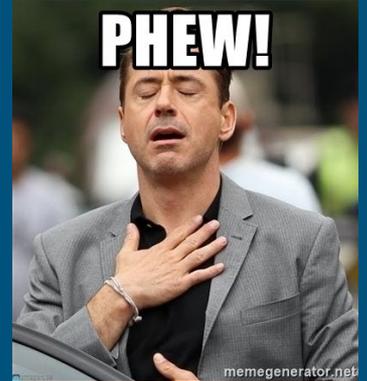
- That's why transplantation is difficult and we try to find close genetic matches



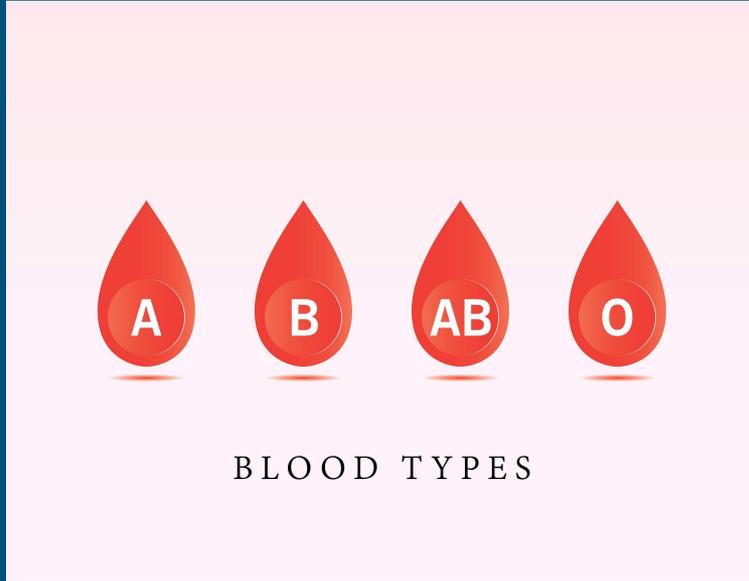
Lab gone wrong!



- Let's imagine you are working on a lab and have an accident where you cut off your arm and lose lots of blood
- Your lab partner offers to donate some blood
- What are some questions you should ask before getting a blood transfusion?



Blood Recognition



- Blood cells are NOT nucleated, which makes it easier to “share”/“donate” blood with non-relatives
- Erythrocytes (red blood cells) comes in 4 different types:

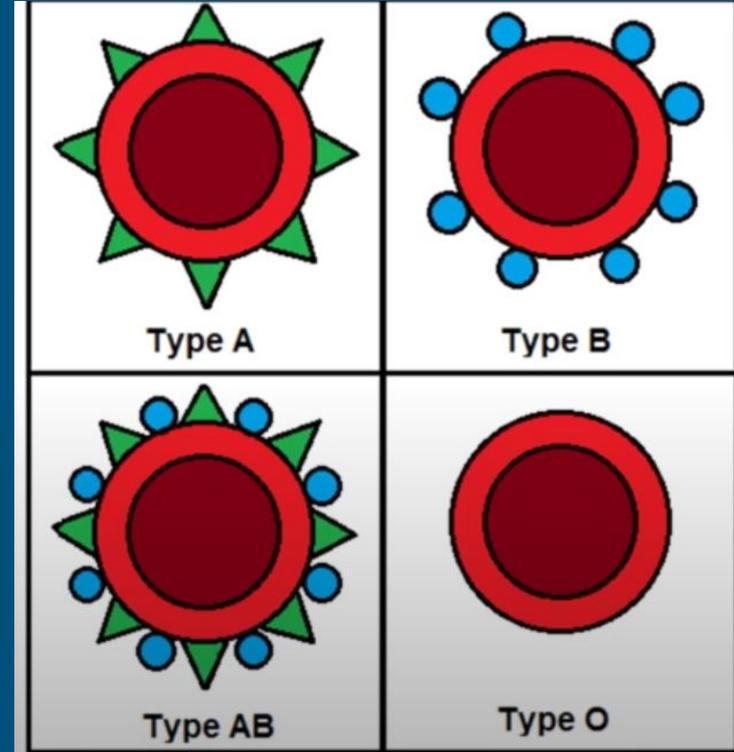
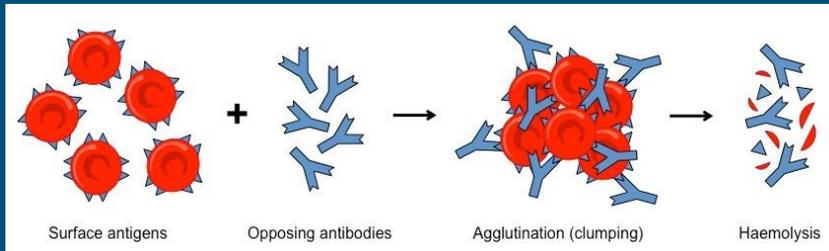
Blood Types

What do you think makes blood types different from each other?

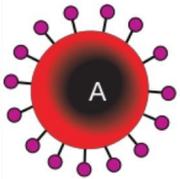
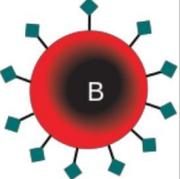
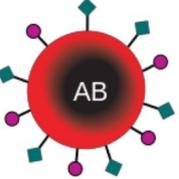
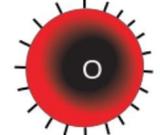
ANTIGEN MARKERS!!!

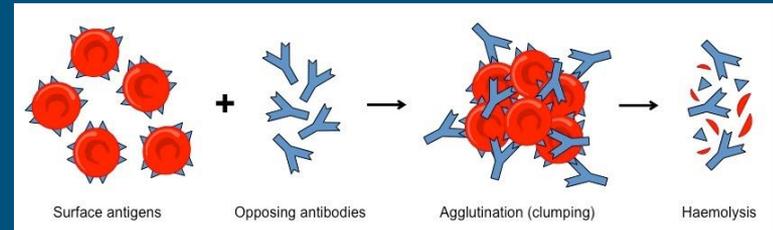
So what do you think would happen if someone receives the wrong blood type in a transfusion?

The body initiates an immune response, most likely leading to death



Blood Types and Antigens

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

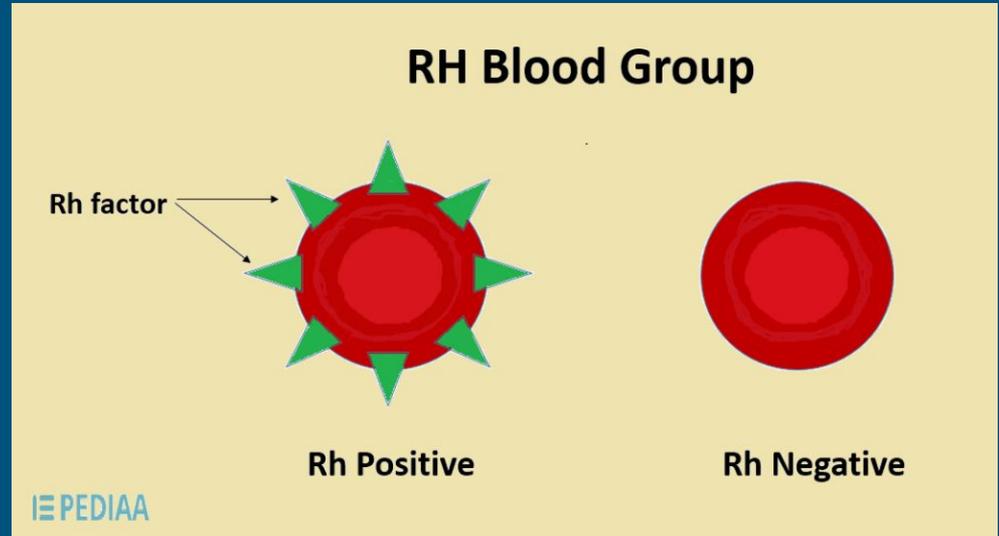


Rh glycoprotein on blood

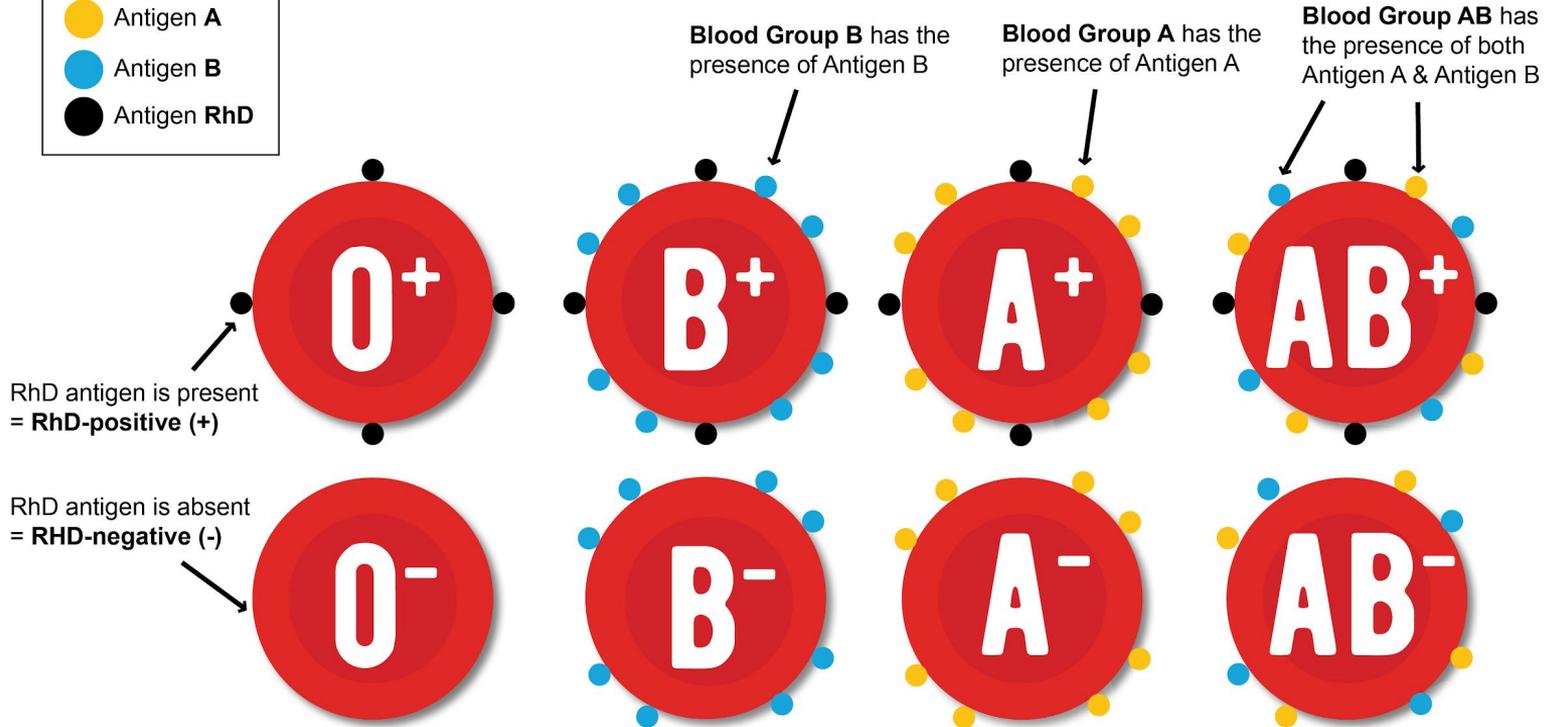
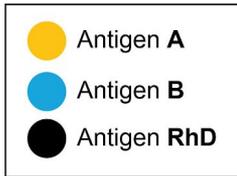
Additionally, the Rh glycoprotein (surface protein) can either be present or absent

If you have Rh = positive

If you do not have Rh = negative

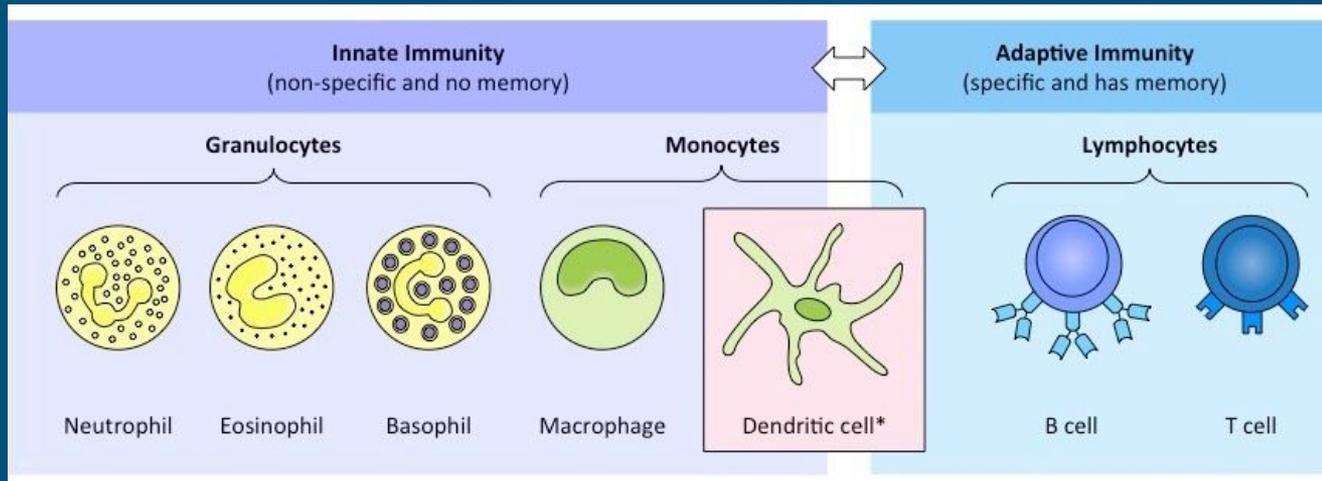


UNDERSTANDING BLOOD TYPES



Leukocytes

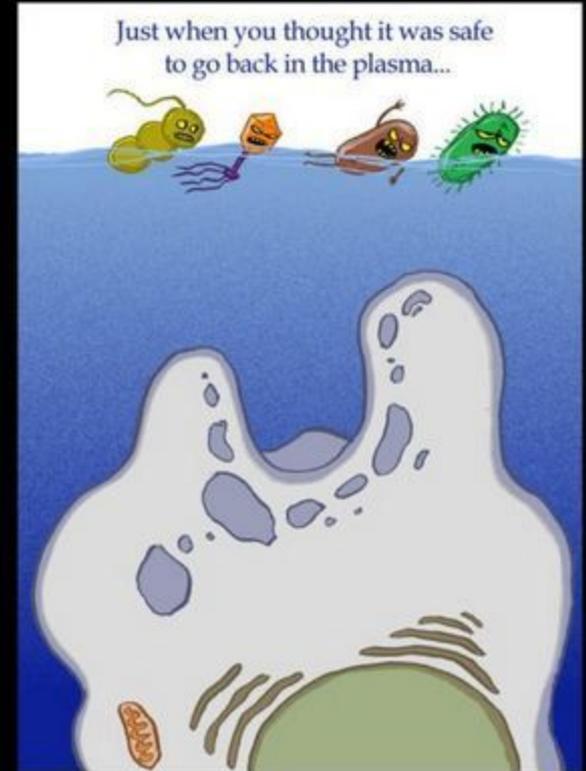
- Leukocytes are white blood cells.
- There are many types of white blood cells, some of them are:
 - Macrophages (phagocytic leukocytes/a form of monocytes)
 - Helper T cells (T lymphocytes) - Trigger adaptive immunity
 - B cells (B lymphocytes)



Primary Immune Response

- **NONSPECIFIC RESPONSE:** Cell encounters foreign organism/cell for the first time and engulfs it (phagocytosis)
- Antigen presentation: some parts of the foreign organism (non self) are presented by the macrophage
- **SPECIFIC RESPONSE:** Helper T cells recognize the identification of the foreign cell and become activated (release cytokines)

PHAGOCYTOSIS



VIRUS

BACTERIA

PROTOZOANS

Role of Helper T Cells and B Cells

- Helper T cells go around and activate B cells that can create the antibody for this foreign substance (antigen).
- The B cell clones itself many times with that same antibody
- There are two types of B cells, effector (plasma) cells and memory cells.
 - Effector cells produce antibodies
 - Memory cells take notes on this invasion and live for a very long time. They float around the plasma waiting for the next invasion

MEMORY CELLS

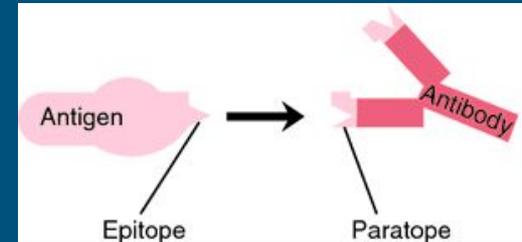
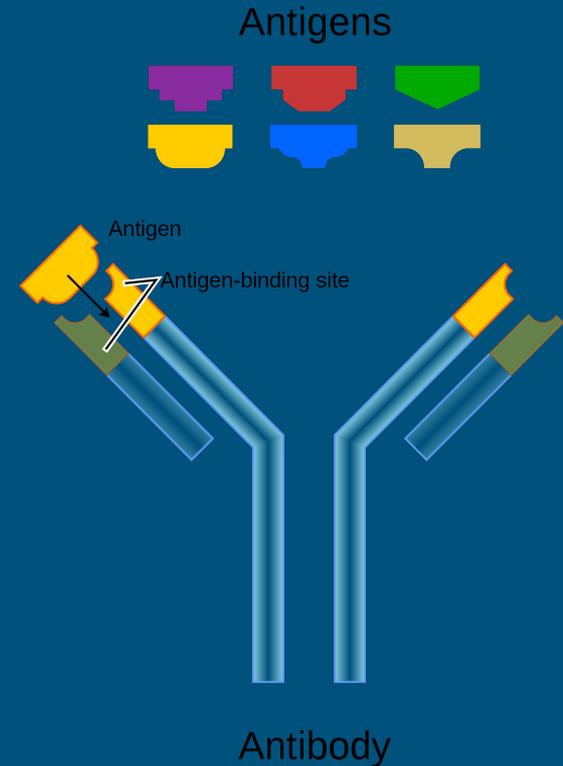


EFFECTOR CELLS



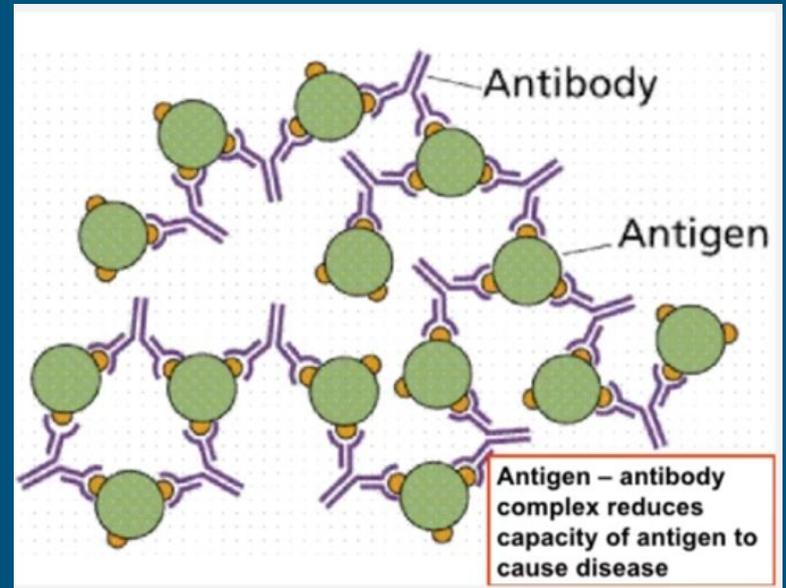
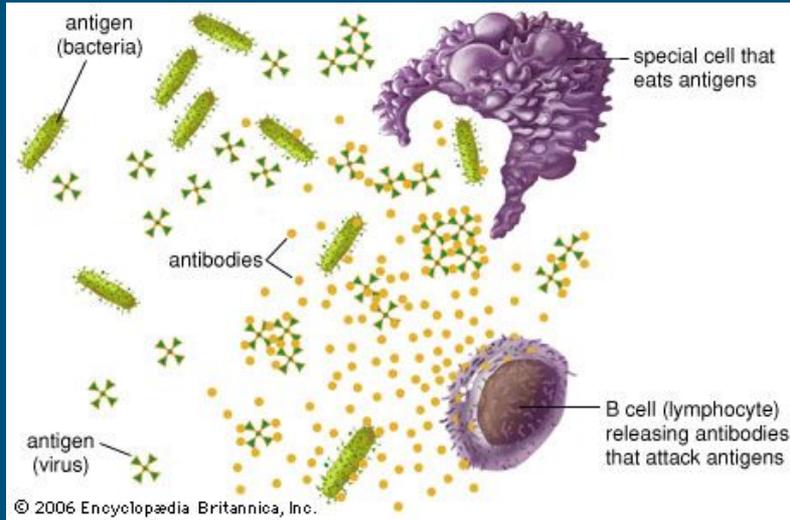
What are antibodies?

- Y-shaped proteins produced by plasma cells
- Because of its shape, it has binding sites at TWO ends
- Each antibody can bind to TWO antigens
- Plasma cell will secrete around 2,000 antibody molecules per second into the bloodstream for roughly 4-5 days.
- **PARATOPE** on antibody binds to **EPITOPE** on non-self substance



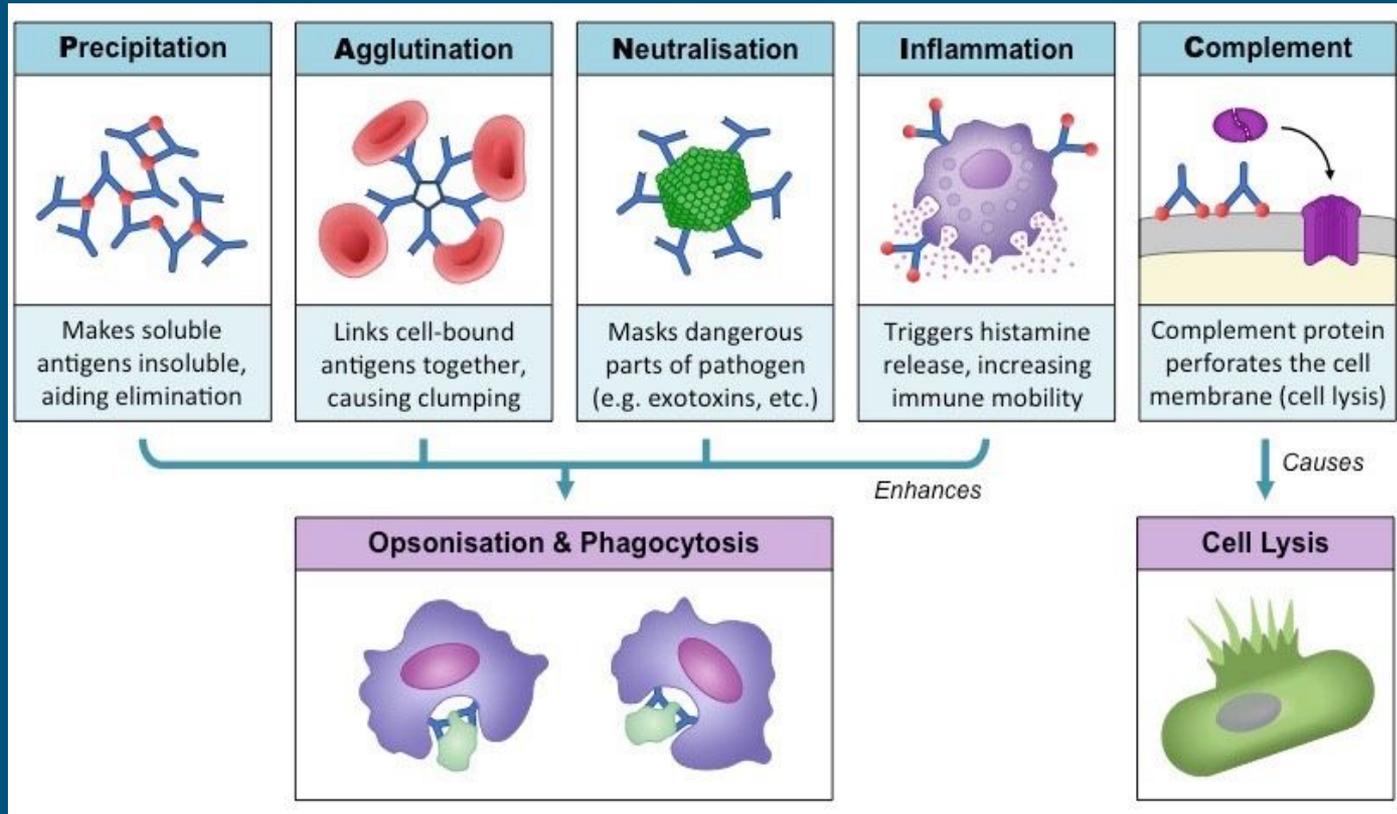
Agglutination

Agglutination = makes it easier for macrophages and other immune cells to find and engulf the clumps of foreign material.



PANIC!!!!

This mnemonic helps us remember all the different “strategies” antibodies use to kill a foreign substance in the body.

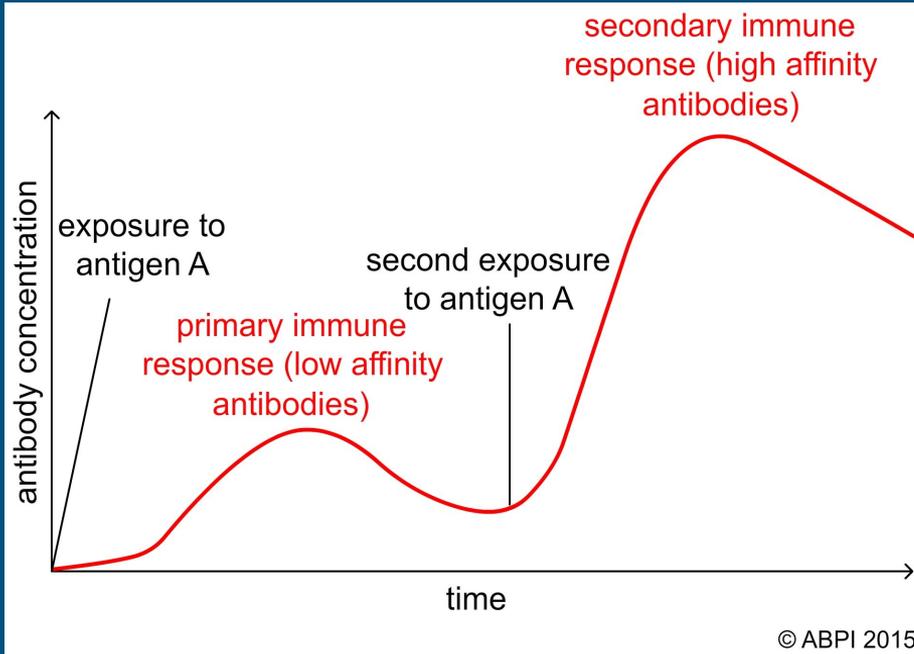


Summary of Primary Immune Response

1. Macrophage encounters a foreign cell
2. Macrophage engulfs the cell through phagocytosis
3. Macrophage presents the antigens of the non-self substance on its surface
4. When a macrophage does “antigen presentation”, T cells are activated and release cytokines.
5. T cells patrol the body to find a B cell that had antibodies which match the antigen of the non-self cell
6. When the right B cell is found, it clones itself many times to create effector and memory cells.

***This takes time and the patient is going through symptoms while this is happening.

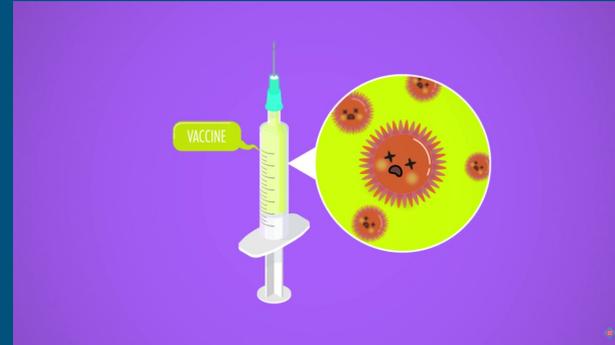
True Immunity



- If our body gets attacked by these invaders a second time, the immune response is quicker because memory cells are already present.
- The person might not even feel symptoms.

How do Vaccines work?

- Organisms can only get immune when they are first exposed to a pathogen.
- Vaccines expose organisms to the pathogen in a safe way to induce a primary immune response and create antibodies and memory B cells.
- This prepares the body in case it actually gets infected with the pathogen in the future.
- Vaccines are usually not the exact pathogen so our body does not get symptoms.
- Vaccines don't PREVENT infections, it just makes sure you have the instructions to get rid of the virus in the future by giving you the tools (antibodies).



Homework

COVID Vaccine Article: Read the article, highlight/take notes and submit a picture on Google Classroom!

<https://www.umms.org/coronavirus/covid-vaccine/facts/mrna>

Crash Course EdPuzzle:

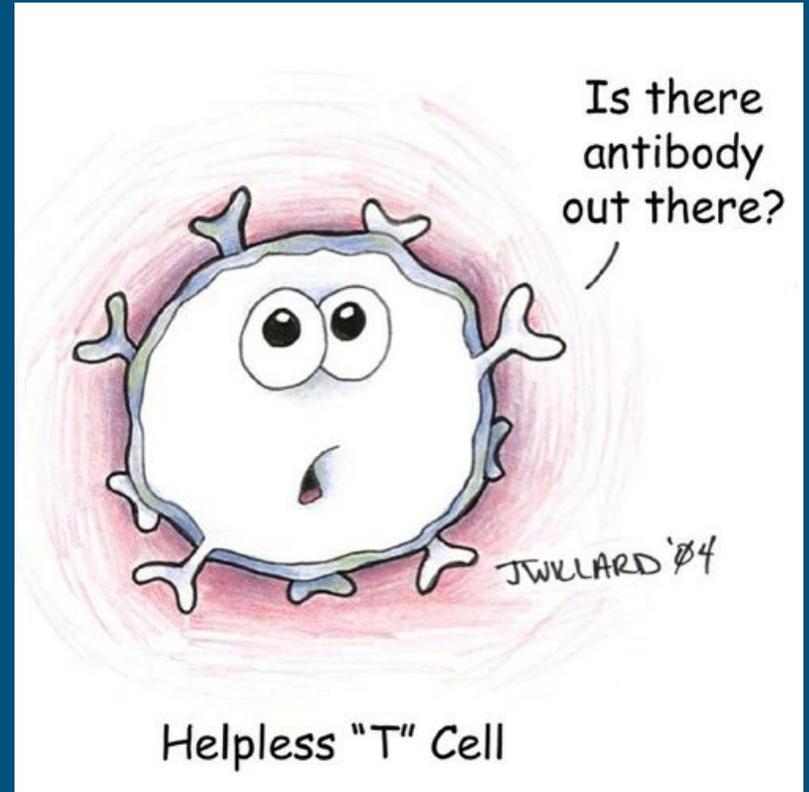
Immune System 1 - Answer the questions, take notes, and submit a picture of your notes on Google Classroom!

Immune System 2 - Answer the questions, take notes, and submit a picture of your notes on Google Classroom!

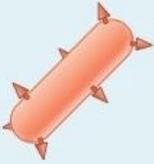
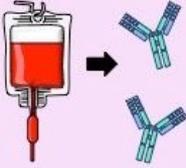


Agenda

- Immunity
- Pathogenesis
- Methods of disease transmission
- Polyclonal vs. Monoclonal Antibodies
- Allergies



Immunity

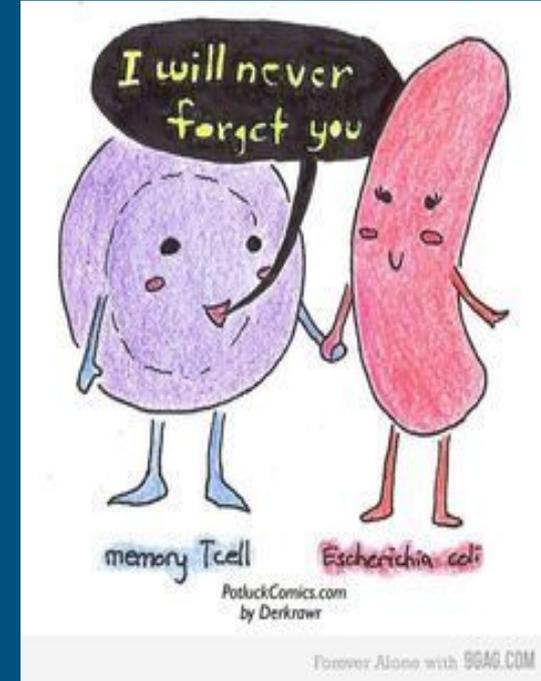
ACTIVE IMMUNITY		PASSIVE IMMUNITY	
Natural	Artificial	Natural	Artificial
			
Infection	Vaccination	Maternal antibodies	Monoclonal antibodies

Passive Immunity

- One organism produces antibodies for another organism.
- Breast milk (colostrum specifically) fed to newborns has lots of antibodies.

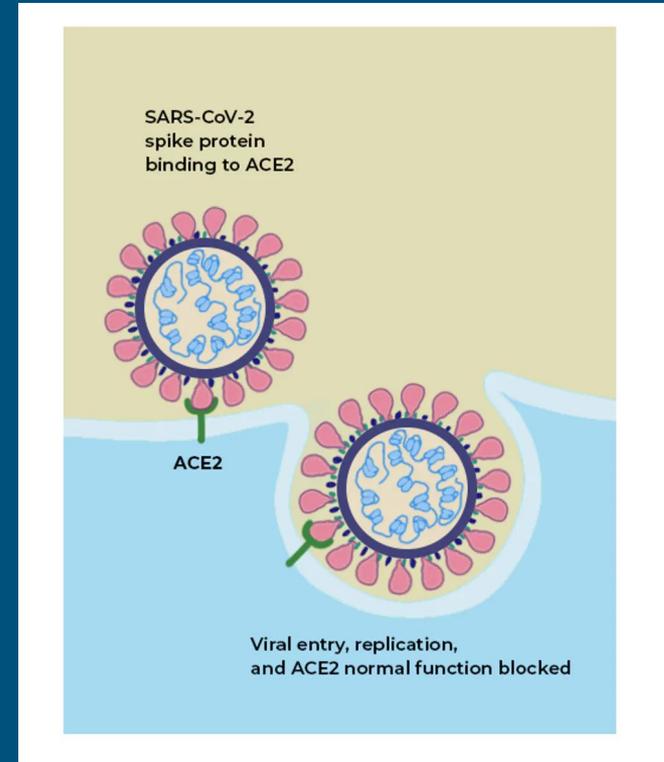
Active Immunity

- Production of your own antibodies after exposure to an infection. Your body must go through a primary immune response.
- Exposure by getting an infection or vaccine.



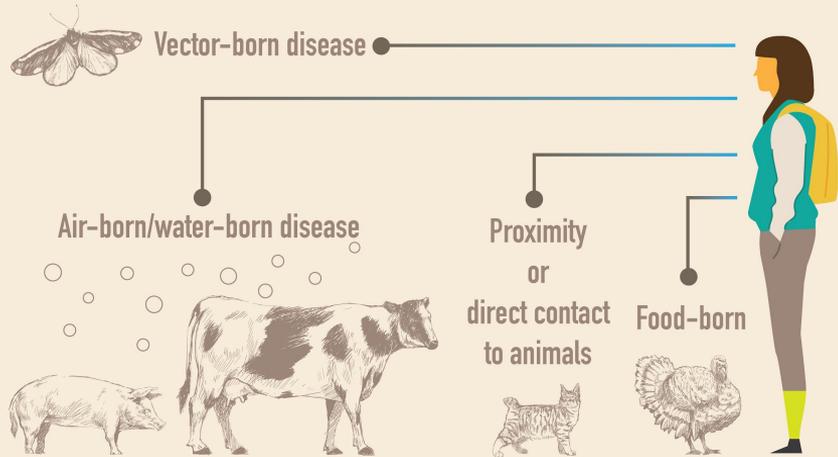
How do diseases spread from one species to another?

- **Pathogenesis** (spread of diseases).
- Bacterial and fungal diseases like salmonella, ringworm, tuberculosis often spread from one species to the next.
- Viruses rarely spread from one species to the next because they are often species-specific. They are only able to inject their DNA in a host cell if that species' cell surface has a receptor cell it can bind to (polio, syphilis, measles, gonorrhea)
- Receptor cells are determined by our genes, so it's usually not possible for something that infects snakes to also be able to infect humans, for example.



Viruses that HAVE spread from one species to another

HOW ZOOONOTIC DISEASES are transmitted

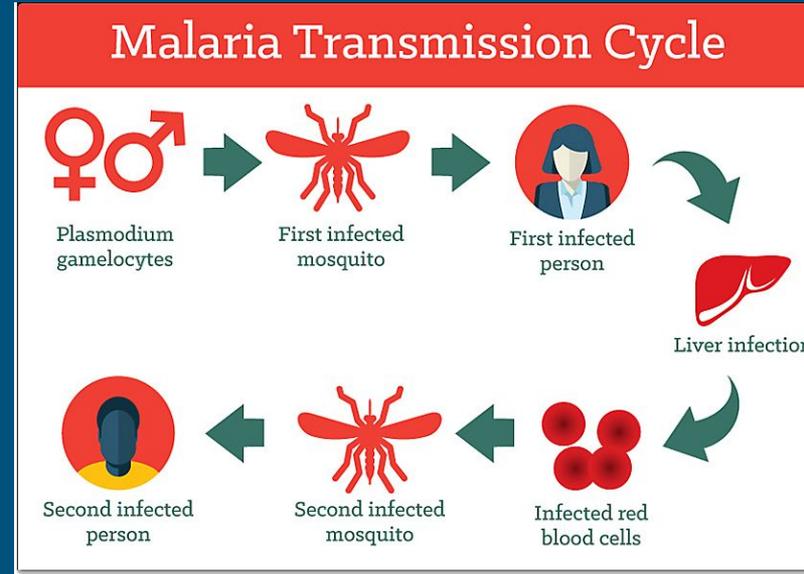


- H1N1 (swine flu), HIV/AIDS, SARS, Ebola, possibly COVID-19?...
 - Lots of things have to be perfect for this to happen
1. We're probably closely related to the species we get this virus from **OR**
 2. The virus can almost fit in the receptor, **OR**
 3. The virus has a mutation that allows it to fit in our receptor cells.

Zoonotic diseases: diseases that spread from one species to the next.

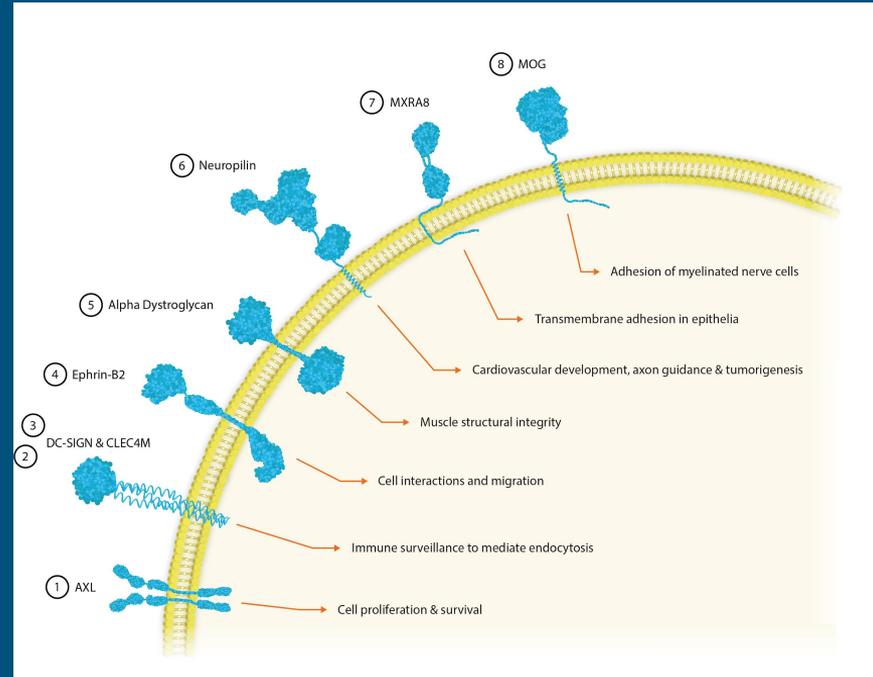
Methods of disease transmission

1. Direct contact - shaking hands when someone sneezed on it (flu)
2. Eating something contaminated (salmonella)
3. Airborne - When there are particles in the air (COVID-19?)
4. Vectors - When a vector passes a disease to you but the vector doesn't get sick (malaria - female mosquitoes pick up the plasmodium parasite, which causes malaria, when they bite people who already have malaria. Then they go and bite another person who isn't sick and leave them with a plasmodium parasite which will cause malaria)



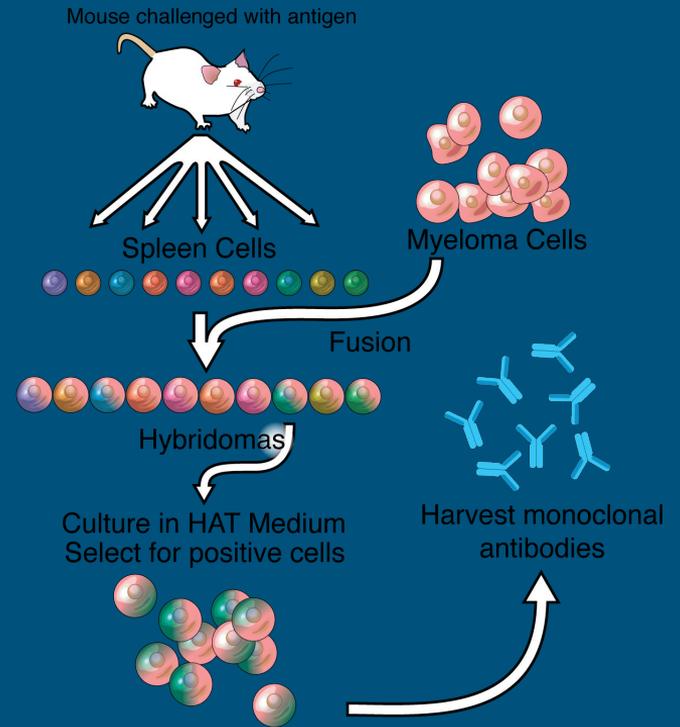
Polyclonal vs. Monoclonal antibodies

- Every virus has MANY different types on antigens on its surface
- Our body responds by creating MANY different B cells, specific to all the different antigens
- So we create MANY different antibodies to fight off each of these different antigens
- This is called a **POLYCLONAL** immune response, where we create many different antibodies
- All of these antibodies are working together and it's hard to separate them, if we want to isolate only one antibody... a **MONOCLONAL ANTIBODY**



Production of Monoclonal Antibodies

- Pathogens have antigens on their surface, causing our cells to create many antibodies. But what if I just want one specific antibody?
1. **Inject** mouse with a specific antigen (not a specific pathogen because remember, every pathogen has multiple antigens)
 2. The mouse will naturally have a **primary immune response** creating B cells
 3. **B cells are harvested** from the mouse's spleen (sorry mouse..)
 4. Fuse B cells with **myeloma cells** (cancer cells) which creates **hybridoma cells**. (We chose cancer cells because they're longer living and quicker to divide so that we can get lots of copies of our antibodies to sell)
 5. Take hybridoma cells and put them through a **test** (ex: ELISA test) to confirm that they have the right antibodies
 6. **Remove antibodies!** (we know they are all the same; monoclonal, because we got them all from a response from one specific antigen)



Use of Monoclonal antibodies to diagnose Pregnancy

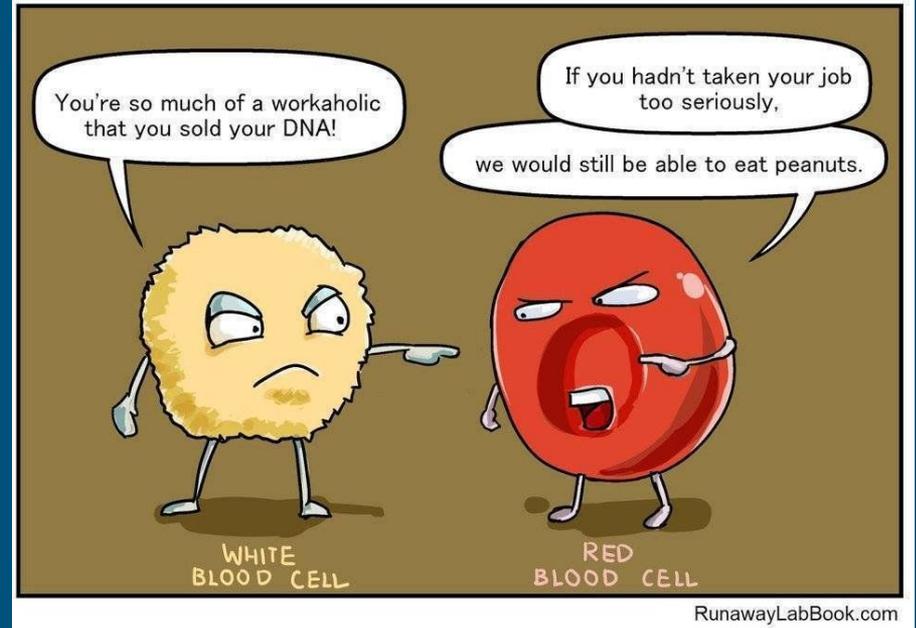
PREGNANCY TESTS!!!

- Pregnant women releases HCG (human chorionic gonadotropin) hormone
- When HCG binds to a specific antibody, it leads to a color change
- A pregnancy test has those antibodies from hybridoma cells, so when a woman pees on the pregnancy test, it changes color if the urine has HCG... which she'll only have if she's pregnant.
- SUPER COOL!



Allergies

- Body reacting to harmless, non-self cells entering our body; usually just in the area of exposure.
- Some people's bodies are able to ignore these, others are not.
- Examples of allergens: pollen, peanuts, egg white, bee venom, etc.



Allergic Response

Allergic response happens in two stages:

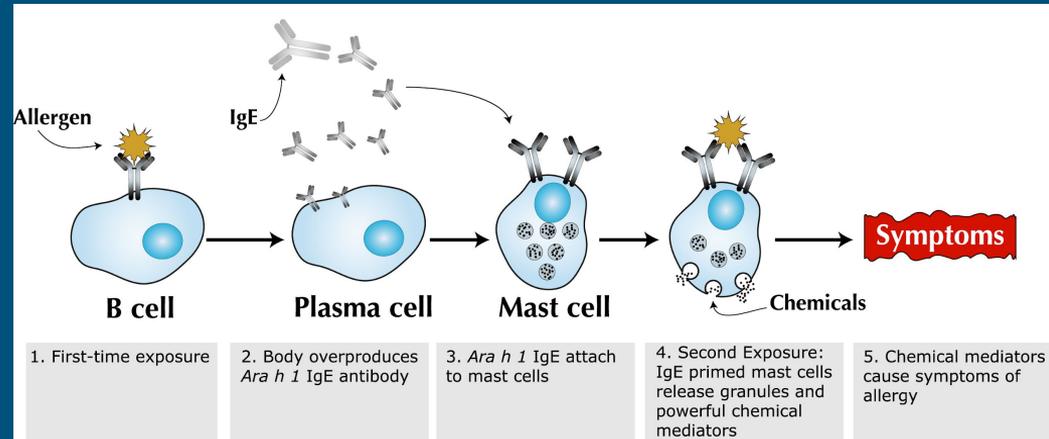
When you're exposed for the first time:

- Your body is trying to create antibodies to respond to these non-self cells
- B cells differentiates into large plasma cell and releases many **IgE** antibodies (specific for allergies)
- IgE antibodies, bind to **MAST CELLS** (white blood cells), instead of binding to the peanut/pollen antigens



When you're exposed for the second time:

- When antibodies encounter the antigen (allergens), they bind to the MAST CELL and it releases **HISTAMINE** (which causes all those allergy symptoms like itching, redness/heat (vasodilation) swelling/pain (capillary permeability), runny nose, etc.)
- That's why we take **ANTIHISTAMINES!!!**



Homework

- EdPuzzle part 3
- Review of the Chapter that I'll post over the weekend! (Due next Wednesday!)

