What is the immune system?

SFB 1335 Aberrant Immune Signals in Cancer

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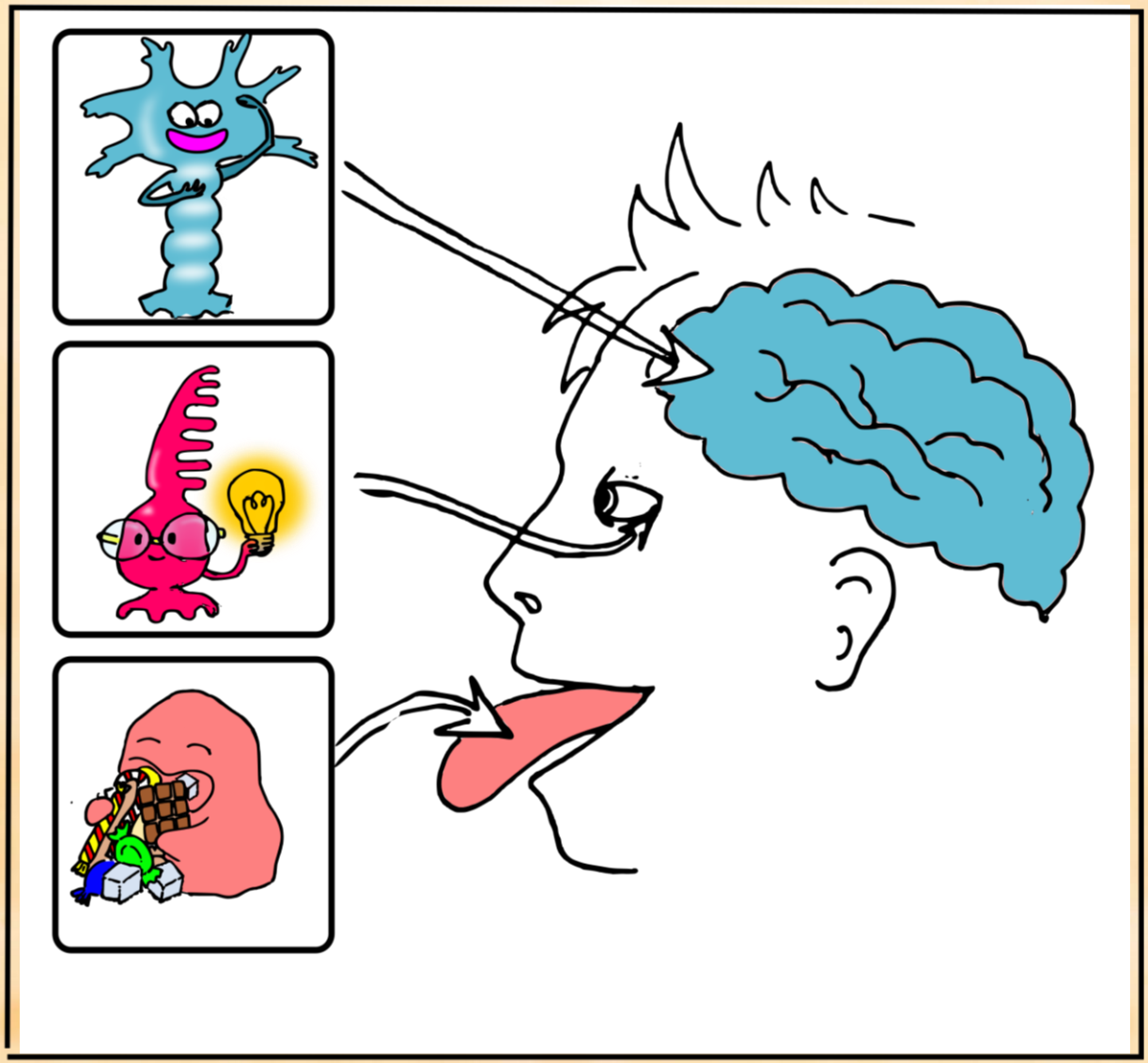
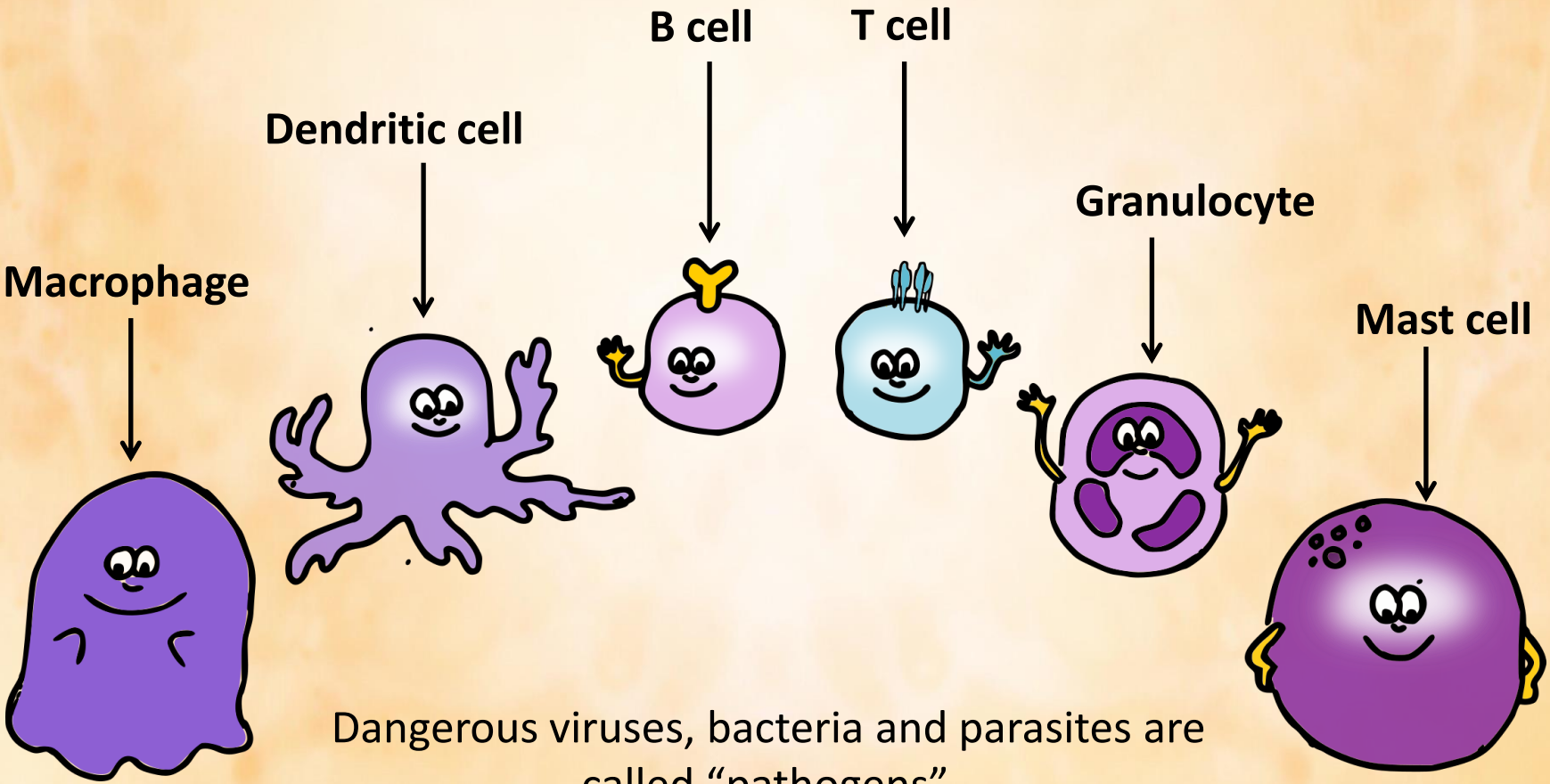
Our body is made of cells

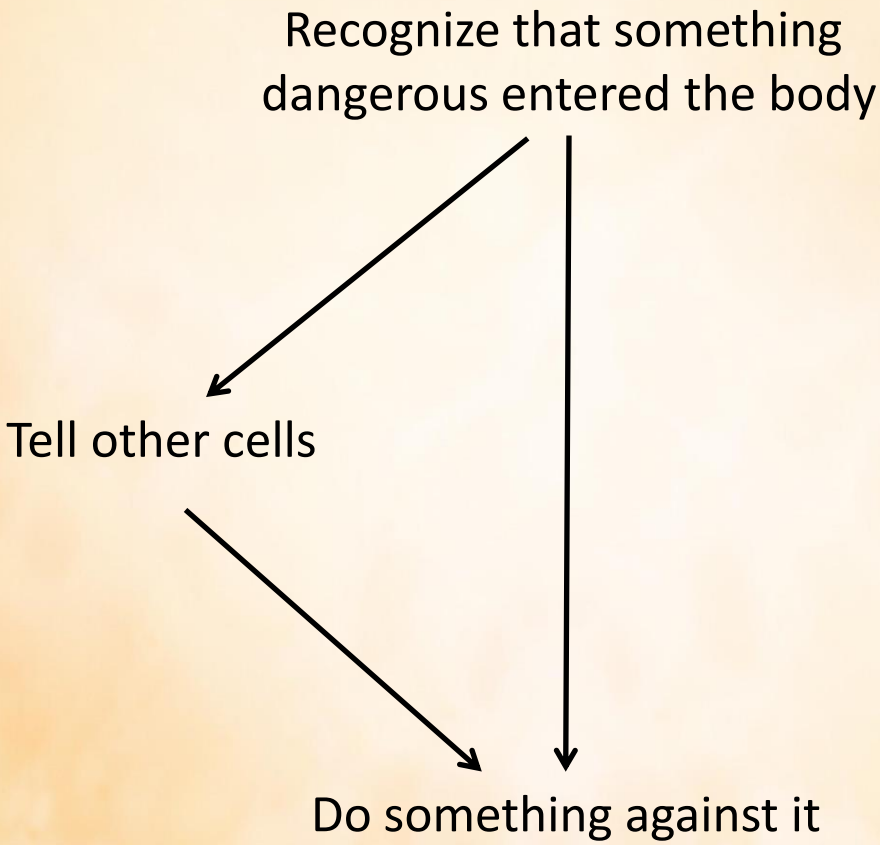


The cells of the immune system help us fight dangerous viruses, bacteria and parasites. Without an immune system we wouldn't be able to survive!
These are the cells of the immune system:



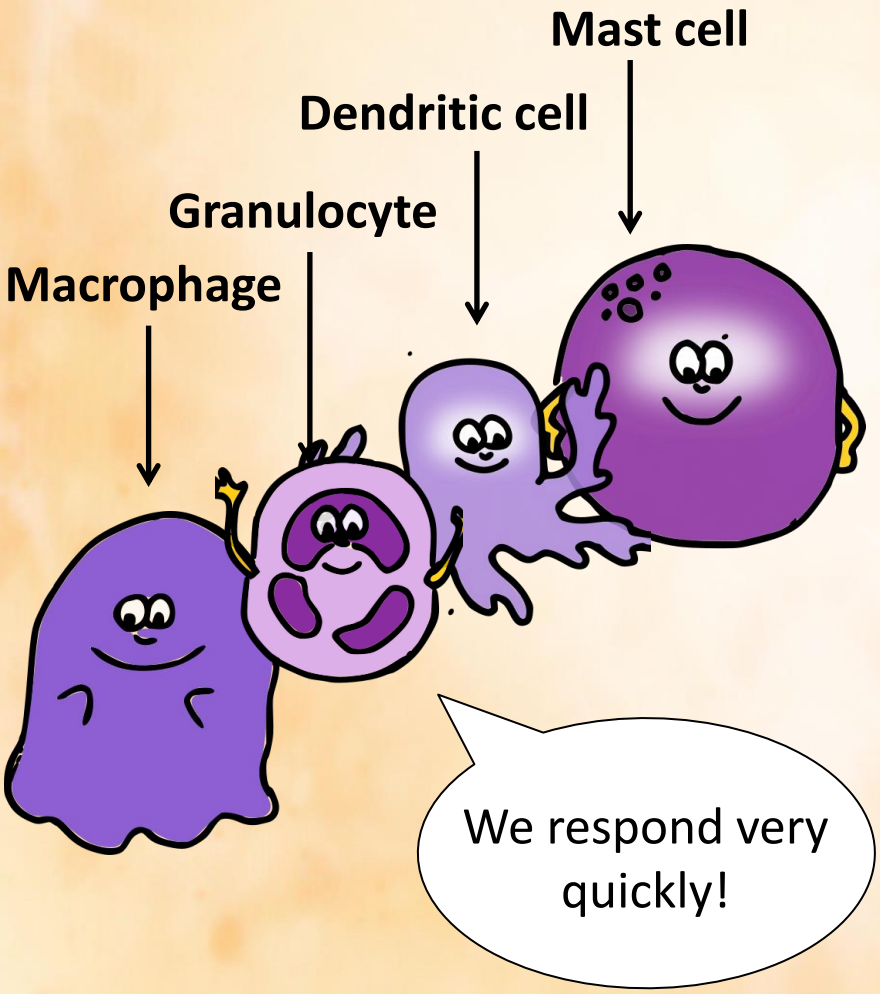
Dangerous viruses, bacteria and parasites are called "pathogens".

This is how the immune response is organized:

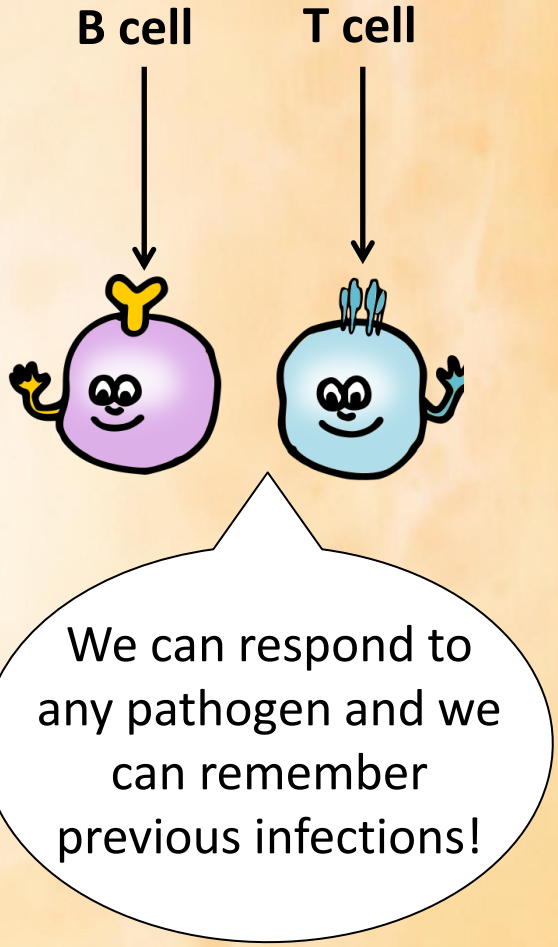


The immune system has two arms:

The innate immune system



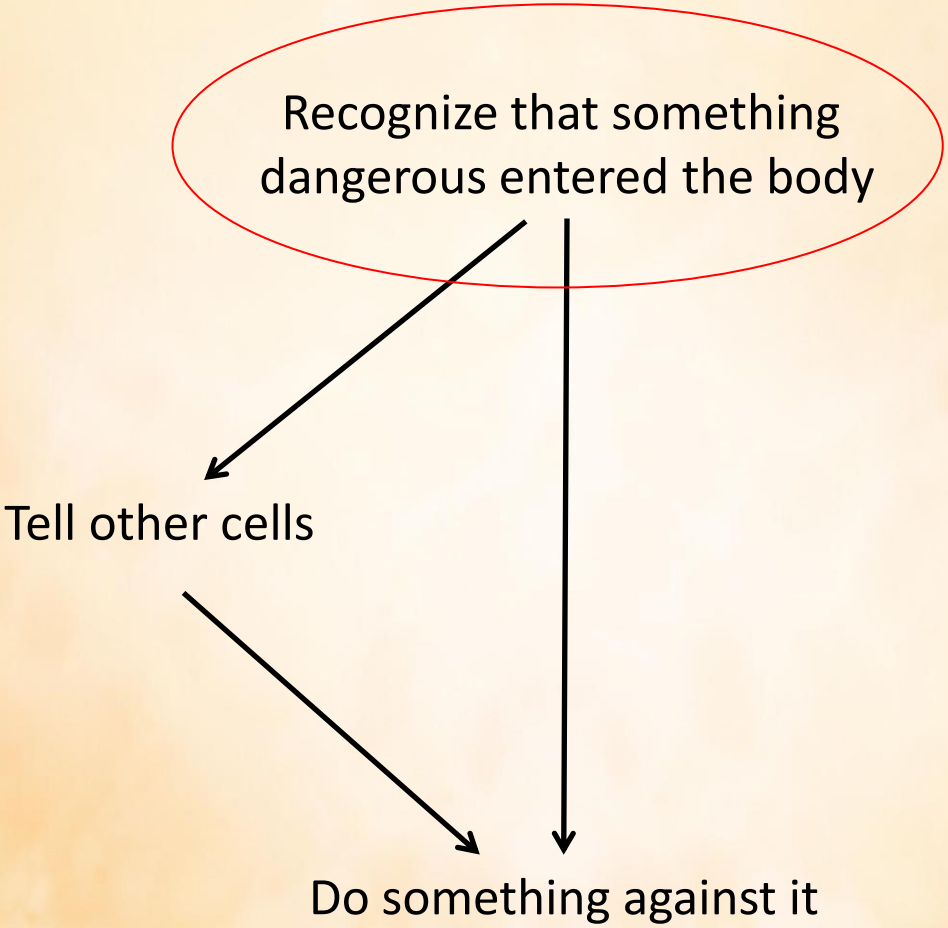
The adaptive immune system



Innate vs adaptive immunity

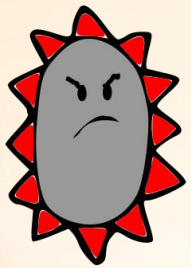
Innate immune response	Adaptive Immune response
Fast	Slow
Recognizes only the most common pathogens	Can recognize basically any pathogen
No “immune memory” (= responds equally fast to a second infection)	“immune memory” (= responds faster if a pathogen infects a second time)

The innate immune system



The most difficult job of the immune system is to recognize what is a pathogen and what is not a pathogen

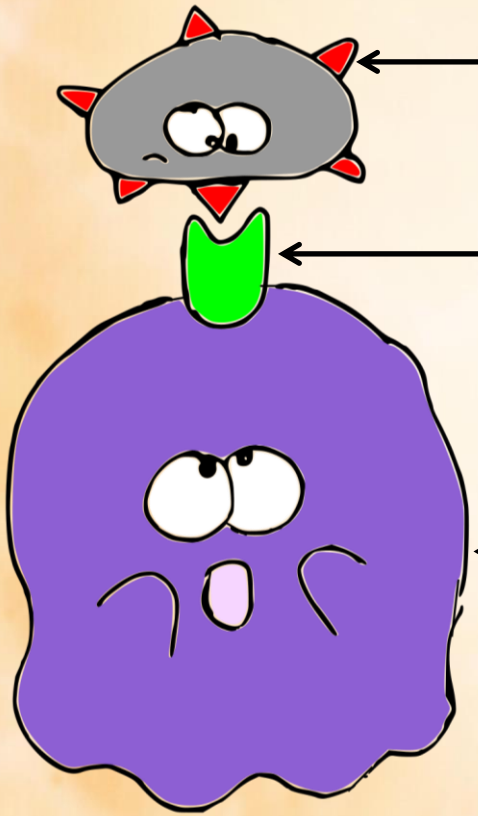
Bacterium



Not a bacterium

The cells of the immune system don't have eyes and ears. They need to use something else to "see" pathogens.

Cells have “receptors”, which help them to figure out what is around them



A structure on the pathogens surface (can be a protein, lipid, sugar structure)

Receptor recognizing the structure

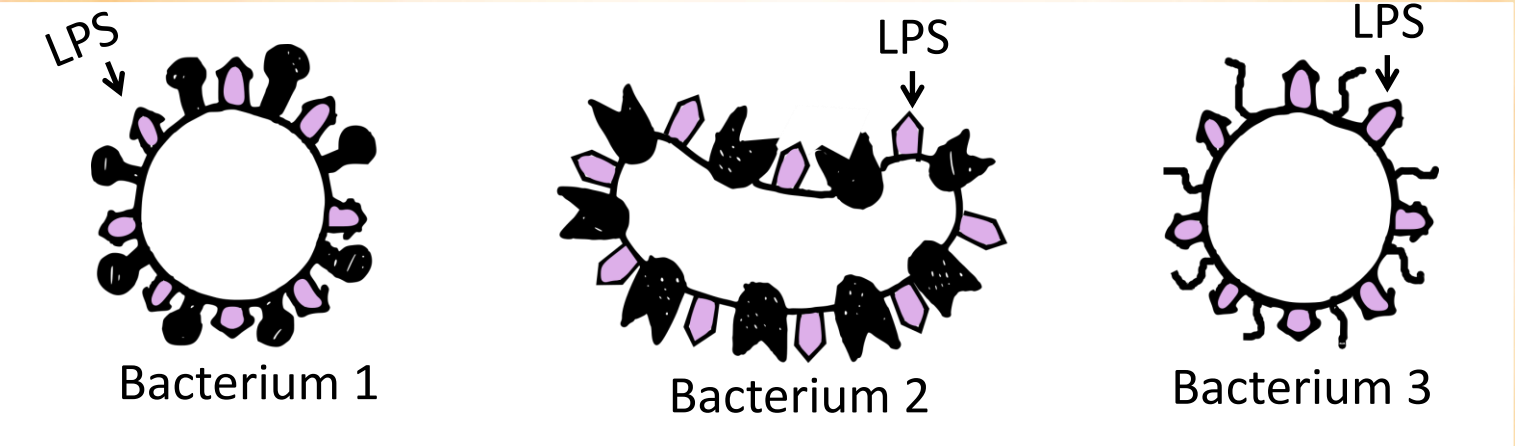
An immune cell knows that a pathogen is close, if the receptor binds to the structure it is made to recognize

Innate immune system

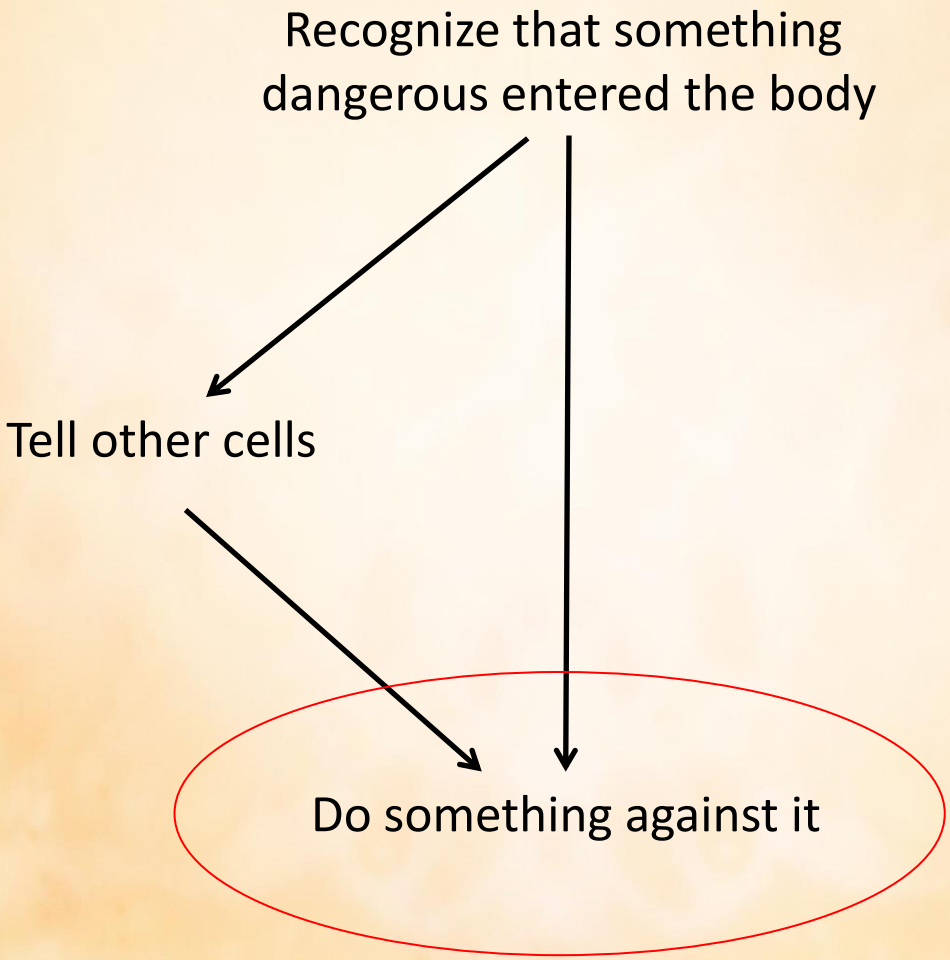
How the cells recognize pathogens:

Cells of the innate immune system use “pattern recognition receptors” = These receptors recognize structures that are common on pathogens

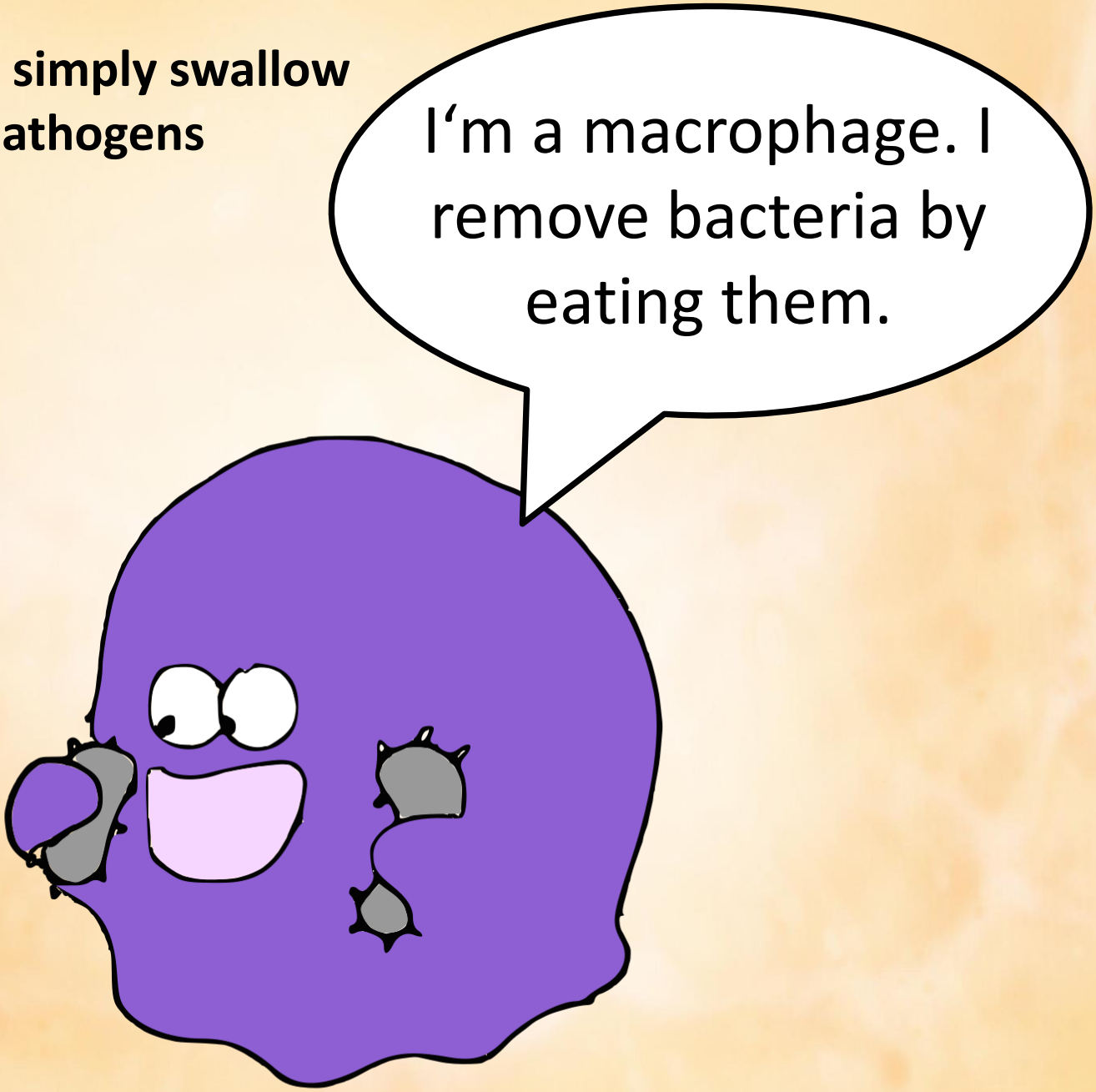
Example:
All the different bacteria bellow have “LPS” on their surface (in purple) a cell of the innate immune system with the “TLR4” receptor can “bind LPS” and therefore is able to tell that a bacterium is close.



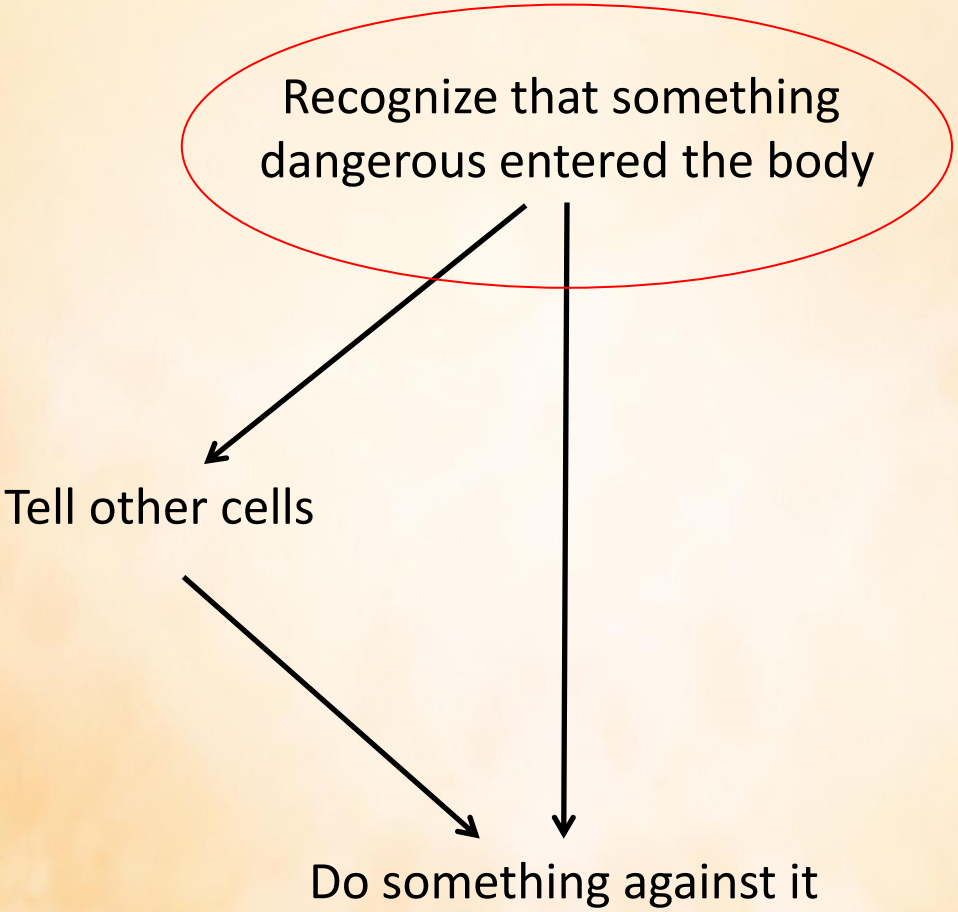
The innate immune system



Some cells can simply swallow whole pathogens

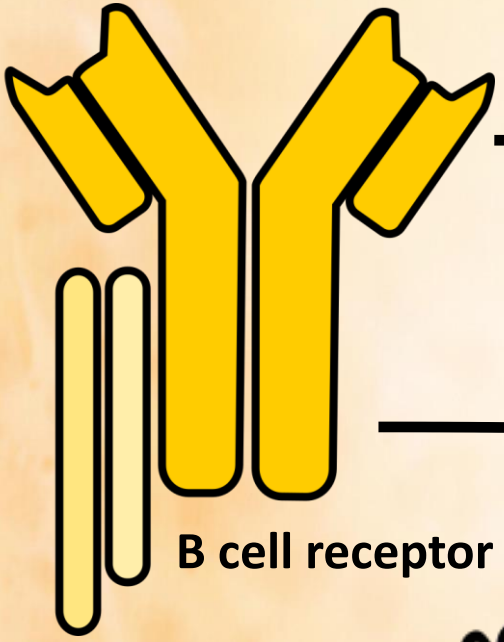


The adaptive immune system

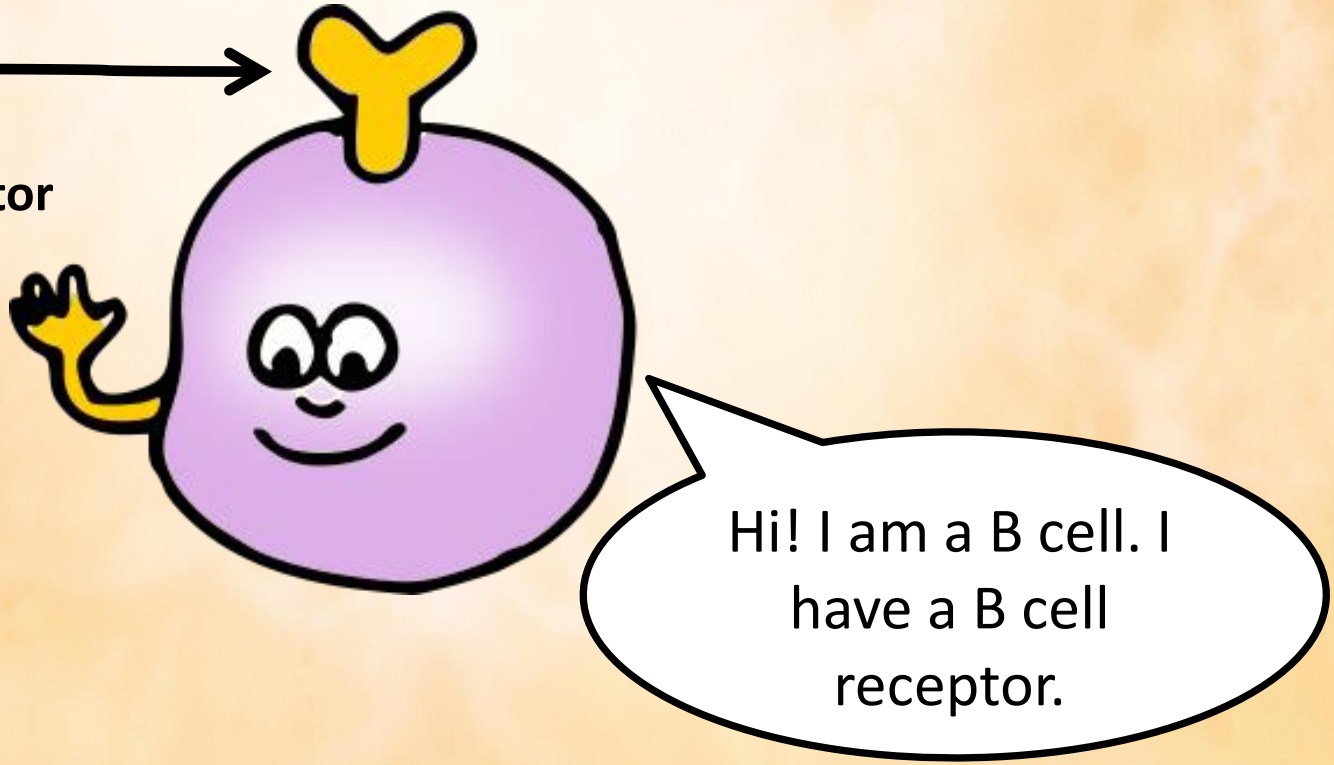


The adaptive immune system

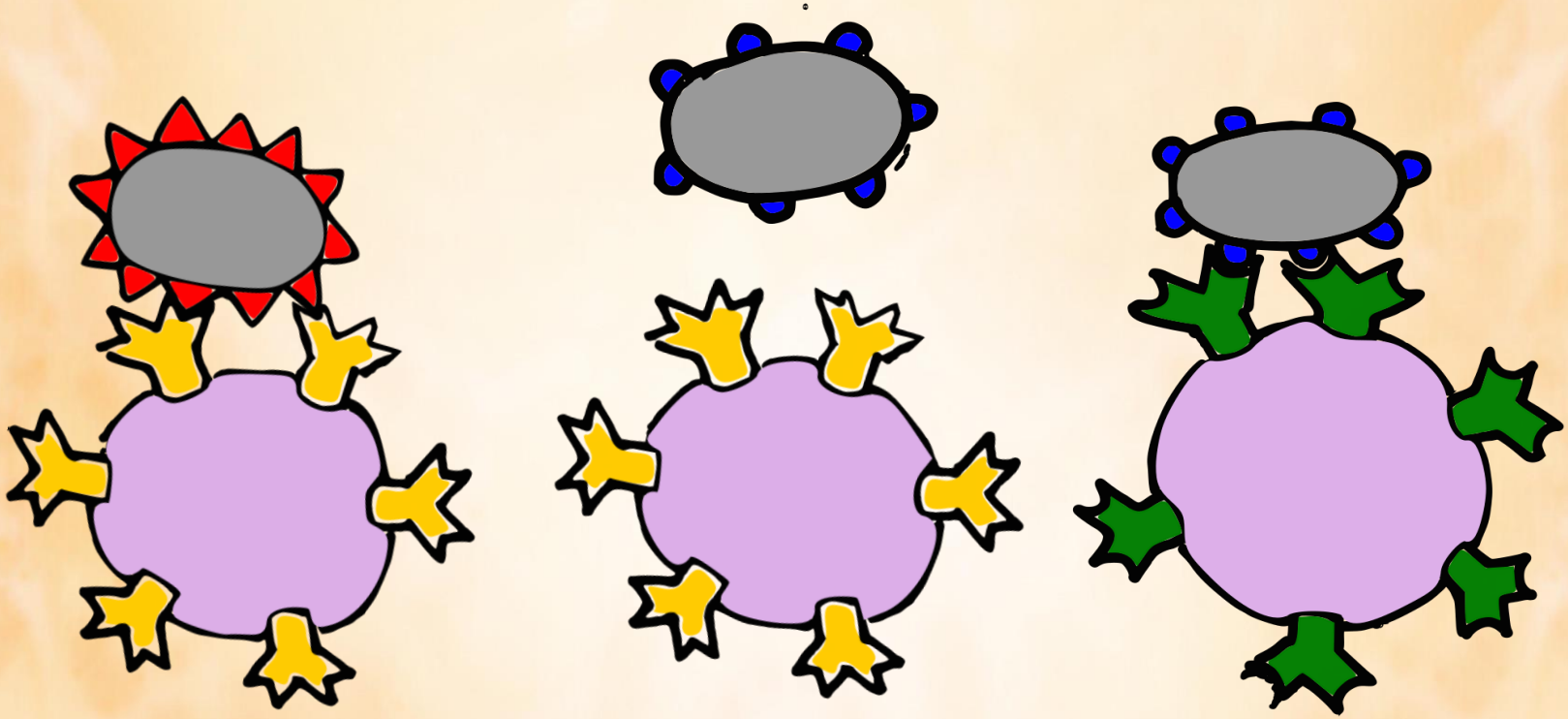
This part is different on individual B cells and is important for recognizing structures on pathogens.



B cell receptor

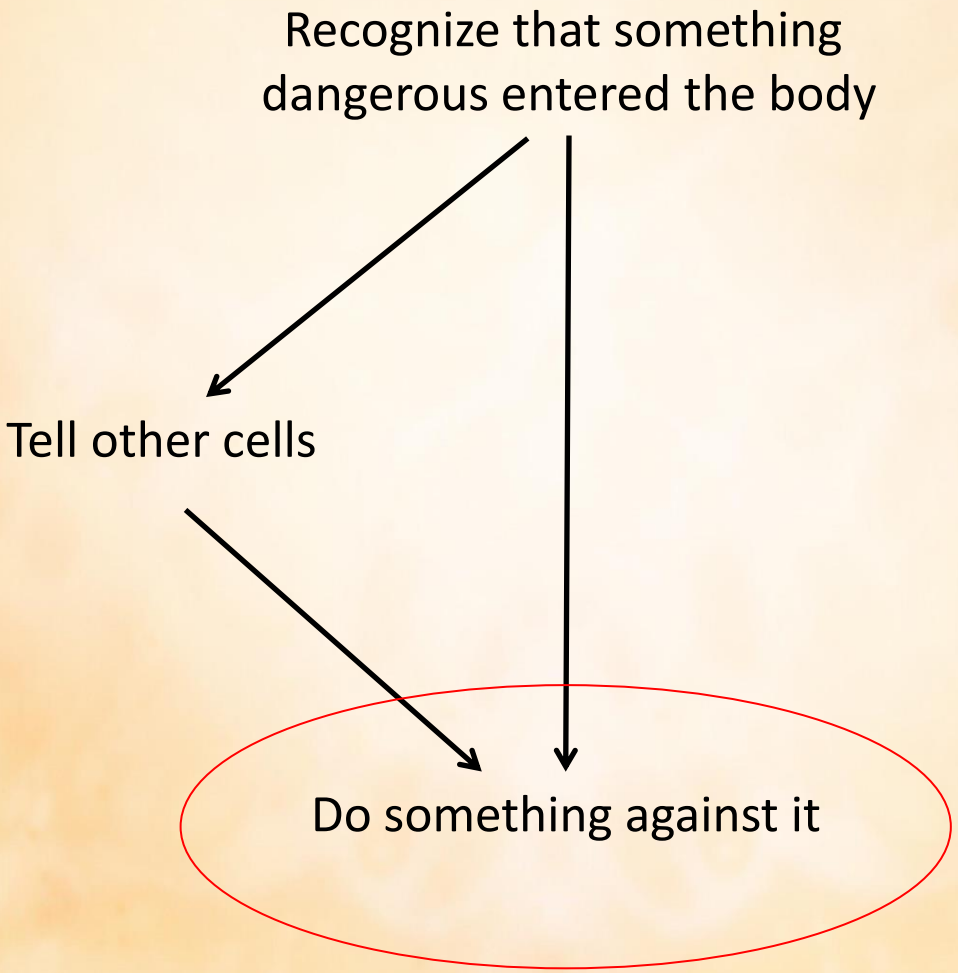


Every B cell has a different B cell receptor and recognizes different structures. We have many B cells in our body and can therefore recognize any pathogen in the world.



In this example the B cell with the “yellow” BCR recognizes the bacterium with the red spikes but not the one with the blue bumps. The bacterium with the blue bumps is recognized by the B cell with the “green” BCR.

The adaptive immune system

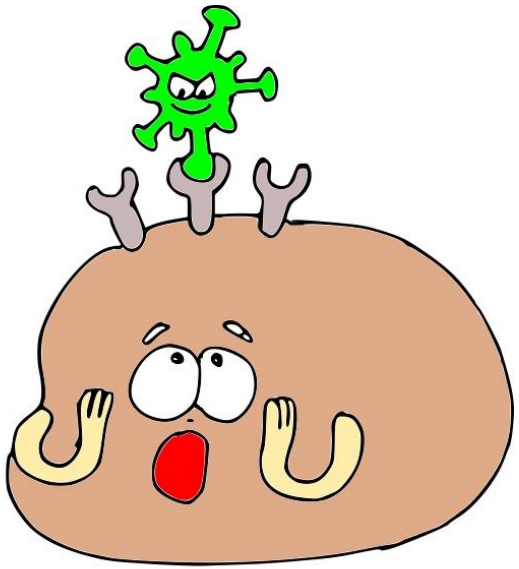


B cells can become plasma cells and make antibodies

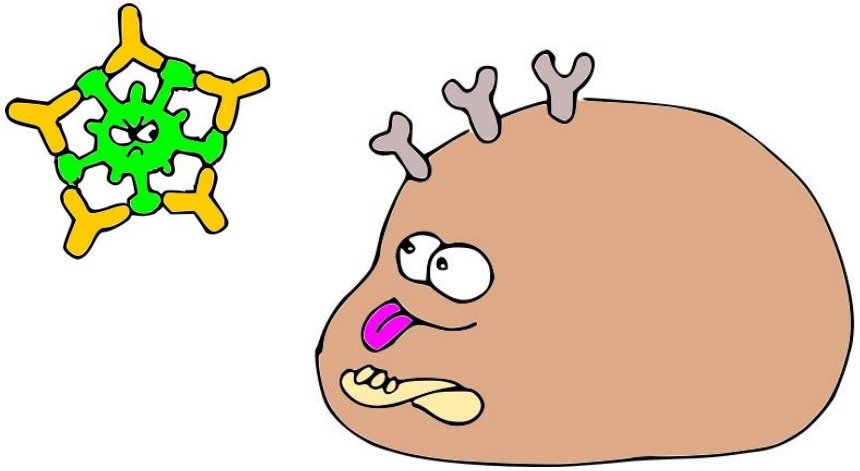
Once a B cell recognizes a pathogen, it gets activated and can become a plasma cell. Plasma cells produce large amounts of antibodies that are released into the blood stream. Antibodies then bind to pathogens.

What are antibodies good for

This virus can enter the cell and make it sick.

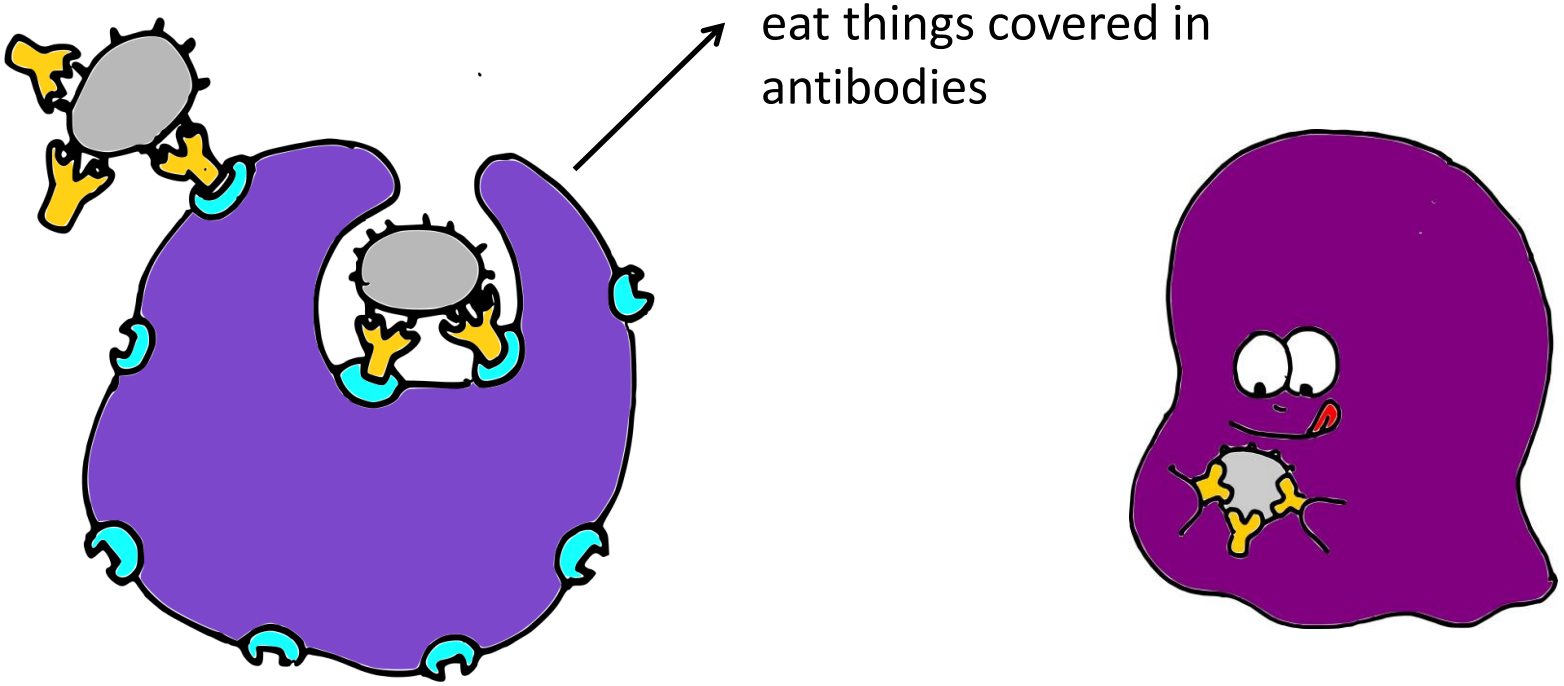


This virus can not enter the cell because antibodies are sticking to it.



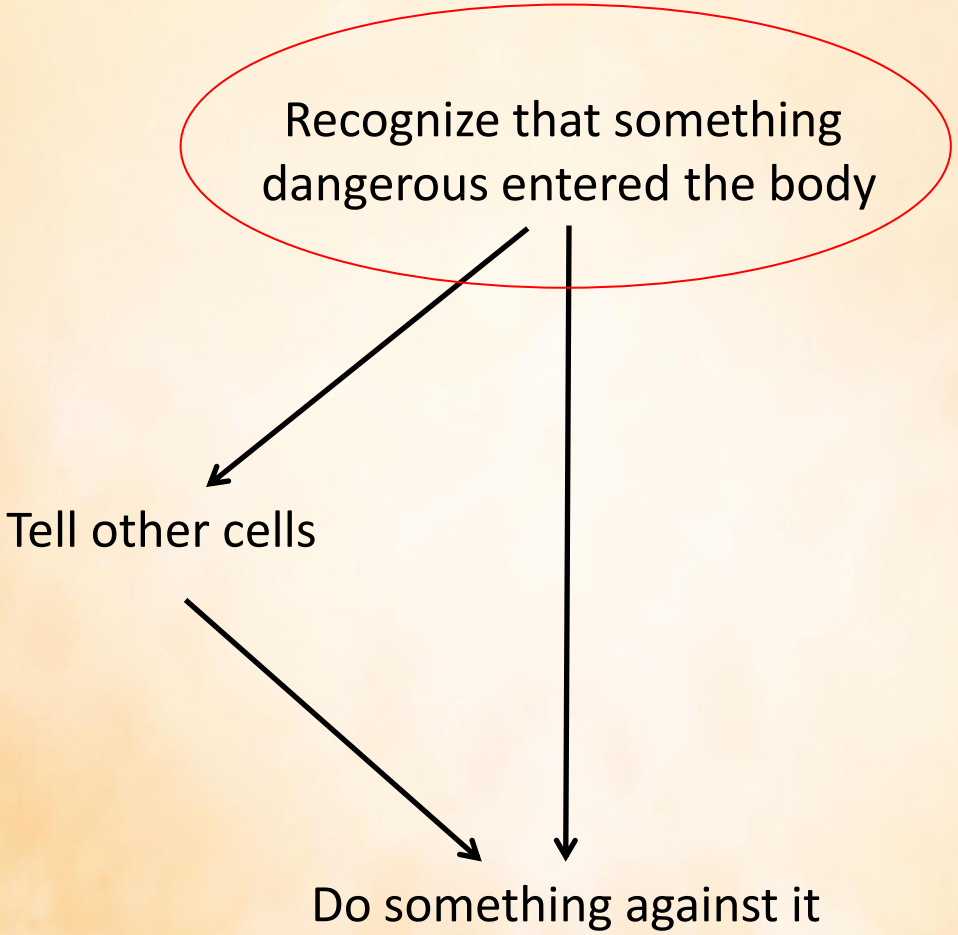
Antibodies can prevent pathogens from entering cells. Pathogens often need to bind to a specific receptor on a cell to be able to get inside. If antibodies are sticking to the virus, the virus cannot interact with the receptor and cannot enter the cell. The cell then doesn't get sick.

What are antibodies good for



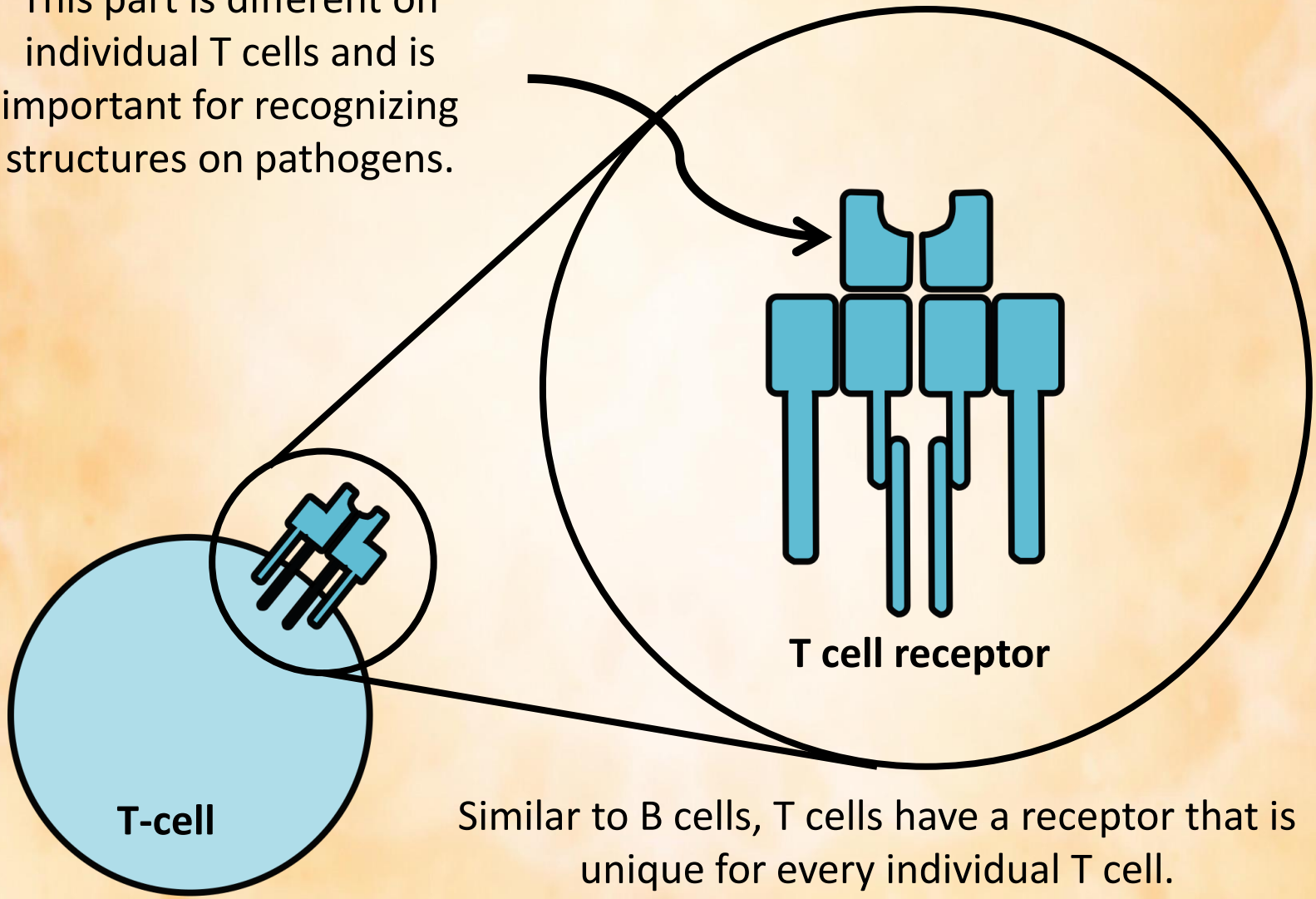
Antibodies make it easier for the cells of the innate immune system to recognize dangerous things. Macrophages have receptors that recognize antibodies. Once they bind antibodies they eat the pathogen that is covered by them.

The adaptive immune system



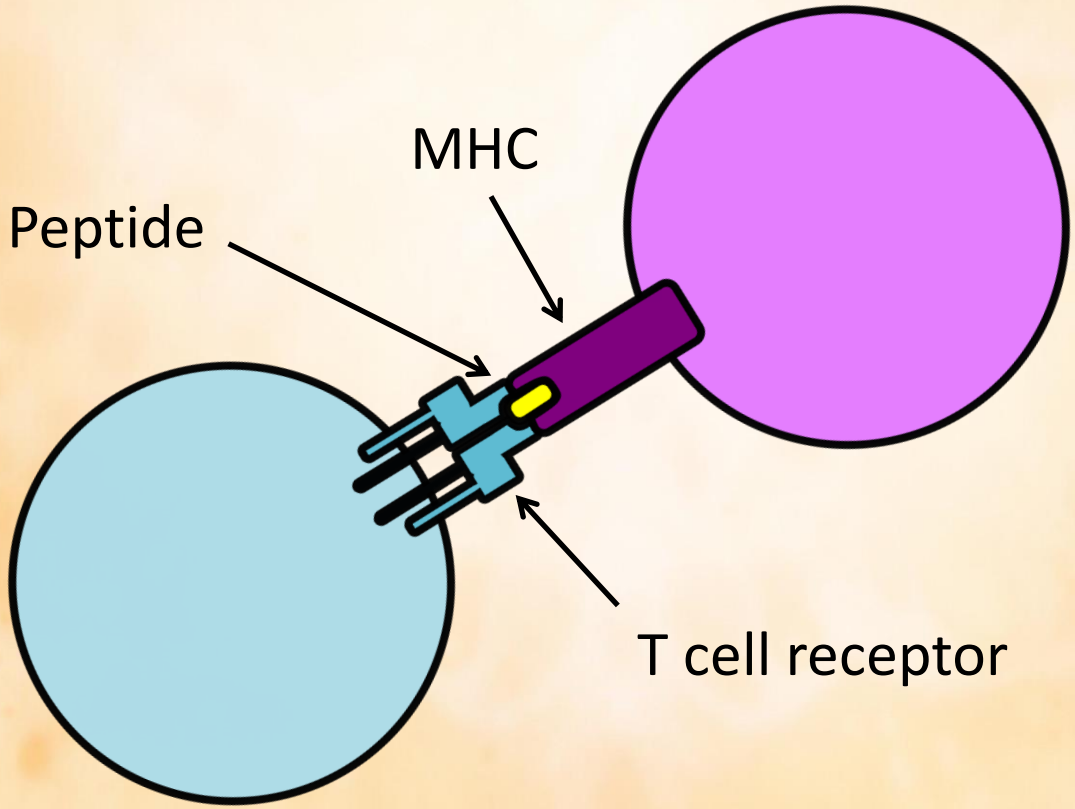
T cells have a T cell receptor

This part is different on individual T cells and is important for recognizing structures on pathogens.

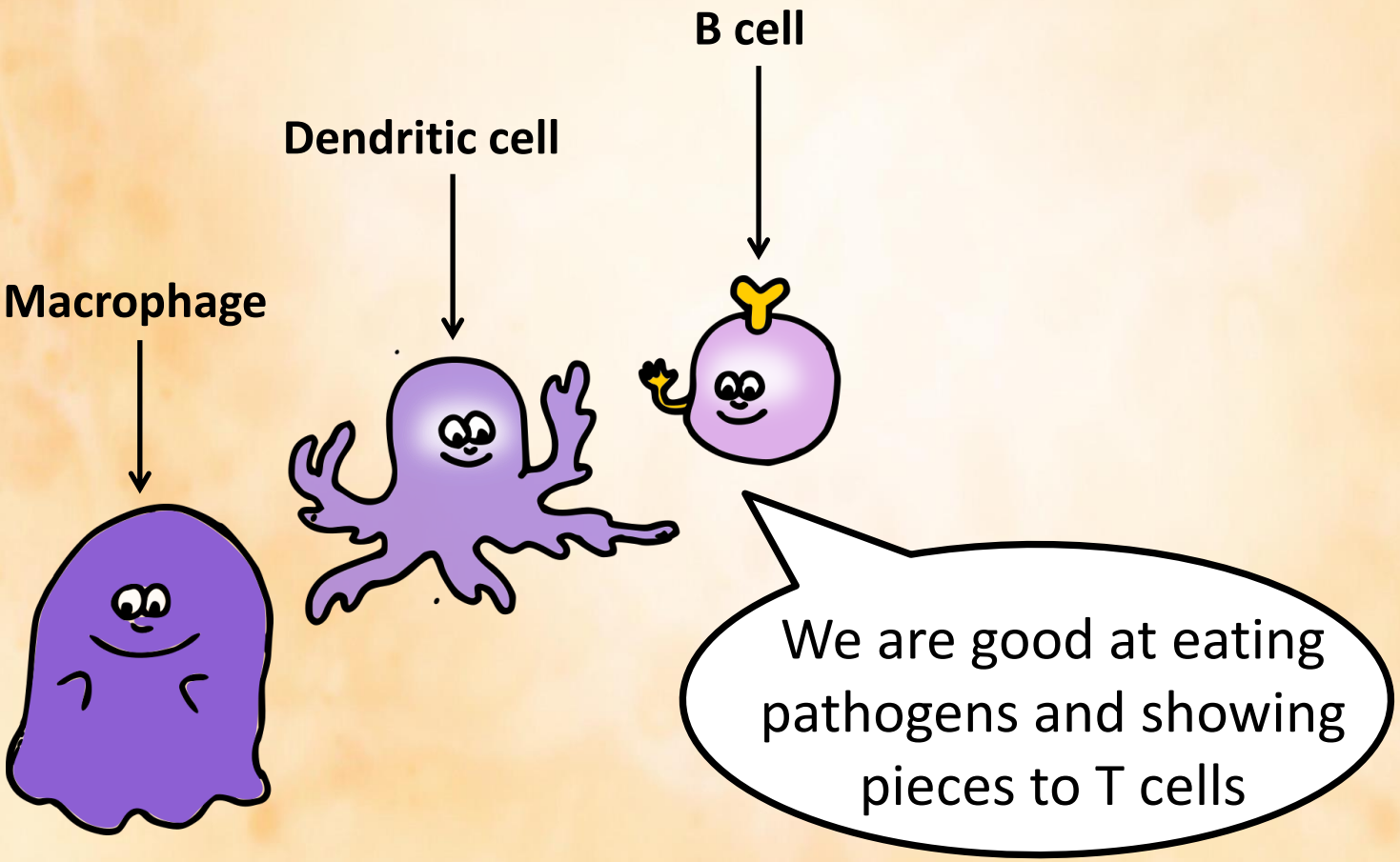


Similar to B cells, T cells have a receptor that is unique for every individual T cell.

T cells don’t recognize whole pathogens, they need other cells to show them pieces of the pathogen. These pieces are called peptides. The other cells have molecules on their surface called MHC to show peptides to T cells. There are two types of MHC molecules: MHC-II and MHC-I.

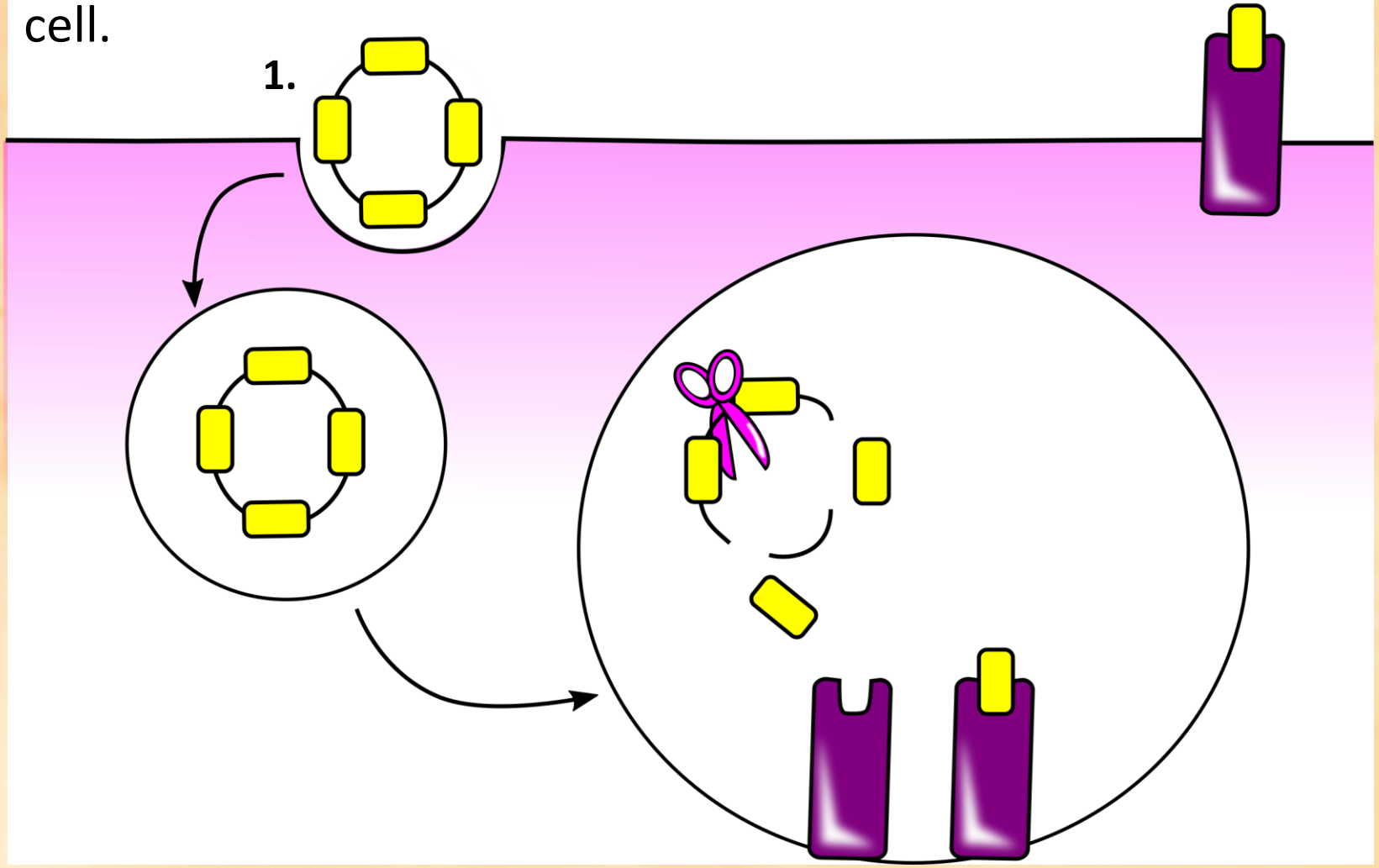


Only some cells have MHC-II molecules. These cells often eat pathogens, cut them into pieces and show the pieces on MHC-II molecules to T cells.

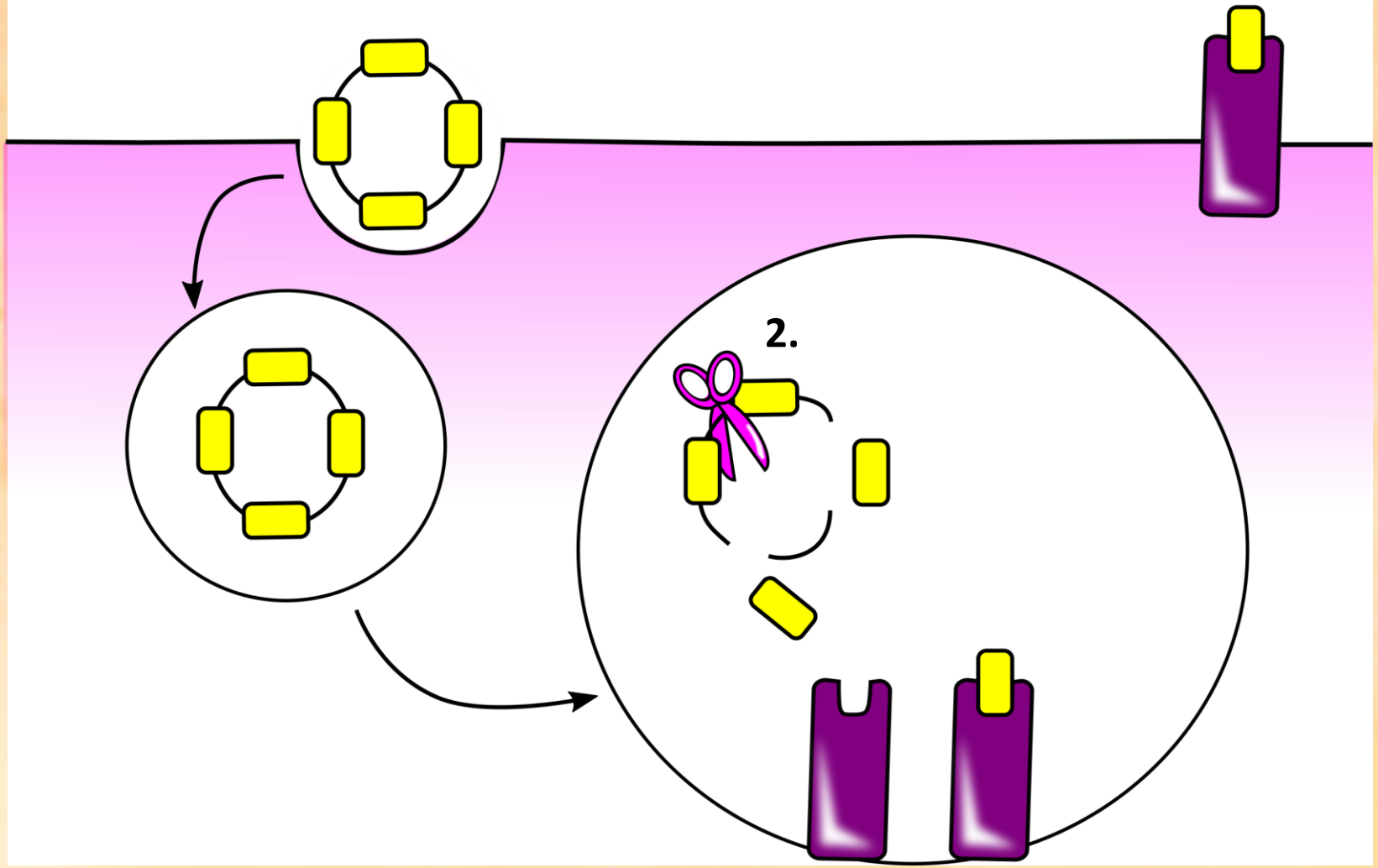


This is what happens inside the cell

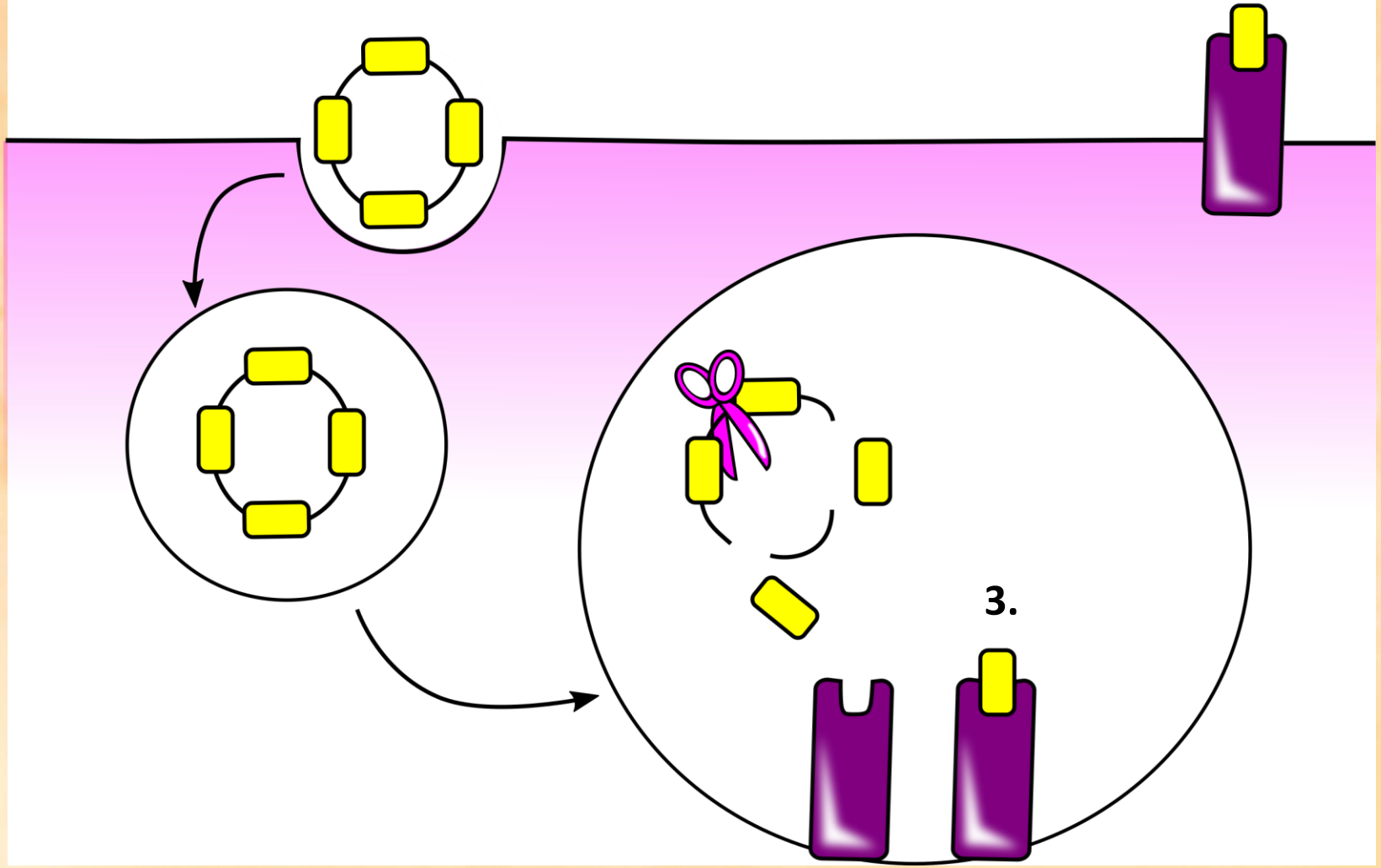
A pathogen or a protein from a pathogen is taken up by the cell.



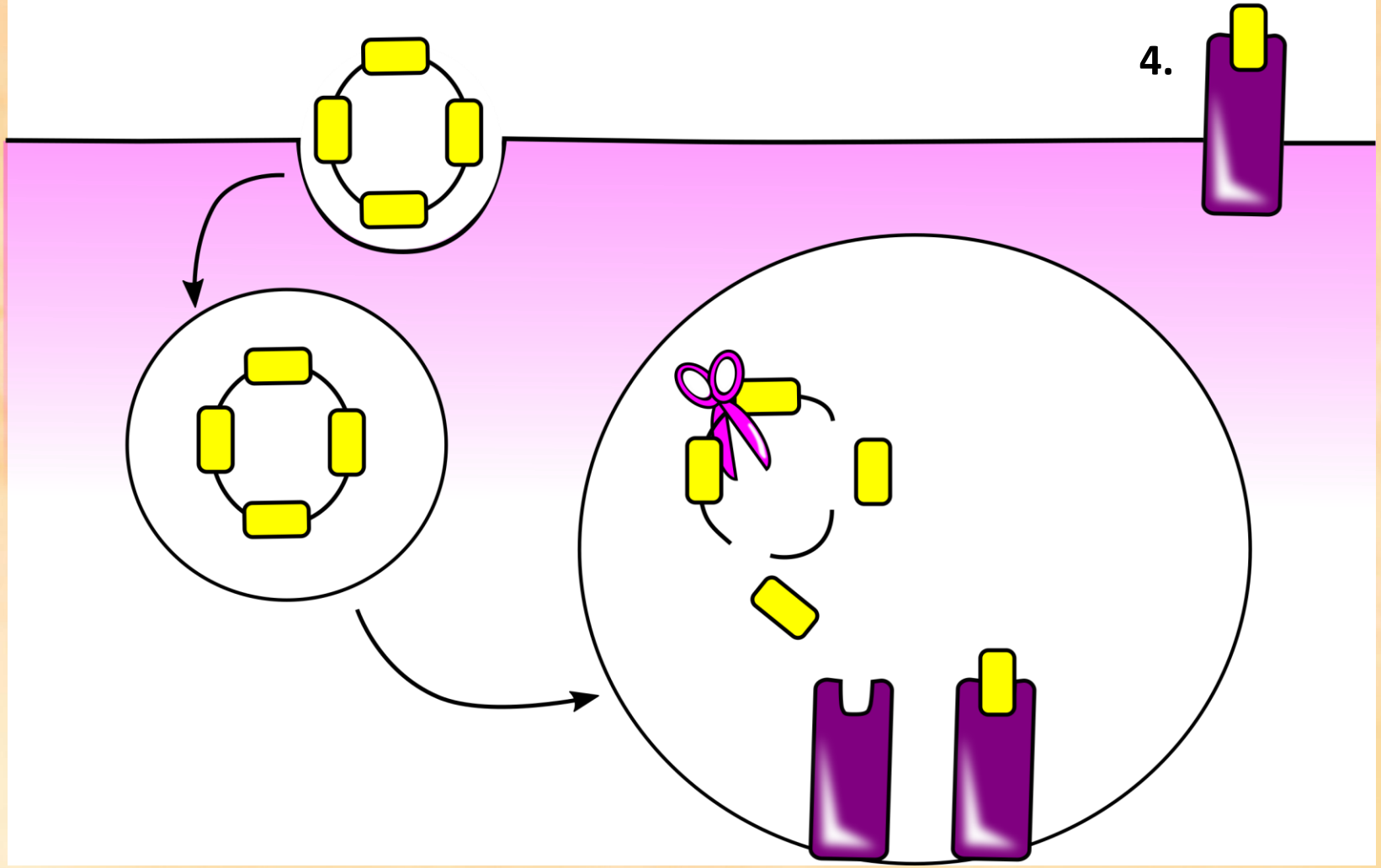
2. The protein is cut into pieces = peptides



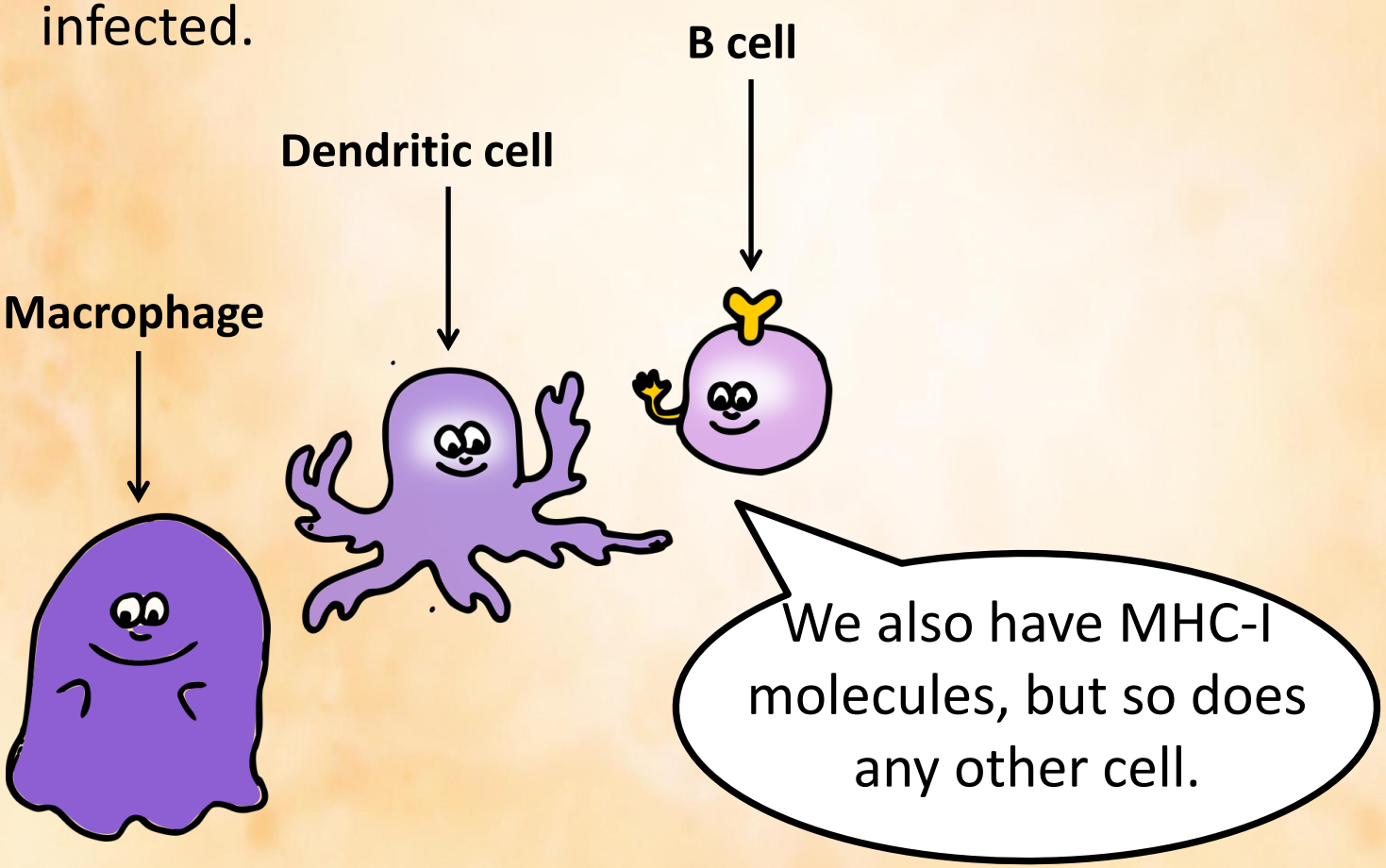
3. The peptides are loaded on MHC-II molecules



4. The MHC-II molecules travel to the surface of the cell to show peptides to T cells.

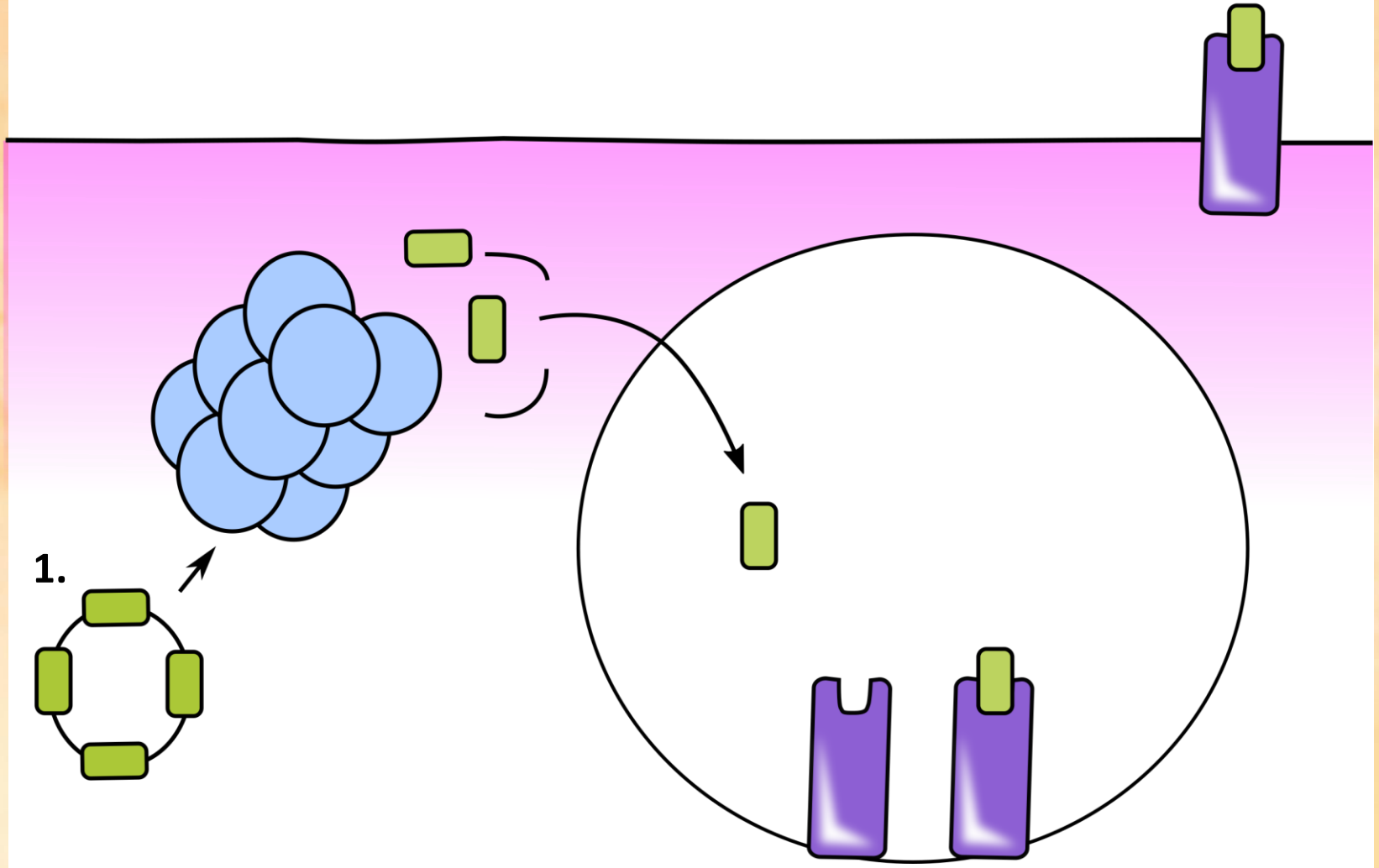


All cells have MHC-I molecules. MHC-I molecules show peptides from the inside of the cell to T cells. This is important if a cell is infected with a virus, it will make virus proteins and show these to T cells to tell them it has been infected.

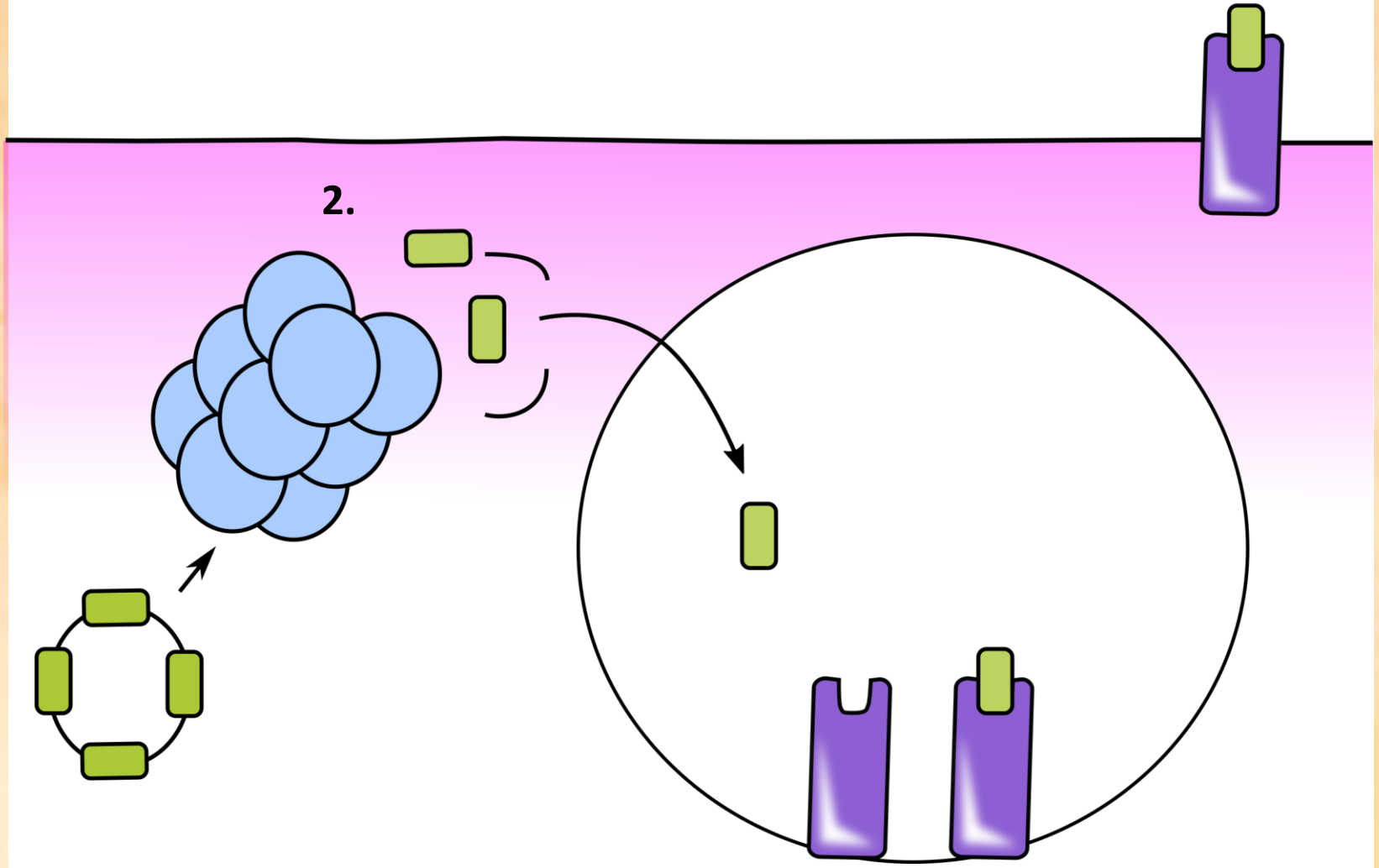


This is what happens inside the cell

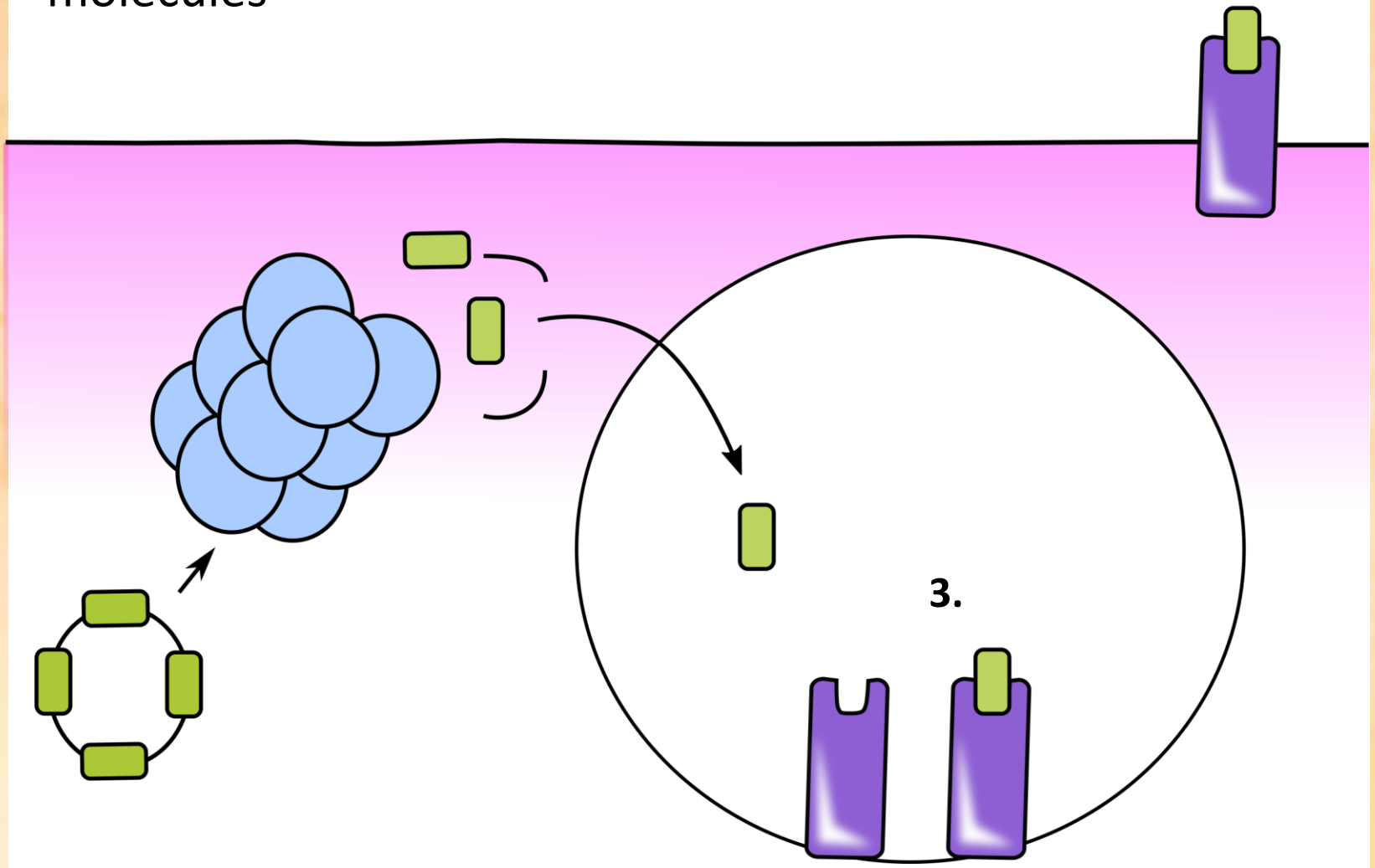
1. A pathogen e.g a virus infects the cell and forces it to make virus proteins.



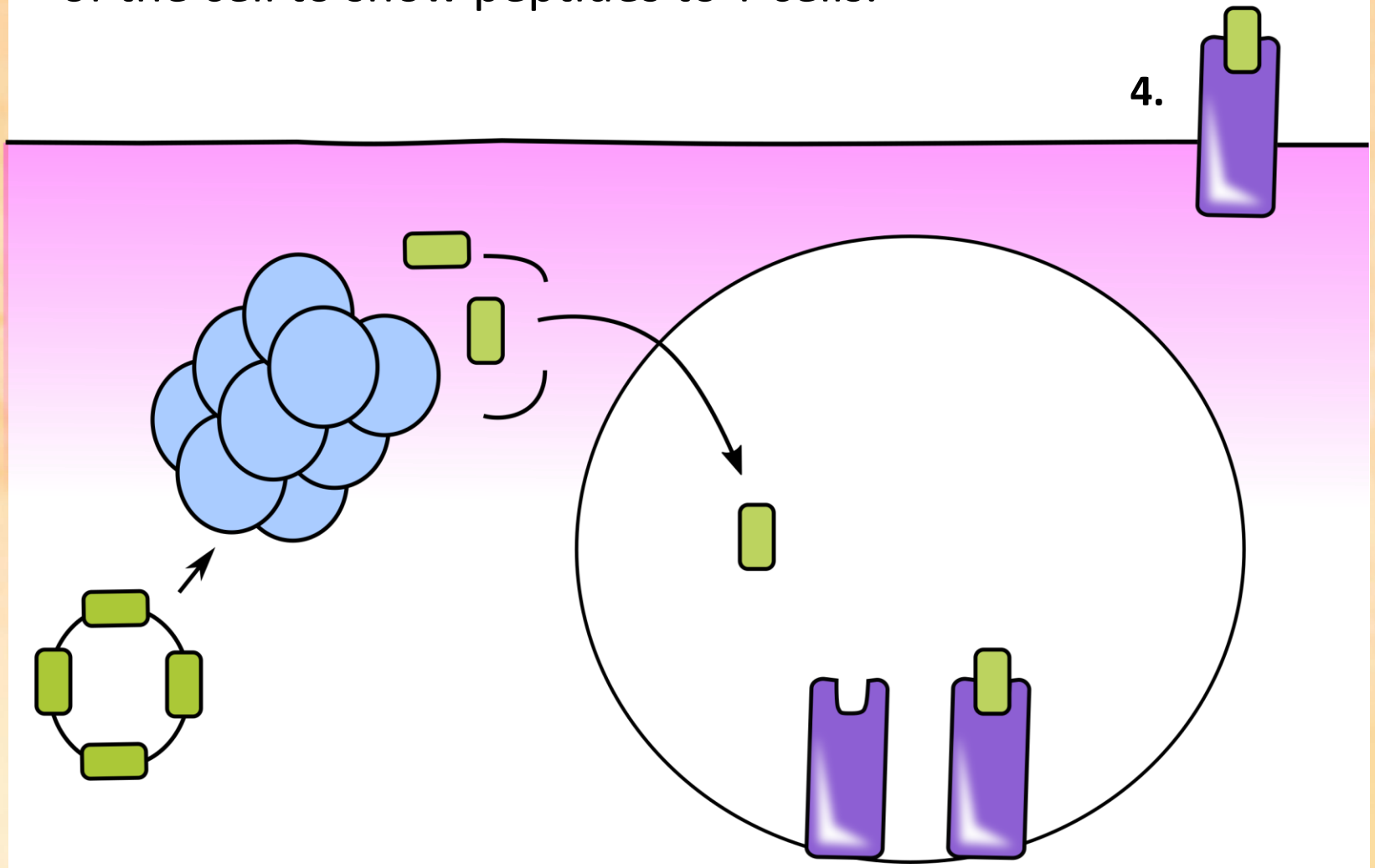
2. The protein is cut into pieces = peptides



3. The peptides are loaded on MHC-I molecules

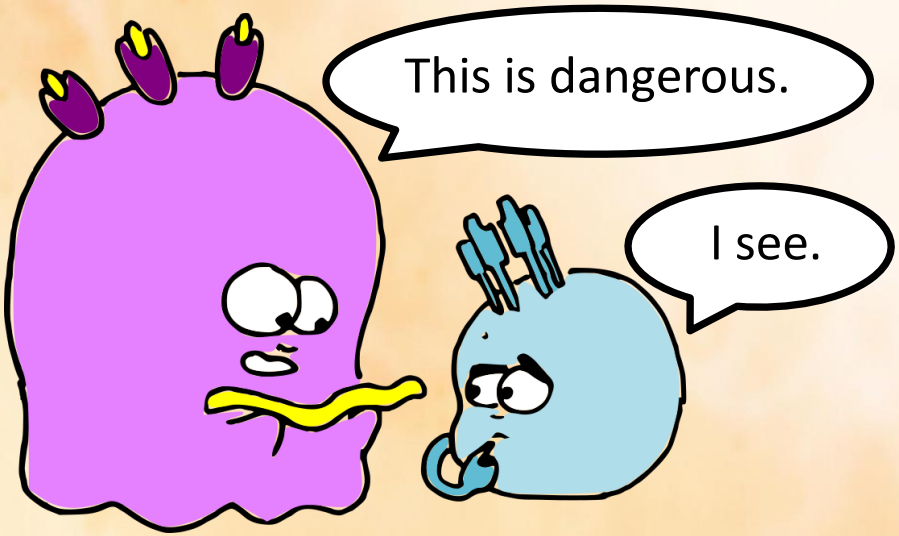


4. The MHC-II molecules travel to the surface of the cell to show peptides to T cells.



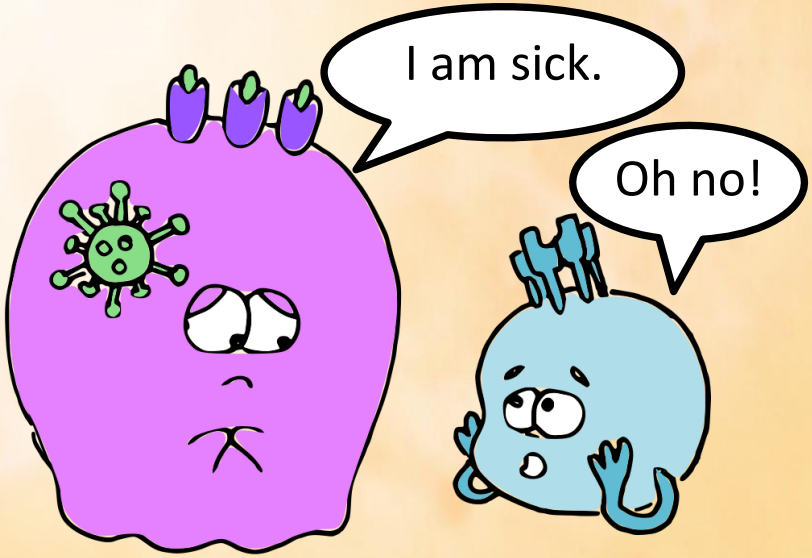
MHC-II

- Only present on cells that like to eat pathogens.
- Show peptides from proteins that come from outside the cell.
- This is meant to tell T cells that pathogens are present in the body

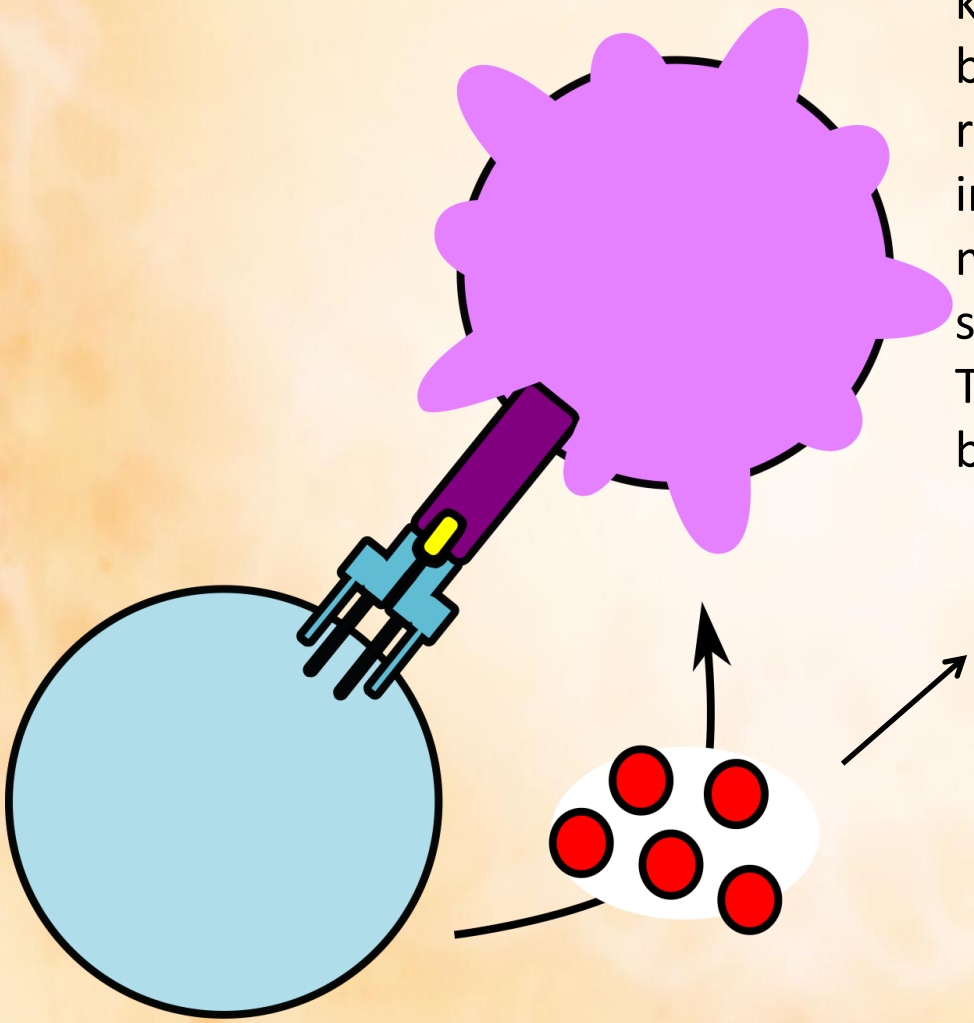


MHC-I

- Present on all cells.
- Show peptides from proteins that come from inside the cell.
- This is meant to tell T cells that the cell is infected or has become a cancer cell



What are T cells good for?

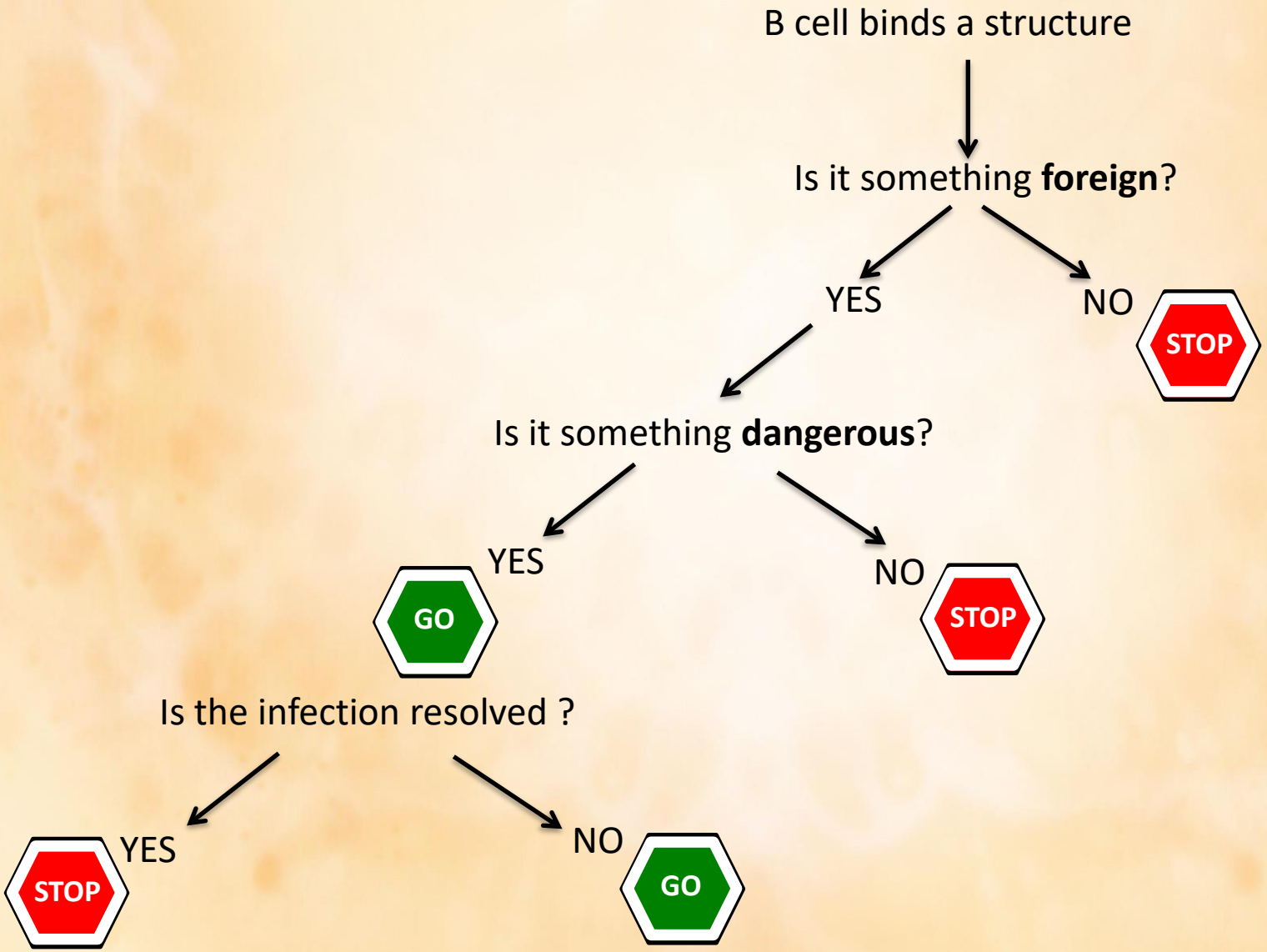


T cells can kill infected cells or cancer cells. If an infected cell is killed this can stop the disease because many pathogens can only replicate in cells. If the first infected cells die, new virus is not made and the body does not get sick.

T cells can also help B cells to better do their work.

T cells can make proteins which make holes into other cells and kill them.

Immune cells need to make tough decisions



What happens is immune cells make the wrong decision?

B cell binds a structure

Is it something **foreign**?

YES

NO

GO

Is it something **dangerous**?

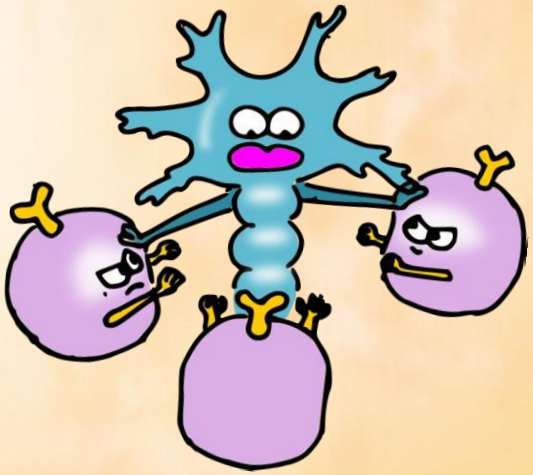
YES

NO

Is the infection resolved ?

YES

NO



Autoimmunity

What happens if immune cells make the wrong decision?

B cell binds a structure

Is it something **foreign**?

YES

NO

Is it something **dangerous**?

YES

NO

GO

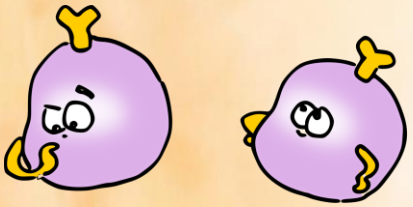
Is the infection resolved ?

YES

NO

Allergy

What happens if immune cells make the wrong decision?



Infection

B cell binds a structure

Is it something **foreign**?

YES

NO

Is it something **dangerous**?

YES

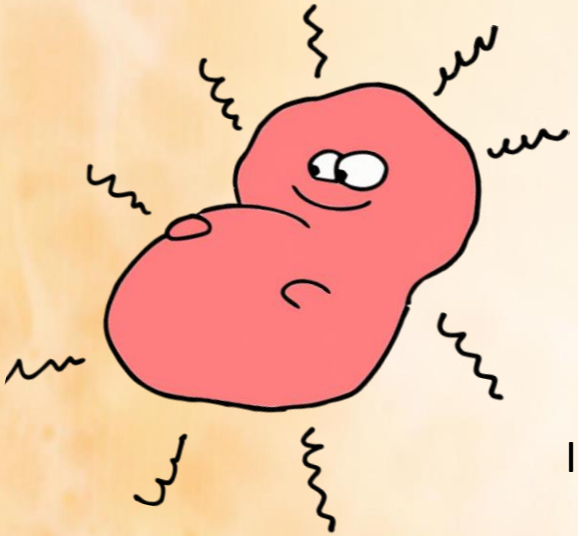
NO

Is the infection resolved ?

YES

NO

What happens if immune cells make the wrong decision?



Cancer

B cell binds a structure

Is it something **foreign**?

YES

NO

Is it something **dangerous**?

YES

NO

GO

Is the infection resolved ?

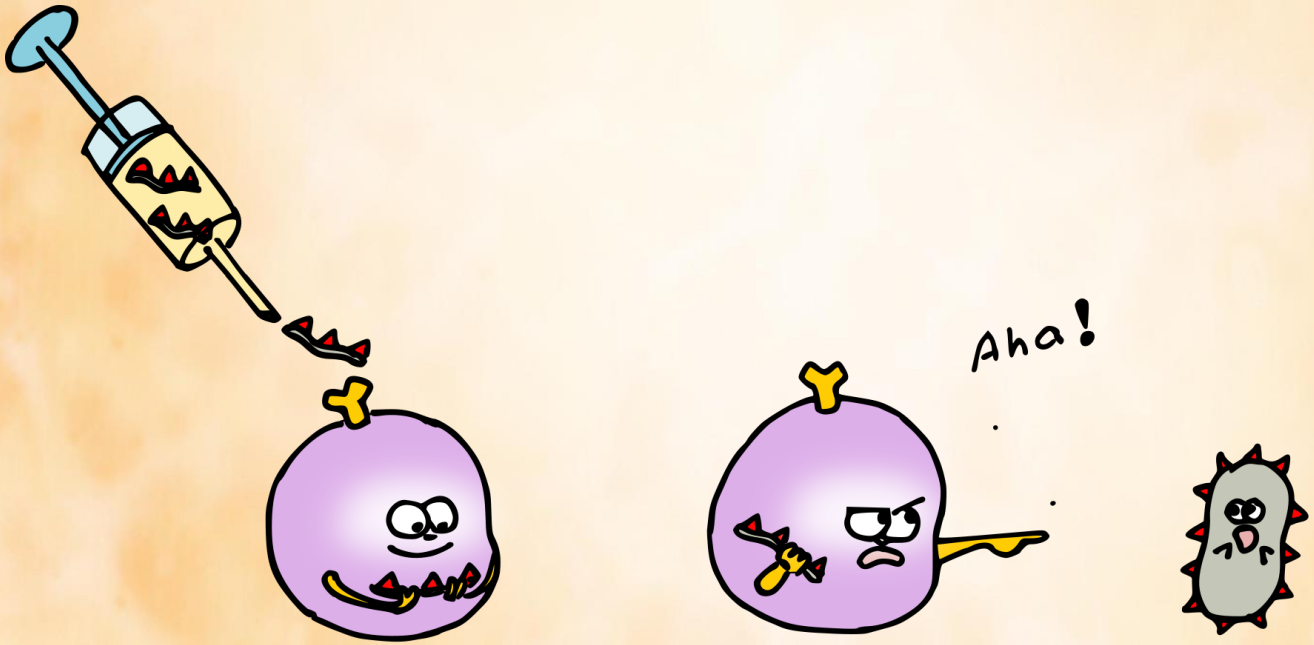
YES

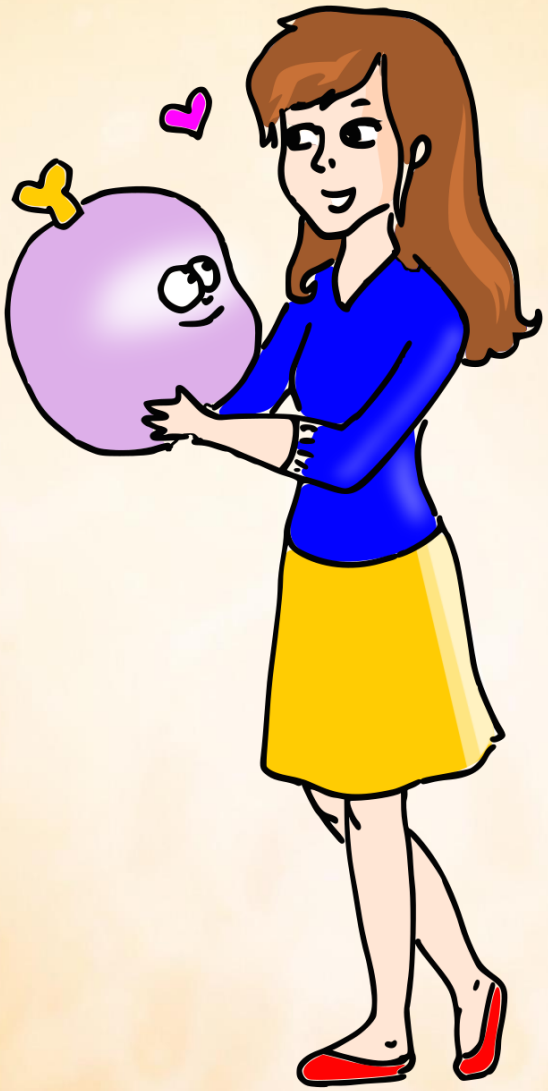
NO

GO

Vaccination

During vaccination, pieces of the pathogen are shown to cells of the immune system making it easier for them to fight once they see the real pathogen.





Our immune system is awesome