

Life's Common Challenges

Response: Defense

Life's Common Challenges

Introduction to Defense

Main Idea

- ***Life is faced with a number of threats.***
 - ***These threats include biotic factors like predators, pathogens, and parasites.***
 - ***Even extreme abiotic factors can threaten the life.***
- ***Living organisms defend themselves by using four general strategies protective barriers, fleeing, hiding, or fighting back.***
- ***Adaptations have resulted in numerous specific strategies that are both unique and fascinating.***

Animals

Defense

Preface to Animal Defenses

- ***Animals face threats at both the organismal level and at the cellular.***
- ***Predators attack the organism itself.***
- ***Pathogens and parasites attack the cells of the organism.***
- ***This presentation will address defense mechanisms against predation and defense against pathogens separately.***

Animal Defenses against Predators

● DETECTION

- **Prey must possess great senses in order to respond to the threat of predators.**
- In some cases general cues like any abrupt movement may be enough.
- In other cases specific cues like a scent or color pattern are needed
- Many rely on multiple cues in order to assess the level of threat
 - *visual- detect identity and intentions*
 - *auditory- detect presence, proximity, identity and direction of travel*
 - *chemical- scents of predators or recently killed prey*
 - *tactile- vibrations can reveal the presence of threat*

Animal Defenses against Predators

● FLEEING

- **Some animal prey species rely on speed, agility and stamina in order to elude predators.**
- However this is far more successful if the predator is detected from afar.
- The closer the predator is the less likely it is for the prey to escape.



Animal Defenses against Predators

- **PROTECTIVE BARRIERS**

- ***The first and most fundamental barrier is the plasma membrane itself.***

- Membranes will be discussed later at this point the focus will remain on the animal itself

- **Animal barriers include skin, armor, scales, fur, feathers, hair, mucous and saliva.**



Animal Defenses against Predators

- **Skin**

- The skin is largest organ of the body.
- The skin provides protection against physical and chemical threats.
- The skin wraps around the body and protects vital organs and cells.
- The skin is composed of multiple layers of thin cells that provide thickness and better ability to protect.

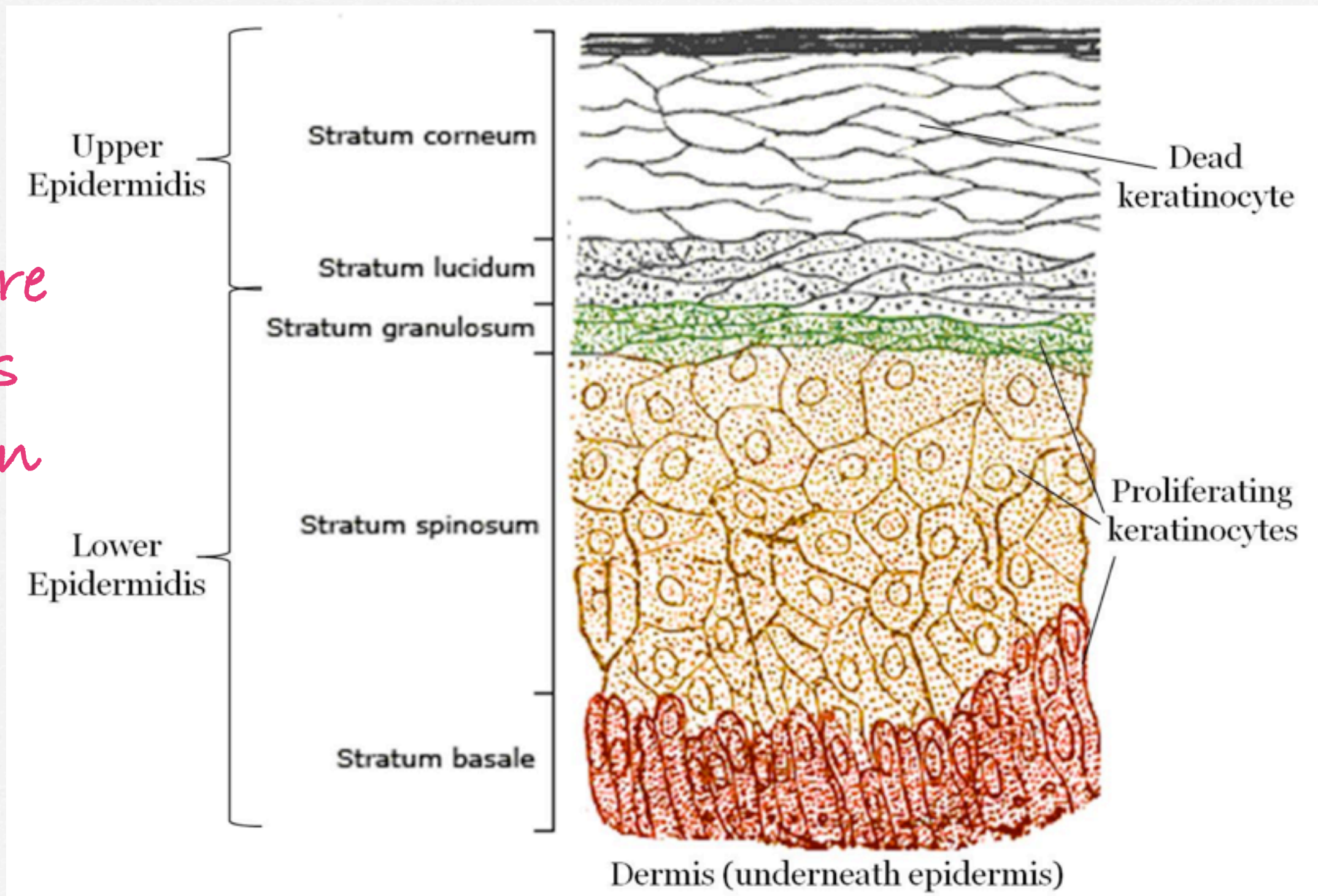
- **Mucous**

- Where skin is thin animals may coat the surface with mucous to supplement the skin's protection
- This mucous can help to trap irritants and pathogens

An Important AP Theme

● Skin

Structure
Dictates
Function



Animal Defenses against Predators

- **Scales & Armor**

- Scales vary in size, shape and structure.
 - Some consist of bone, enamel, minerals or collagen.

Animal Defenses against Predators

- **Hair, Fur & Feathers**

- Thick fur and hair can not only protect from the animal from cold but it protects the animal from the claws and teeth of predators.
- Some fur is modified into spines like that of the porcupine.
- Also in some animals it is the hair, fur or feathers that are responsible for the camouflage of animals
- In fact the Shar Pei dog was bred to have rolls of fat and spiny hair that protected vital organs during dog fights.



Animal Defenses against Predators

- **CAMOUFLAGE & HIDING**
- **Animal's can hide in places where predators can not go or see.**
- **Animal's can also hide out in the open by employing camouflage.**
 - Blending is the most effective approach
 - The colors are a result of different pigments
 - Sometimes animals mimic structures in the environment like twigs or coral.

Animal Defenses against Predators

● **Types of Camouflage:**

- *Solid Colors* for solid backgrounds
- *Colored patterns* to match background
- *Counter-shading* dark upper bodies and light lower bodies
 - when light hits dark color animal appears lighter, when light hits light area animal appears darker
 - this works well with fish, when looking up into the sun its harder to a fish with a white belly
- *Copy-cats* involve shape, behavior or looking like something else that is common in the environment.

Amazing Camouflage

Animal Defenses against Predators

- **FIGHTING BACK!**

- **Some animals are able to deter predation by presenting the predator with a formidable challenge or danger that the predator may decide to avoid.**
- **The fight may come to the predator in the form a chemical or physical defense.**
 - The most chemical defenses include poisons/toxins that can be delivered in a number of different ways.
 - Physical defenses may include horns, antlers, spines, quills, tusks and claws.
 - Some prey travel in groups and mob the attacker

Animal Defenses against Predators

- **INTIMIDATION**

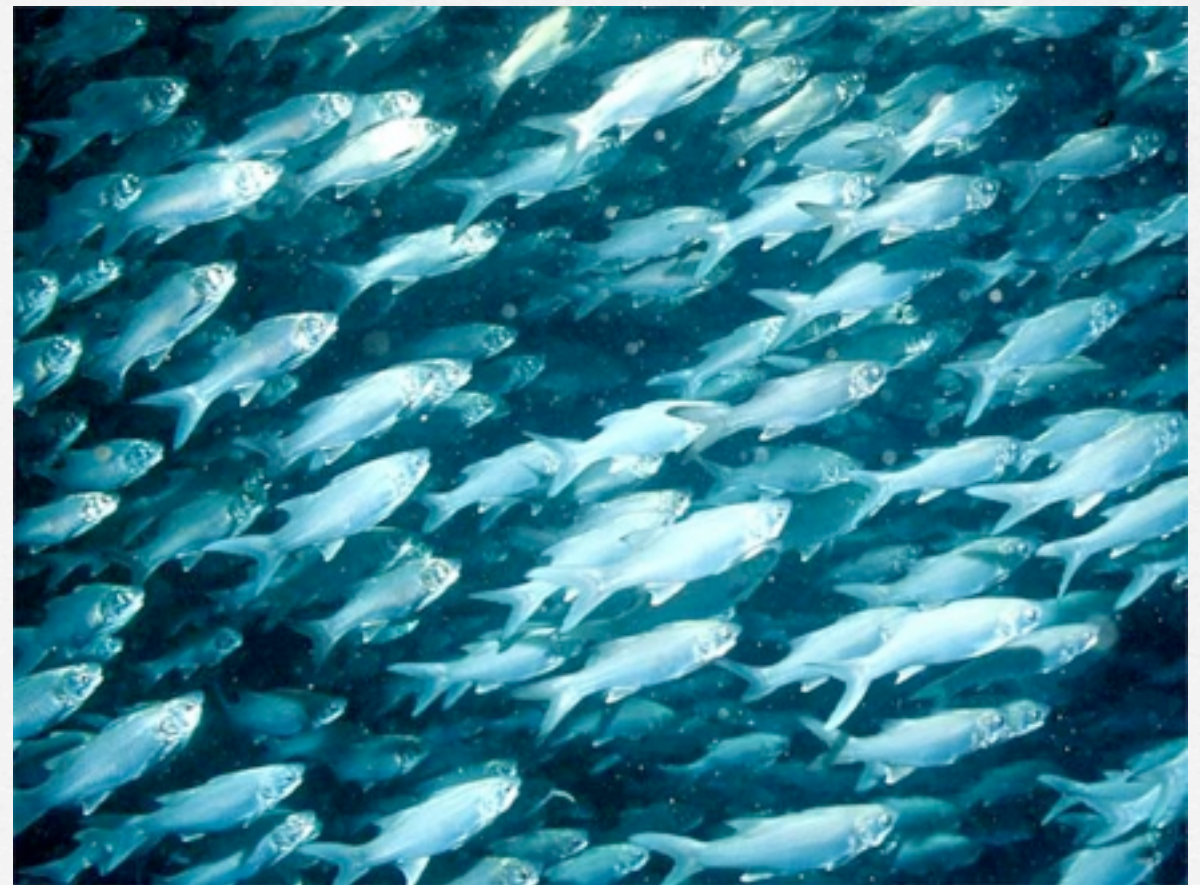
- **Some animals warn predators by visual displays**

- Colorful reptiles and amphibians warning signs that they are poisonous to predators.



Animal Defenses against Predators

- **SAFETY in NUMBERS**
- **Some animals travel in herds or schools.**
 - This strategy lessens the chances of any one individual being picked and eaten by the predator.



Animal Defenses against Predators

- **BEHAVIOR**

- **Some behaviors are innate.**

- avoiding habitats where predators are found
 - ex. Anolis lizard become arboreal with ground predators
- being active at different times of the day than the predators
- inflating bodies or some physical act that conveys a larger size or greater fitness to the predator
 - ex. lizards do push-ups and gazelles stot

Animal Defenses against Predators

● BEHAVIOR

● **Some behaviors are learned.**

- altering activities due to threat
 - *ex. decorator crabs cover themselves with leaves and debris*
 - *walking stick insects move like twigs in the wind*
- play dead since most predators due want carrion
 - *ex. opossum plays dead when threatened*
- some animals use alarm calls to warn fellow prey
 - *ex. dwarf mongoose stand up and look for birds of prey while others forage for food*

Crazy Animal Defenses



(Image via salamandarcandy)

The **horned lizard** is a seemingly normal looking lizard found in the southwest region of the United States. It doesn't use its horns to defend itself, as you might expect. Rather, when attacked, it pressures its own sinus cavities until the blood vessels in its eyes burst, and it sprays its attacker with blood from its eyes.



(Images via Canterbury)

Oh, there's nothing like a pulsating jet of foul boiling anal fluid to say "Howdy, neighbor!" The **bombardier beetle** may look innocent enough, but it is famous for being able to spray boiling hot and chemically toxic bodily fluids in the direction of any would-be predator. The bombardier beetle doesn't exactly melt in your mouth (but it will melt you).

Crazy Animal Defenses



(Image via cafeaguau)

You know **Malaysian ants** – always exploding all over themselves, ruining the fun. All kidding aside, it's really true. Malaysian ants internally combust under threat, causing their bodies to explode (they wait until their enemies are close enough to die before detonating). *Camponotus saundersi* soldier ants have large glands full of poison inside their bodies. When they sense a threat, they contract their abs, causing the glands on either side of their bodies to explode and spray poison.



(Image via NCSU)

Like our little friend the **komodo dragon**, potato beetle babies (larvae) cover themselves in their own poop to avoid being eaten. Unlike baby komodos, the **potato beetle's feces** are actually poisonous to predators. Smelly but effective!

Crazy Animal Defenses



(Image via Illinois Dept. of Natural Resources)

The skunk, or polecat, is actually an attractive little mammal and some people keep them as pets (sans glands, of course). **Skunks** are omnivores but will turn to trash and carrion when no fresh insects or honeybees, their favorite food, are available. Though their amazing musk can be smelled miles away, their vision is exceptionally weak, and most skunks can only see about 10 feet in front of them. As a result, many are run over – half of all skunk deaths, in fact, are due to humans. All Mustelidae family members (like weasels and ferrets) can spray musk, but skunks are famously the most potent. The skunk's anal musk is so powerful that if sprayed directly, the victim will experience temporary blindness.



(Images via reefseekers and alaskaunderseatours)

The sea cucumber can literally take on different body states – from hard to liquid – in order to defend itself. From **wikipedia**: "Like other **echinoderms** the cuke has a type of **collagen** in its skin capable of excreting or absorbing more water effectively changing from a 'liquid' to a 'solid.' They can turn their bodies into mush, climb through small cracks and then solidify into small lumps so that they cannot be extracted." Even more amazing than effectively scattering yourself into pieces of your collective whole and then reassembling: the ability to turn yourself inside out so that your digestive tract's toxic juices poison your enemies. Yeah, the sea cucumber can do that, too. Do not mess.

Crazy Animal Defenses

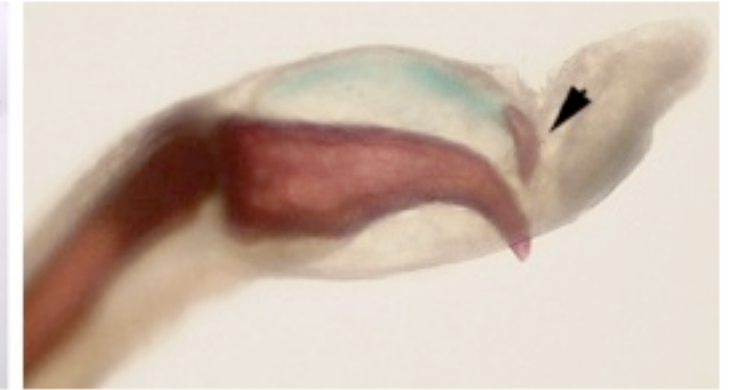


(Image via animalphotos)

The cute little opossum has a number of tricks up its defensive sleeve. It can play dead. It can foam at the mouth in an attempt to convince its predators that it is toxic, sick or perhaps just bat sh*t insane. It can also emit a green anal fluid that smells nearly as bad as a skunk's offensive spray (though mercifully it can easily be washed off). **Opossums playing dead** actually slip into a semi-comatose state, thus removing any excitement of the kill for a predator.



(Images via New Scientist)



The hairy frog or "horror frog" intentionally breaks its own bones to turn out a wicked set of cat-like claws. Like Wolverine, only slimy and a lot more terrifying because *it's a freaking frog*. Scientists don't know if the claw is able to retract once it pierces through the skin. According to **New Scientist**: "*Trichobatrachus robustus* actively breaks its own bones to produce claws that puncture their way out of the frog's toe pads, probably when it is threatened." Also, it is apparently hairy. This doesn't stop Cameroon locals from spearing and roasting hairy frogs as a tasty snack.

Top 10 most odd mammal defenses go to- <http://listverse.com/2010/05/18/top-10-mammals-with-odd-defense-mechanisms/>

To see top 10 most bizarre bird defenses go to- <http://listverse.com/2010/12/23/10-birds-with-truly-odd-defenses/>

A blue spiral-bound notebook with silver rings at the top. The text "Shift now to Pathogens..." is written in white on the page.

Shift now to Pathogens...

Animal Defenses against Pathogens

Now we will explore the fight against the smallest invaders whose threat can be just as great as larger predator.

- The animal strategy against bacteria, viruses and parasites has two goals.
- **First goal:** Do not let the pathogen in the body or cell(s).
- **Second goal:** Should the pathogen “get in” then the animal must find, recognize and destroy it before it inflicts it damage.

Animal Defenses against Pathogens

Note: Vertebrate defense mechanisms are so similar to invertebrates that we study the human model and apply the concepts and mechanisms to all other animals.

- **First goal:** Do not let the pathogen in the body or cell(s).
 - *This is accomplished through the Integumentary, Lymphatic & Immune Systems*
 - *This immunity is called innate immunity or non-specific defenses.*
- **Second goal:** Should the pathogen “get in” then the animal must find, recognize and destroy it before it inflicts it damage.
 - *This is accomplished through the Immune System.*
 - *This immunity is called acquired immunity or specific defenses.*

Animal Defenses against Pathogens

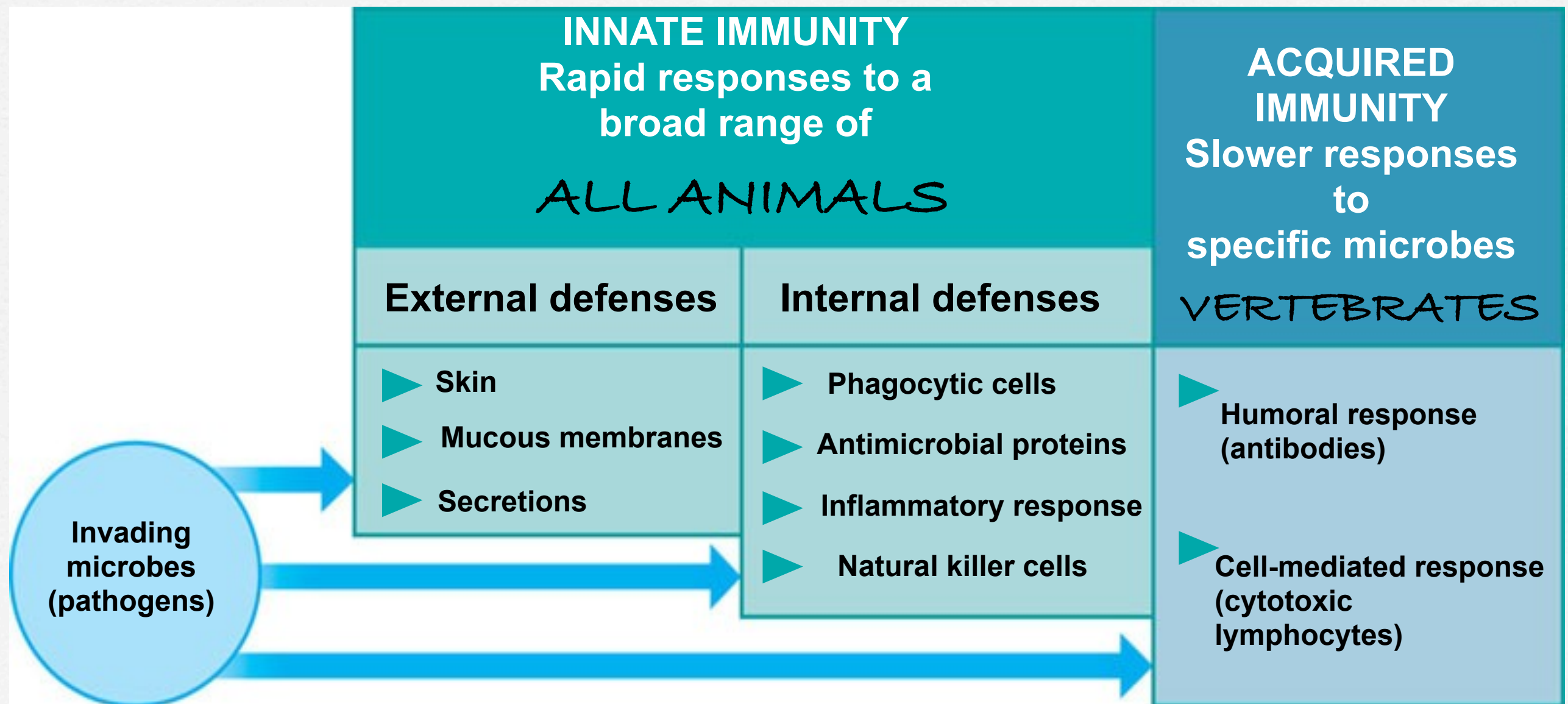
Why do you suppose pathogens "want in"?
Why do they infect multicellular organisms?

Multicellular organisms have worked hard to provide an ideal environment for the cells that make up the organism; they are protected, they are fed, they wastes are eliminated etc and the pathogens are looking for a free ride!

Animal Defenses against Pathogens

Always present even before exposure to pathogen etc.

Develops after exposure to pathogen etc.



Animal Defenses against Pathogens

Non-Specific External Defenses. (PHYSICAL BARRIERS)

- SKIN: physical barrier against microbes etc.
 - *multiple layers of flat skin cells provide increased protection*
- MUCOUS MEMBRANES: produce a viscous fluid that traps microbes
 - *much of this mucous ends up in the stomach a very inhospitable place*
- RESIDENT BACTERIA: prevents the attachment of foreign microbes

Animal Defenses against Pathogens

Non-Specific External Defenses. (CHEMICAL BARRIERS)

- SECRETIONS: create a hostile environment against microbes
 - *create a skin pH of 3-5 and it also contains lysozyme an enzyme that digests the cell wall of many bacteria*
 - *ANTIMICROBIAL AGENTS: generate lysozymes that punch holes into the bacteria thus killing them*

can vomiting and diarrhea be considered innate immunity? why? or why Not?

Yes...Both indiscriminately purge harmful agents

Animal Defenses against Pathogens

Non-Specific Internal Defenses.

- All internal defenses requires the identification of “self” and “non-self”
- This “self” and “non-self” identification requires *molecular recognition*.
 - *where receptor molecules bind to specific molecules that are foreign or molecules that are part of foreign cells*

Animal Defenses against Pathogens

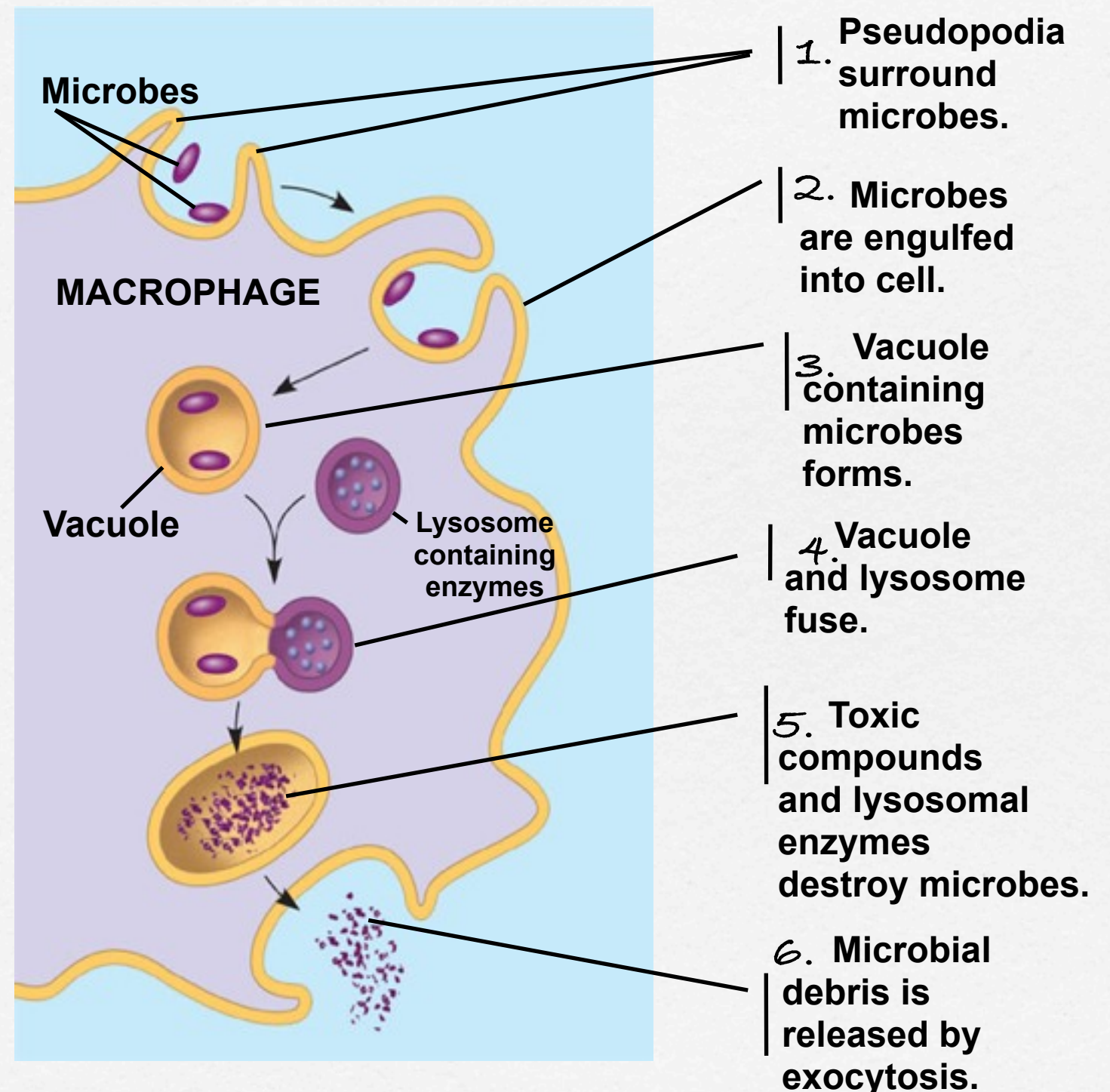
Non-Specific Internal Defenses. (CHEMICAL AGENTS)

- **INTERFERONS**: provide innate *protection against viruses* and activate *macrophages*
- **HISTAMINES**: increased capillary permeability with *increased blood flow* brings more white blood cells to area of infection (*inflammation*).
- **PYROGENS**: inhibits pathogen reproduction by *inducing fever*.

Animal Defenses against Pathogens

Non-Specific Internal Defenses. (PHAGOCYTOSIS)

- PHAGOCYTES:
white blood cells
- *ingest invading microbes & initiate the inflammatory response*
- MACROPHAGES:
a specific type of phagocyte can be found migrating through the body



Animal Defenses against Pathogens

Non-Specific Internal Defenses. (FURTHER DEFENSES)

- **EOSINOPHILS & DENDRITIC CELLS:** eosinophils defend *against multicellular invaders like parasitic worms*
- **NATURAL KILLER CELLS:** patrol body looking for cells that are infected with *viruses*.
 - *when an infected cell(s) is found they trigger apoptosis (cellular suicide) to prevent the spread of infection*
- **COMPLEMENT SYSTEM:** a group of 30 or so proteins that lyse invading cells, recruit white blood cells and help to activate the *inflammatory response*

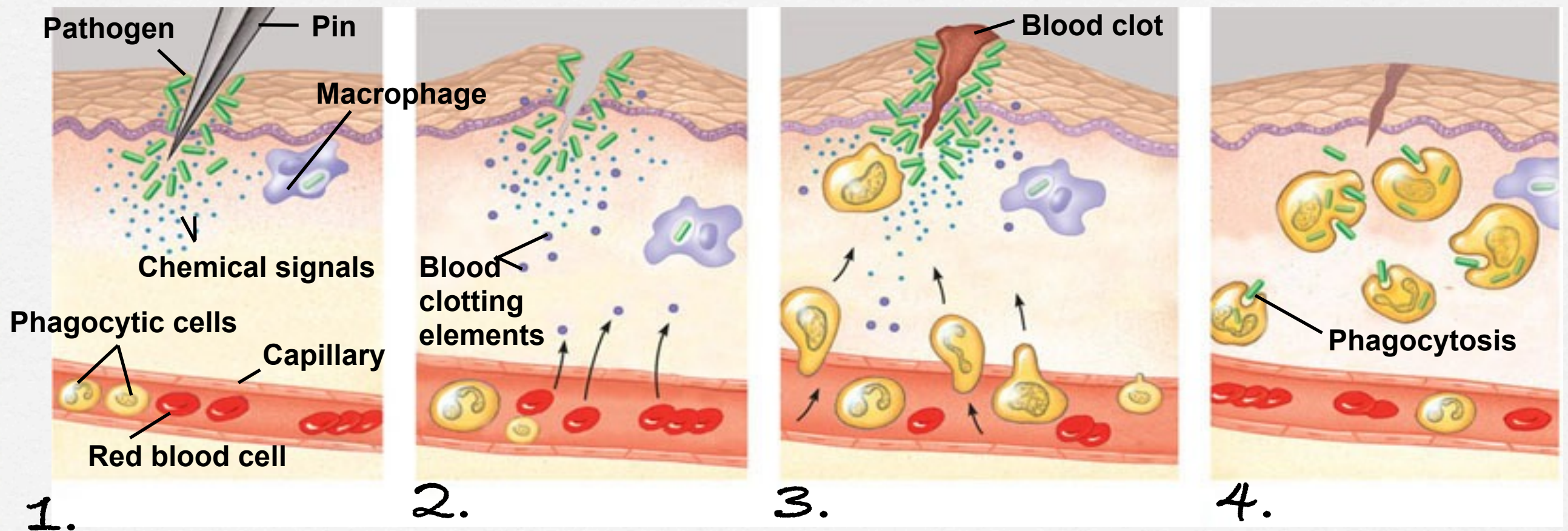
Animal Defenses against Pathogens

Non-Specific Internal Defenses. (INFLAMMATION)

- INFLAMMATORY RESPONSE: *dilates blood vessels that allow more fluid, phagocytes and antimicrobial proteins to enter the tissues at the site of infection.*
- *the response is trigger by the release of histamines and other chemicals from the injured cells*

Animal Defenses against Pathogens

Inflammation



1. Chemical signals released by activated macrophages and mast cells at the injury site cause nearby capillaries to widen and become more permeable.

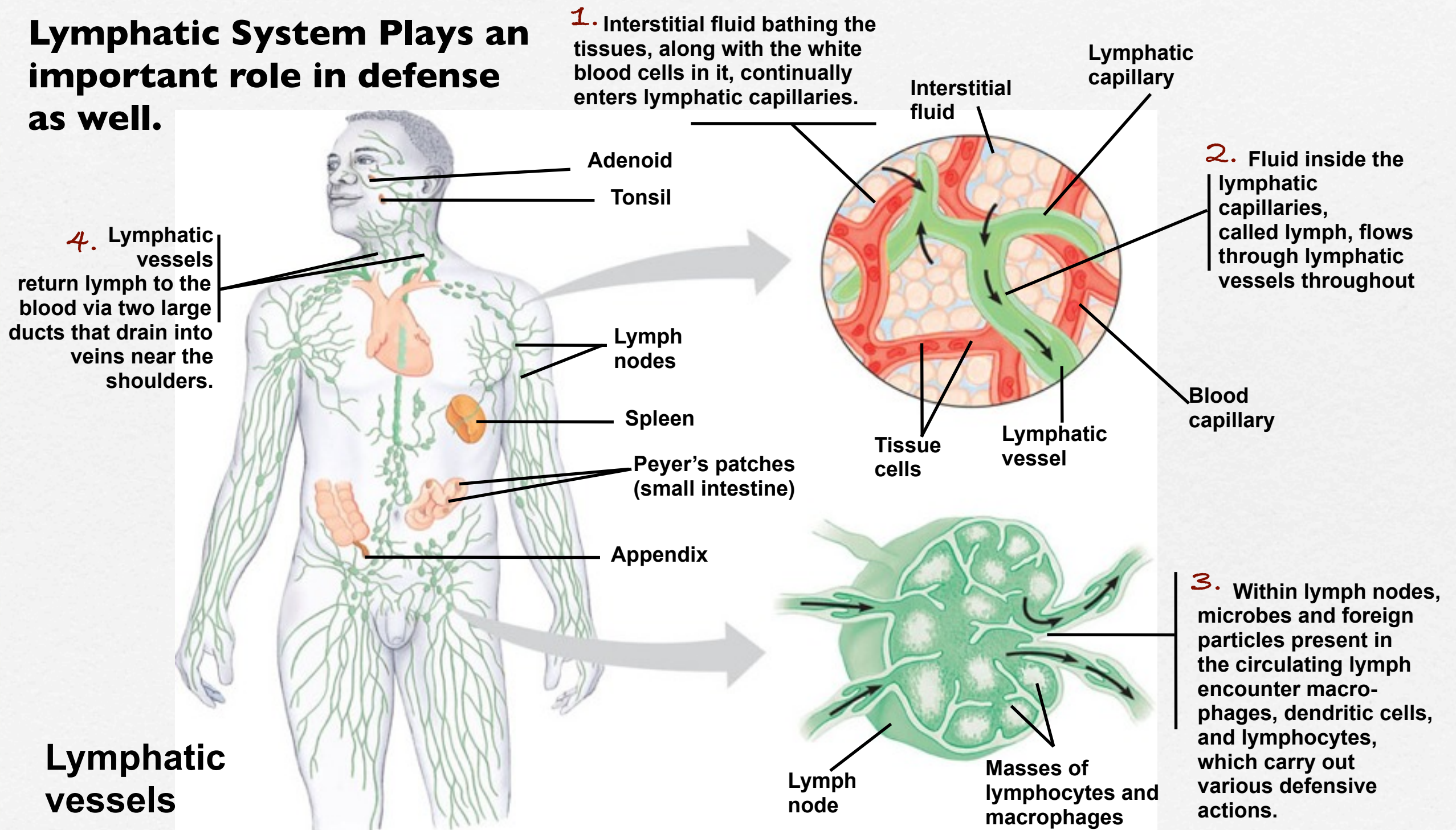
2. Fluid, antimicrobial proteins, and clotting elements move from the blood to the site. Clotting begins.

3. Chemokines released by various kinds of cells attract more phagocytic cells from the blood to the injury site.

4. Neutrophils and macrophages phagocytose pathogens and cell debris at the site, and the tissue heals.

Animal Defenses against Pathogens

Lymphatic System Plays an important role in defense as well.



Animal Defenses against Pathogens

Specific Internal Defenses.

- ACQUIRED or ADAPTIVE IMMUNITY: 4 Characteristics
 - 1. **Immense diversity**- of lymphocytes & receptors (millions)
 - 2. **Self Tolerant**- should not attack own cells
 - 3. **Proliferation**- activation of immune response creates many more T cells and B cells
 - 4. **Immunological Memory**- stronger and more rapid response to a previously encountered antigen

Animal Defenses against Pathogens

Specific Internal Defenses.

- ACQUIRED or ADAPTIVE IMMUNITY: lymphocytes provide **specific** defenses against infection.
 - it is the bodies second line of defense
 - it again involves lymphocytes
 - (general=white blood cells) (specifically T cells and B cells)
 - it looks for and recognizes **antigens**

Adaptive immunity is found only in vertebrates

Animal Defenses against Pathogens

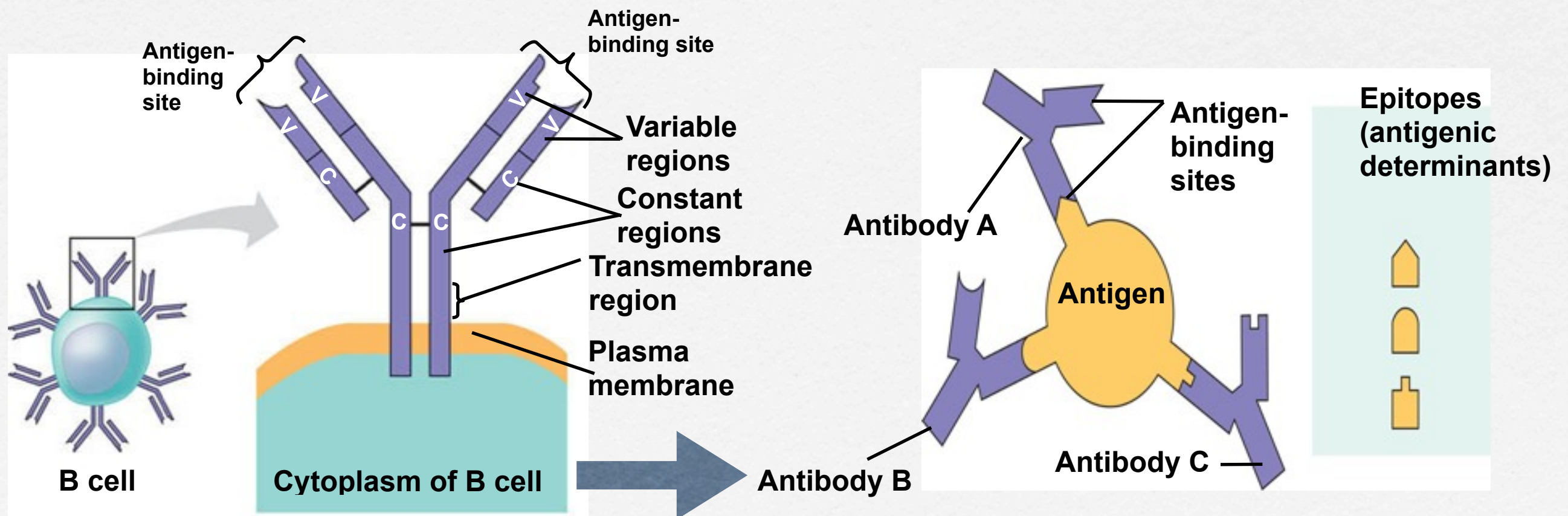
Antigens

- An antigen is foreign molecule that is recognized by T cells and B cells as “not self”
- The lymphocytes recognize and bind to antigens by the “shape” of the antigen

Animal Defenses against Pathogens

B Cells

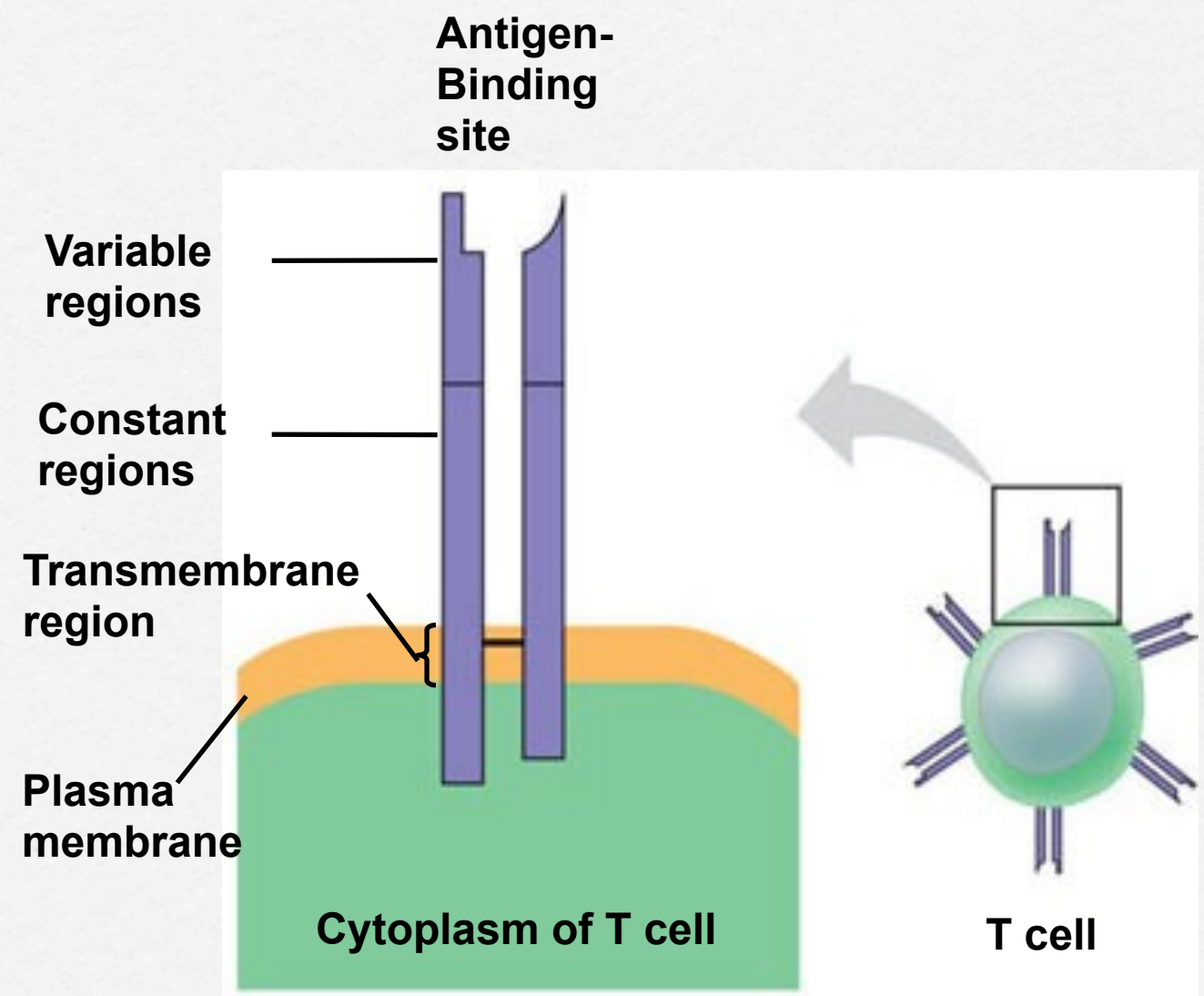
- B cells bind to epitopes of “whole” or “intact” antigens that are circulating in body fluids
- Once B cells recognize the antigen, they produce and secrete antibodies that identically shaped to B cell antigen receptors



Animal Defenses against Pathogens

T Cells

- T cells bind only to fragments of antigens that are displayed on the surface of host cells
- The antigen presentation requires another protein called the major histocompatibility complex (MHC)

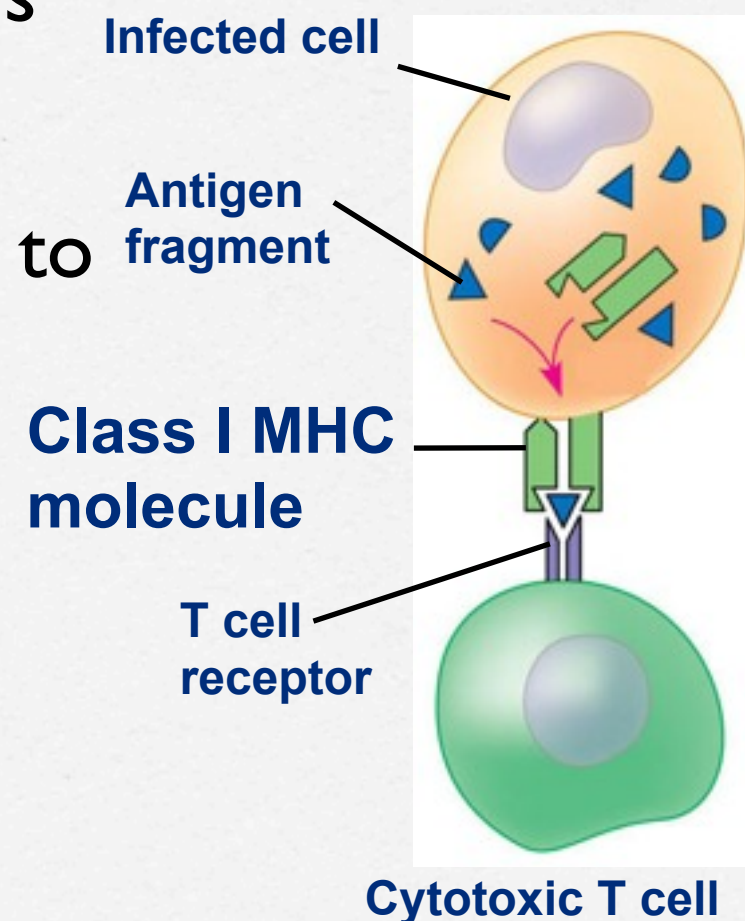


Animal Defenses against Pathogens

Antigen:

Presentation & Recognition

- Class I MHC molecules, found on almost all nucleated cells of the body.
- Display peptide antigens to cytotoxic T cells



1.

A fragment of foreign protein (antigen) inside the cell associates with an MHC molecule and is transported to the cell surface.

2.

The combination of MHC molecule and antigen is recognized by a T cell, alerting it to the infection.

Animal Defenses against Pathogens

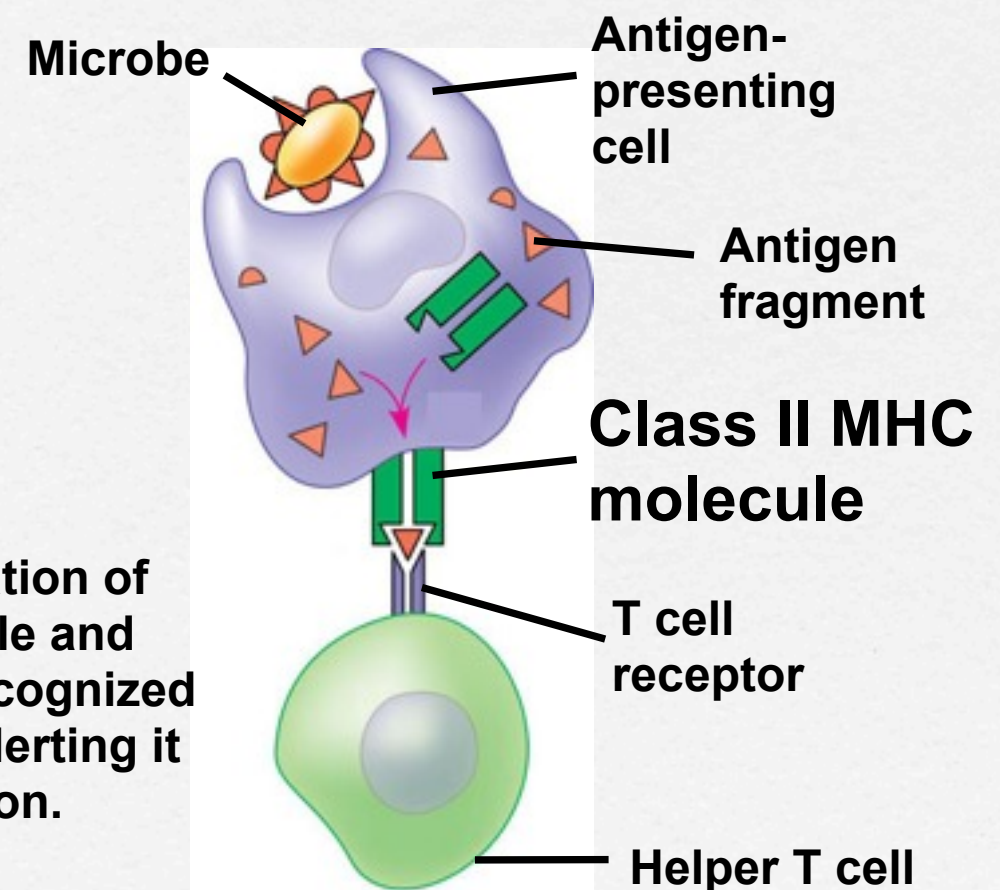
Antigen:

Presentation & Recognition

- Class II MHC molecules, found on dendritic cells, macrophages and B cells.
- Display peptide antigens to helper T cells

1. A fragment of foreign protein (antigen) inside the cell associates with an MHC molecule and is transported to the cell surface.

2. The combination of MHC molecule and antigen is recognized by a T cell, alerting it to the infection.



Review & Build

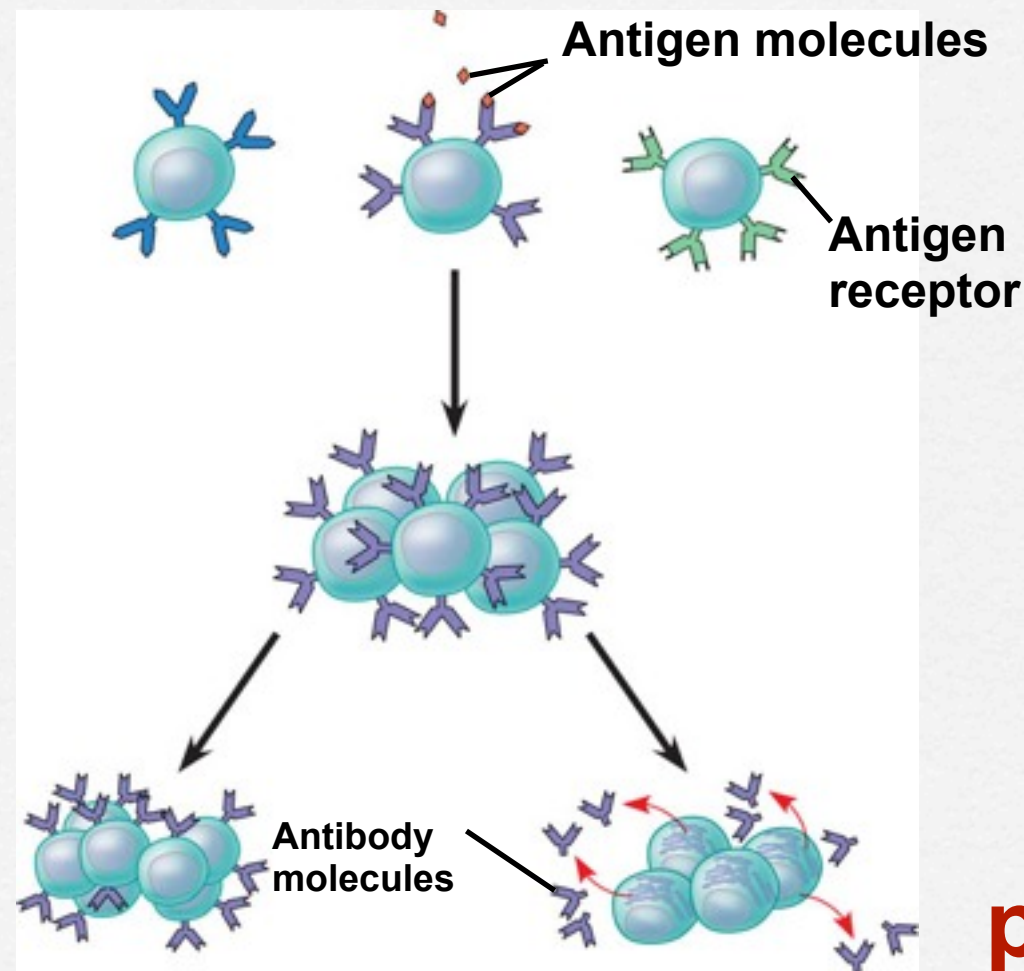
- ACQUIRED or ADAPTIVE IMMUNITY: 4 Characteristics
- **I. Immense diversity- of lymphocytes & receptors (millions)**
 - achieved by shuffling genes around to create a thousands of different proteins later assembled to produce millions of different receptors

Review & Build

- ACQUIRED or ADAPTIVE IMMUNITY: 4 Characteristics
- **2. Self Tolerant- should not attack own cells**
 - the generation of B cell and T cell diversity is somewhat random, as a result some carry receptors for its own epitopes
 - those that carry its own epitopes (ID tags) must be killed so that the immune system does attack it"self"

Review & Build

- ACQUIRED or ADAPTIVE IMMUNITY: 4 Characteristics
- 3. Proliferation- activation of immune response creates many more T cells and B cells



**Clone of
memory cells**

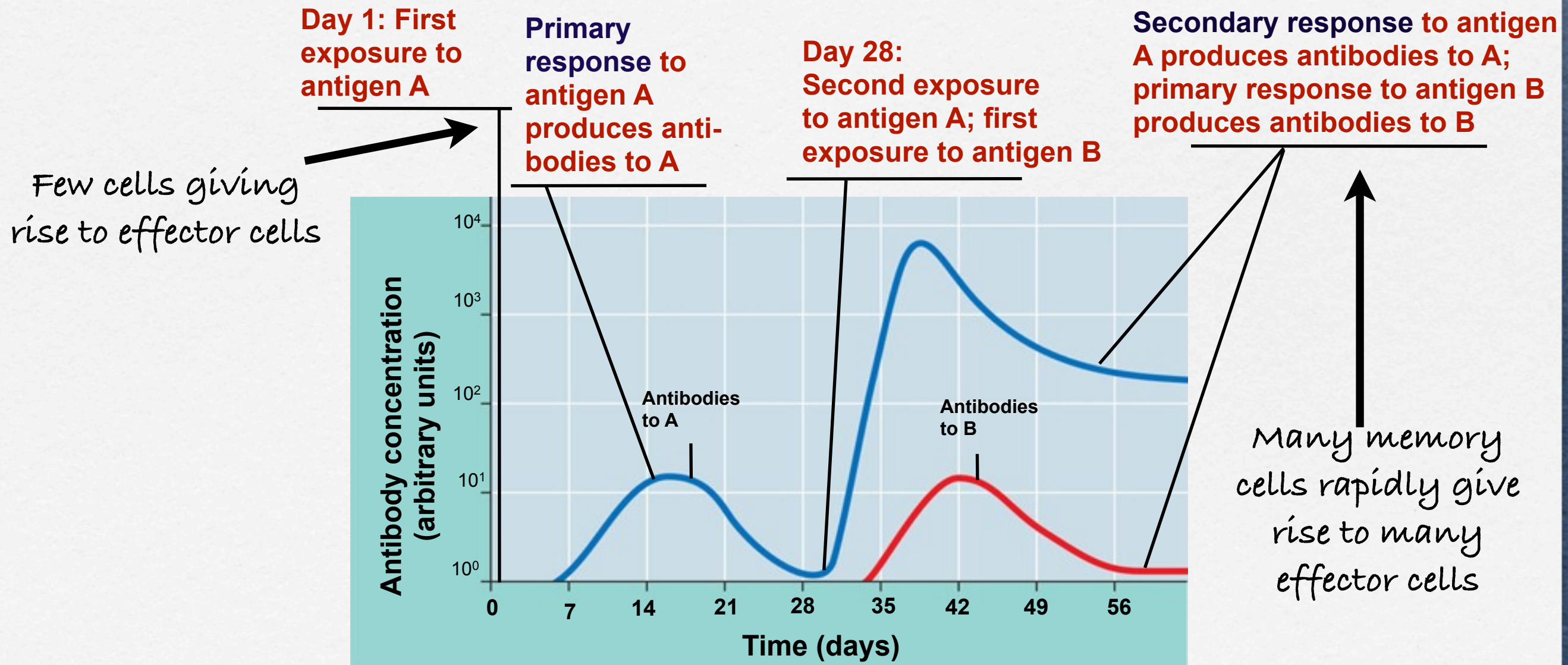
long lived

**Clone of
plasma cells**

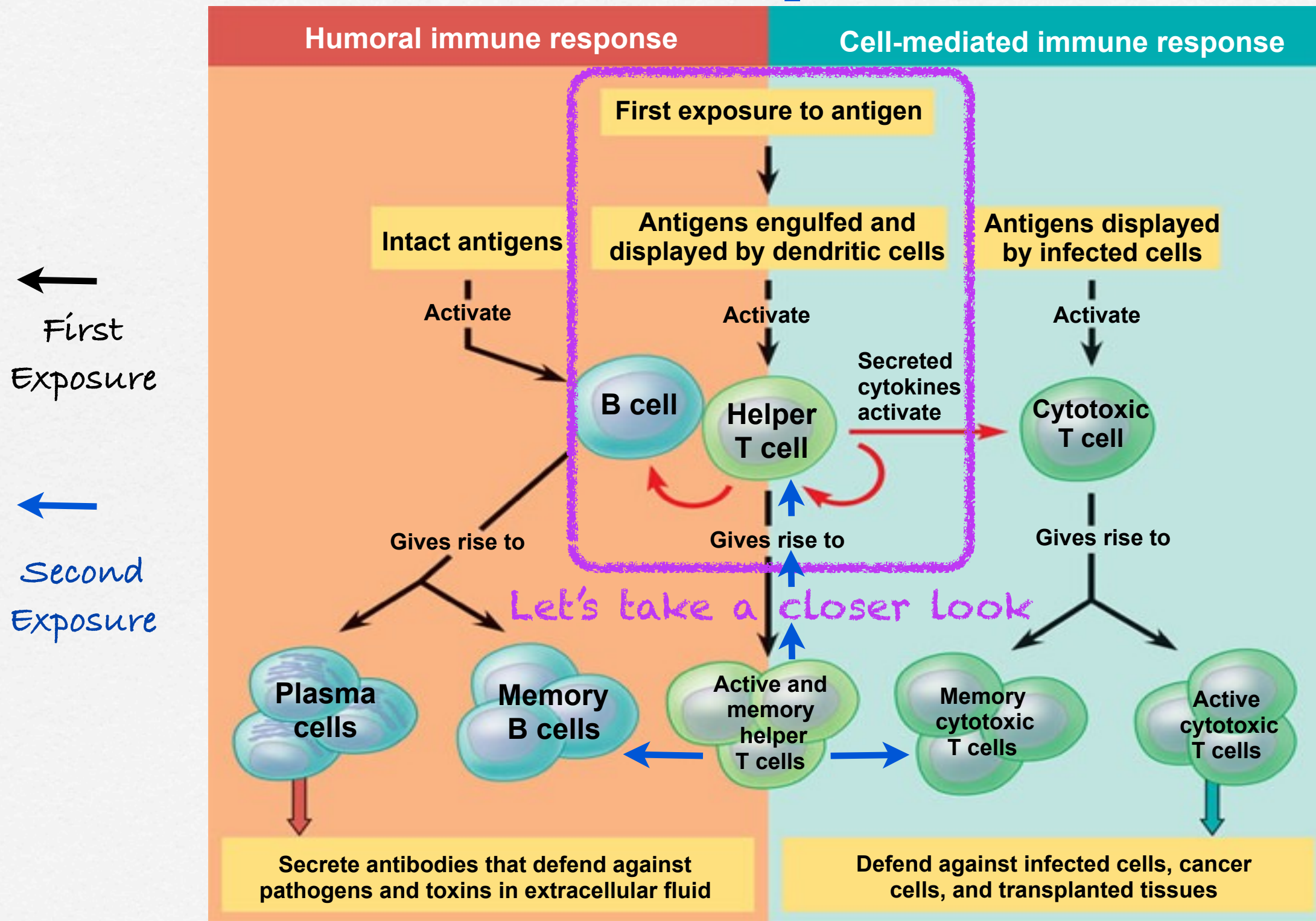
short lived "effector cells"

Review & Build

- ACQUIRED or ADAPTIVE IMMUNITY: 4 Characteristics
- 4. Immunological Memory- stronger and more rapid response to a previously encountered antigen

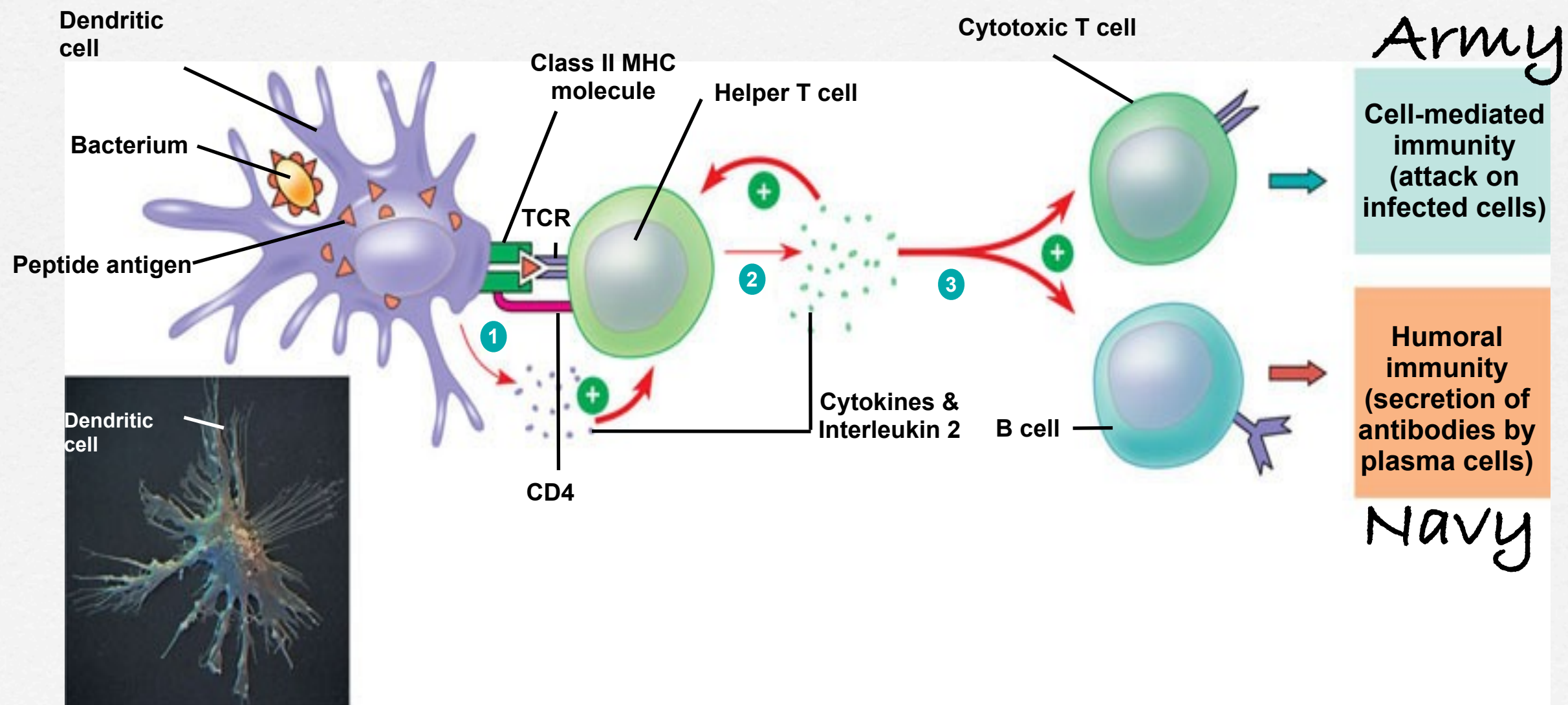


Overview Of Acquired Immunity

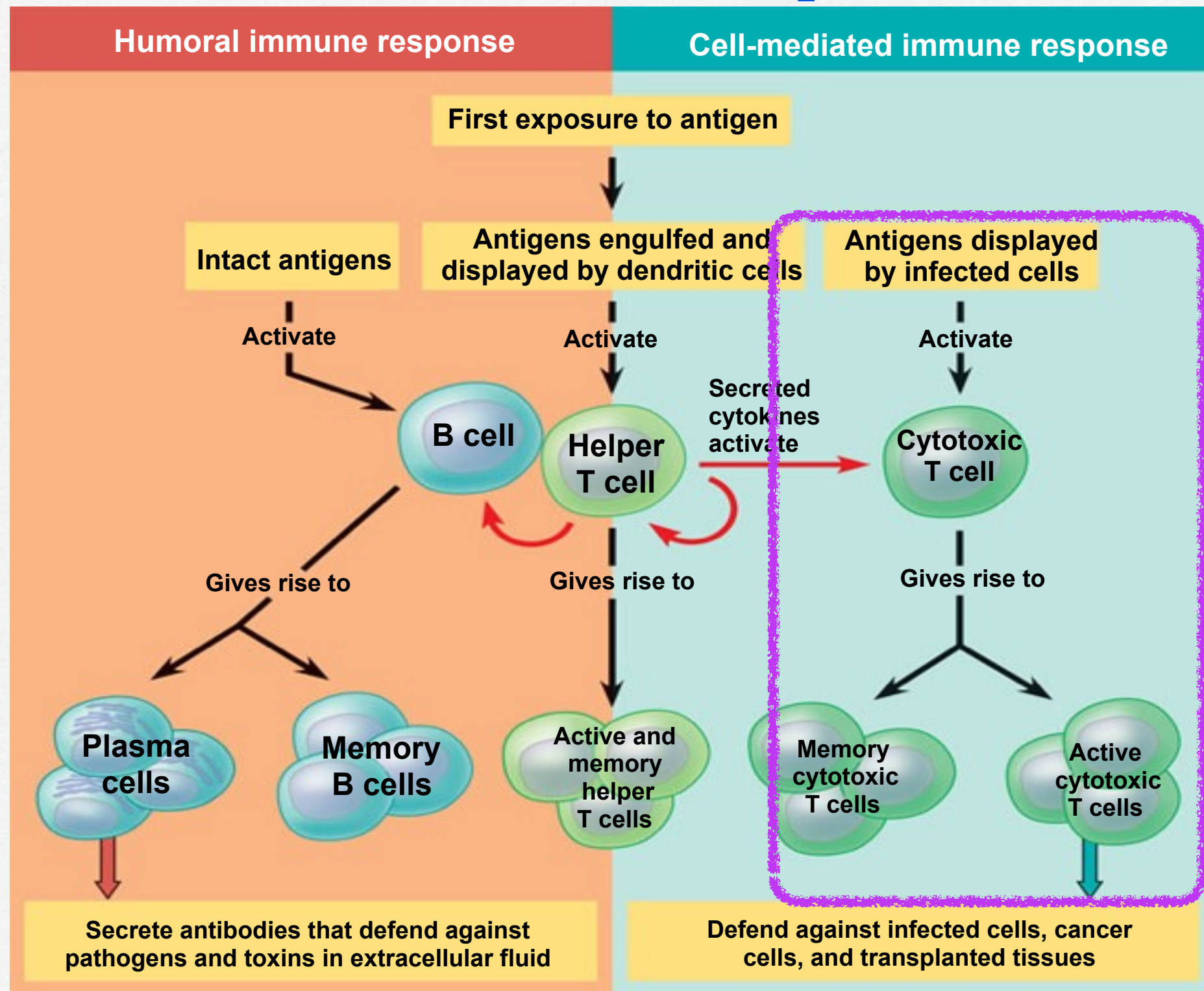


Central Role of Helper T Cells

The "General" tells body its going to war!
calls up the Army and Navy



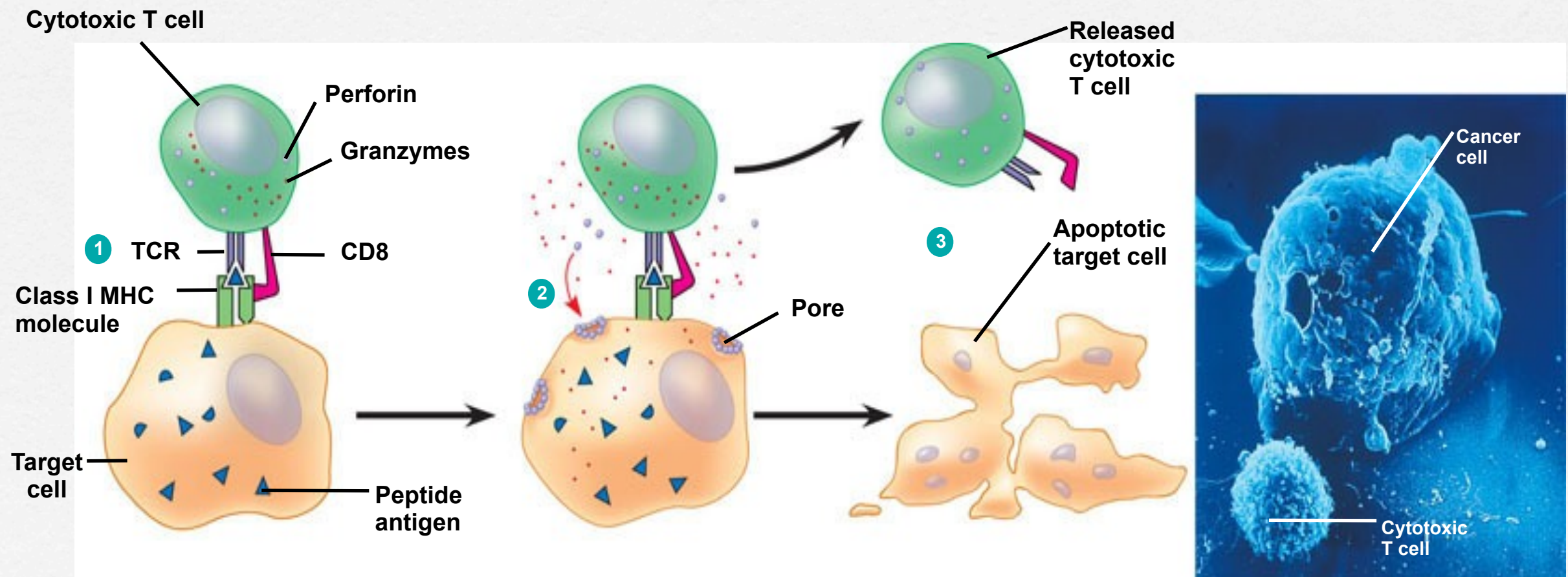
Overview Of Acquired Immunity



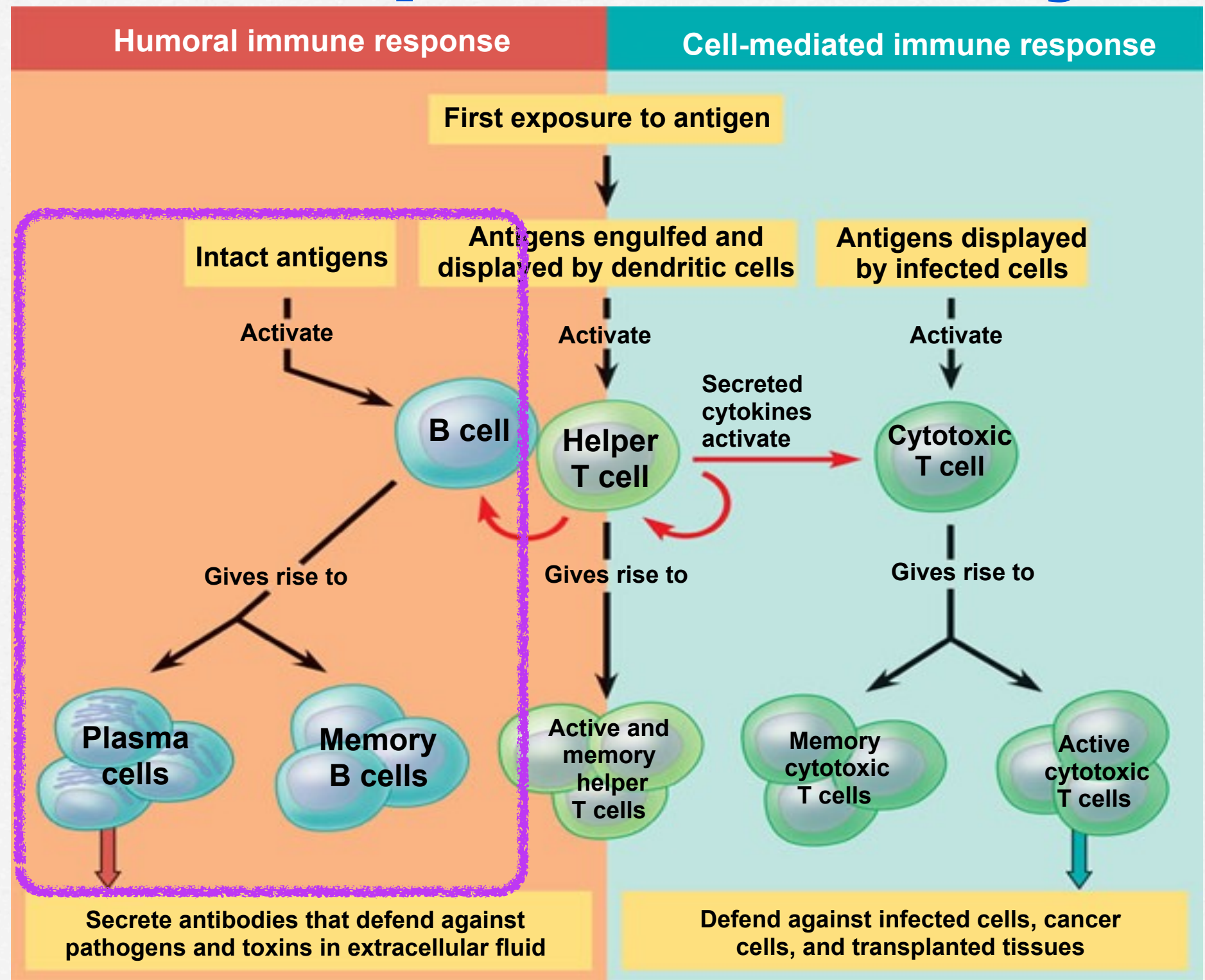
Let's take a closer look

Cytotoxic T Cells

This division (the army) attacks body cells that are already infected

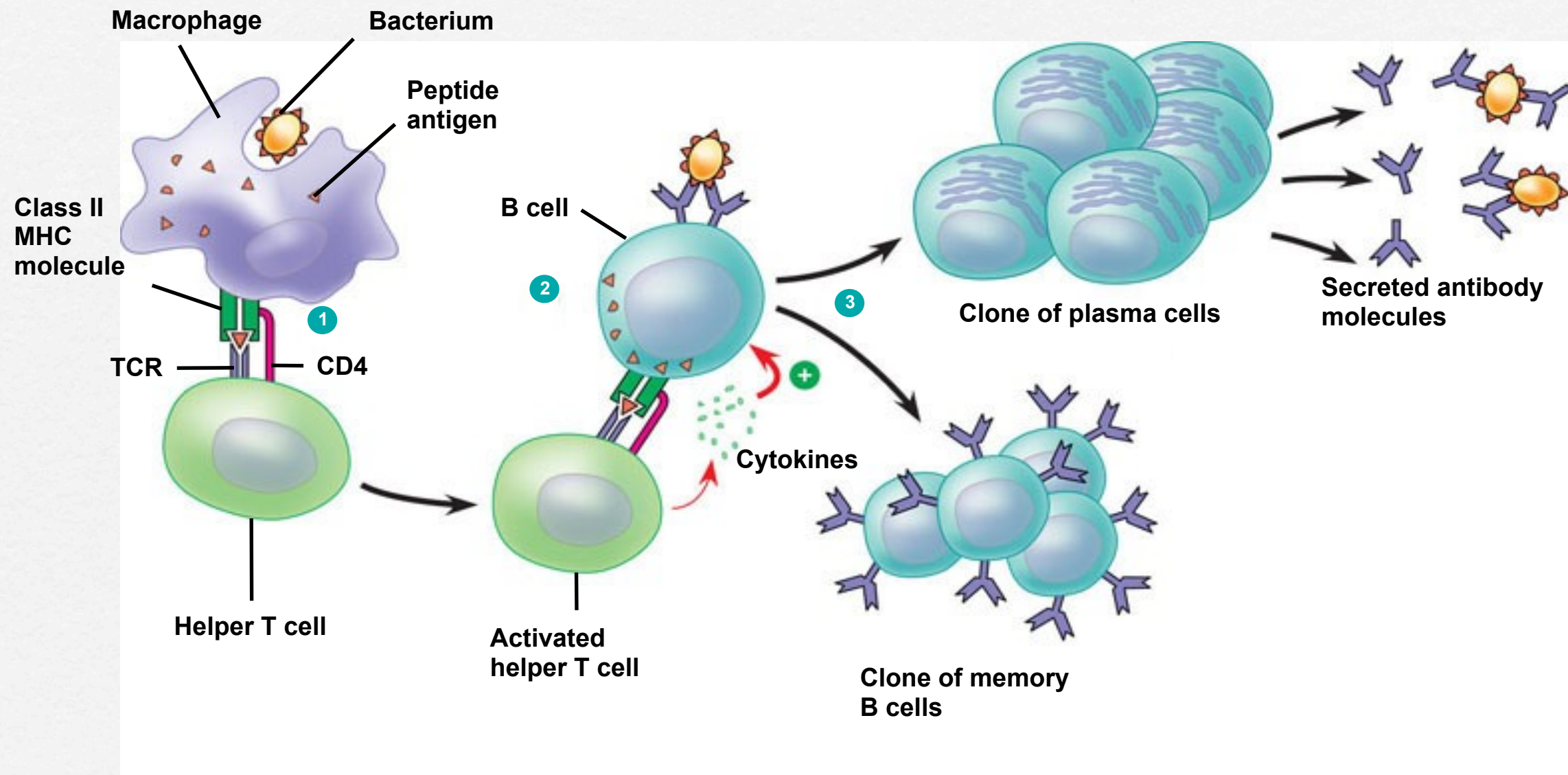


Overview Of Acquired Immunity



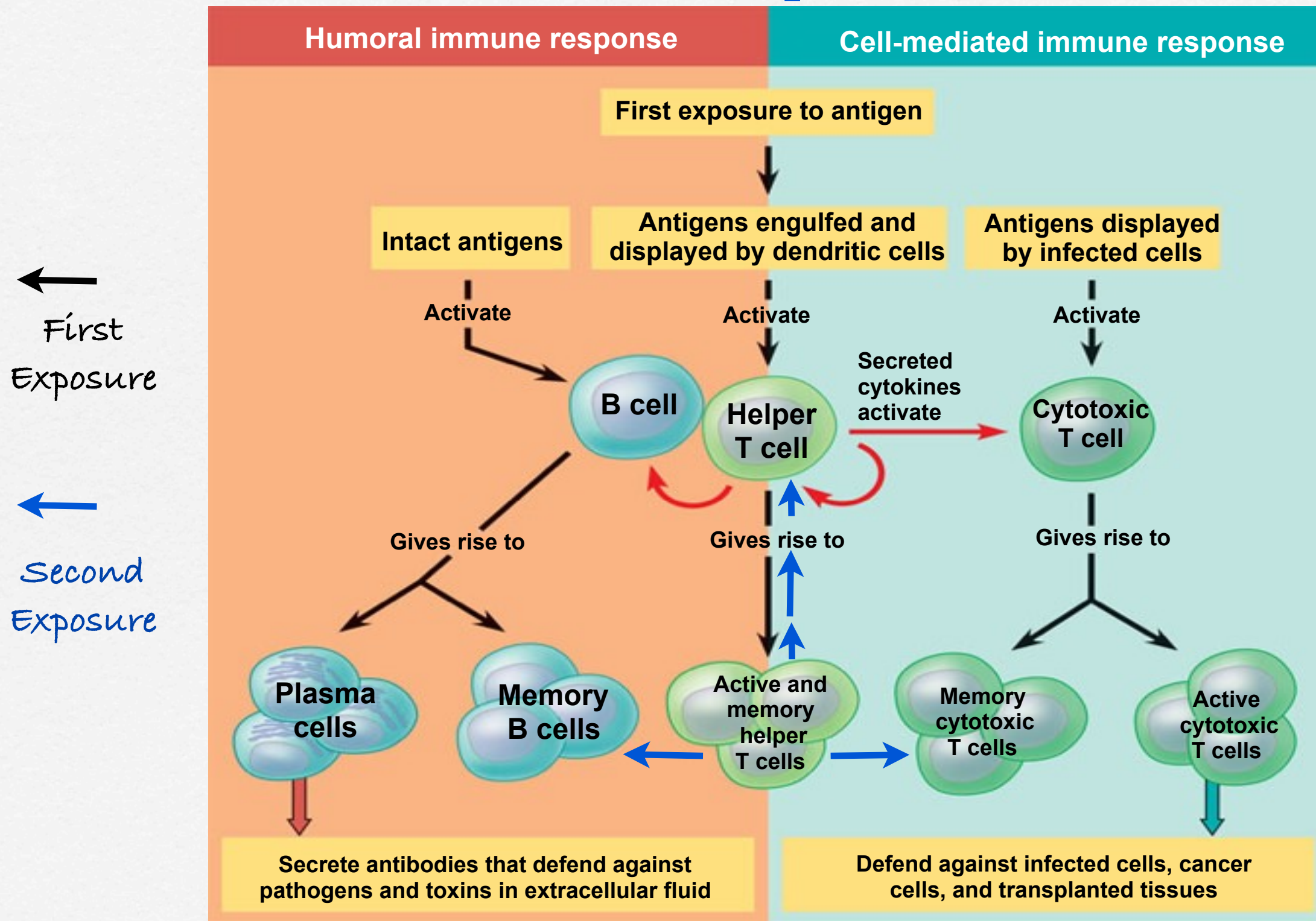
Let's take a closer look

Humoral Immune Response

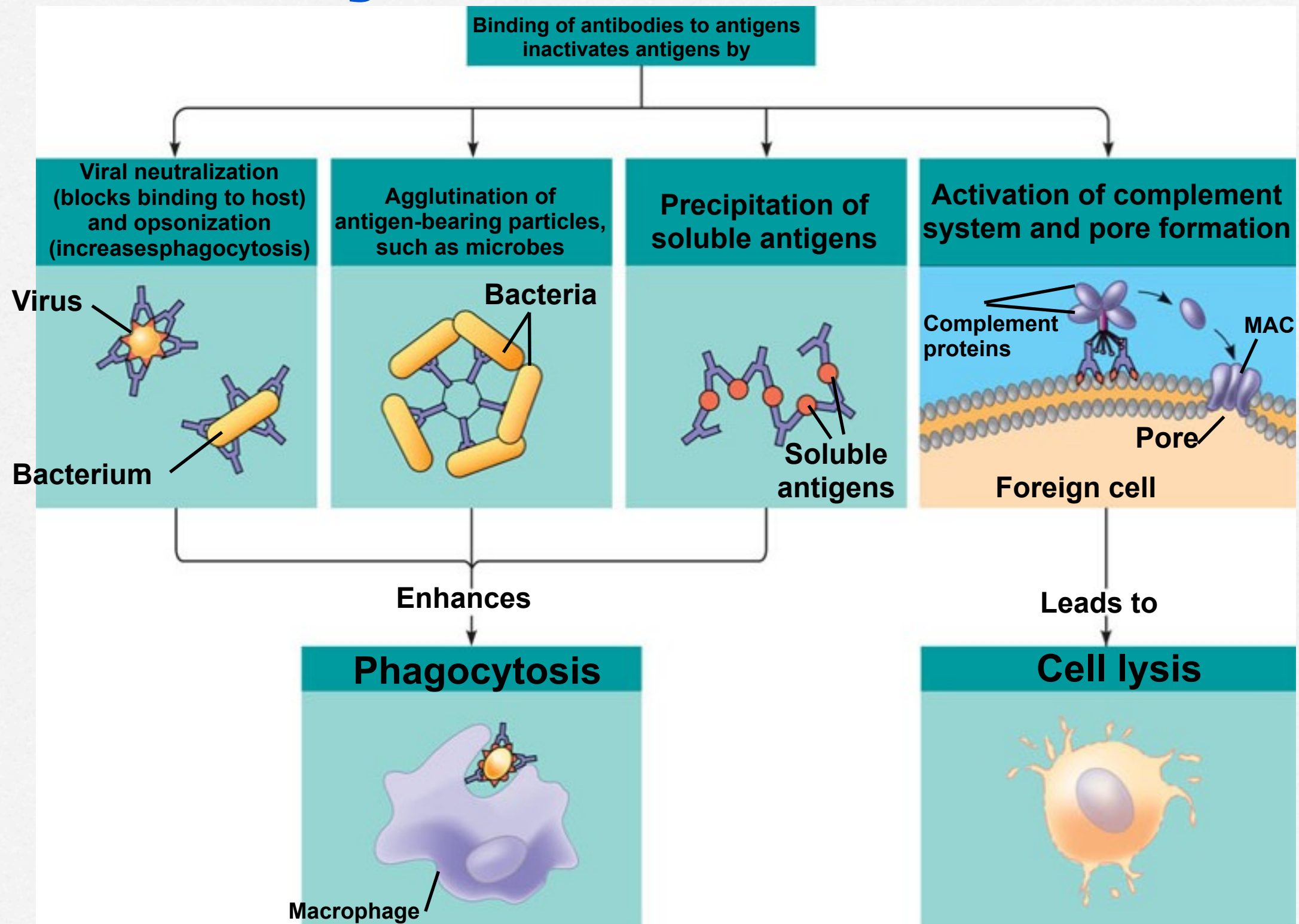


This division (the navy) stays in the body fluids and blood looking for pathogens not yet in cells

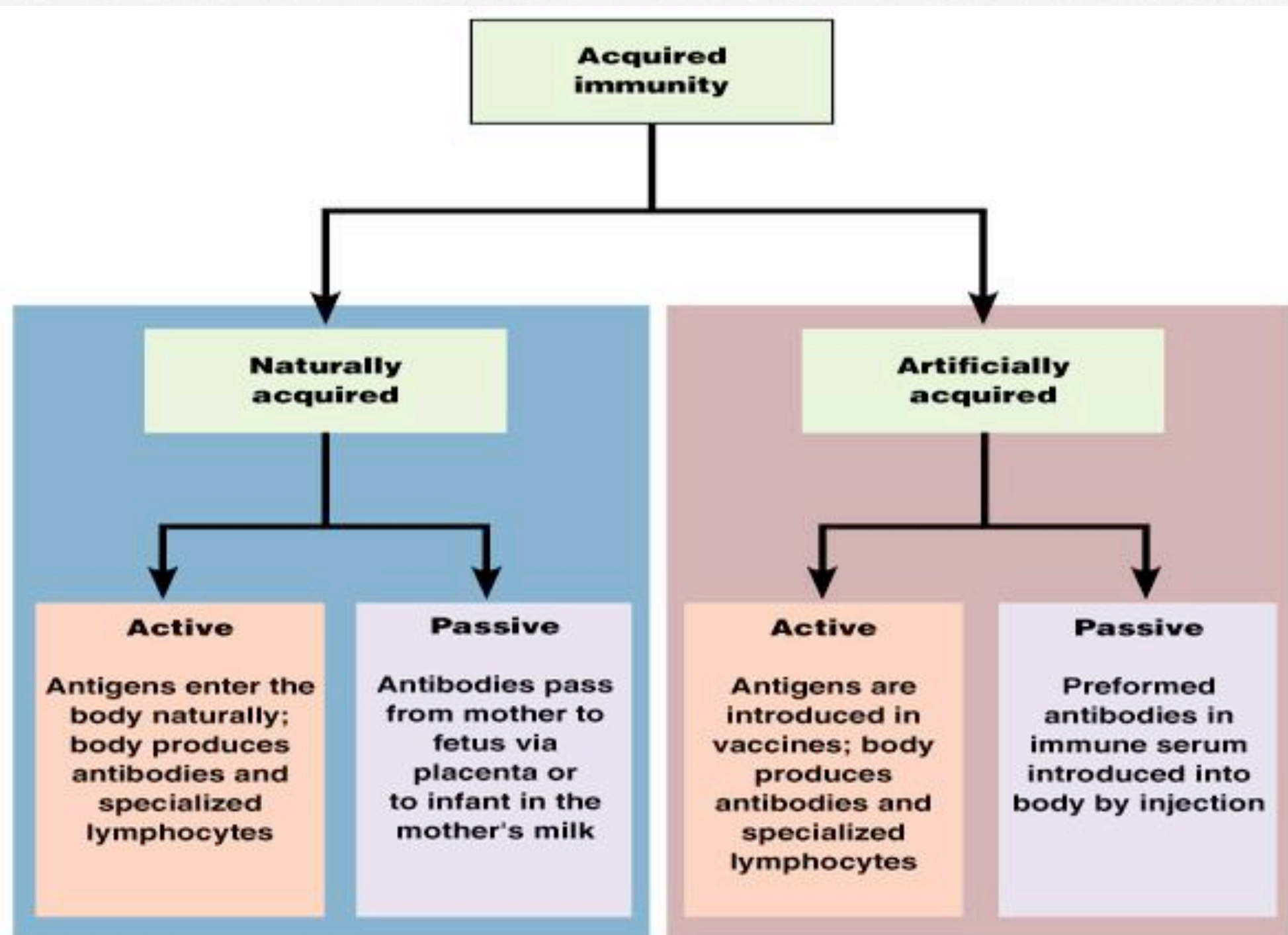
Overview Of Acquired Immunity



Antibody Mechanisms of Action



Active & Passive Immunity



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Immunizations

Active & Passive Immunity

- **Active: Natural or Artificial**
 - slower to acquire immunity but lasts much longer
 - involves patient's T cells or B cells thus memory develops
- **Passive: Natural or Artificial**
 - immediate immunity but lasts only for a few weeks/months
 - does not involve patient's T cells or B cells

Immunizations / Vaccinations

● **Active or Passive Immunity: “Artificially”**

- 1796 Edward Jenner noticed milkmaids were immune to severe and dangerous smallpox symptoms
- Edward Jenner injects people with cowpox virus (antigens)
 - (a weak but similar virus to smallpox)
- cowpox antigen generates active immunity including memory against cowpox and smallpox
- Today's vaccines might include weakened toxins, killed pathogens, pathogen pieces or weakened pathogens

What can we deduce about the cowpox virus if it can serve as a smallpox vaccine?

The surface of each virus must be very similar

Immune Rejection- Blood Groups

- Keep in mind blood, tissue and organ rejection is a sign of a healthy immune system!

Table 43.1 Blood Groups That Can and Cannot Be Safely Combined in Transfusion*

Recipient's Blood Group	Antibodies in Recipient's Blood	Presence (+) or Absence (–) of Transfusion Reaction: Donated Blood Group (Packed Cells)			
		A	B	AB	O
A	Anti-B	–	+	+	–
B	Anti-A	+	–	+	–
AB	No anti-A or anti-B	–	–	–	–
O	Anti-A and anti-B	+	+	+	–

* Individuals with type AB blood are universal recipients (blue row); those with type O blood are universal donors (green column).

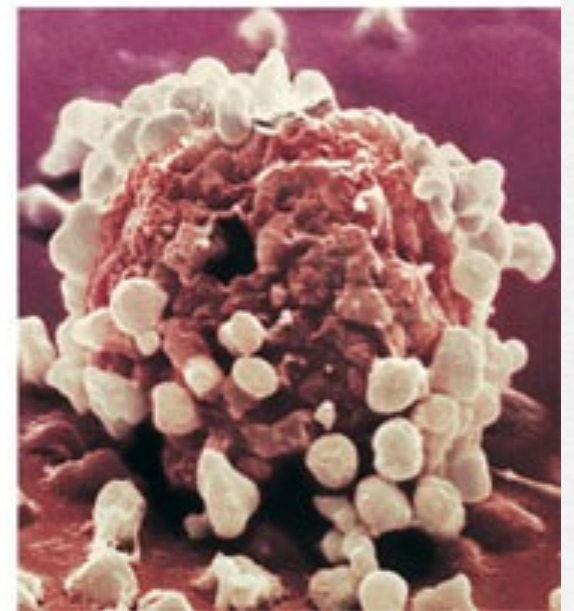
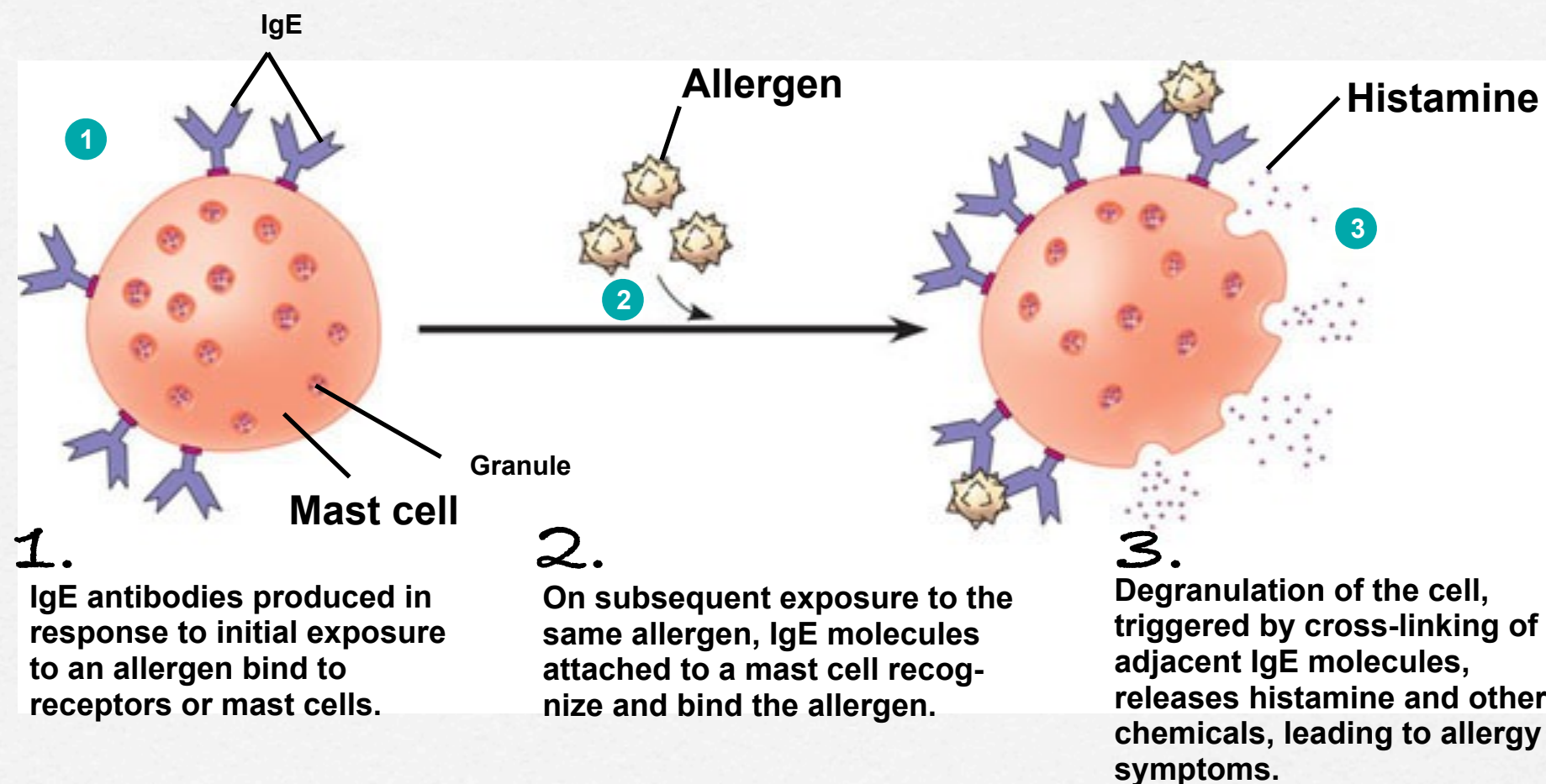
Immune Rejection- Transplants

- **The diversity of MHC molecules (“cell ID Tags”) guarantees that almost no two people with have the same markers.** ?
- The trick with tissue/organ transplants is to find donors that have very similar MHC molecules.
- Often this is not enough and tissue/organ recipients require life long drug regimens that suppress their immune system as well.
- The rejected tissue can also occur when donor tissue rejects recipients...consider bone marrow transplants.

Identical twins have identical MHC molecules

Immune Disorders- Allergies

- Allergies are hypersensitive responses to certain antigens called allergens.



- Antihistamines can diminish allergy symptoms and inflammation by blocking histamine receptors on cell surfaces.

Disorders- Autoimmune Diseases

- **In some the immune system loses the ability to distinguish “self” and “non-self”.**
- *Lupus*
- *Rheumatoid Arthritis*
- *Type I Diabetes*
- *Multiple Sclerosis*
- Gender, genetics and environment all influence susceptibility to autoimmune disorders.

HOMEWORK: BRIEFLY RESEARCH ONE DISORDER AND BE ABLE TO DISCUSS AND EXPLAIN THAT DISORDER IN CLASS

Plants

Defense

Main Idea

- ***Life is faced with a number of threats.***
 - ***These threats include biotic factors like predators, pathogens, and parasites.***
 - ***Even extreme abiotic factors can threaten the life.***
- ***Living organisms defend themselves by using four general strategies protective barriers, fleeing, hiding, or fighting back.***
- ***Plants however can not flee or hide.***

Preface to Plant Defenses

- ***Plants face threats at both the organismal level and at the cellular.***
- ***Herbivores attack the organism itself.***
- ***Pathogens and parasites attack the cells of the organism.***
- **This presentation will address defense mechanisms against herbivory and defense against pathogens separately.**

Plant Defenses against Pathogens

- **1st Line of Defense- PHYSICAL BARRIERS**

- Remember the first and most fundamental barrier is the plasma membrane and cell wall itself.
- **Plant barriers include the periderm and epidermis (basically bark).**
 - Unfortunately these barriers are not impenetrable.

- **2nd Line of Defense- CHEMICAL ATTACK**

- Chemicals destroy pathogens and prevents its spread from site of infection.
- Similar to animals, plants can recognize certain pathogens

Plant Defenses against Herbivores

- **PROTECTIVE & PHYSICAL BARRIERS**

- **Plant barriers include bark, spines, thorns, trichomes (hairs).**



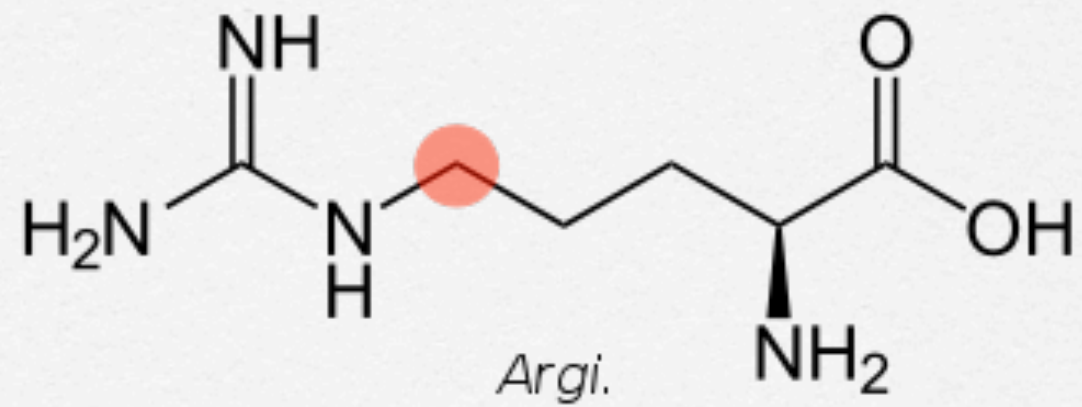
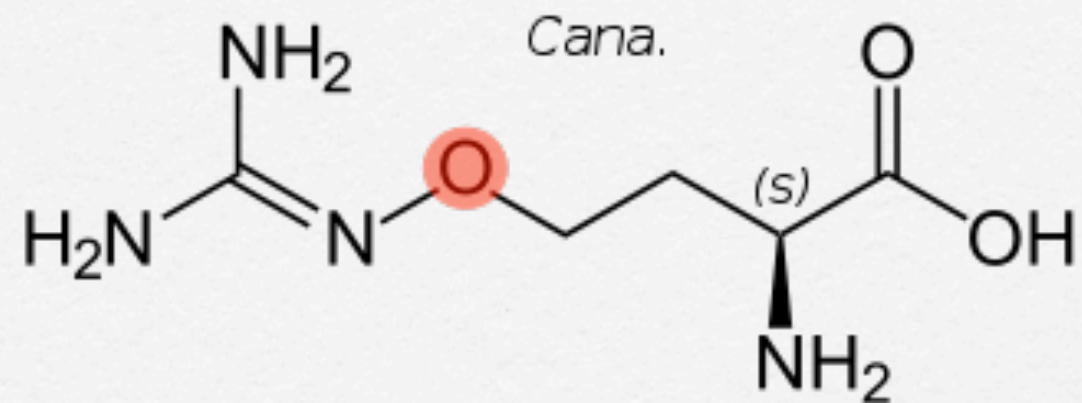
Plant Defenses against Herbivores

- **CHEMICAL DEFENSES**

- **Plants can produce distasteful or toxic chemicals.**

- Canavanine is a chemical that resembles the amino acid arginine.
- It is different enough that organisms that build proteins with it have misshapen proteins.
- These misshaped proteins do function properly and the organism dies.

Canavanine vs Arginine



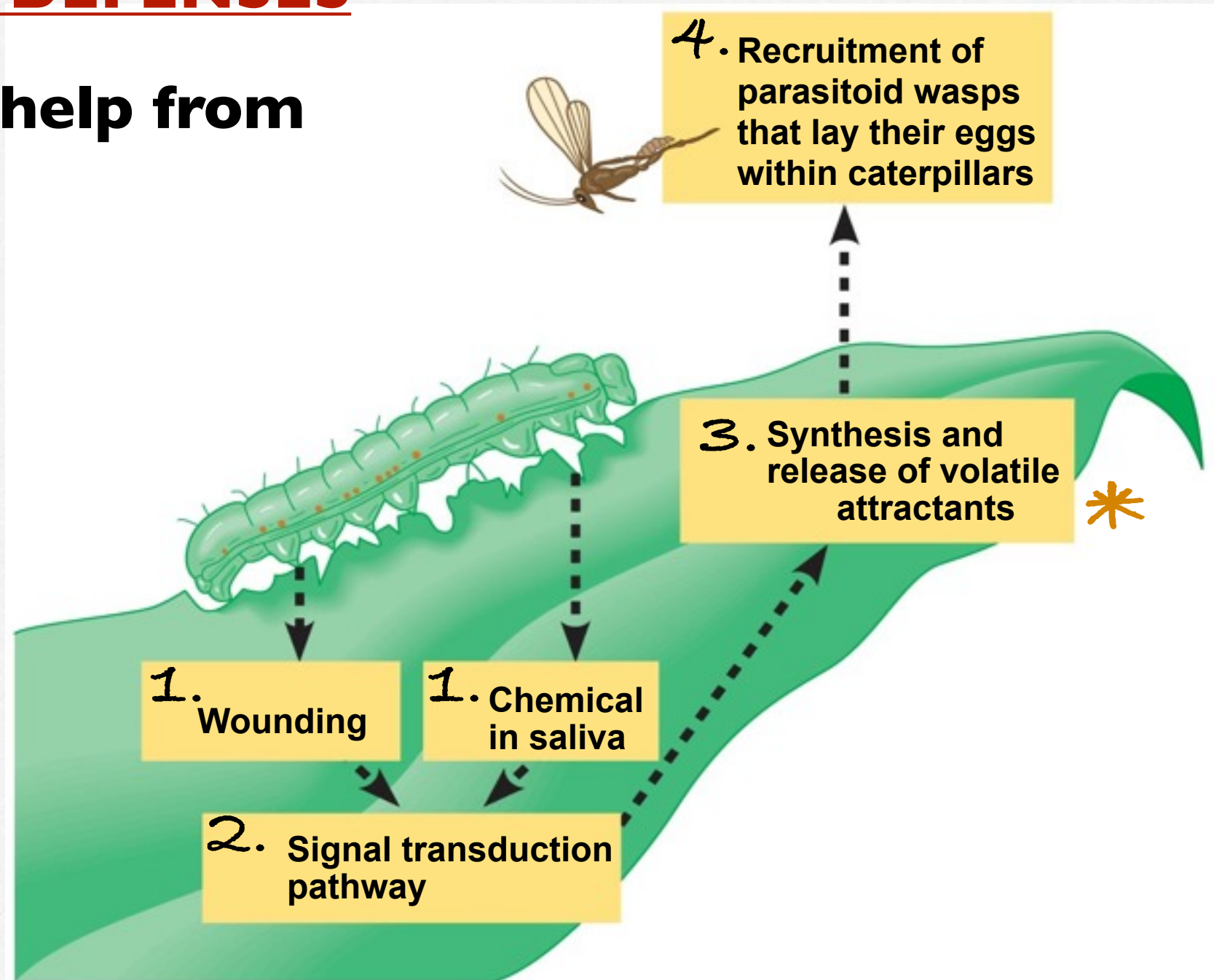
Structure
Dictates
Function

Plant Defenses against Herbivores

● RECRUITMENT DEFENSES

- **Plants can elicit help from other species.**

* These volatile attractants can also warn nearby plants, so that they might make biochemical changes that make them less susceptible themselves



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Remember

- ***Plant life is faced with a number of threats.***
 - ***Even extreme abiotic factors can threaten the life of plants.***
 - Extreme temperatures, salty soils, floods, droughts and mechanical pressures are examples of abiotic threats.
 - Plants DO have mechanisms for dealing with each and everyone of these.
 - The details for each have been or will covered in other “common challenges” units

A blue spiral-bound notebook with silver rings at the top. The word "Fungi" is written in large white letters, and "Defense" is written in yellow letters below it.

Fungi

Defense

Main Idea

- ***Fungi are faced with a number of threats.***
 - ***These threats include biotic factors like other bacteria, viruses, and cells of animal immune systems.***
 - ***Even extreme abiotic factors can threaten the life.***
- ***Fungi defend themselves by using general strategies such as protective barriers and fighting back.***

General Fungal Defenses

- **PROTECTIVE BARRIERS**

- The first and most fundamental barrier is the **plasma membrane** itself.
- An additional protective barrier for fungi is their **cell walls**.
 - Recall that the cell wall keeps the fungal cell from bursting when introduced into a hypoosmotic environment.
 - The cell walls may also protect them from a variety of biotic threats

General Fungal Defenses

● CHEMICAL DEFENSES

- Some fungi produce *antibiotics*, chemicals that kill certain bacteria.
- In 1928, Alexander Flemming showed that the fungus *Penicillium rubens* released a substance that had antibiotic properties.
- This substance would be known as penicillin and the era of antibiotic discovery began.
- The discovery of penicillin was as Flemming admits... an accident.
- Penicillin was successful in a handful cases during the 1930's
- The mass production began during WWII
- It is the most widely administered antibiotic to date

General Fungal Defenses

- **CHEMICAL DEFENSES**

- Antibiotics have different mechanisms of action
 - They destroy bacterial cell walls.
 - Some target the plasma membrane
 - They interfere with bacterial metabolism (enzymes).
 - Some block protein synthesis
 - Yet others interfere with reproduction

Protists

Defense

Main Idea

- ***Protista are faced with a number of threats.***
 - ***These threats include biotic factors like bacteria, viruses, and cells of animal immune systems.***
 - ***Even extreme abiotic factors can threaten the life.***
- ***Protista defend themselves by using general strategies such as protective barriers, fleeing, hiding, or fighting back.***

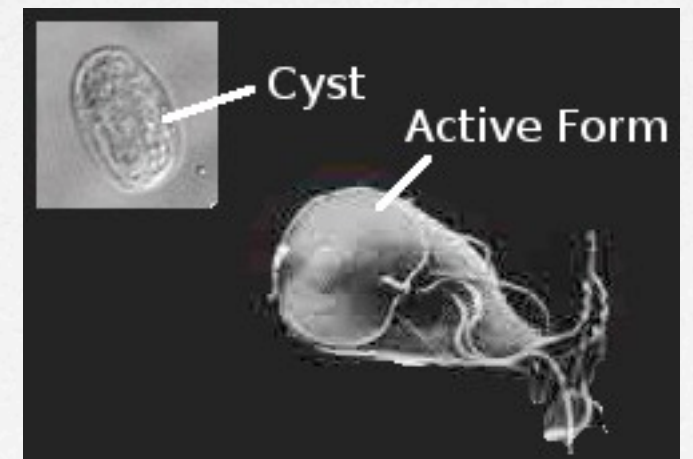
General Protistan Defenses

● PROTECTIVE BARRIERS

- The first and most fundamental barrier is the **plasma membrane** itself.
- Only some protists however have **cell walls**.
 - Animal like protists- the protozoa do not have cell walls.
 - Algae do have however cell walls.
- Some protists also possess have **pellicles**, a thin layer that supports the plasma membrane.
- Some have armor plates made of cellulose, this protective covering is known as the **theca**.

Protistan Defense Against Harsh Abiotic Conditions

- **Cysts**
- When environmental conditions become hostile some protists can form tough, protective coat
- Cysts allow certain protists to lie dormant until conditions improve.
- Cysts differ from bacterial endospores (learn about later) in their composition and degree of resistance
- EX. *Entamoeba histolytica* (dysentary)
- EX. *Giardia lamblia* (Montezuma's Revenge)



Protistan Defense Against Predators

- **Bioluminescence**

- Some protists emit a blue-green light
 - They emit the light to startle predators
 - They can flash the light on and off like a burglar alarm to ward off predators
 - The light can draw attention to itself so that its predator is now more vulnerable to predators from a higher trophic level.
 - these bioluminescent protists are the both rare and fragile



Bioluminescence

Agitation activates the
defensive response



Bioluminescence



Bacteria

Defense

Main Idea

- ***Bacteria are faced with a number of threats.***
 - ***These threats include biotic factors like bacteria, viruses, and cells of animal immune systems.***
 - ***Even extreme abiotic factors can threaten the life.***
- ***Bacteria defend themselves by using general strategies such as protective barriers, fleeing, hiding, or fighting back.***

Preface to Bacterial Defenses

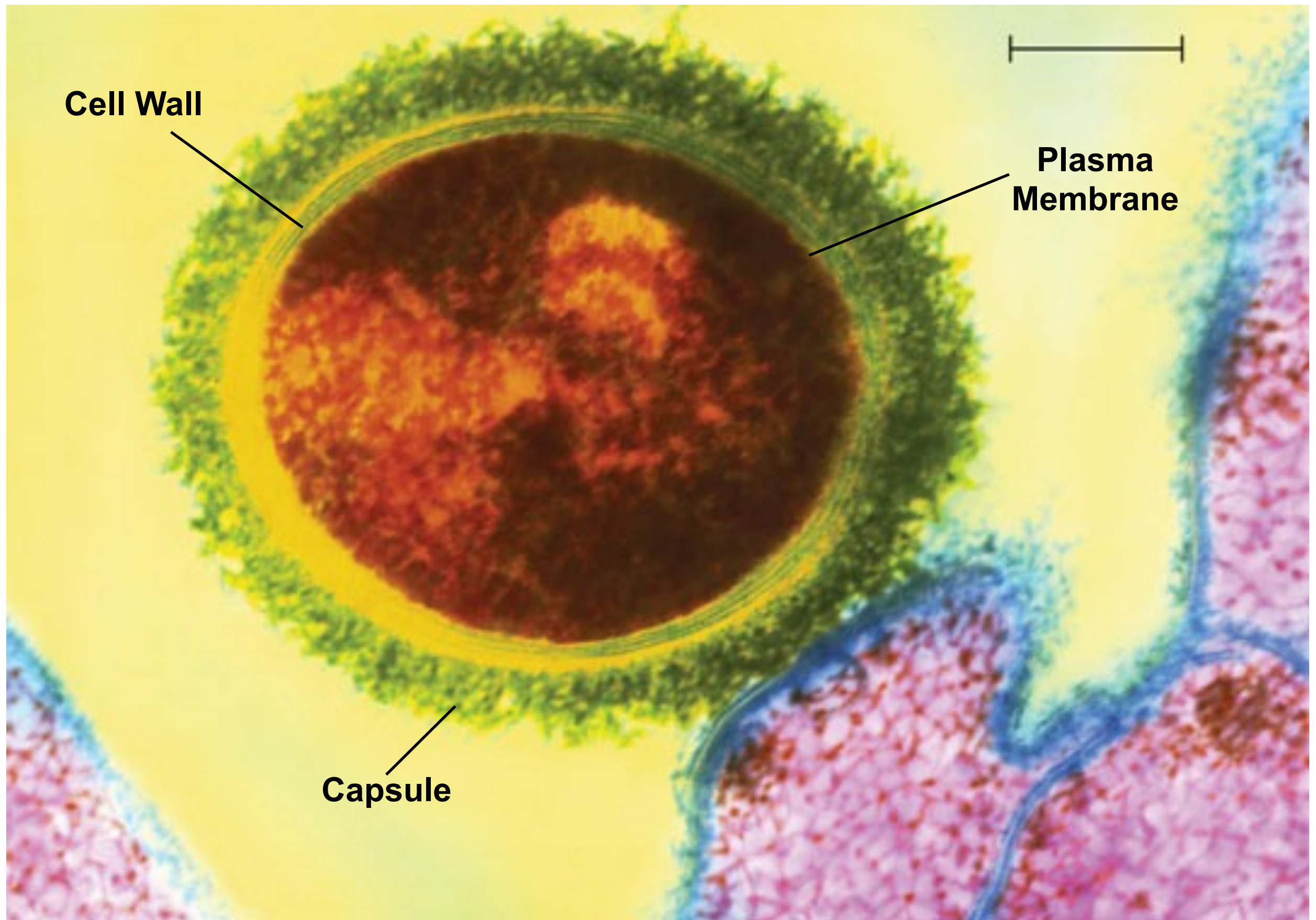
- ***Bacteria face a number threats.***
 - ***Unfavorable environmental conditions***
 - ***Viruses can attack bacteria.***
 - ****Immune Systems of animals attack bacteria.***
 - The very best pathogens do not elicit an immune response or evade the immune response once it has occurred
 - Over millions of years pathogens have co-evolved with their hosts, they have developed defensive strategies against immune system attacks.
 - **we will not explore these topics in MYP*

General Bacterial Defenses

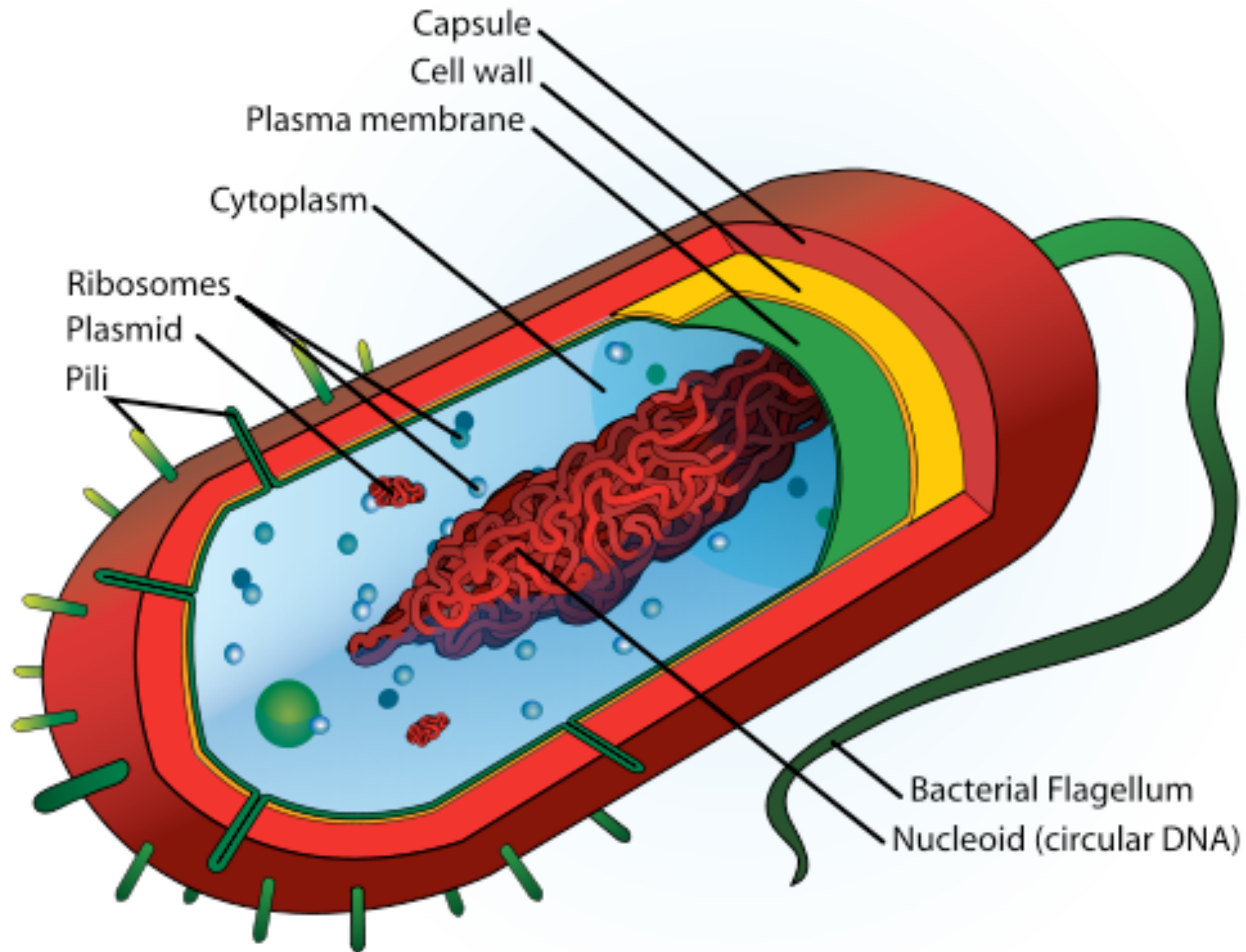
- **PROTECTIVE BARRIERS**

- The first and most fundamental barrier is the **plasma membrane** itself.
- The key protective barrier for bacteria is however their **cell walls**.
 - Recall that the cell wall keeps the bacterial cell from bursting when introduced into a hypoosmotic environment.
 - The cell walls protect them from a variety of biotic threats
- Many bacteria have a sticky or slime layer around the cell wall called a **capsule** that provides an additional layer of protection.

Protective Barriers in Bacteria



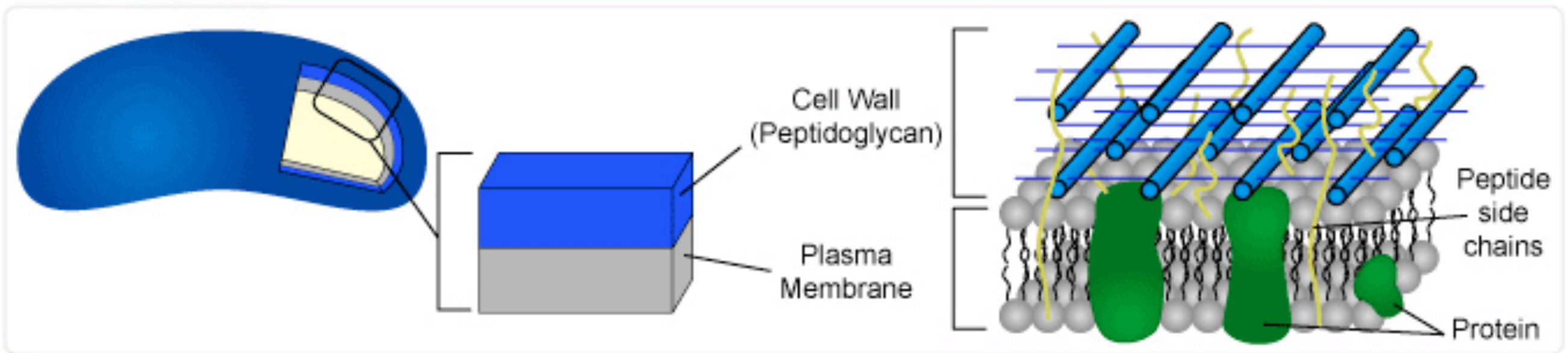
Bacterial Capsules



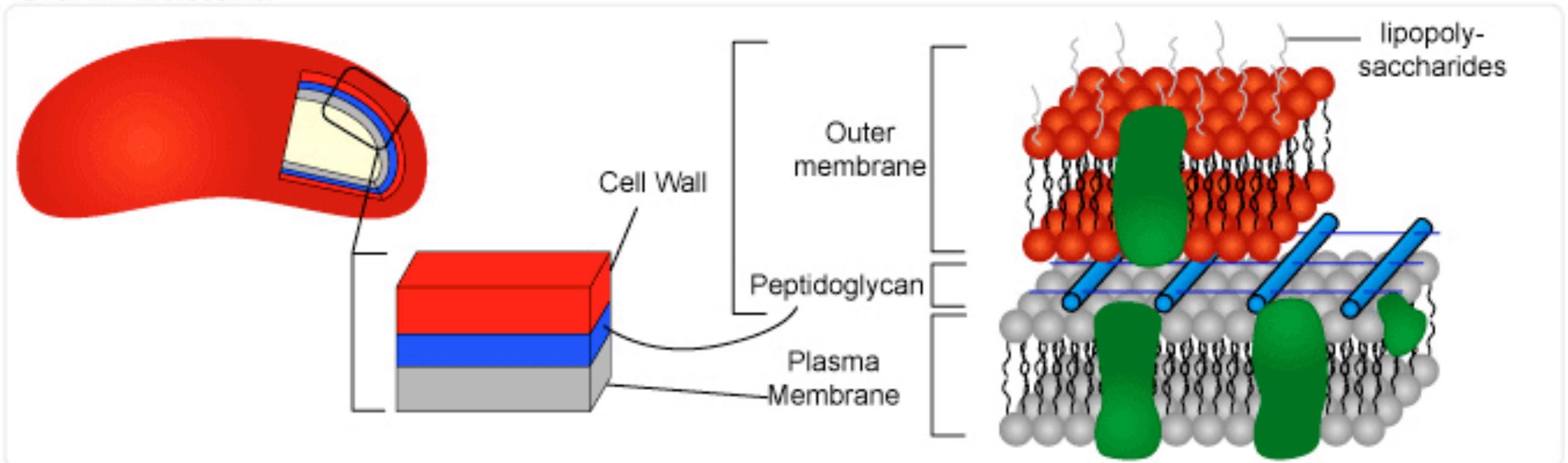
Bacterial Cell Walls

Bacterial cell walls are different from eukaryotic cell walls like those found in fungi and plants. Plants and fungal cell walls are composed of cellulose or chitin. Bacterial cell walls are composed of peptidoglycan, a sugars crossed linked with polypeptides.

Gram⁺ Bacteria



Gram⁻ Bacteria



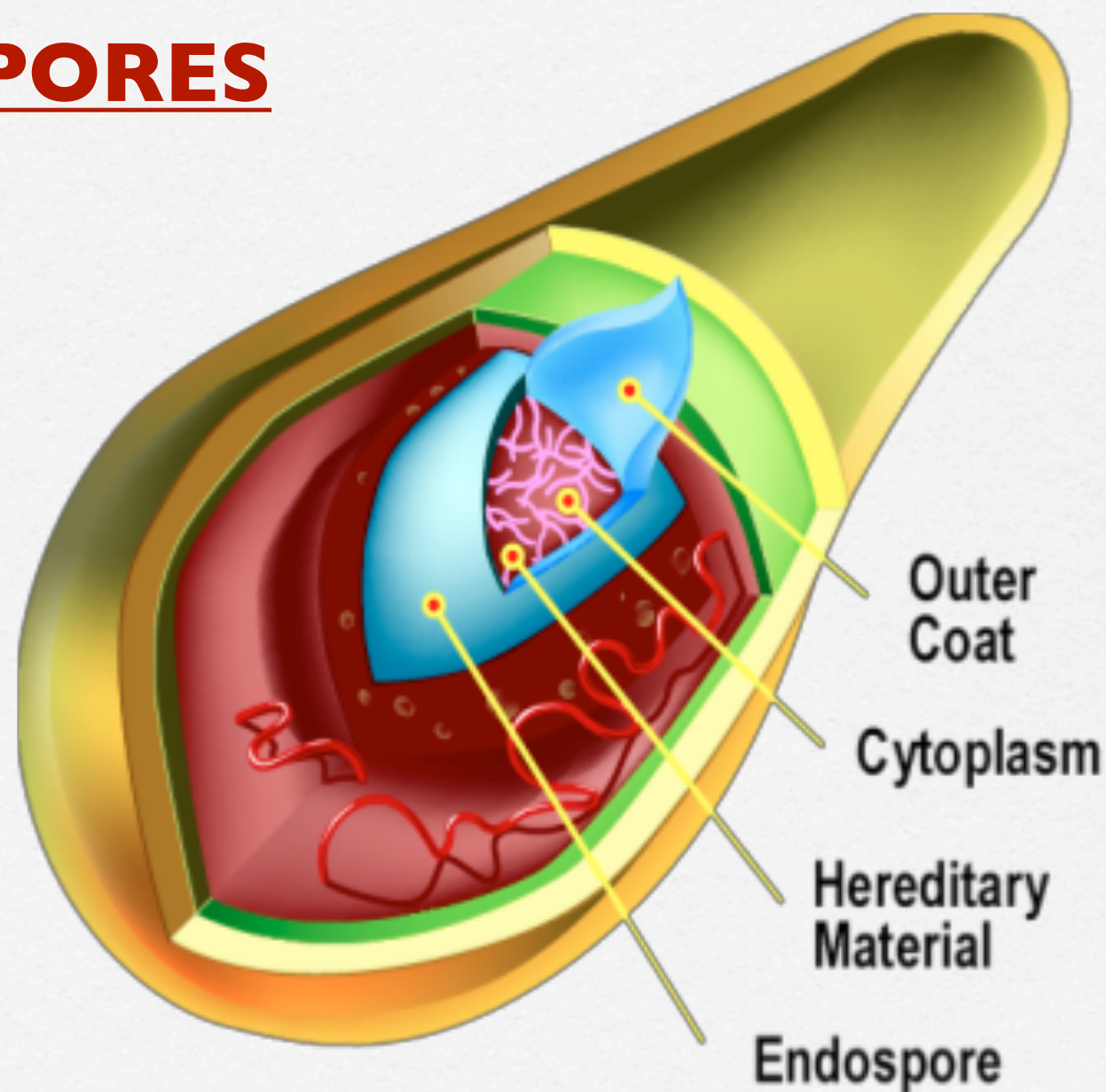
Bacterial Defense Against Harsh Abiotic Conditions

- **ENDOSPORES**

- When environmental conditions become hostile some bacteria can form tough, protective coat around its DNA called an *endospore*.
- Endospores allow bacteria lie dormant for millions of years or until conditions improve.
- Endospores survive without nutrition and resist extreme heat, freezing, UV radiation, desiccation and chemical disinfectants
 - EX. *Bacillus anthracis* (anthrax)
 - EX. *Clostridium tetani* (tetanus)

Bacterial Defense Against Harsh Abiotic Conditions

- **ENDOSPORES**

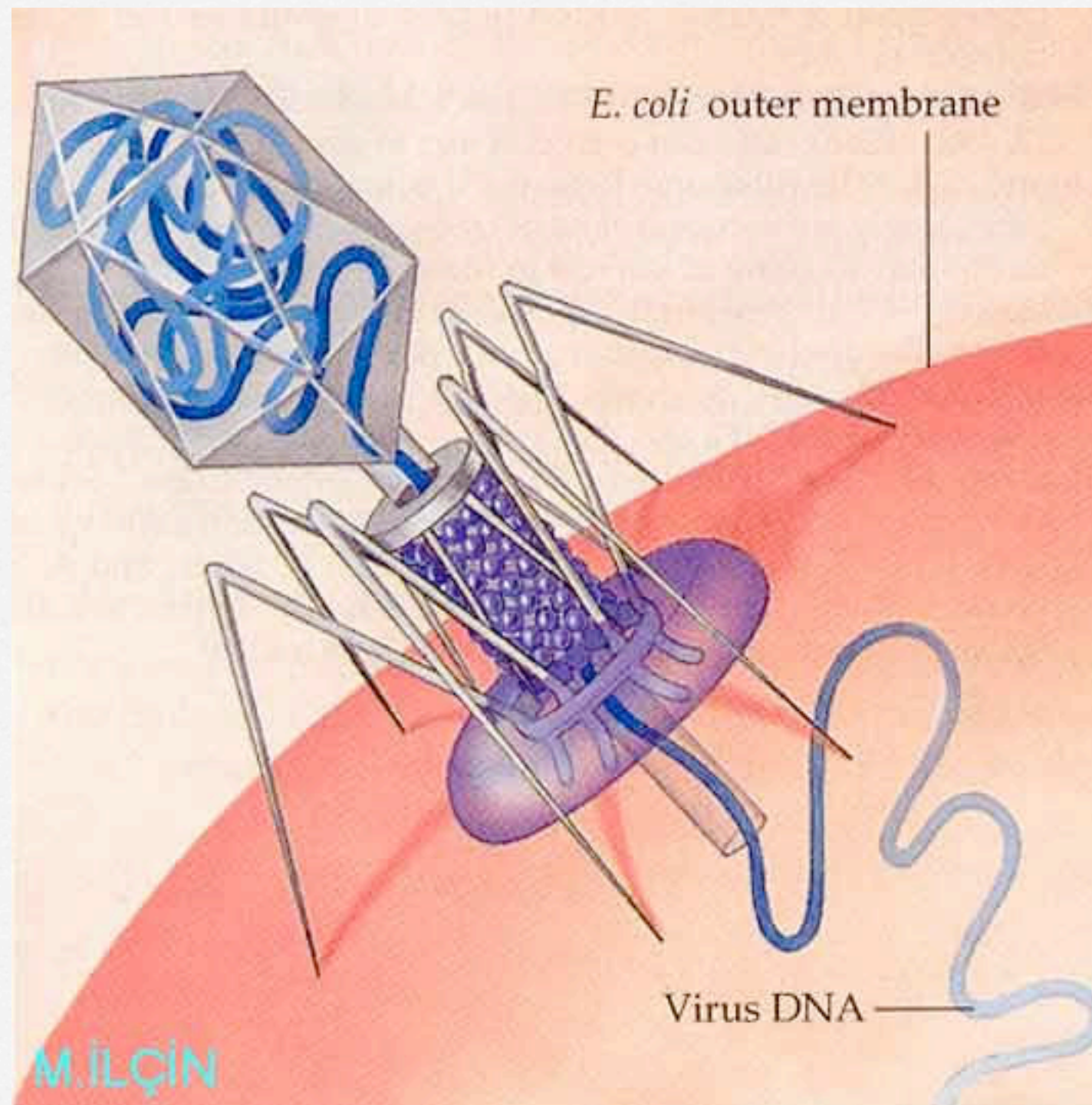


Bacterial Defense of Viruses

● Viral Defenses

- Some viruses can and do attack bacteria, they all called *bacteriophages*.
- Bacteriophages dock to the surface of the bacteria
- inject its viral DNA, the viral DNA hides among the bacteria's own DNA
- later the viral DNA takes control of the bacterial cell, instructing to replicate and assemble viral protein components
- finally as the new viruses emerge from the bacterial host the host dies.

Bacteriophage Attacking

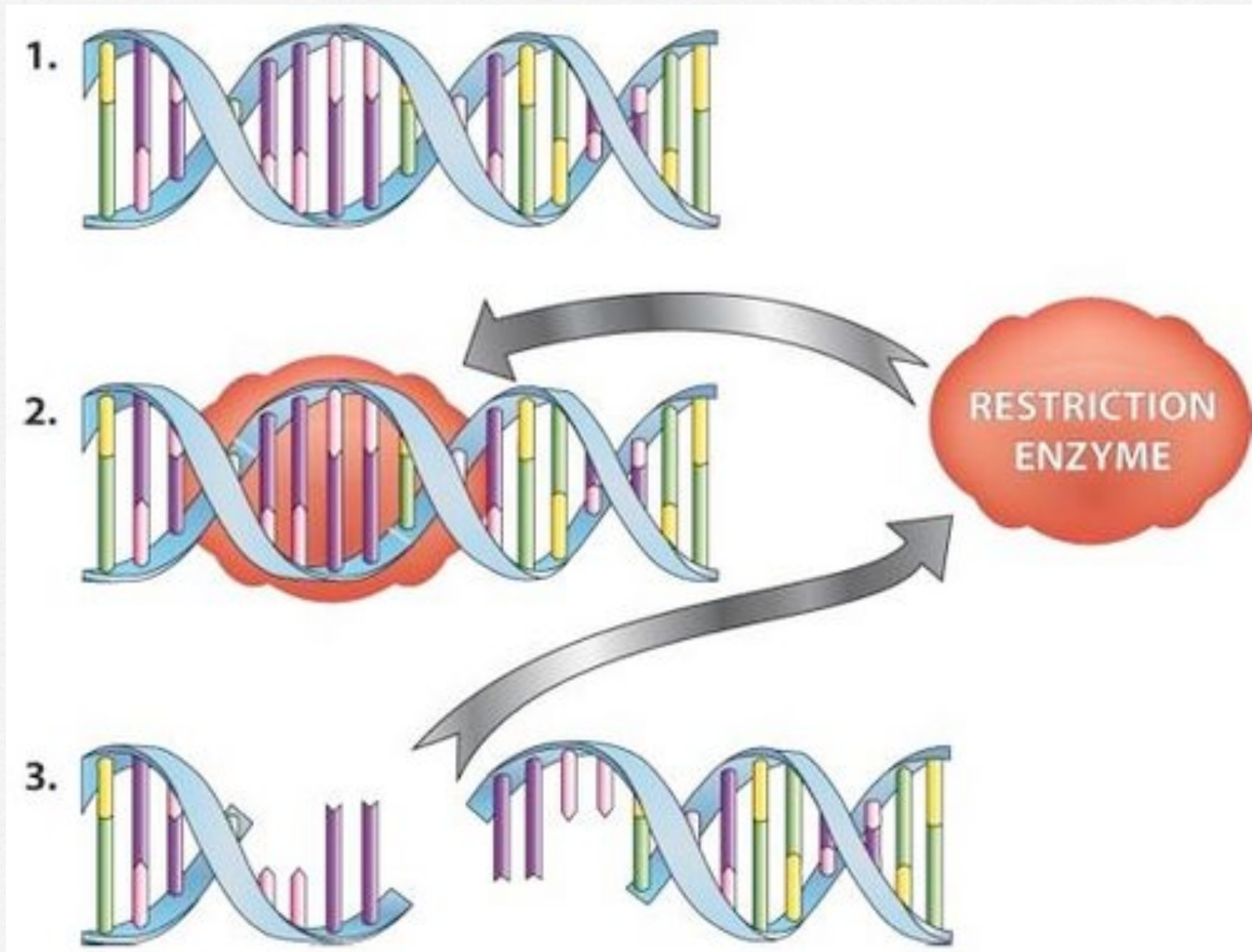


Bacterial Defense of Viruses

- Bacteria Fight Back Against Viral Attacks!
- **Bacteria posses “restriction enzymes” that cut DNA into pieces**
- if the restriction enzymes find viral DNA in time then the Viral DNA is cut into pieces and the infection is averted
- bacteria must also protect their own DNA from the restriction enzymes otherwise their DNA would be destroyed as well.

These restriction enzymes are of great value to the field of biotechnology. They are used in gene cloning and other related biotechnologies, also to be discussed later.

Restriction Enzyme Cutting DNA



Host-Pathogen Coevolution

- **Virulent** pathogens kill the host.
- **Avirulent** pathogens do not kill the host.

Which of the two is more common? Why?

Avirulent is more common; if not then the host and pathogen would perish together

Host-Pathogen Coevolution

- **Oddly enough this host-pathogen coevolution illustrates yet another example of “Trade-Offs” common in nature.**
- Complete resistance is energetically very expensive to organism
 - this would make less able to compete for other resources
- No resistance is energetically very inexpensive to the organism but would kill the organism
- Thus we find a compromise between pathogen and host.
 - The best pathogens gain access to plant to perpetuate itself but does not severely damage the plant.