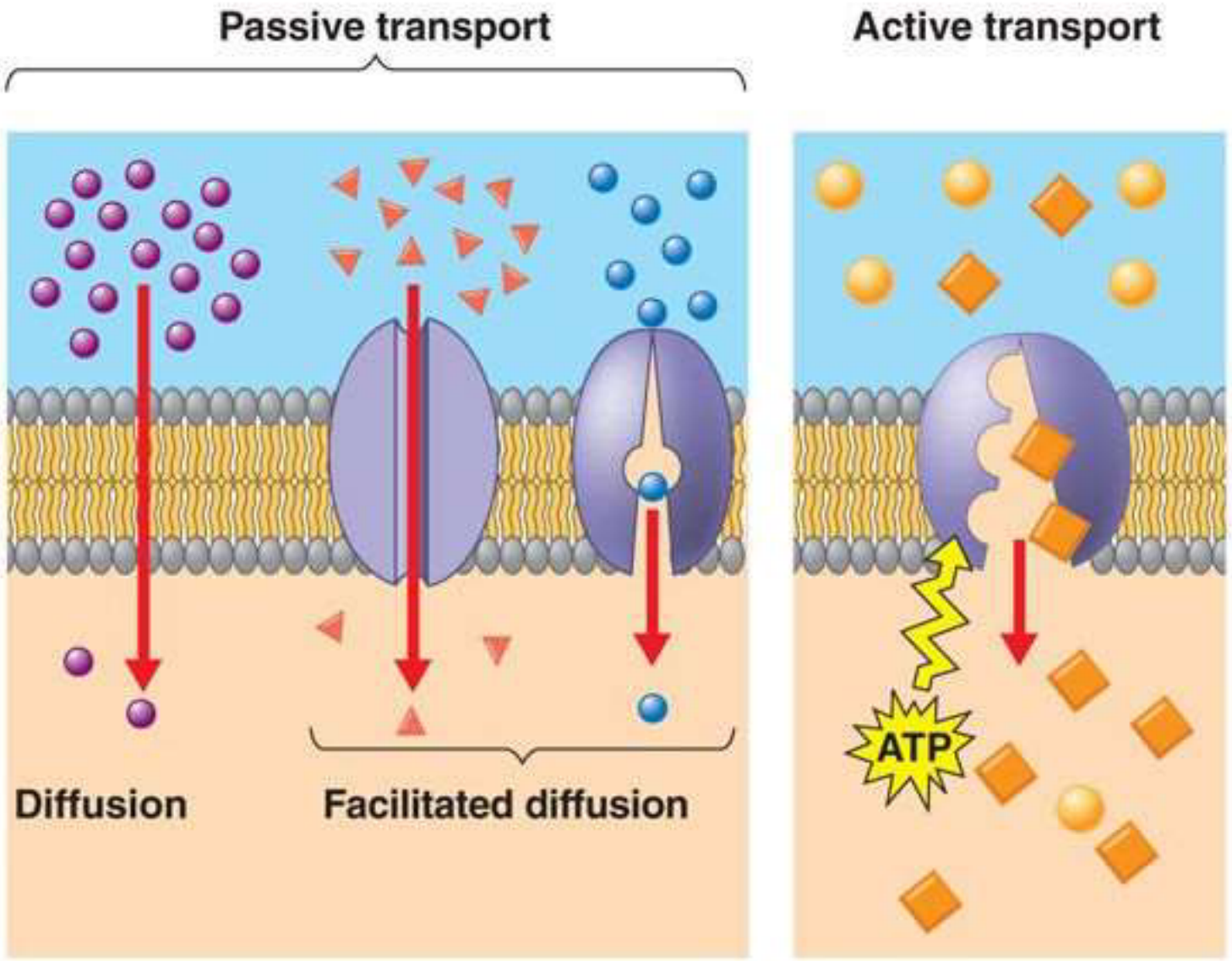
Unit V- Transport Phenomenon in Biological Systems

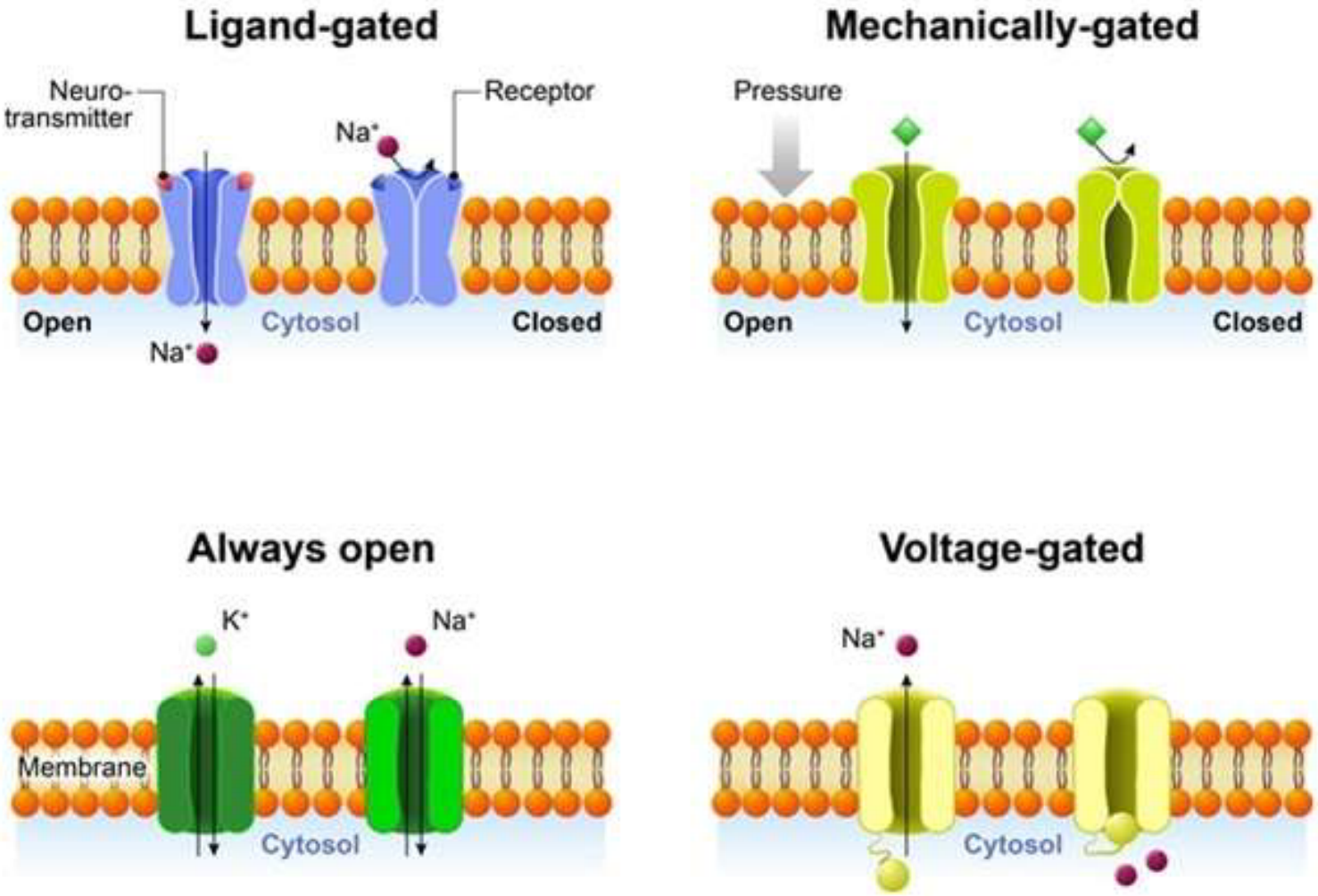
- Membrane channels and ion channels
- Fluid flow and mass transport (Nutrients and ions)
- In plants: Xylem and phloem
- In animals: blood and lymph
- Transport of gases: oxygen and carbon dioxide
- Heat transport: body temperature regulation
- Communication: cell junctions and cell signaling
- Hormones, pheromones and cell behavior
- Defense mechanisms: in plants: herbivory and secondary metabolites
- In animals: innate and adaptive immune system

Transport in animals

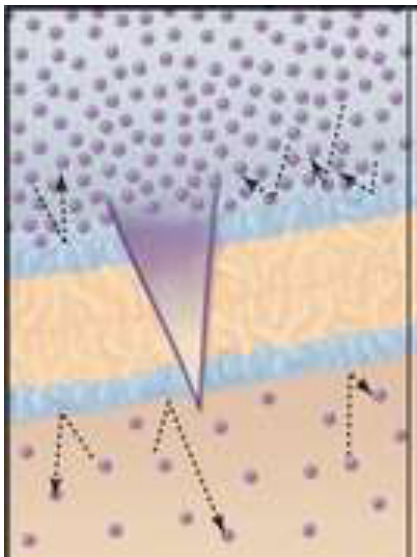
- Every organism must exchange materials with its environment.
- Exchanges ultimately occur at the cellular level.
- In unicellular organisms, these exchanges occur directly with the environment.
- For most cells making up multi-cellular organisms, direct exchange with the environment is not possible.

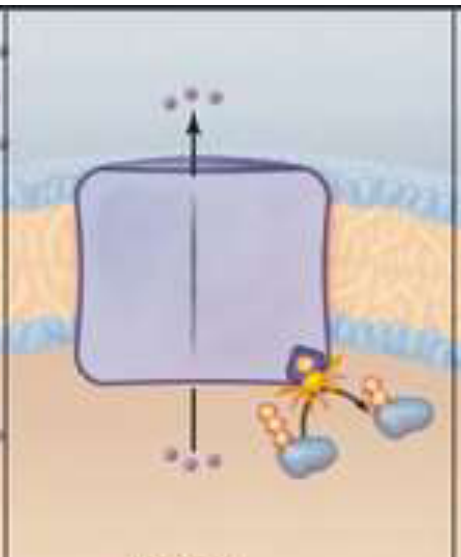

Passive transport
Active transport
Diffusion
Facilitated diffusion
ATP

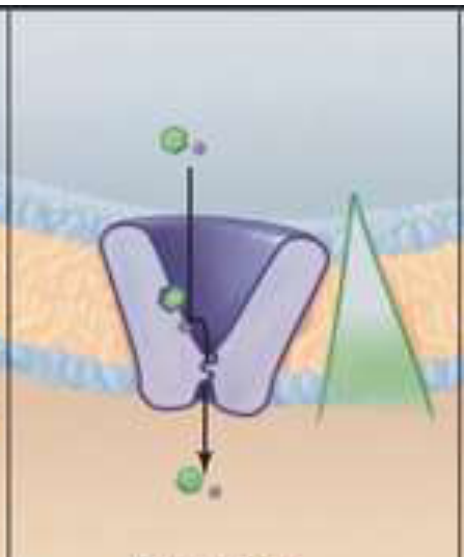
ION CHANNEL

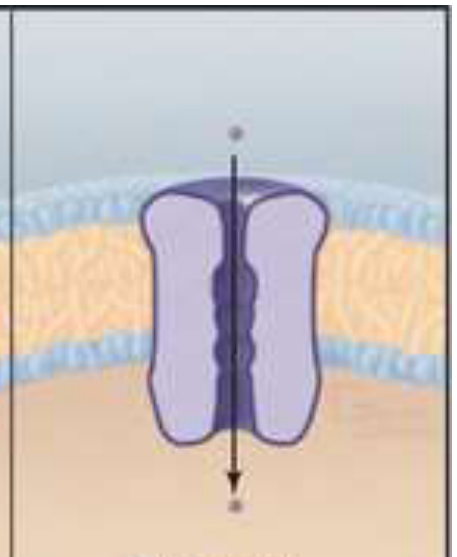

Ligand-gated
Neuro-
transmitter
Receptor
Na+
Open
Cytosol
Closed
Na+
Mechanically-gated
Pressure
Open
Cytosol
Closed
Always open
K+
Na+
Membrane
Cytosol
Voltage-gated
Na+
Cytosol

Membrane proteins and ion channels



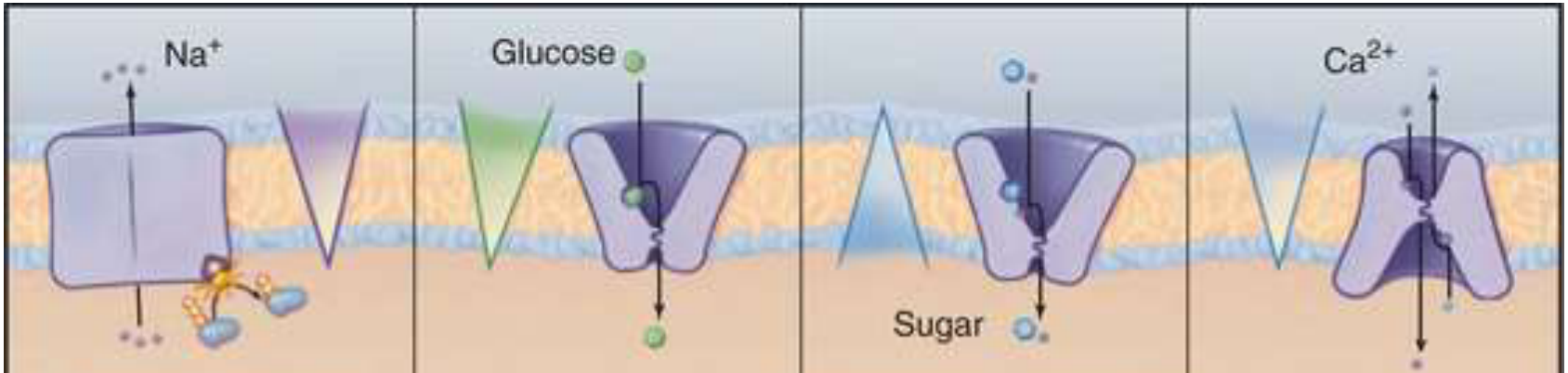




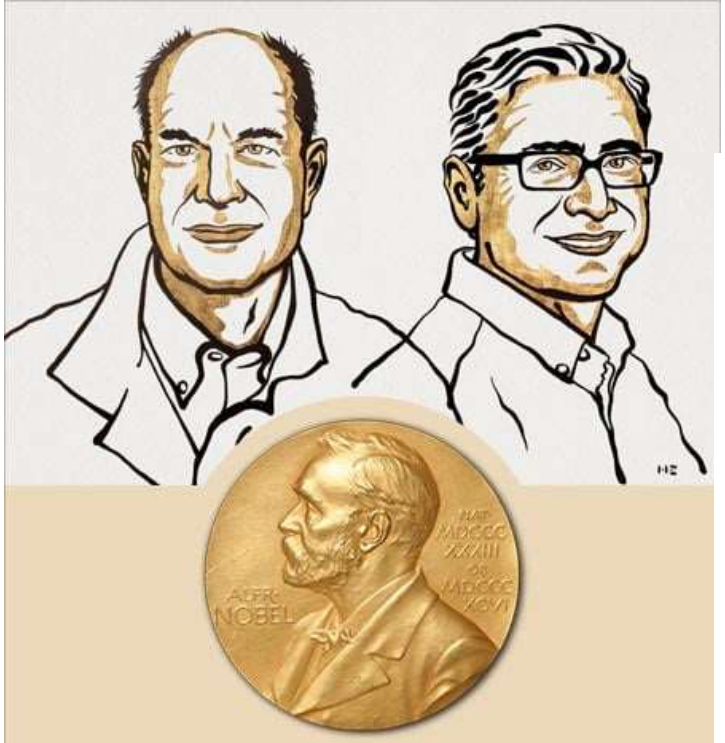


	Pump	Carrier	Channel
Specificity	Absolute	Intermediate	Only 10–20×
Rate (ions/s)	100	<1000	10^6
Gradient	Uphill	Downhill*	Downhill
Energy input	Required	No	No
Ions/conformational change	~1	~1	Many

*May pull another solute uphill



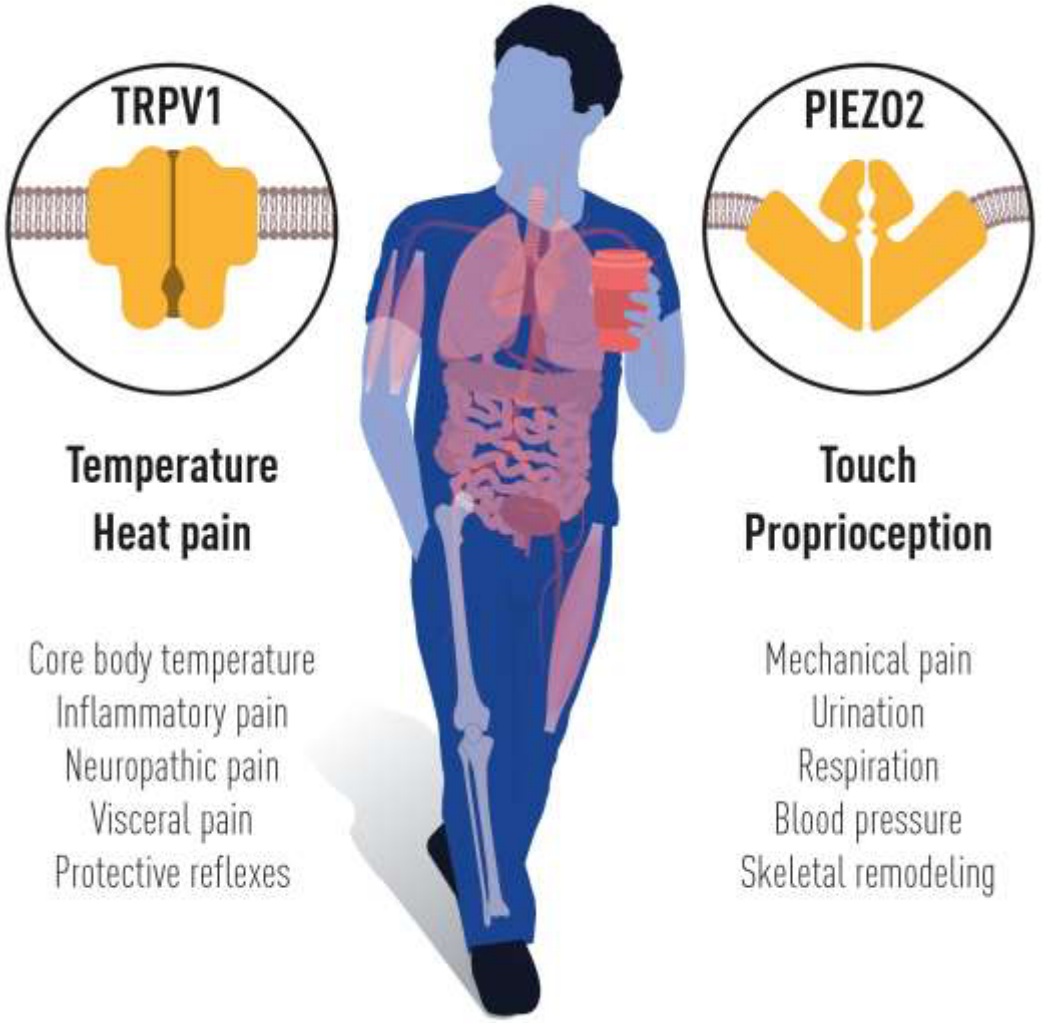
Pump	Uniporter	Symporter	Antiporter
Na^+/K^+–ATPase	Glucose Amino acid	Na^+/sugar Na^+/amino acid Na^+/Cl^- $Na^+/K^+/2Cl^-$ $Na^+/H_2PO_4^-$	Na^+/H^+ Na^+/Ca^{2+} Cl^-/HCO_3^-



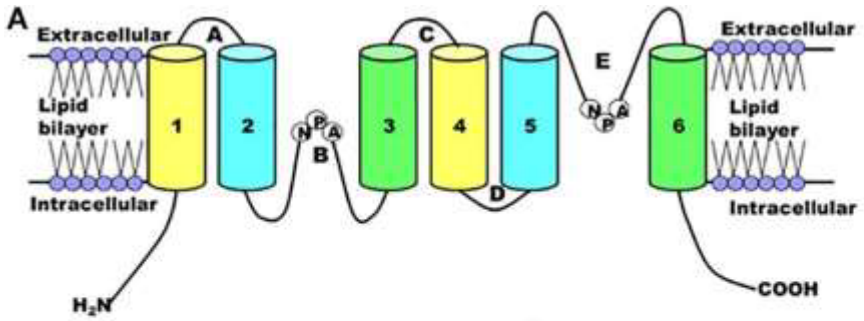
The 2021 Nobel Prize Laureates

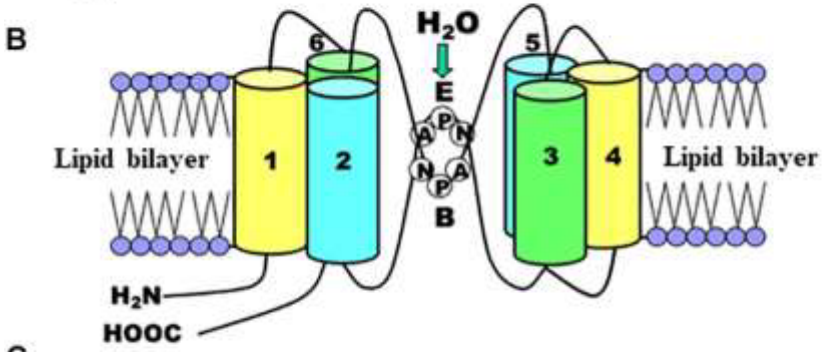
David Julius and Ardem Patapoutian were awarded the 2021 Nobel prize in Physiology or Medicine "for their discoveries of receptors for temperature and touch".

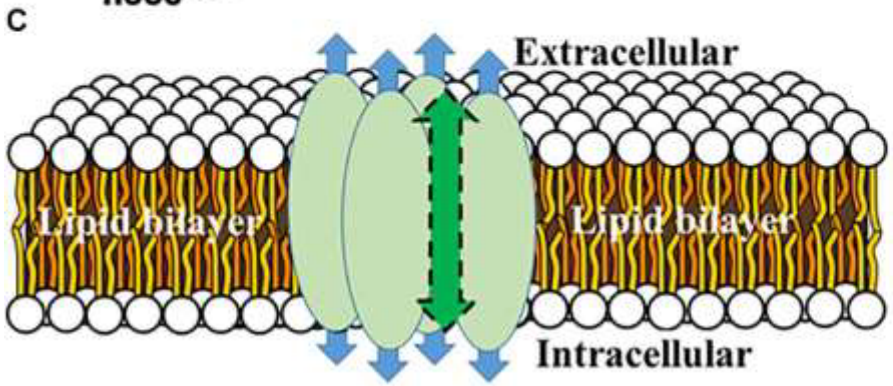
CREDIT: Ill. Niklas Elmehed © Nobel Prize Outreach

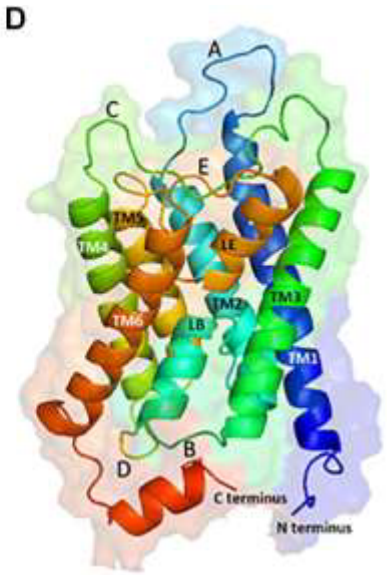


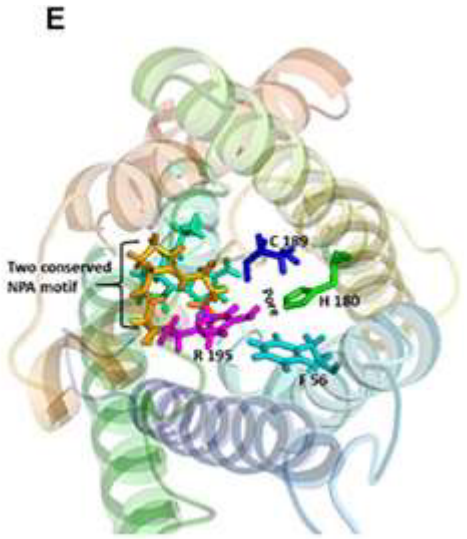
Structure of Aquaporin

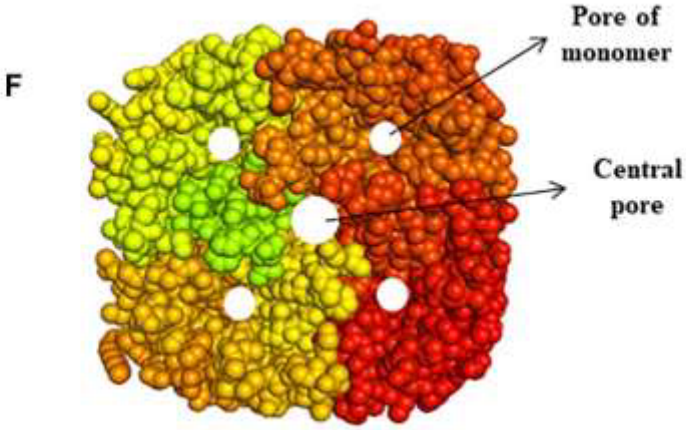


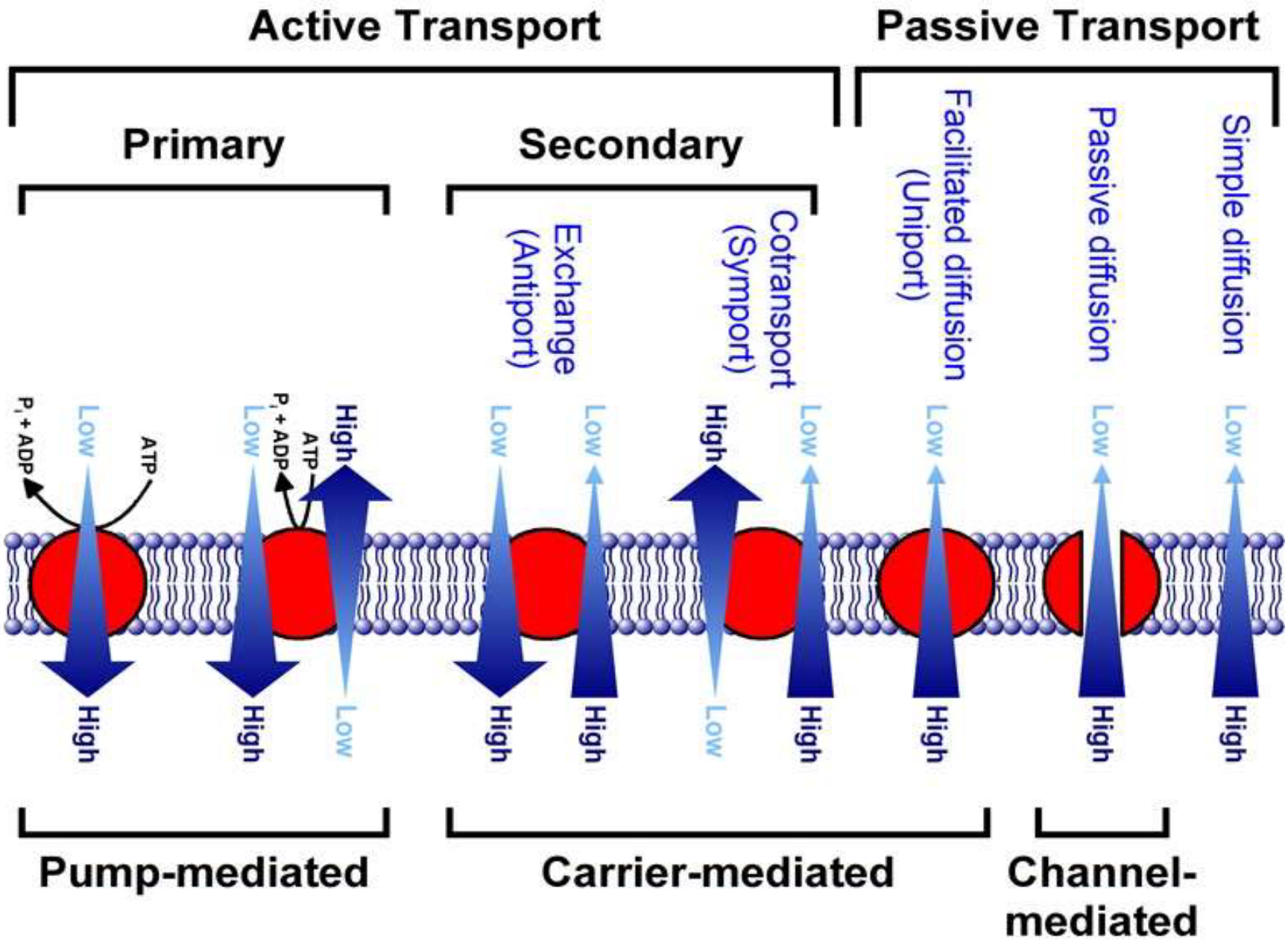












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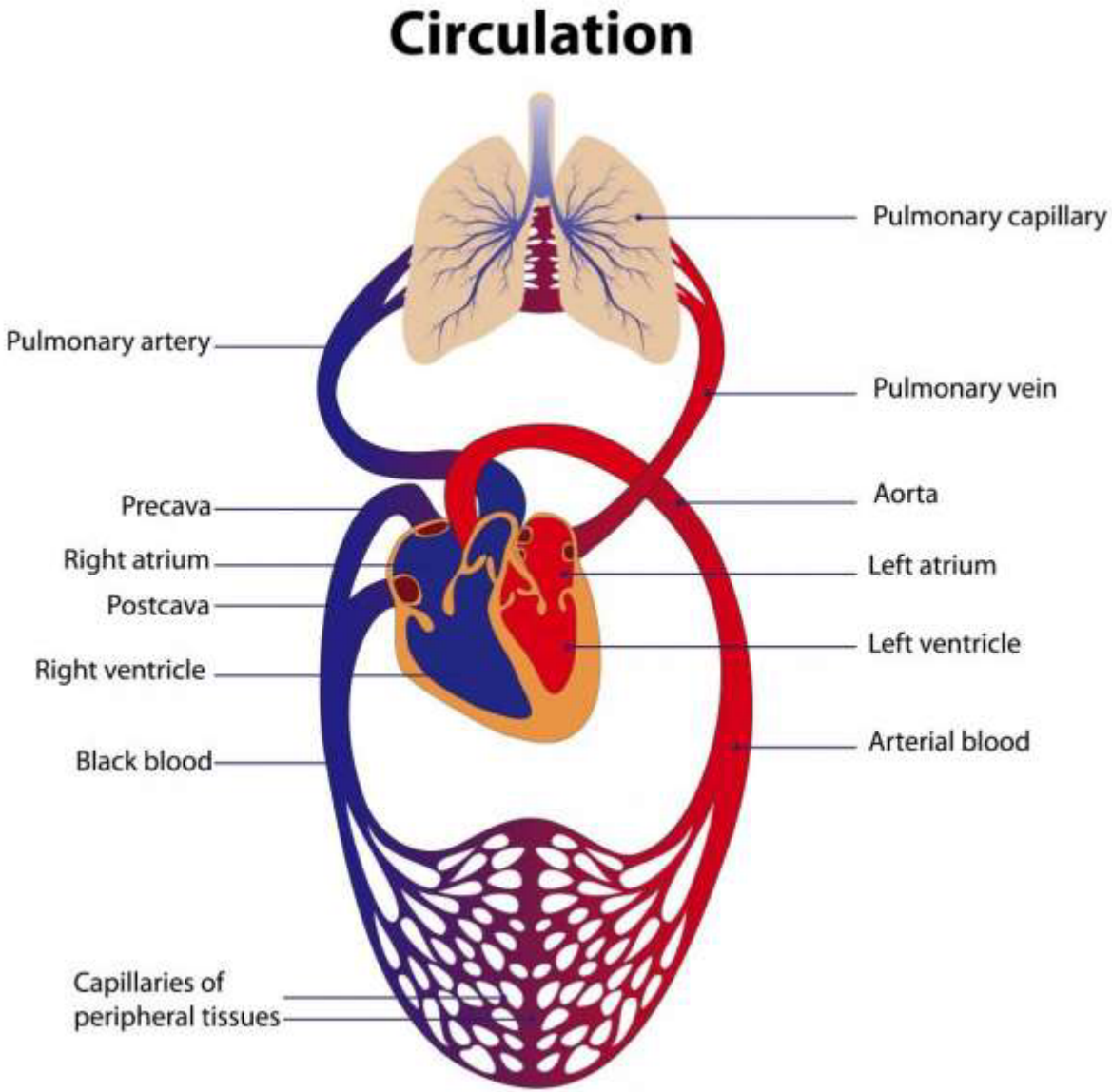
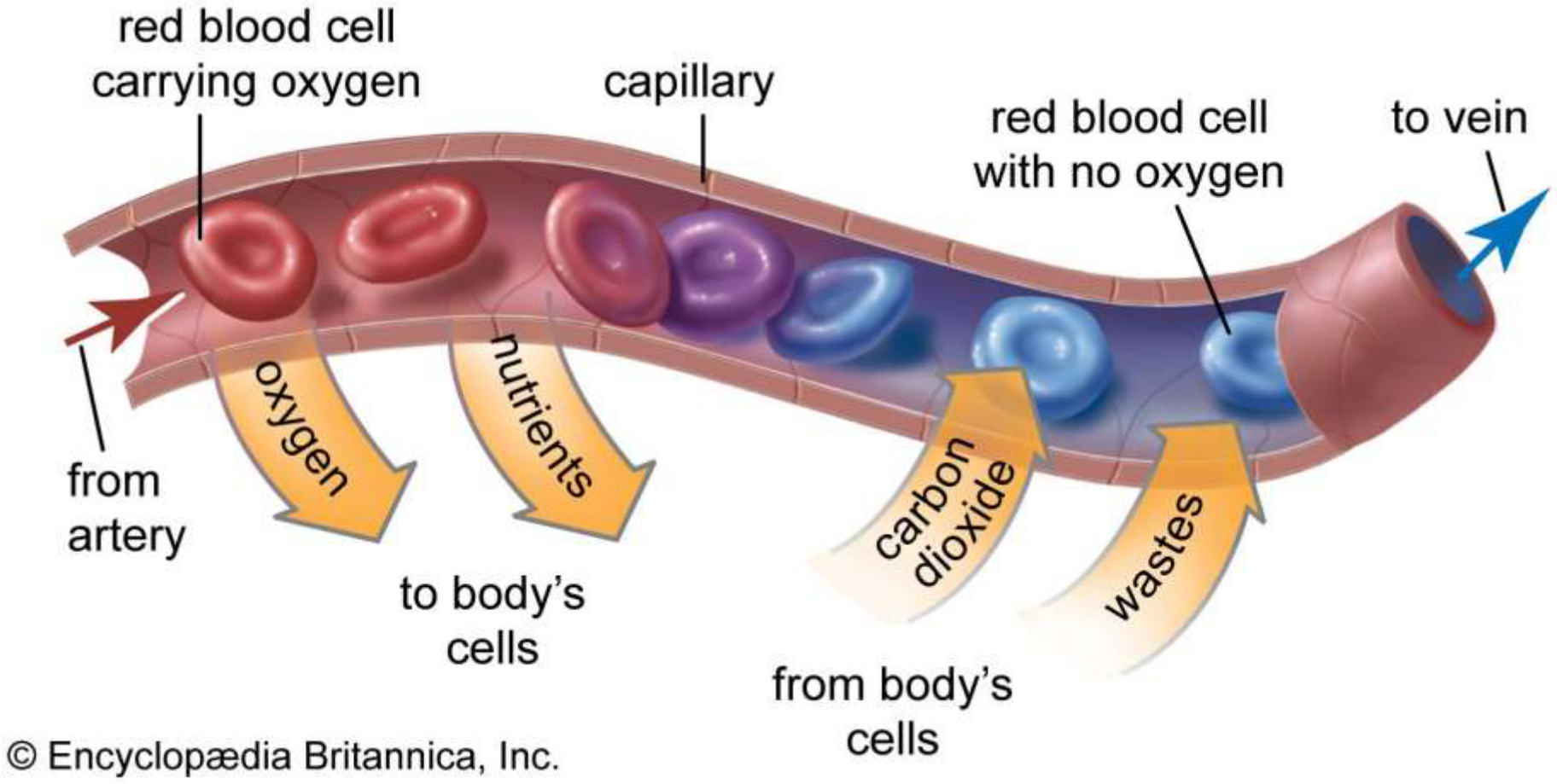
Fluid flow and mass transport (Nutrients and ions)



Exchange at cellular level



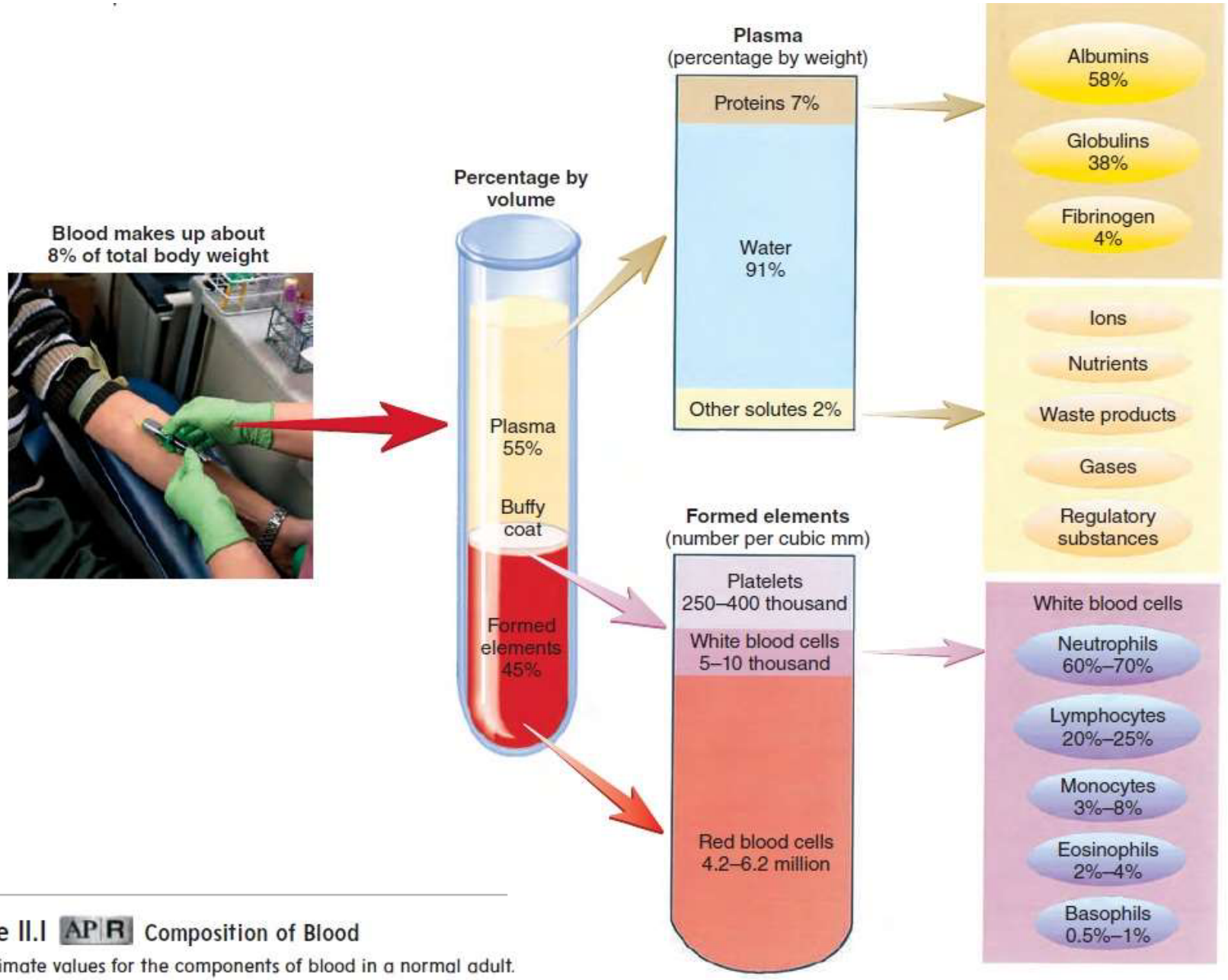
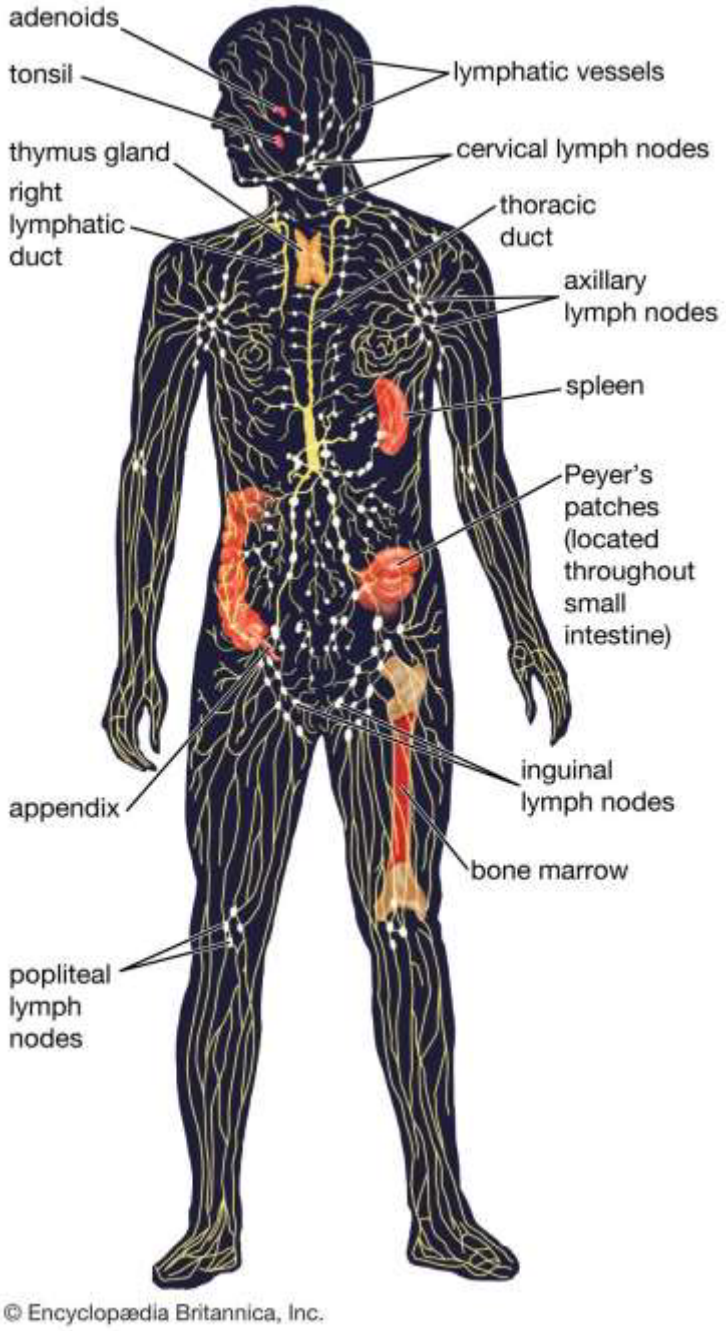


Figure II.1 AP R **Composition of Blood**

Approximate values for the components of blood in a normal adult.

Lymphatic system

- Maintains fluid level
- Absorbs dietary fat
- Protects body



In animals: blood and lymph

- More complex animals have either open or closed **circulatory systems**.
- Both systems have three basic components:
  - A **circulatory fluid** = blood or hemolymph.
  - A set of tubes = **blood vessels**.
  - A muscular **pump** = the **heart**.
- Humans and other vertebrates have a closed circulatory system, often called the **cardiovascular system.**
- The three main types of blood vessels are:

  arteries - away from the heart.

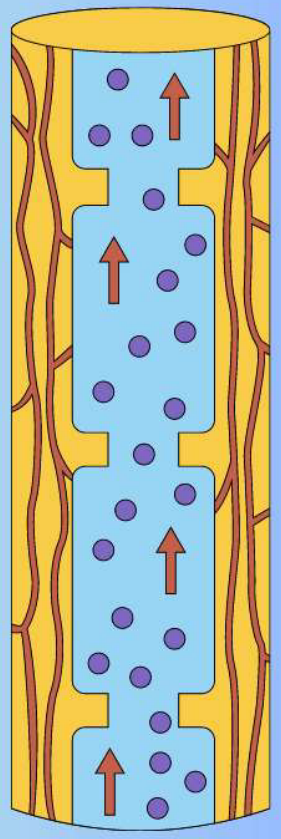
  veins - toward the heart.

  capillaries - exchange with body cells.

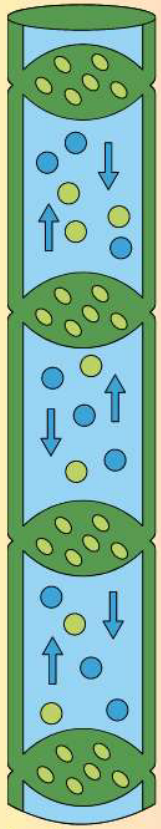
Xylem and Phloem

Plant Vascular System

- Transports water and minerals
- One-way (upward) flow
- Transport is bulk flow due to negative pressure
- Hollow dead cells
- No end walls
- Form center of the vascular bundle
- Rich in lignin, which supports the plant

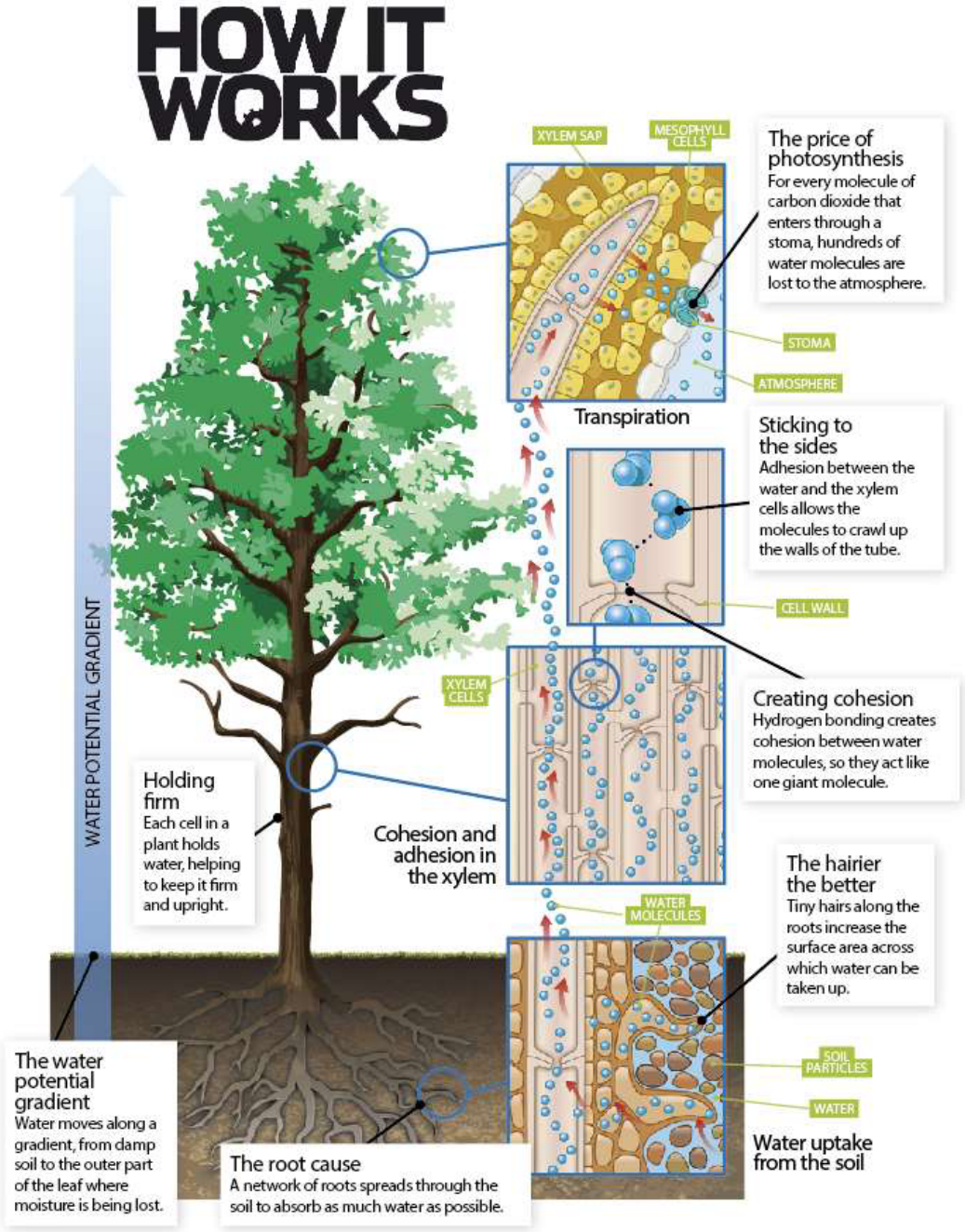


Xylem



Phloem

- Transports food in the form of sugars
- Two-way flow
- Transport is by osmosis/turgor pressure
- Live cells with no nucleus
- Perforated end walls
- Outside edge of vascular bundle
- Also transports amino acids, mRNA, and hormones



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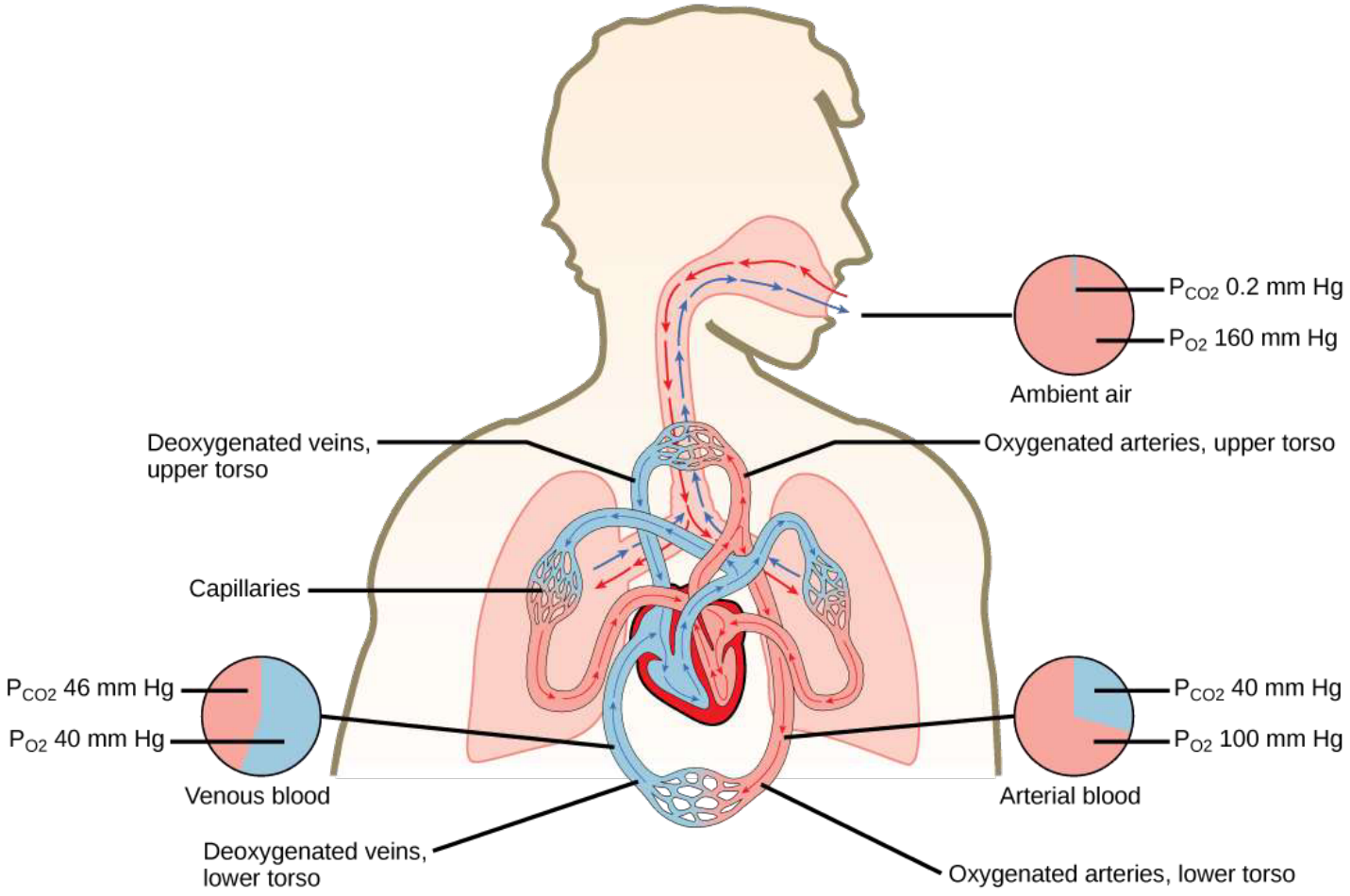
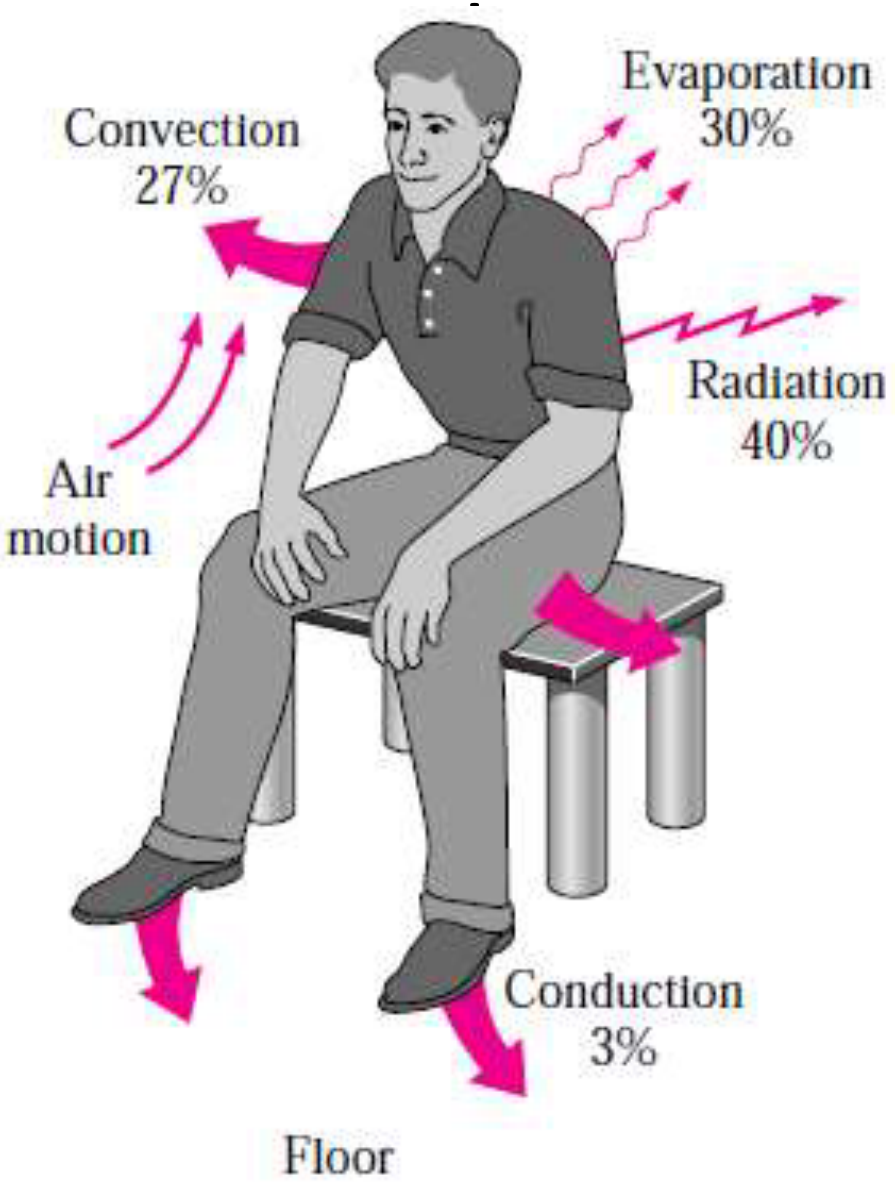
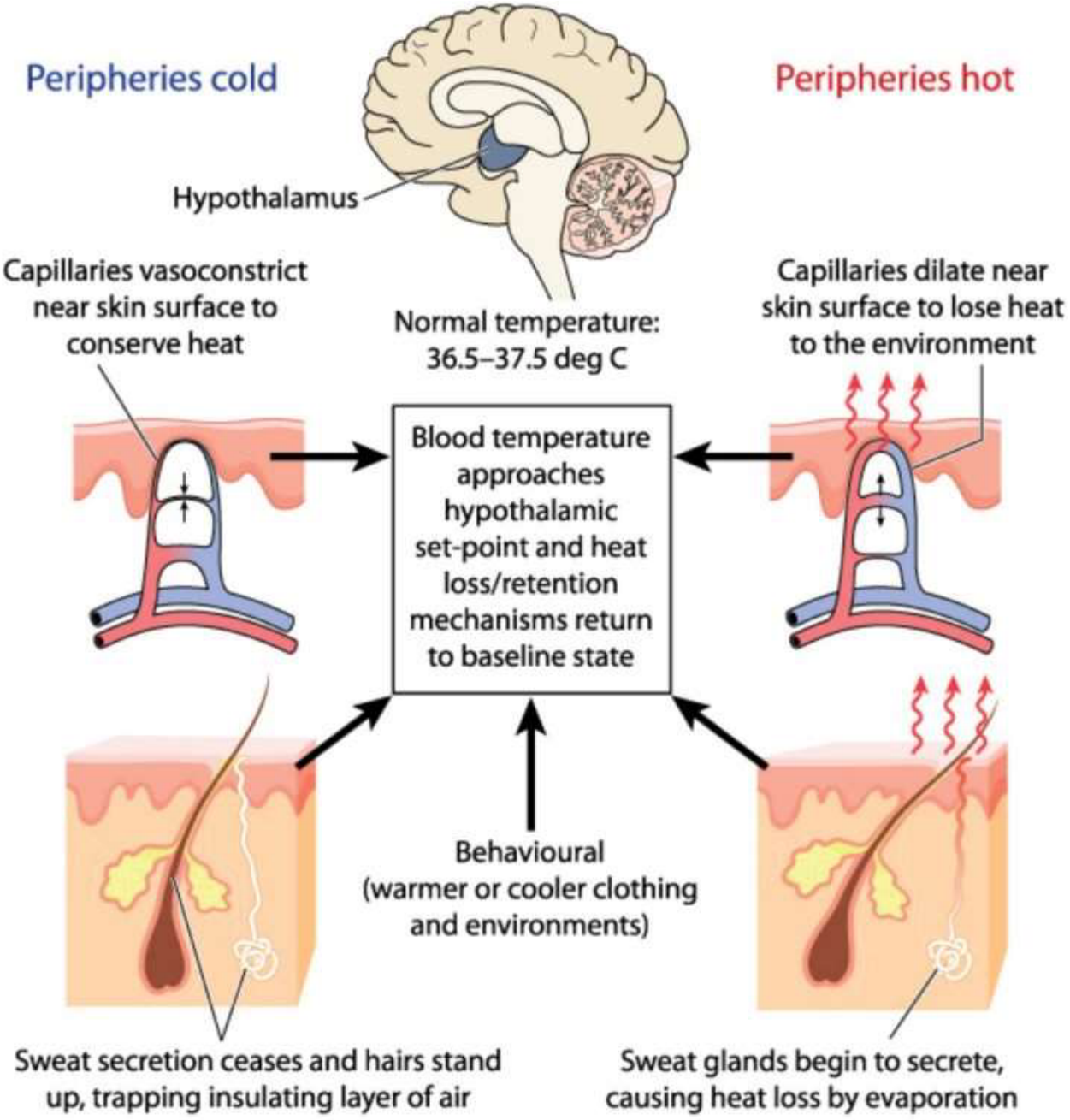
Transport of gases: oxygen and carbon dioxide

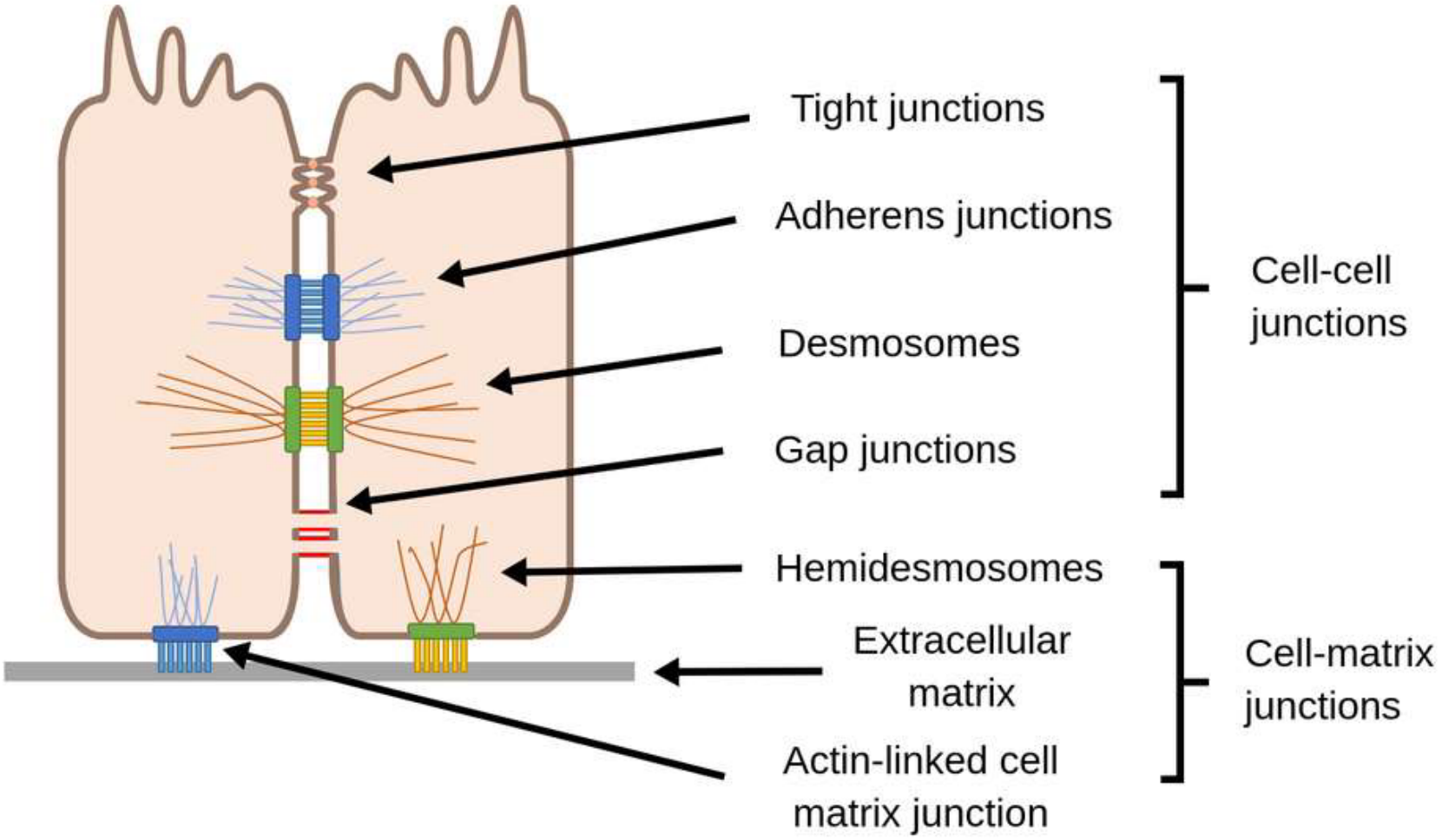


Heat transport: body temperature

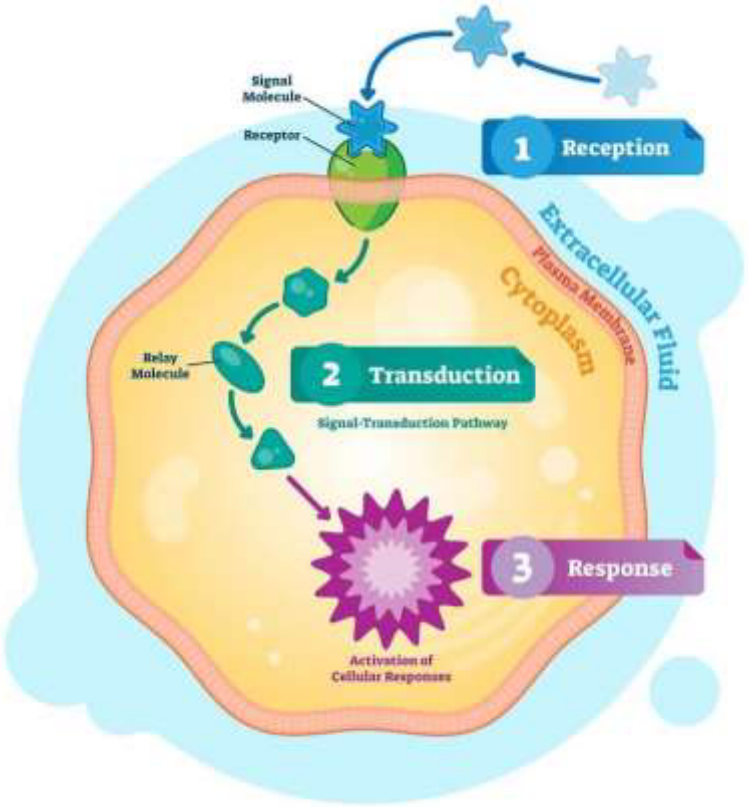



Peripheries cold
Peripheries hot
Hypothalamus
Normal temperature:
36.5–37.5 deg C
Capillaries vasoconstrict
near skin surface to
conserve heat
Capillaries dilate near
skin surface to lose heat
to the environment
Blood temperature
approaches
hypothalamic
set-point and heat
loss/retention
mechanisms return
to baseline state
Behavioural
(warmer or cooler clothing
and environments)
Sweat secretion ceases and hairs stand
up, trapping insulating layer of air
Sweat glands begin to secrete,
causing heat loss by evaporation

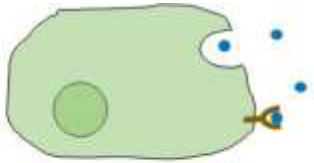
Communication: cell junctions and cell signaling



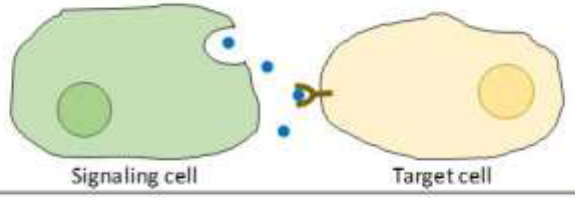
Cell Signaling



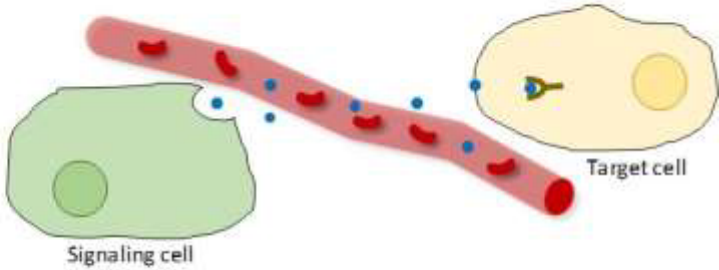
Autocrine signaling
a cell targets itself



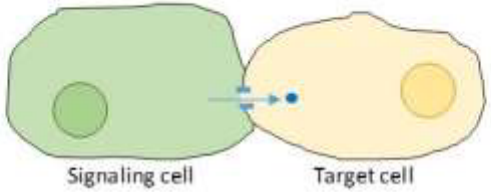
Paracrine signaling
a cell signals a nearby cell



Endocrine signaling
a cell targets a distant cell through the bloodstream



Direct signaling
a cell targets a neighboring cell through a gap junction

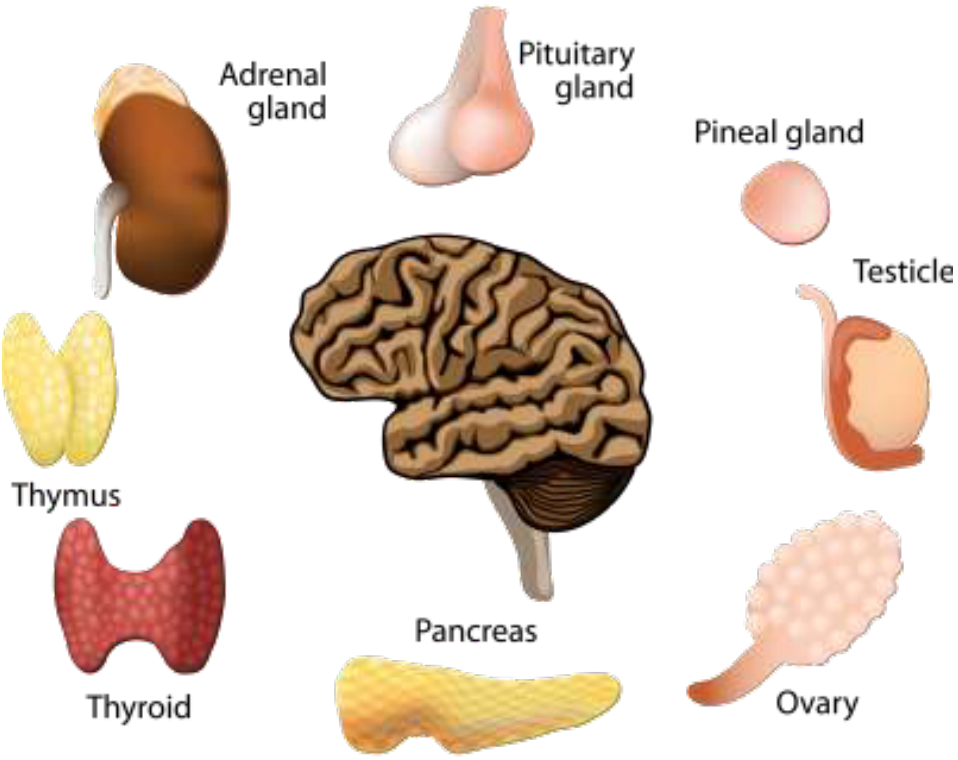


Hormones, pheromones and cell behavior

A Hormone is a chemical substance released by a cell or a gland which acts like a messenger molecule in our body. It helps to co-ordinate different processes and overall growth in many events of the organism.

Based on chemical structure the hormone can be-

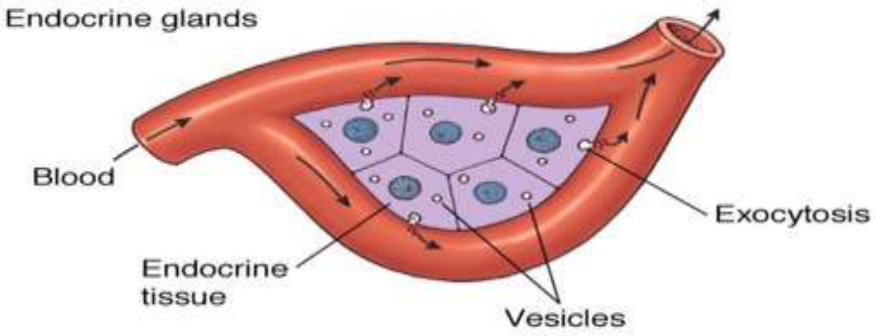
1. Amino acid derivative
2. Fatty acid derivative
3. peptide hormone
4. Steroid hormone

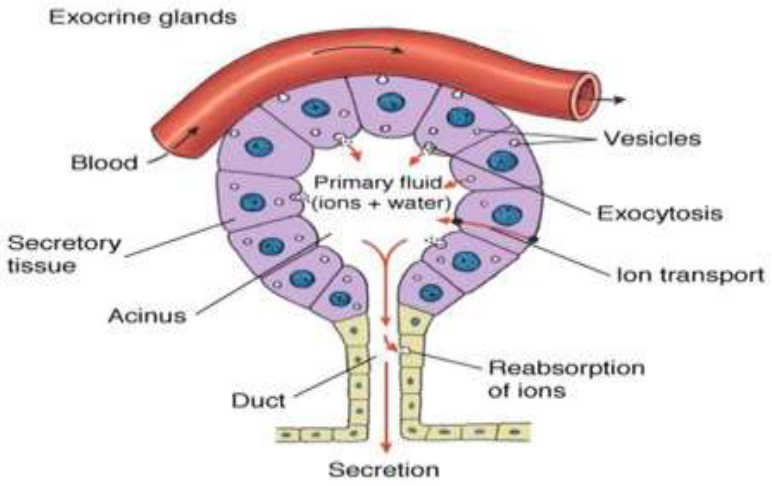


Endocrine and Exocrine glands

- Ductless
- Secretes hormones
- Remote effect
- Pituitary, thyroid, adrenal gland

- Glands withDuct
- Secretes hormones and enzymes
- Located near effecter organ
- Liver, sweat gland, pancreas, Gallbladder, lachrimal gland

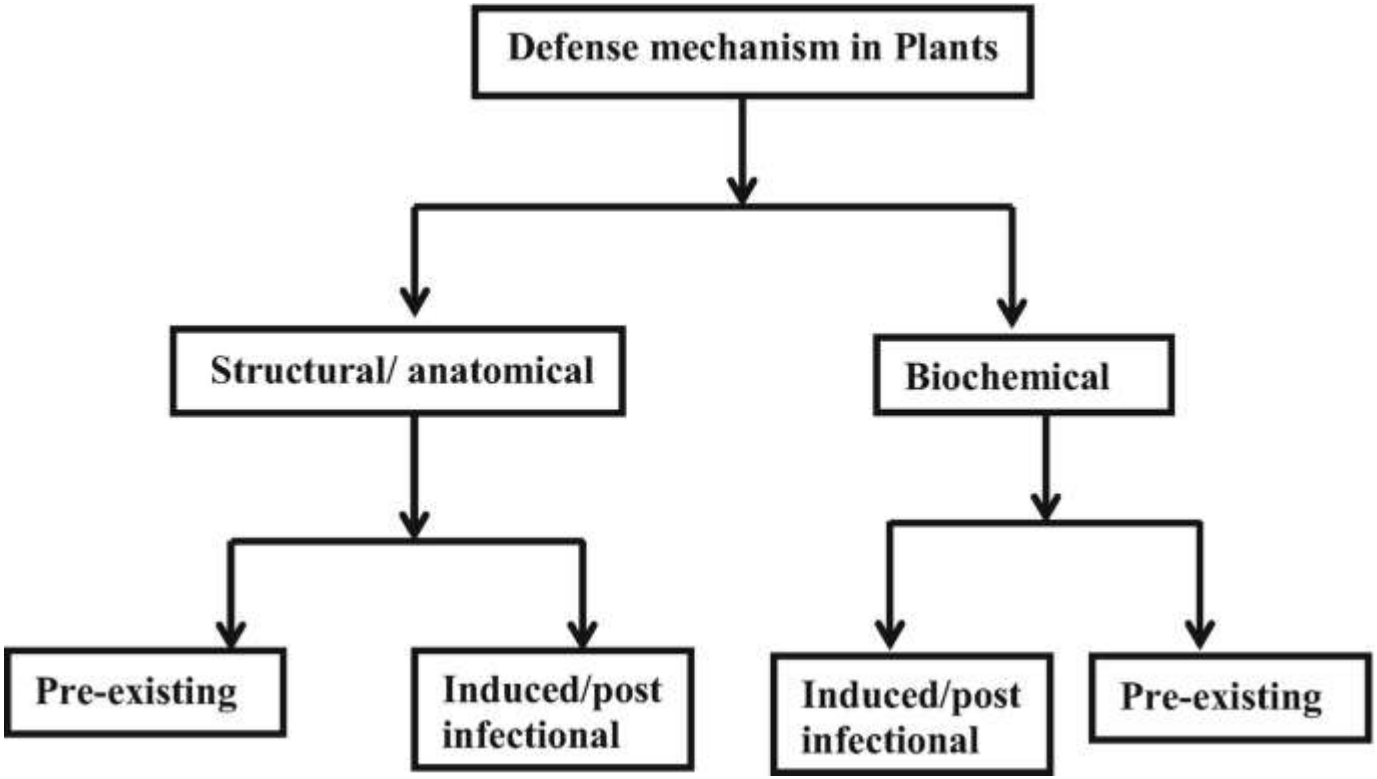


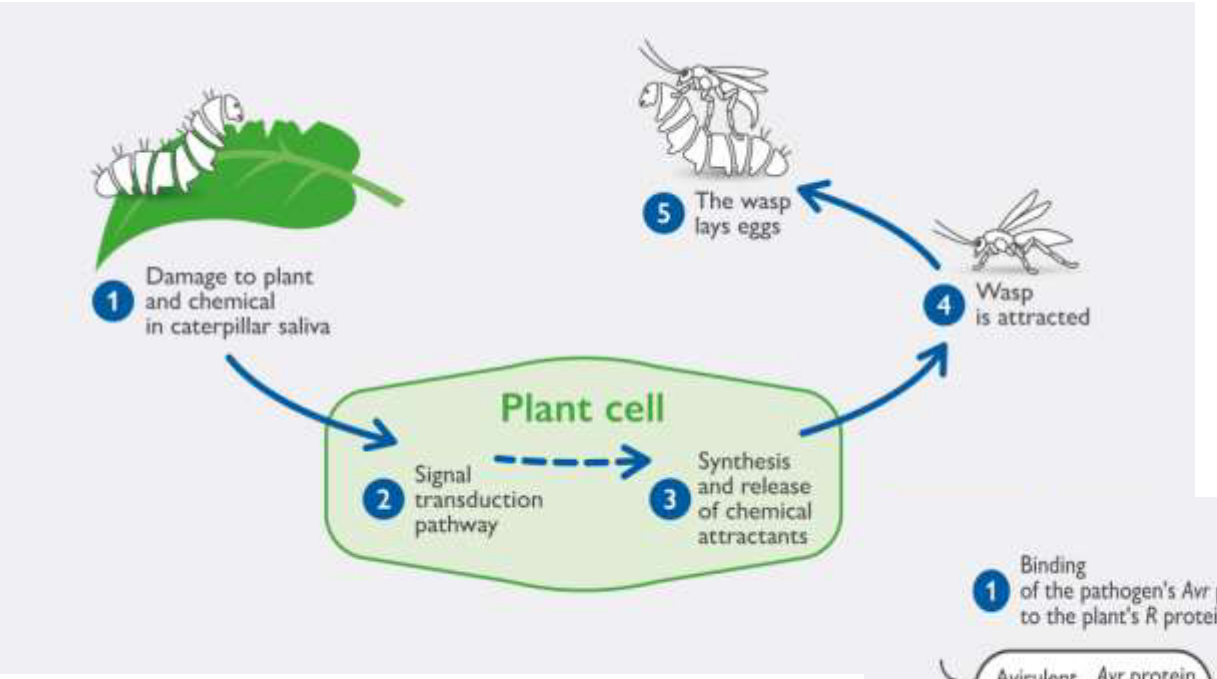


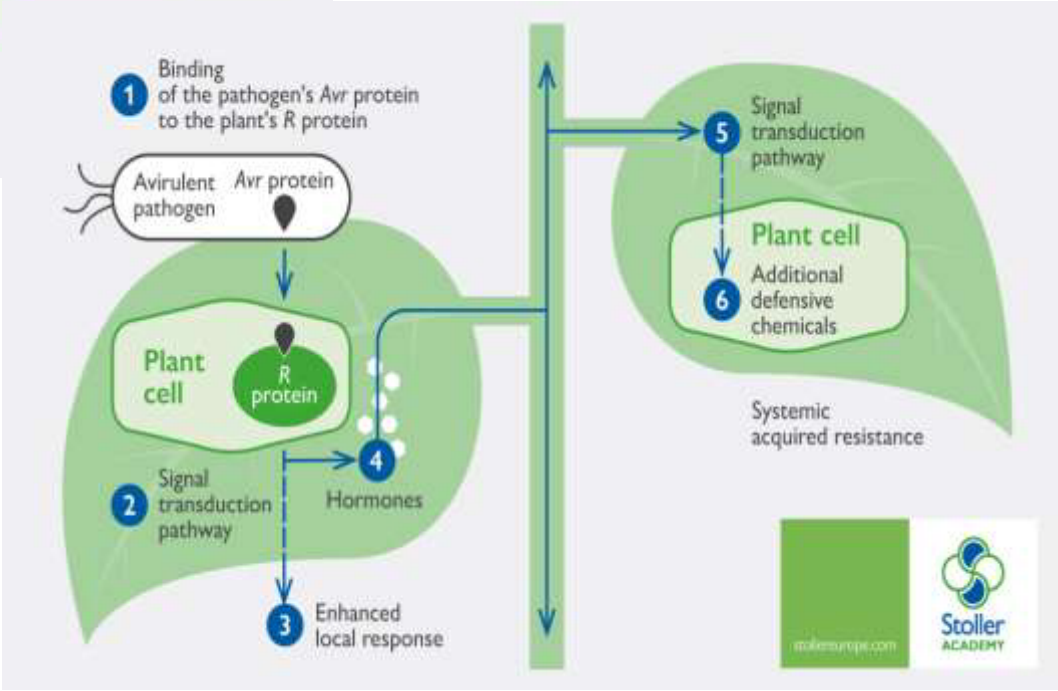
Pheromones and Behavioral Patterns

- Powerful chemical messages that triggers social response in members of same species mostly through olfactory senses and neuro-endocrine system.
- Functions is sexual partner selection, threat or predator detection, anxiety, aggression, defensive behavior, rearing and adoption or cannibalization in colony regulation etc.

Defense mechanisms: in plants: herbivory and secondary metabolites







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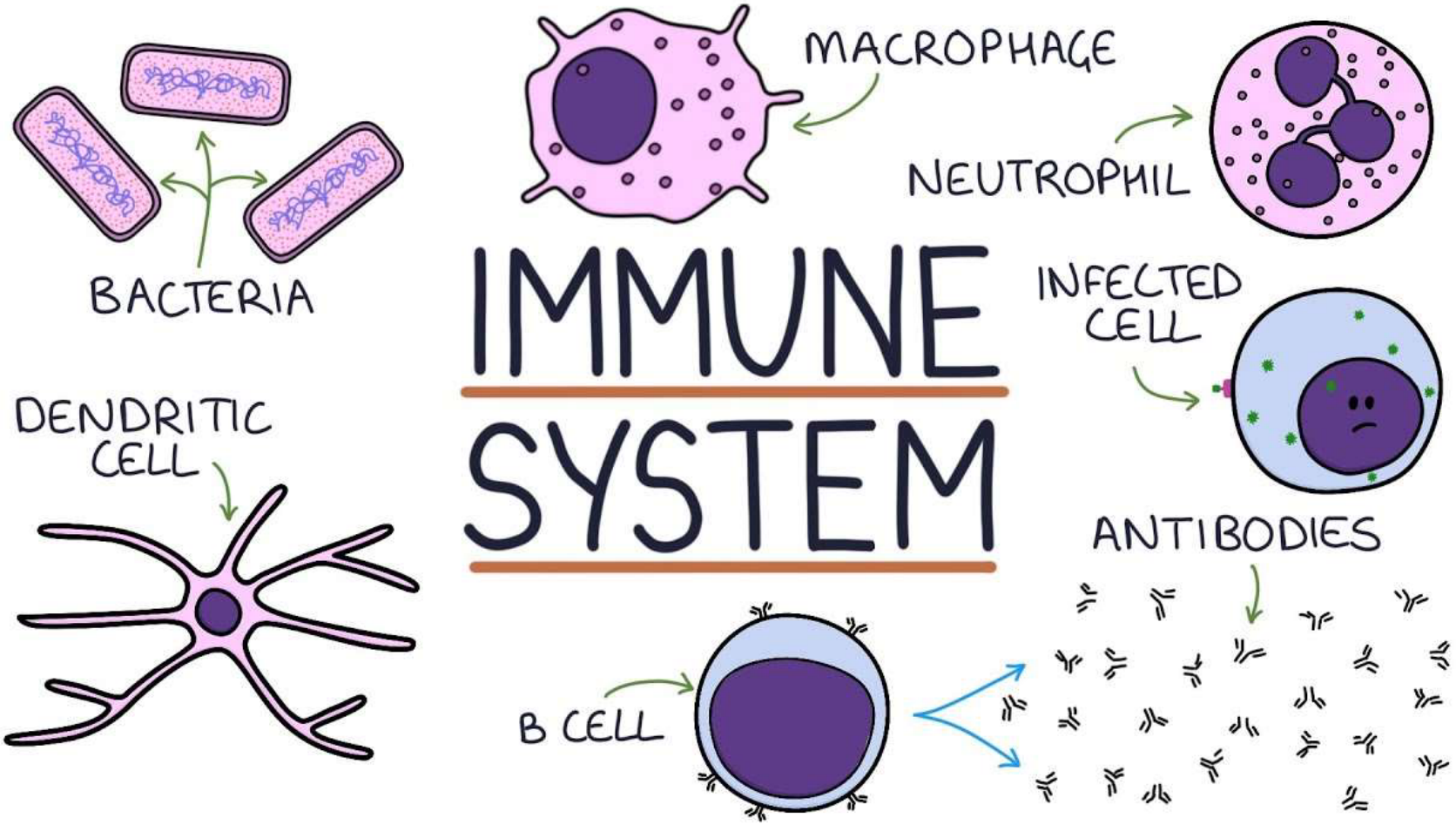
In animals: innate and adaptive immune system



Antigen

- Antigen is a substance which when introduced into the body, stimulates the defense system of the body reacts with it specifically in an observable manner
- Properties of antigens-

1. Heterogeneity and molecular weight
2. Foreignness
3. Immunogenicity
4. Immunological reactivity

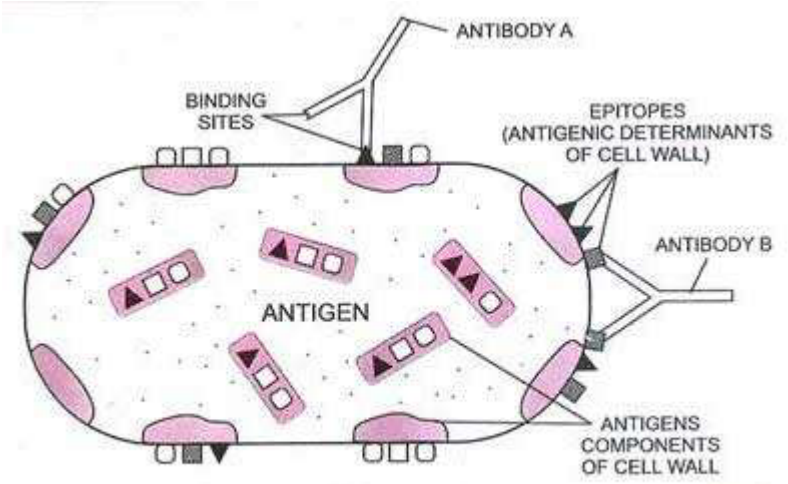
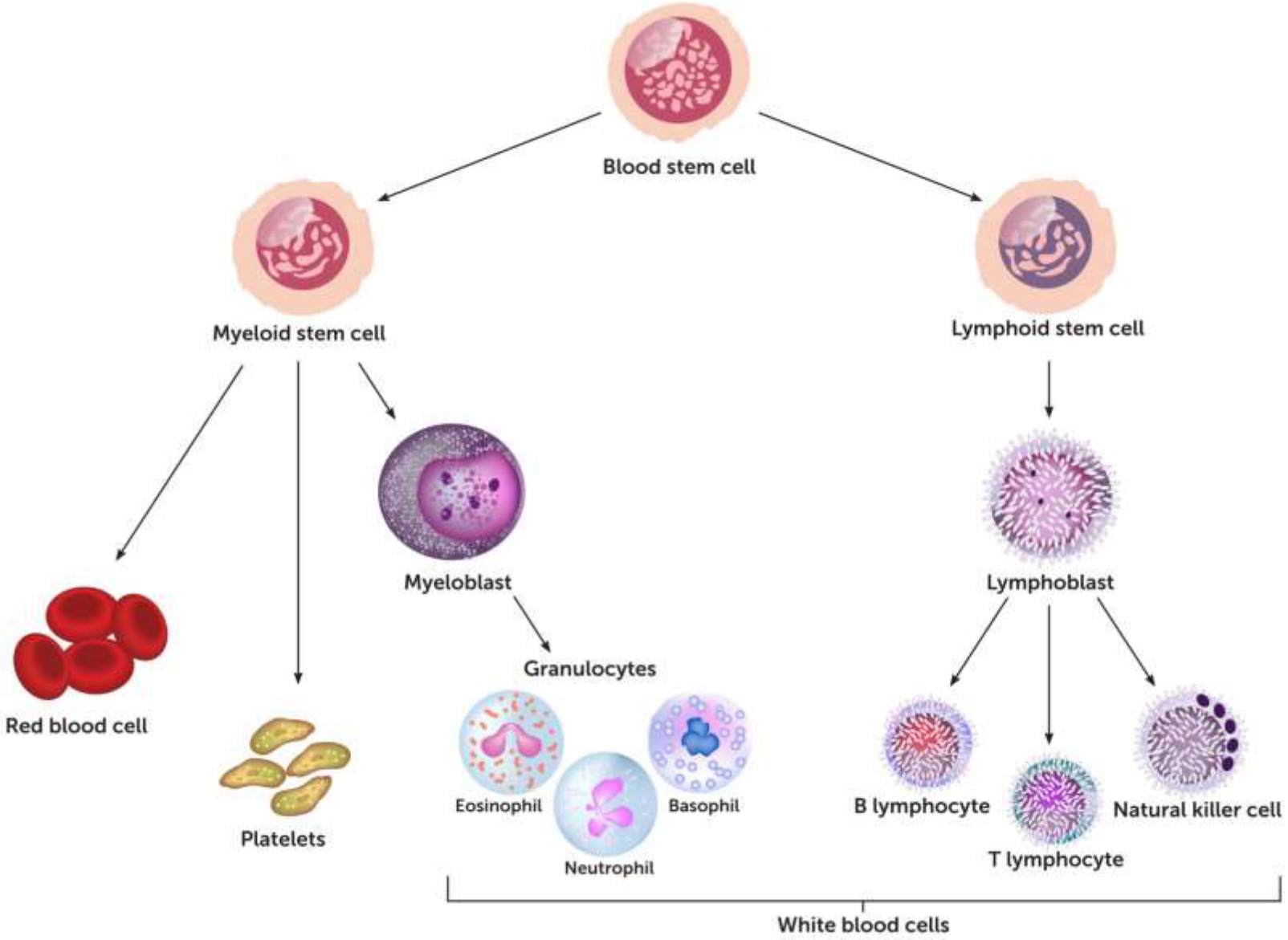
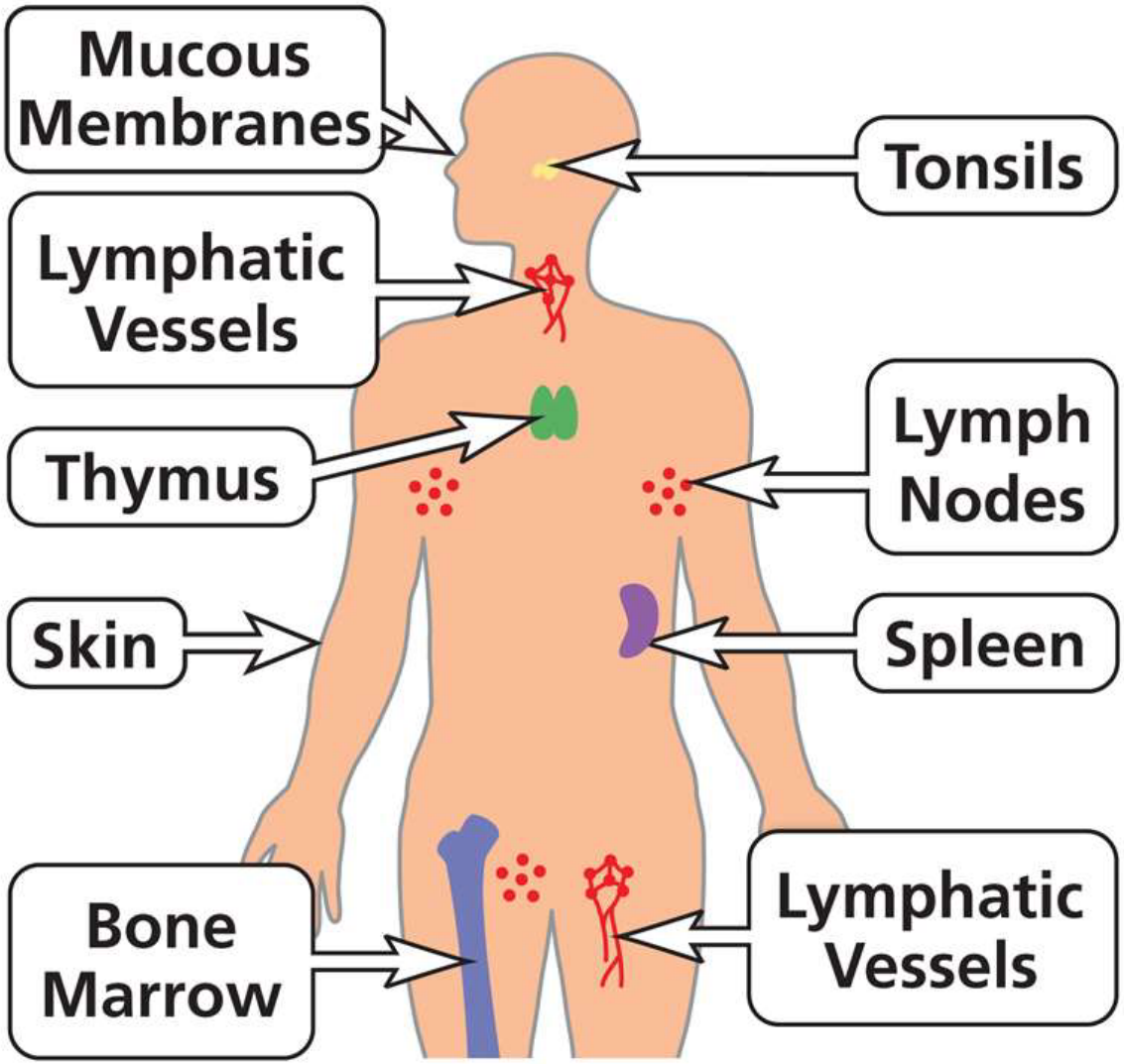


Diagram showing an antigen with epitopes (antigenic determinants). Two attached antibodies are also shown.\

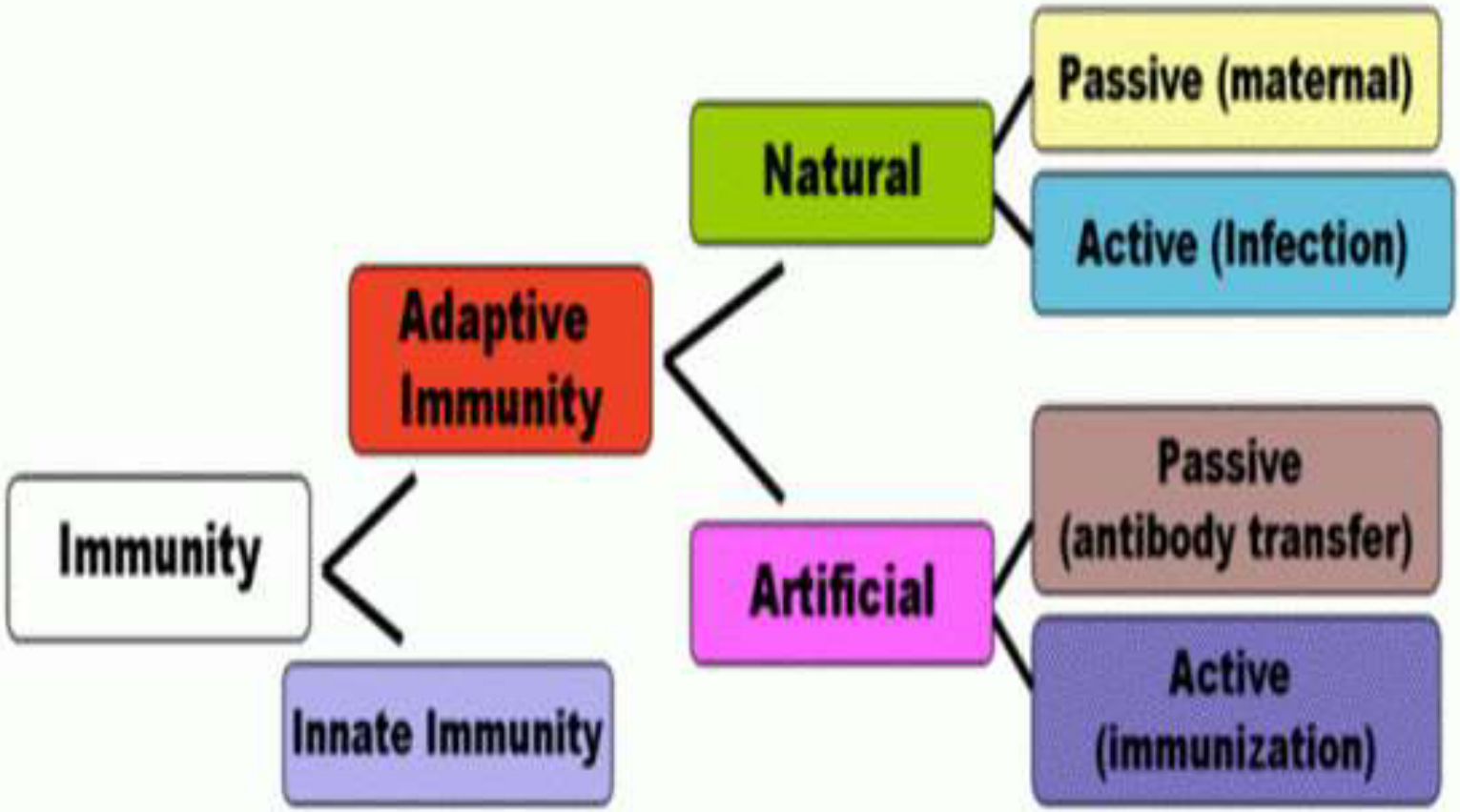
Cells of immune system



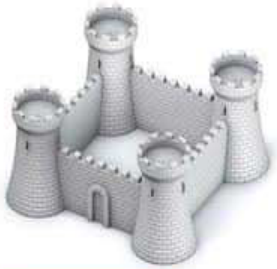
Organs of immune system



Types of immune system



First Line of Defence



Physical

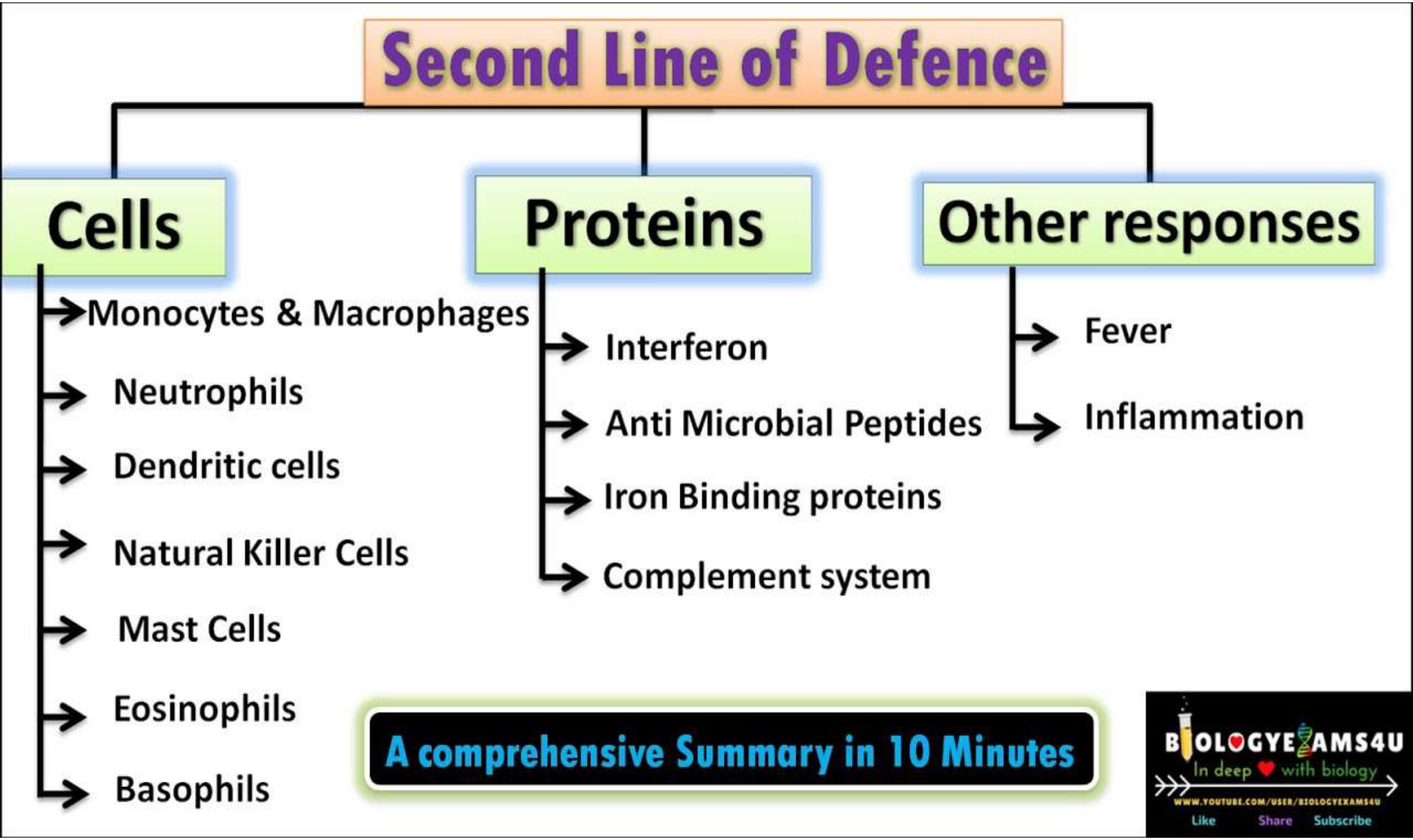
- Skin
- Nasal hair
- Eyelashes &eyelids
- Mucous membranes
- Mucociliary Clearance
- Urination

Chemical

- **Low pH**
  - Skin – pH 5.5
  - Gastric acid – pH 1-3
  - Vagina – pH 4.4
- **Antimicrobial molecules**
  - IgA, Sebum
  - Mucous
  - Lysozyme, lactoperoxidase
  - Beta defensins
  - Pepsin

Biological

- Microbiome



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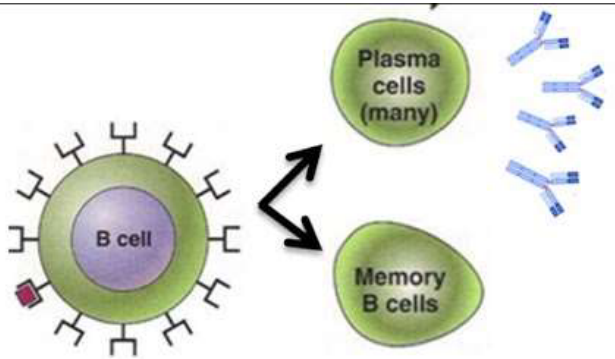
THIRD LINE OF DEFENSE

B lymphocytes



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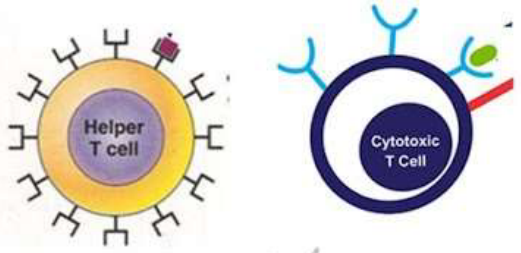
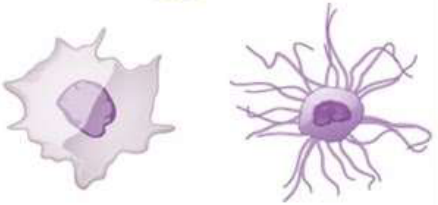
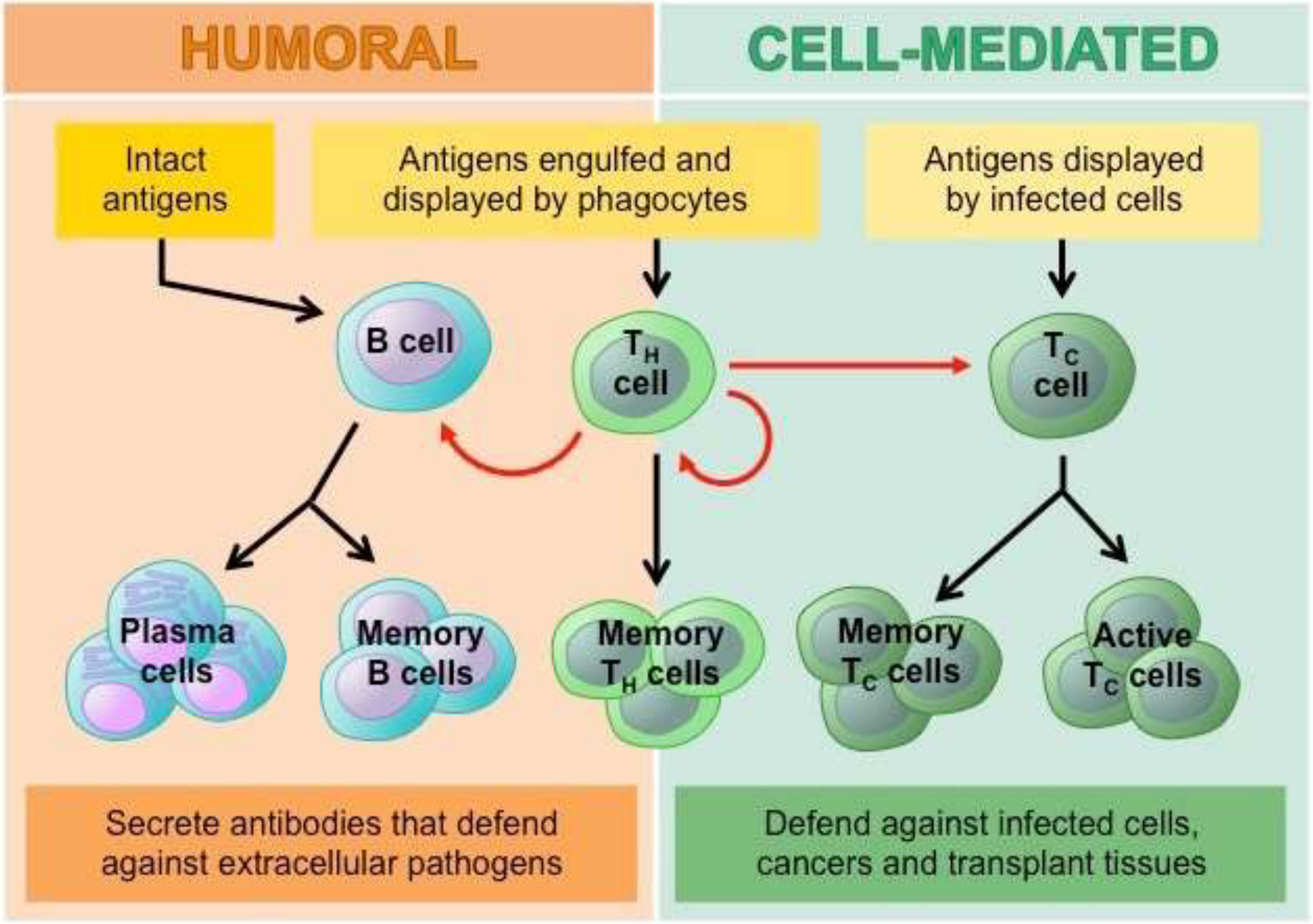


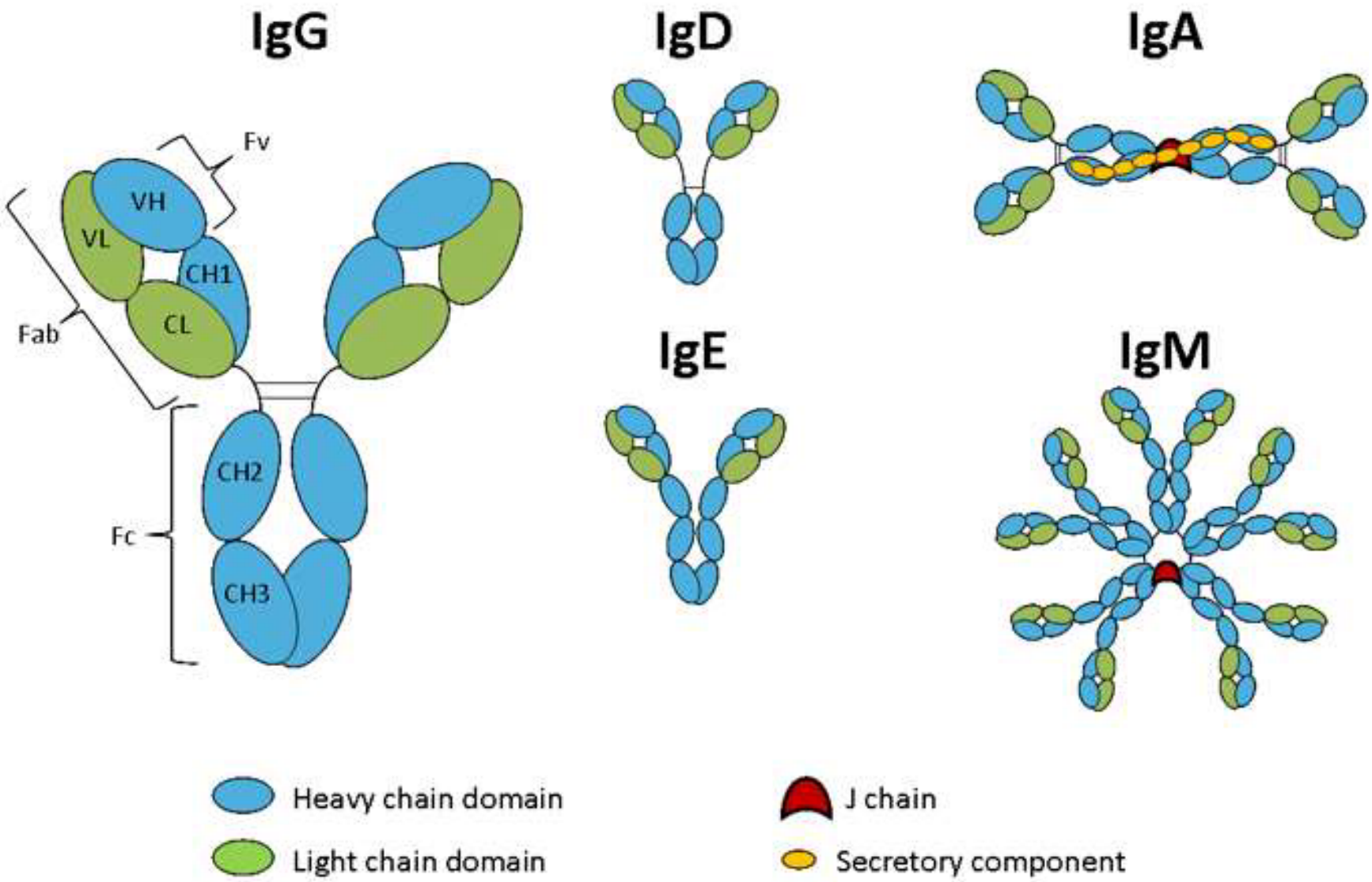
Antigen Presenting Cells



A simplified Summary



END OF LECTURE


IgG
Fv
VH
VL
CH1
CL
Fab
CH2
Fc
CH3
IgD
IgA
IgE
IgM
Heavy chain domain
Light chain domain
J chain
Secretory component

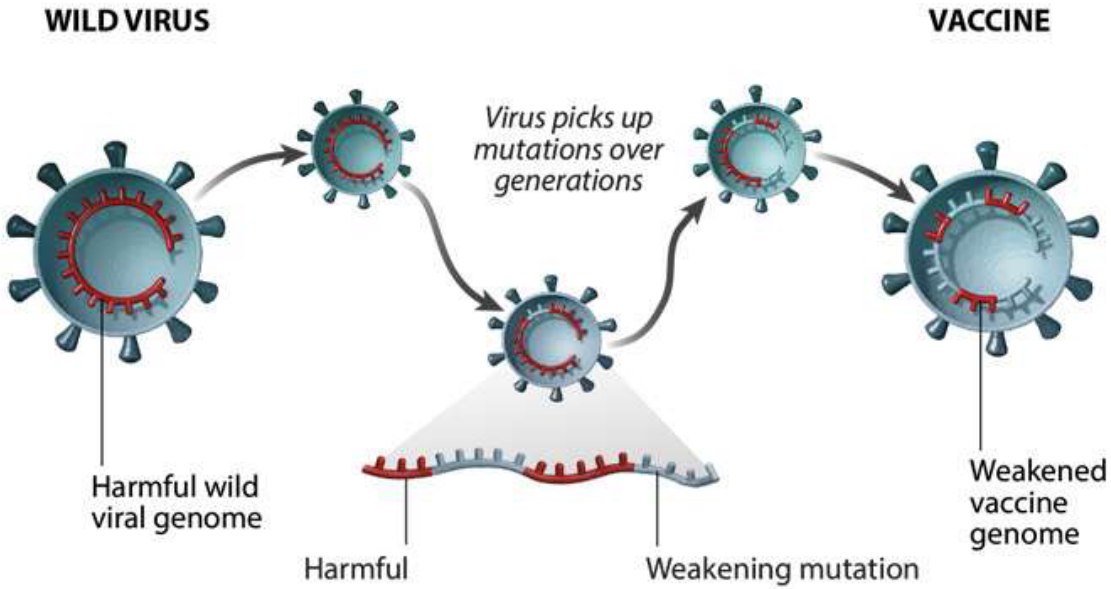
Types of antibodies 0

Name	Properties
IgA	Found in mucous, saliva, tears, and breast milk. Protects against pathogens.
IgD	Part of the B cell receptor. Activates basophils and mast cells.
IgE	Protects against parasitic worms. Responsible for allergic reactions.
IgG	Secreted by plasma cells in the blood. Able to cross the placenta into the fetus.
IgM	May be attached to the surface of a B cell or secreted into the blood. Responsible for early stages of immunity.

Vaccines- are biological preparations that improves the immunity against the particular disease

What are Live, Attenuated Vaccines?

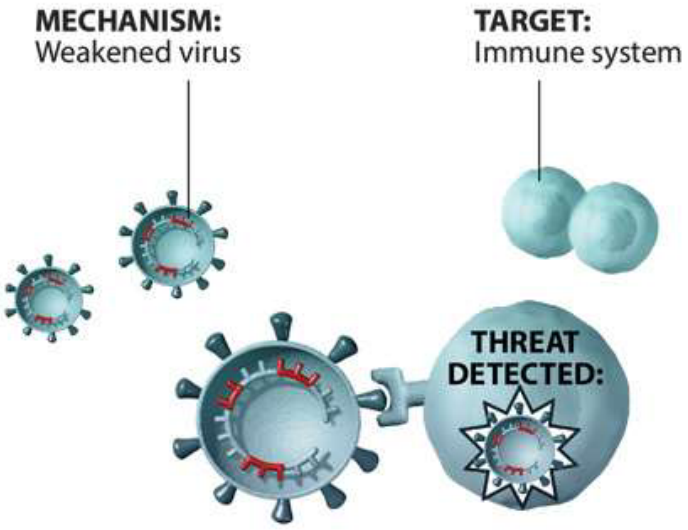
Live vaccines are "wild" viruses or bacteria that have been weakened.* In the lab, generally the virus is passed through many generations of cells to pick up genetic mutations which weaken it - so much it won't cause disease in your body.



*Did You Know?: "Attenuated" means weakened.

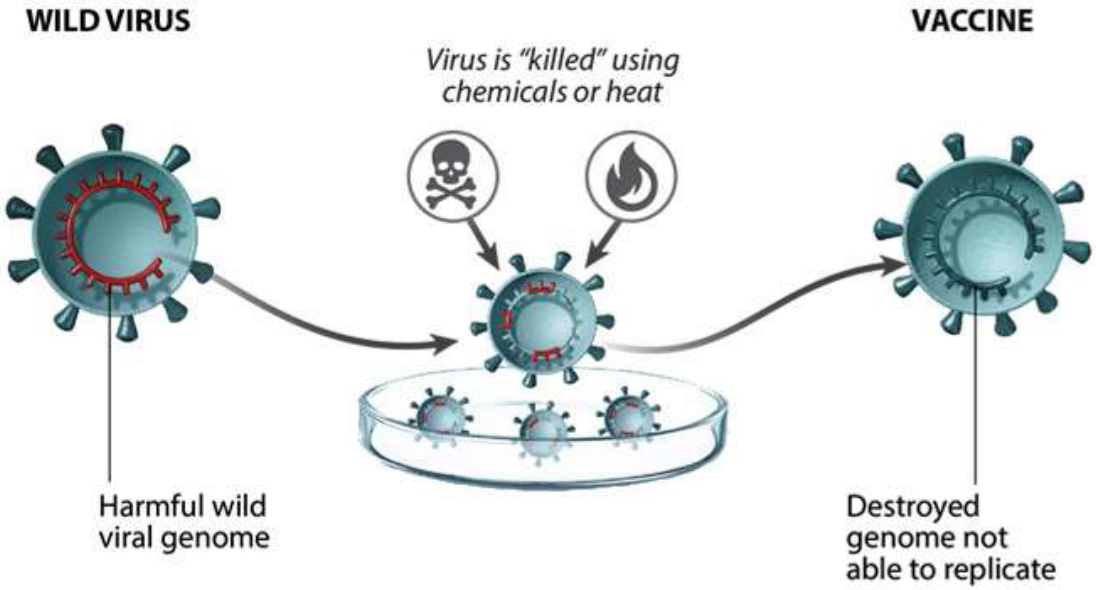
Vaccine Target

Live, attenuated vaccines target your body's immune system directly. They are strong enough to trigger the immune response, but too weak to cause disease.



What are Inactivated Vaccines?

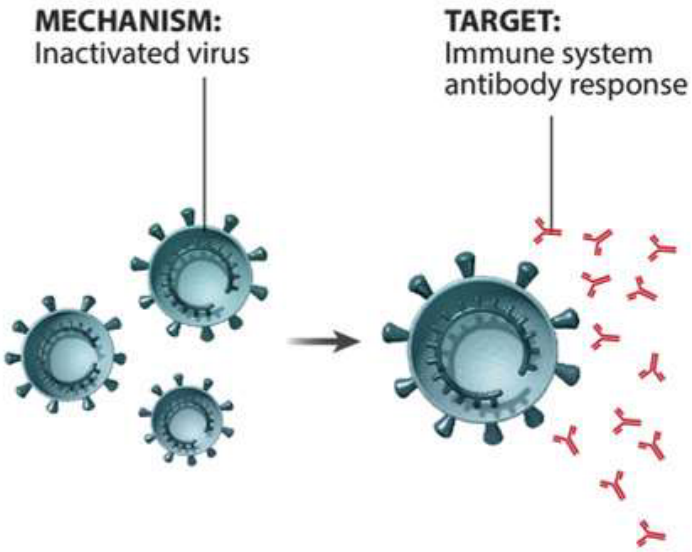
Live vaccines are "wild" viruses or bacteria that have been inactivated.* In the lab, a wild virus is "killed" with heat or chemicals so it cannot replicate or cause disease in your body, and is safe for immunodeficient people.



*Did You Know?: "Inactivated" means the virus cannot replicate or cause harm.

Vaccine Target

Inactivated vaccines target your body's antibody production. This is weaker than natural infection or live vaccines, so inactivated vaccines often require multiple doses.

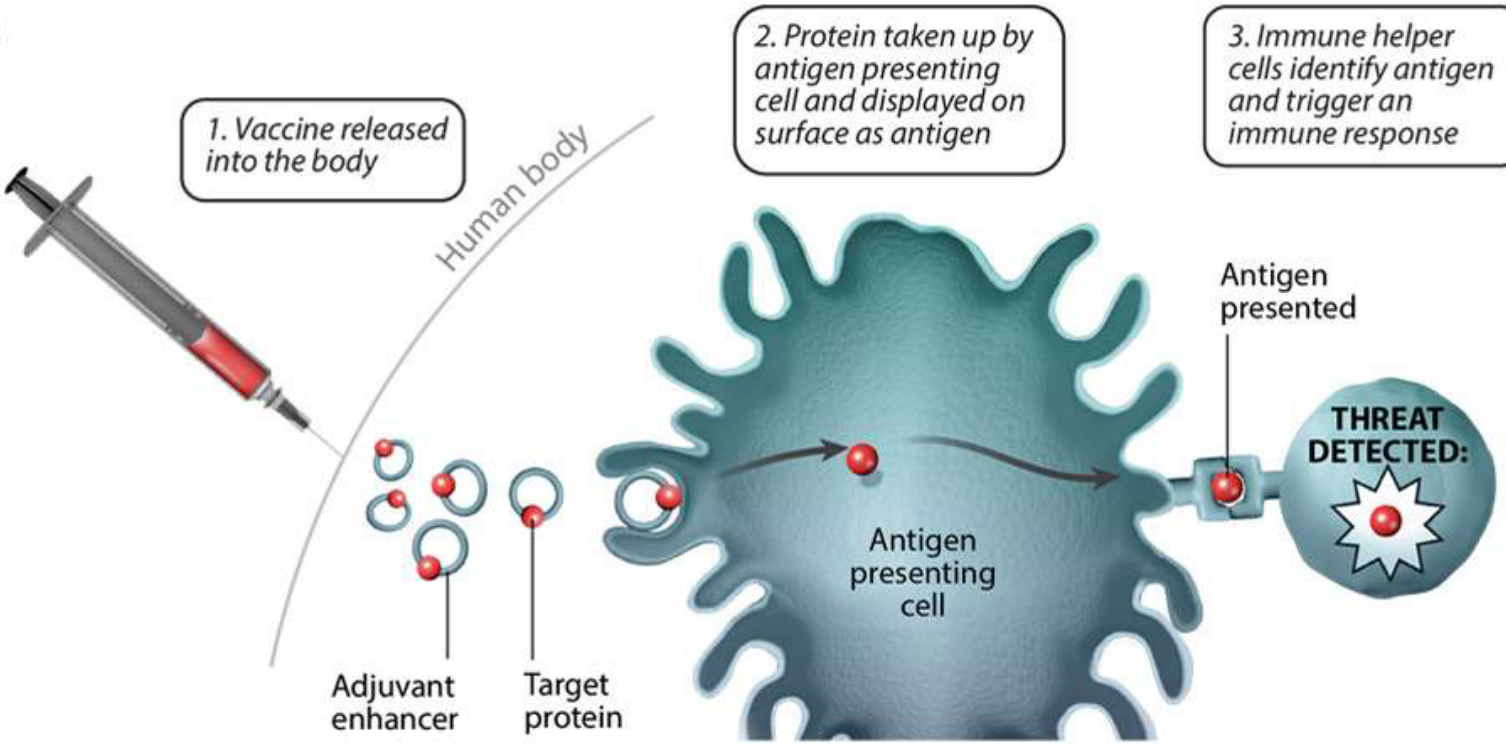


What are Subunit (recombinant, polysaccharide, and conjugate) vaccines?

Subunit vaccines use a portion of a bacteria or virus to cause an immune response independent of its virus or bacteria of origin. Elements of subunit vaccines can be proteins, polysaccharide chains, or a combination of these.

PROTEIN VACCINES

Viral proteins are isolated in a lab, mixed with an adjuvant immune-system stimulator, and injected into the body to cause an immune response without the virus that makes you sick.

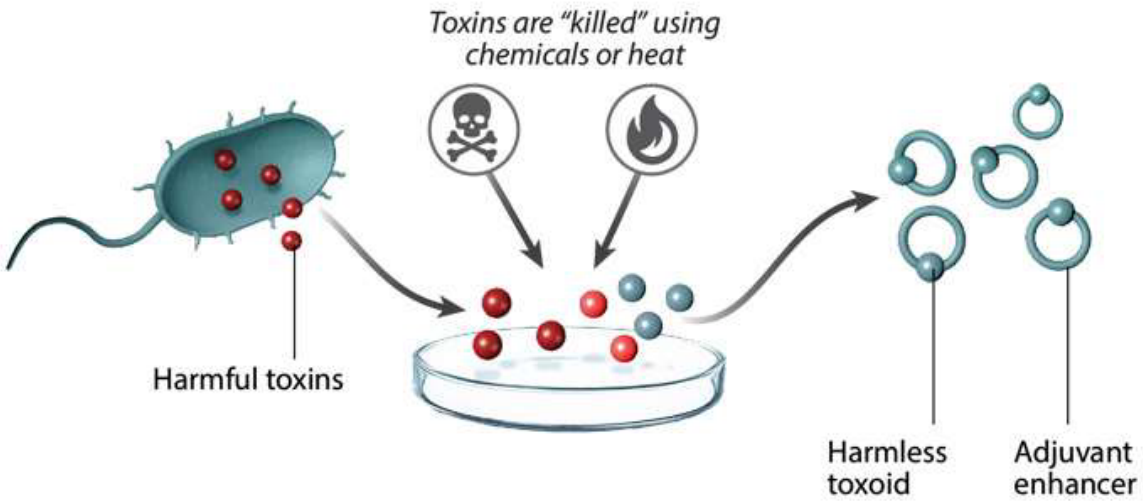


What are Toxoid Vaccines?

Toxoid* vaccines neutralize the toxic activity created by bacteria, instead of the harmful bacteria itself, neutralizing activity which normally makes you sick.

WILD BACTERIA PRODUCING TOXINS

VACCINE



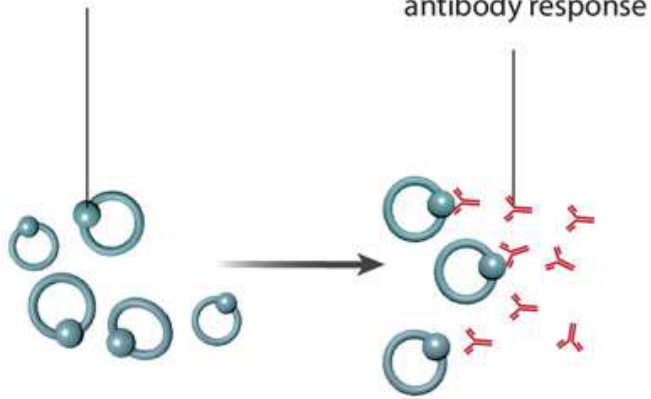
*Did You Know?: A toxoid is an inactivated, harmless form of a toxin.

Vaccine Target

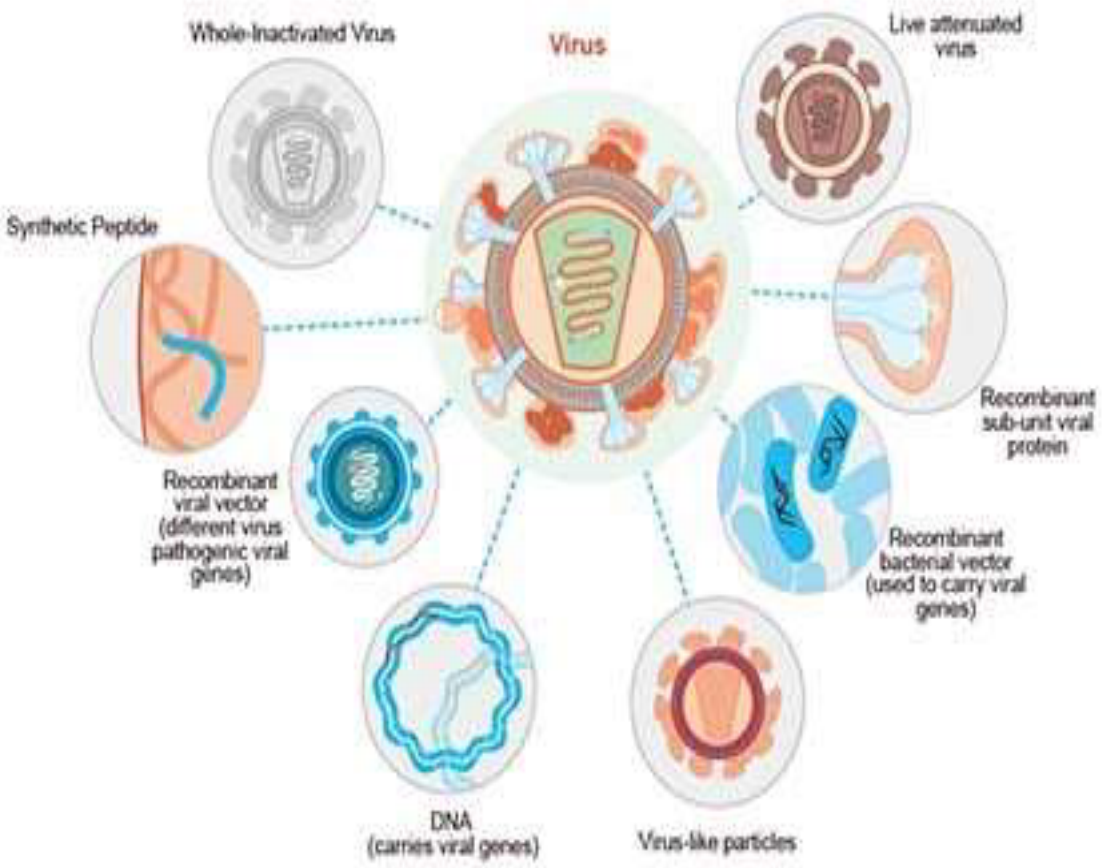
The vaccine targets toxic activity, creating an antibody response to that toxin.

MECHANISM:
Inactivated toxins

TARGET:
Immune system antibody response



Types of Vaccines



Live attenuated (LAV)

- Tuberculosis (BCG)
- Oral polio vaccine (OPV)
- Measles
- Rotavirus
- Yellow fever

Inactivated (killed antigen)

- Whole-cell pertussis (wP)
- Inactivated polio virus (IPV)

Subunit (purified antigen)

- Acellular pertussis (aP).
- *Haemophilius influenzae* type B (Hib).
- Pneumococcal (PCV-7, PCV-10, PCV-13)
- Hepatitis B (HepB)

Toxoid (inactivated toxins)

- Tetanus toxoid (TT).
- Diphteria toxoid

END OF LECTURE