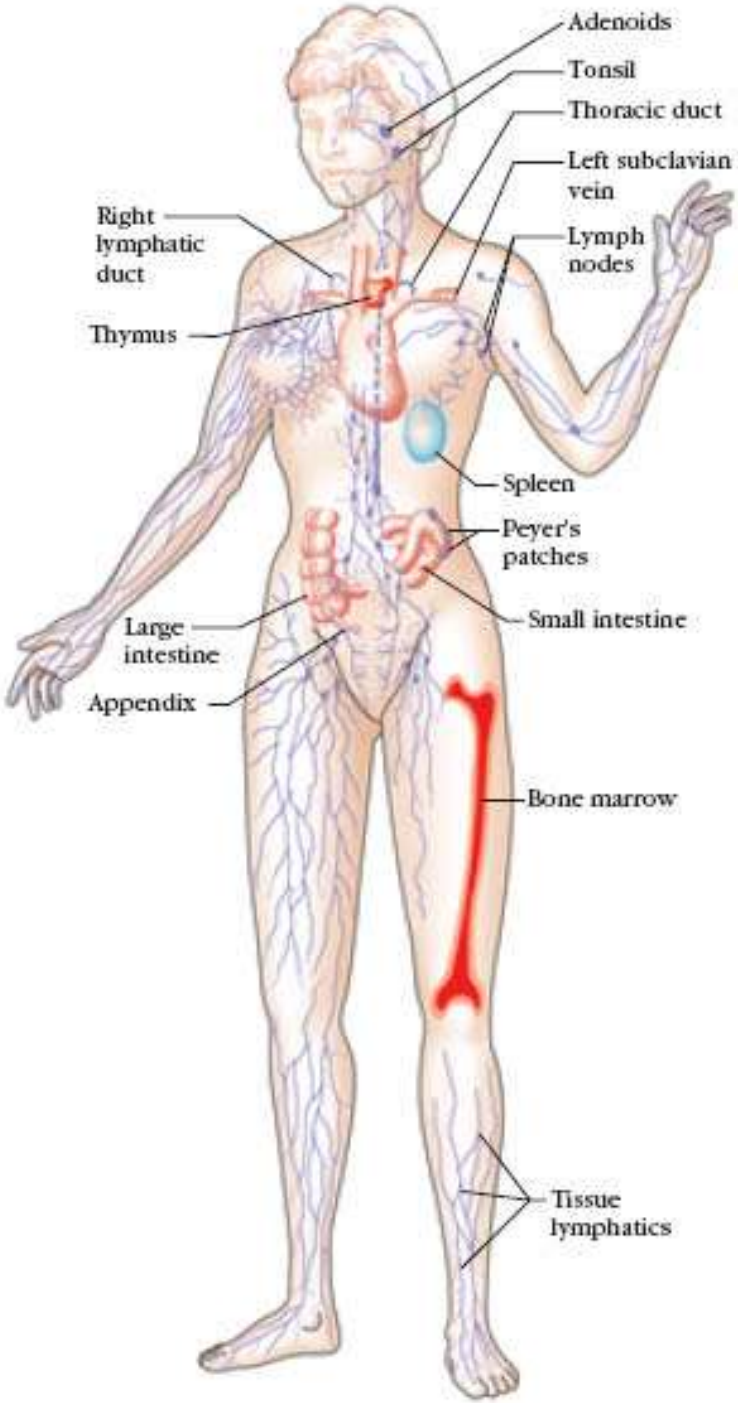
GENERAL ANATOMY OF THE IMMUNE SYSTEM

THE IMMUNE SYSTEM - A SYSTEM WHICH CONTROLS PRESERVE GENETIC INTEGRITY OF THE ORGANISM.

BODILY FUNCTIONS PROTECTION OF ANTIGENS CALLED IMMUNITY (FROM THE LATIN WORD IMMUNITAS - EXEMPTION ANYTHING) TO ENSURE THE SAFETY CONSTANT INTERNAL ENVIRONMENT AND DEFENSE REACTIONS.

IMMUNE SYSTEM GENERAL FUNCTIONS

1. Protection from pathogens
    - Bacteria
    - Viruses
    - Fungi
    - Protozoan
    - Parasites such as hookworms, tapeworms
    - Protect from non dangerous pathogens also
    - Creates an allergic response
2. Clean up!
    - Removal of dead and damaged cells and components
3. Recognition and removal of abnormal cells
    - Cancers
    - Autoimmune disorders
4. Produced immune cells, especially lymphocytes and plasma;
5. Provide recognition and destruction of cells that infiltrated the body of therein and other substances that have signs of genetic strange information.



ACCORDING TO FUNCTIONS

IMMUNE ORGANS ARE DIVIDED INTO:

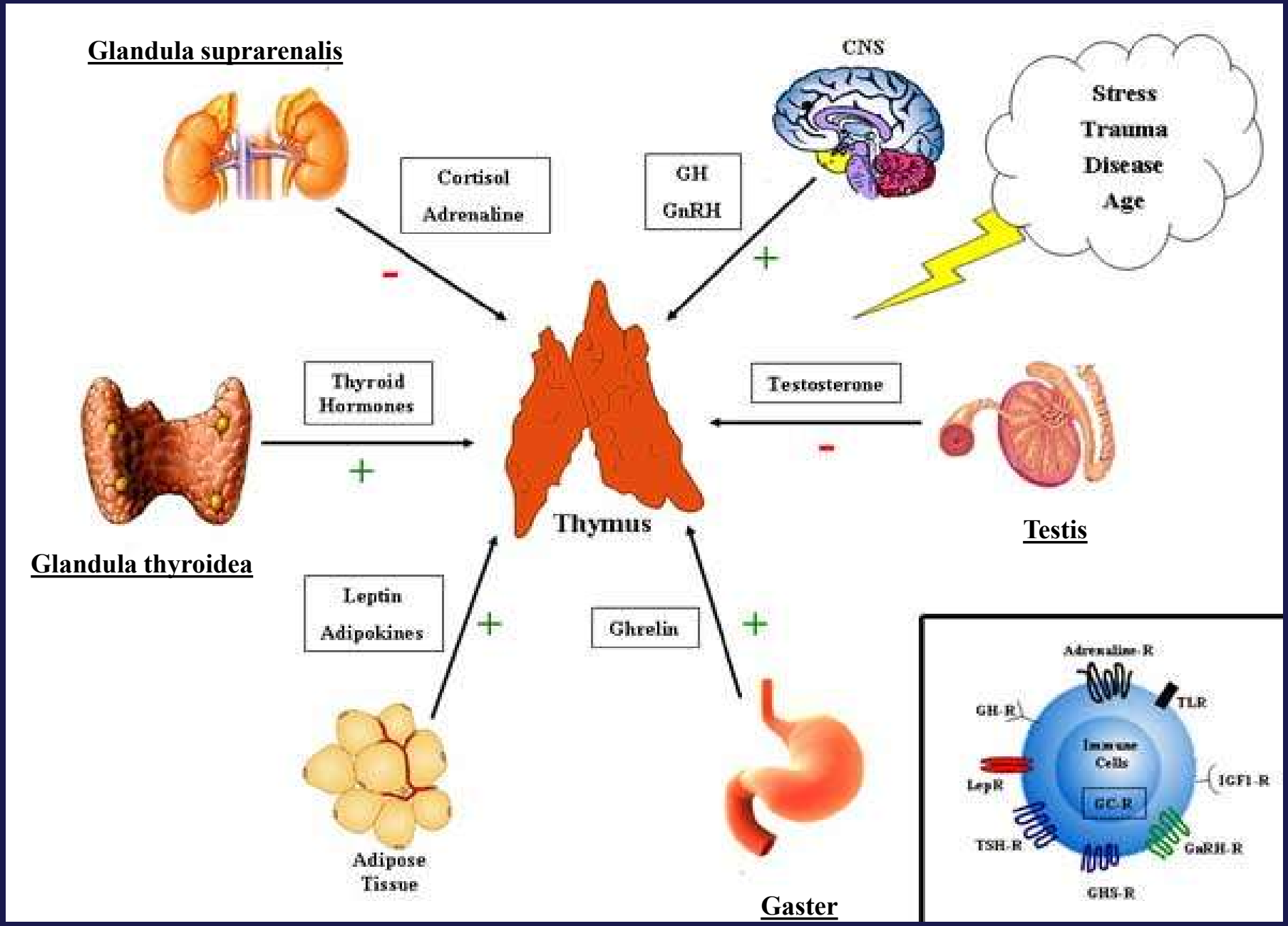
- CENTRAL
- PERIPHERAL

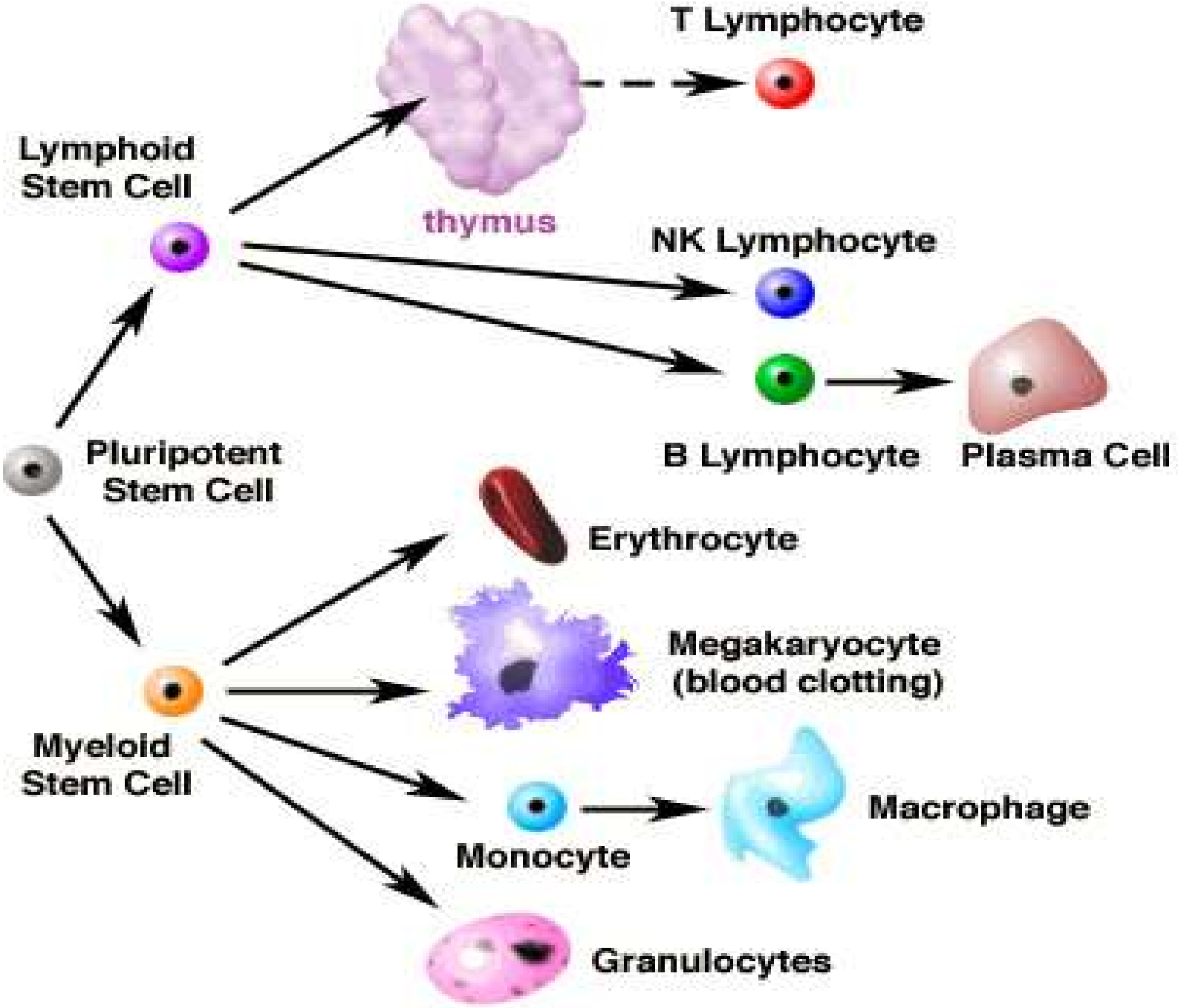
The central immune system include:

- **Bone marrow**
- **Thymus**

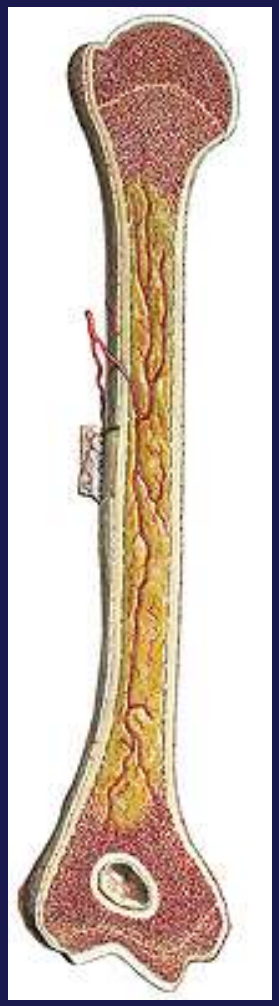
The peripheral immune system include:

- **Spleen**
- **Lymph nodes**
- **Clusters of lymphoid tissue in the walls of hollow organs of digestive and respiratory tract**
- **Tonsils**
- **Lymphoid nodules appendix and ileum**
- **Single lymphoid nodules**


Glandula suprarenalis
CNS
Stress
Trauma
Disease
Age
Cortisol
Adrenaline
GH
GnRH
-
+
Thyroid
Hormones
+
Testosterone
-
Thymus
Glandula thyroidea
Testis
Leptin
Adipokines
+
Ghrelin
+
Adipose
Tissue
Gaster
Adrenaline-R
TLR
GH-R
Immune
Cells
LepR
IGF1-R
GC-R
TSH-R
GnRH-R
GHS-R


T Lymphocyte
Lymphoid
Stem Cell
thymus
NK Lymphocyte
B Lymphocyte
Plasma Cell
Pluripotent
Stem Cell
Erythrocyte
Megakaryocyte
(blood clotting)
Myeloid
Stem Cell
Monocyte
Macrophage
Granulocytes

THE BONE MARROW



NOWADAYS BONE MARROW IN THE HUMAN IMMUNE SYSTEM REGARDED AS ANALOGUES TO FABRICIUS BAGS - CELL ACCUMULATION IN THE WALL OF KLOAC PART OF BOWEL BIRDS. BONE MARROW IS A COMPONENT OF THE BLOOD AND IMMUNE SYSTEM.

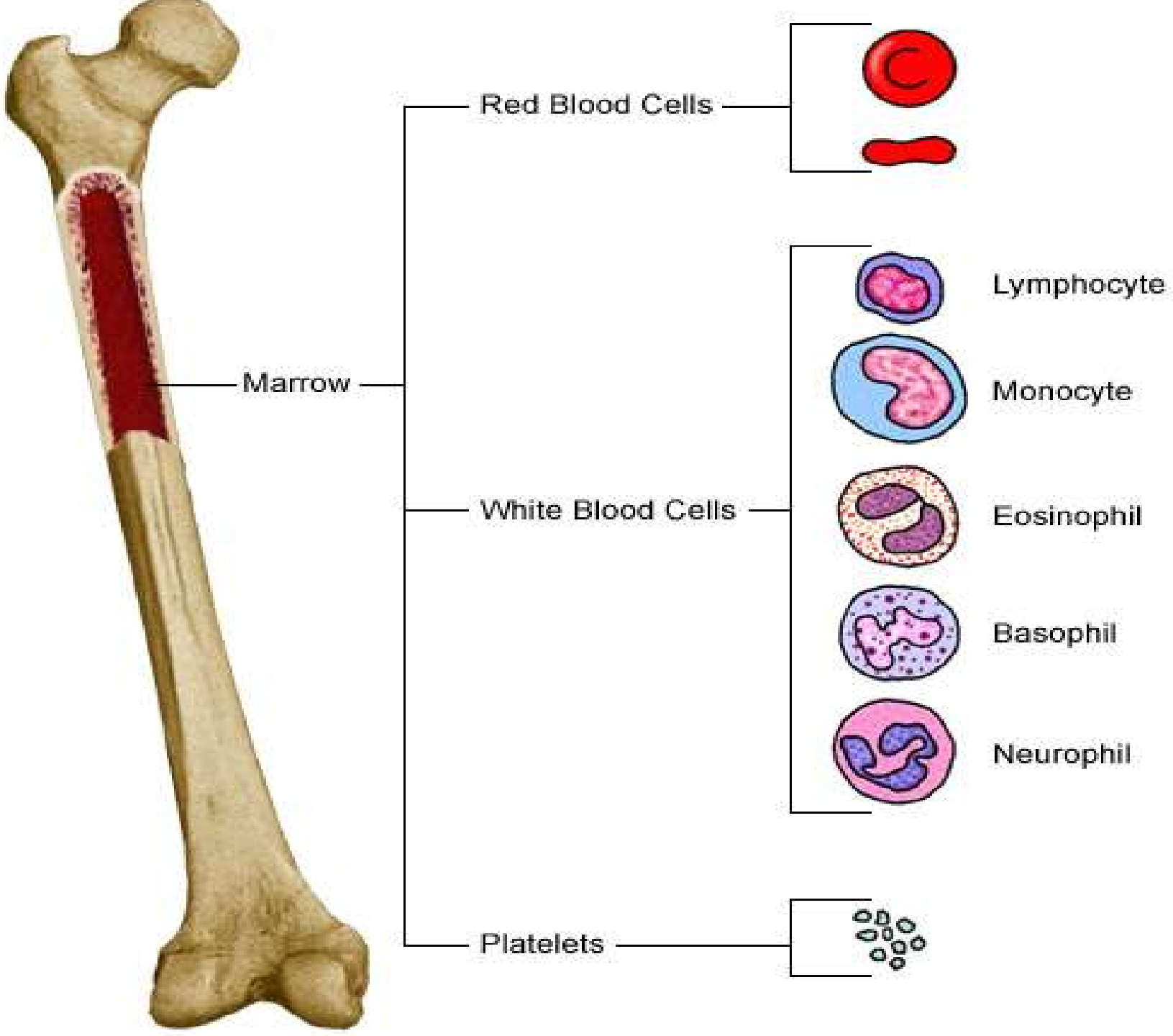
IN THE BONE MARROW THERE ARE STEM CELLS WHICH FORMED B-LYMPHOCYTES, IN IT INDEPENDENT ZONE FROM THYMIC DIFFERENTIATION.

THERE IS A DIFFERENTIATION IN THE THYMUS T-LYMPHOCYTES (THYMUS-DEPENDENT), WHICH ARE FORMED FROM STEM CELLS.

THERE ARE RED BONE MARROW, WHICH IN THE ADULT IS LOCATED IN THE CELL SPONGE FLAT AND SHORT BONES EPIPHYSIS OF LONG BONES AND YELLOW BONE MARROW,

WHICH FILLS THE DIAPHYSIS CAVITY OF LONG BONES.

THE TOTAL MASS OF THE BONE MARROW OF ADULTS - ABOUT 2.5-3 KG (4.5-4.7% OF BODY WEIGHT). ALMOST HALF IS RED BONE MARROW, BALANCE– YELLOW.


Marrow
Red Blood Cells
White Blood Cells
Platelets
Lymphocyte
Monocyte
Eosinophil
Basophil
Neurophil

RED BONE MARROW CONSISTING OF MYELOID TISSUE, WHICH INCLUDES THE RETICULAR TISSUE AND HEMATOPOIETIC ELEMENTS. IT CONTAINS STEM HEMATOPOIETIC CELLS - PRECURSORS OF ALL CELLS IN THE BLOOD AND LYMPH.

- **IN THE BONE MARROW STEM CELLS ARE PREDECESSORS OF T- AND B-LYMPHOCYTES.**
- **PRECEDED BY T-LYMPHOCYTES MIGRATE TO THE THYMUS.**
- **PRECEDED BY B-LYMPHOCYTES IN THE BONE MARROW DEVELOP IN TO B-LYMPHOCYTES.**
- **LATER THE LYMPHOCYTES ENTER TO THE PERIPHERAL DEPENDENT ZONE OF IMMUNE SYSTEM.**

10-30% OF THE POPULATION LOF YMPHOCYTES – ARE B-LYMPHOCYTES.

THE MAIN PROPERTY OF B-LYMPHOCYTES IS THE PRESENCE ON THE SURFACE IMMUNOGLOBULIN IDENTIFICATION ANTIGEN RECEPTORS.

AFTER INTERACTION WITH THESE RECEPTORS ANTIGEN B LYMPHOCYTES DIFFERENTIATE INTO PLASMA CELLS WHOSE PRIMARY FUNCTION IS THE PRODUCTION OF IMMUNOGLOBULINS - ANTIBODIES.

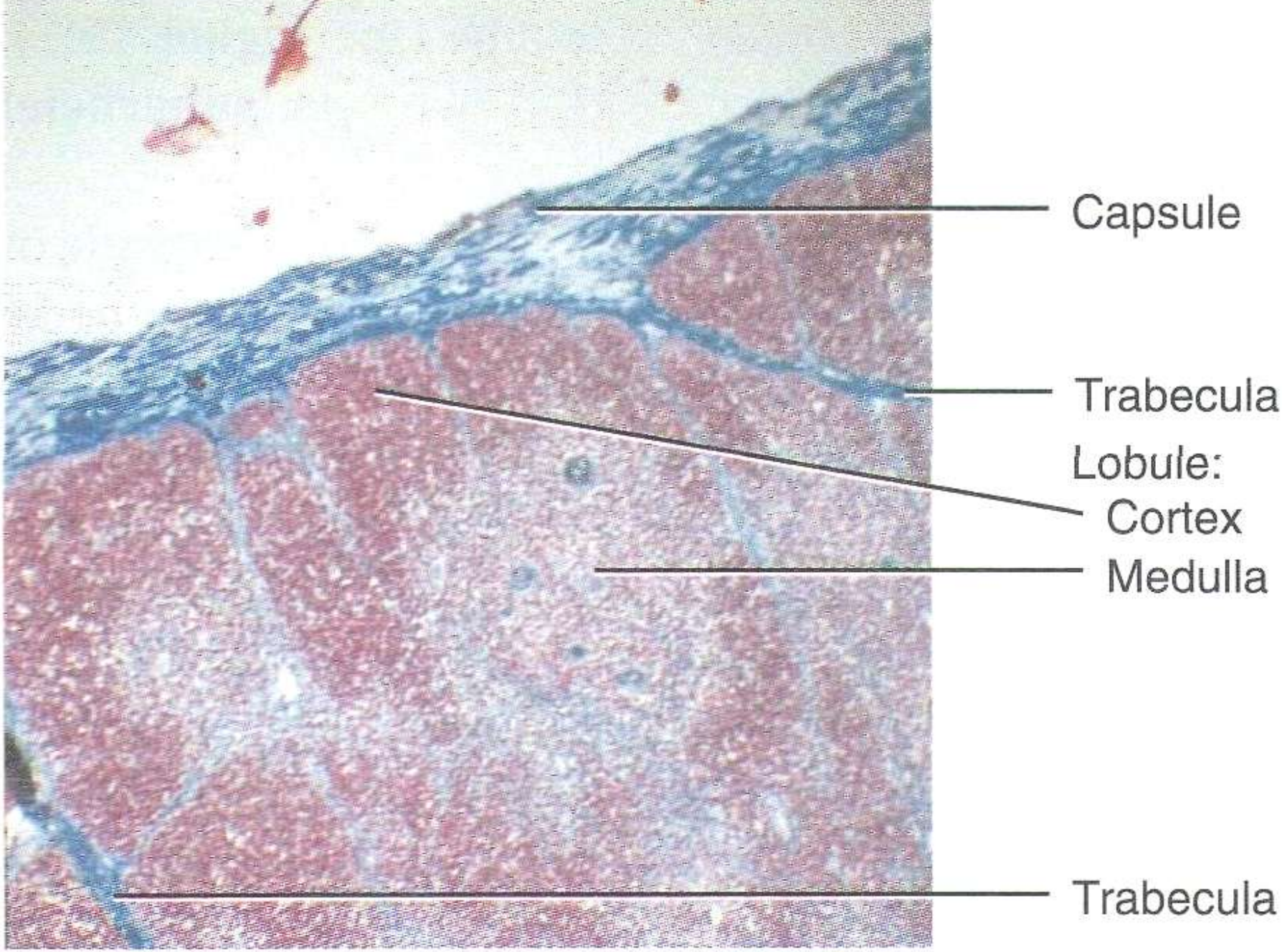
B-LYMPHOCYTES PERFORM THE FUNCTION OF **HUMORAL IMMUNITY** IN WHICH THE MAIN ROLE BELONGS TO BLOOD, LYMPH, SECRETIONS OF GLANDS THAT CONTAINS ANTIBODIES AND PARTICIPATES IN IMMUNE RESPONSES.

B-LYMPHOCYTES ARE PROVISIONAL OF PLASMA CELLS AND LYMPHOCYTES WITH INCREASED ACTIVITY. THEN THEY COME IN DEPENDING ZONE OF LYMPH NODES AND SPLEEN.

THYMUS

IT IS A TEMPORARY ORGAN, ATTAINING ITS LARGEST SIZE AT THE TIME OF PUBERTY, WHEN IT CEASES TO GROW, GRADUALLY DWINDLES, AND ALMOST DISAPPEARS. LOCATED ALONG THE MIDDLE LINE, SITUATED PARTLY IN THE THORAX, PARTLY IN THE NECK, AND EXTENDING FROM THE FOURTH COSTAL CARTILAGE UPWARD. IT IS COVERED BY THE STERNUM AND BY MUSCLES OF THE NEACK.

THYMUS HAS 2 LOBULES EACH OF THEM CONSIST OF:
- CORTEX - CONTAINS A LARGE NUMBER OF LYMPHOCYTES;
- MEDULLA - ACCUMULATION OF RETICULAR CELLS THAT ARE CALLED HASSALYA'S CELLS.


Capsule
Trabecula
Lobule:
Cortex
Medulla
Trabecula
LM
40x

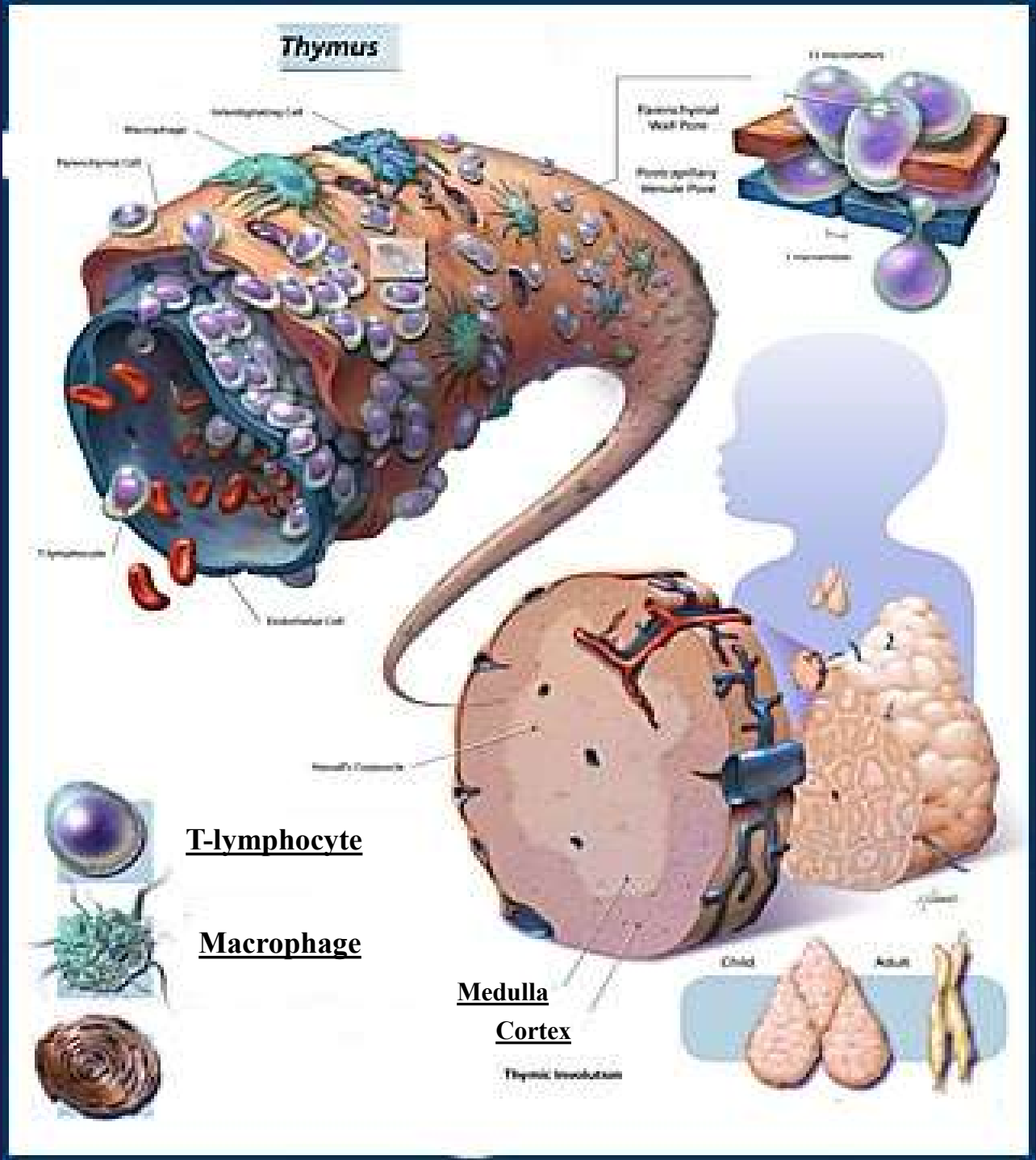
MEDULLAS CELL SECRETES HORMON OF THYMUS WHICH CALLED "TYMICHAL (HUMORAL) FACTOR" INFLUENCING DIFFERENTIATION OF T-LYMPHOCYTES WITH PROGENITOR CELLS IN THE CORTEX OF THE THYMUS.

T-LYMPHOCYTES – INCLUDES 70-90% OF THE LYMPHOCYTES POPULATION.

IN T-DEPENDENT PERIPHERAL AREAS FORM:

- **T-KILLER**
- **T-HELPERS**
- **T-SUPPRESSOR.**

T-LYMPHOCYTES COLONIZE THE THYMUS-INDEPENDENT ZONES OF LYMPH NODES, SPLEEN AND PROVIDES BOTH IMPLEMENTATION OF CELL IMMUNITY BY ACCUMULATION AND THE INTRODUCTION OF THE SENSITIZING LYMPHOCYTES.


Thymus
T-lymphocyte
Macrophage
Medulla
Cortex
Child
Adult
Thymic involution

DEFECTS OF THYMUS:

- **ALIMFOPLAZIYA**
- **HYPOPLASIA**
- **DYSPLASIA**
- **TYMOMEHALIYA**

PERIPHERAL IMMUNE SYSTEM

PERIPHERAL IMMUNE ORGANS ARE DIVIDED INTO:

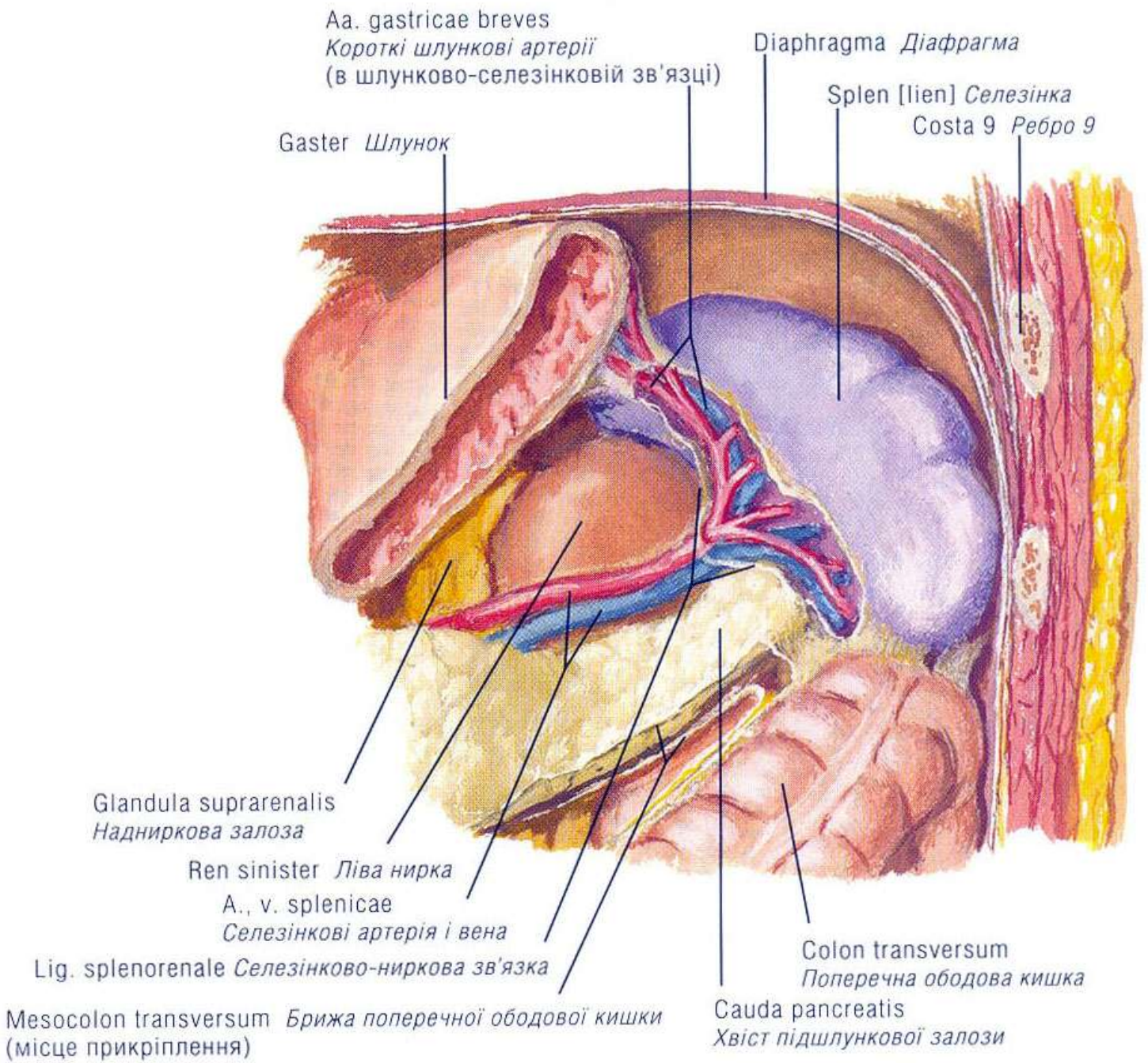
CAPSULATED - SPLEEN,
ENCAPSULATED - LYMPH NODES

FUNCTION OF PERIPHERAL IMMUNE SYSTEM IS BEING UNDER THE INFLUENCE OF CENTRAL IMMUNE.

SPLEEN

LYMPHOID TISSUE IN THE SPLEEN IS CONNECTED TO THE CIRCULATORY SYSTEM. SPLEEN IS ON THE WAY OF BLOOD FLOWING FROM ARTERIAL SYSTEM (AORTA) TO THE SYSTEM OF PORTAL HEPATIC VEIN.

SPLEEN IS DRIVE BLOOD, IT OCCURS ON THE ONE HAND, THE DESTRUCTION OF RED BLOOD CELLS AND PLATELETS, ON THE OTHER HAND, LYMPHOCYTOPOIESIS. WITH THE FORMATION LYMPHOCYTES RELATED PROTECTIVE FUNCTION OF THE SPLEEN, ITS PARTICIPATION IN THE IMMUNE RESPONSE.



Селезінка in situ

SPLEEN CONSIST OF:

- **RED PULP (70-80% PARENCHYMA)**

- **WHITE PULP (17-19% PARENCHYMA).**

WHITE PULP INCLUDE:

- LYMPHOID NODES AROUND ARTERIES

- PERIARTERIAL LYMPHOID SHEATH.

LYMPHOID NODULES AROUND THE ARTERY PROVIDES:

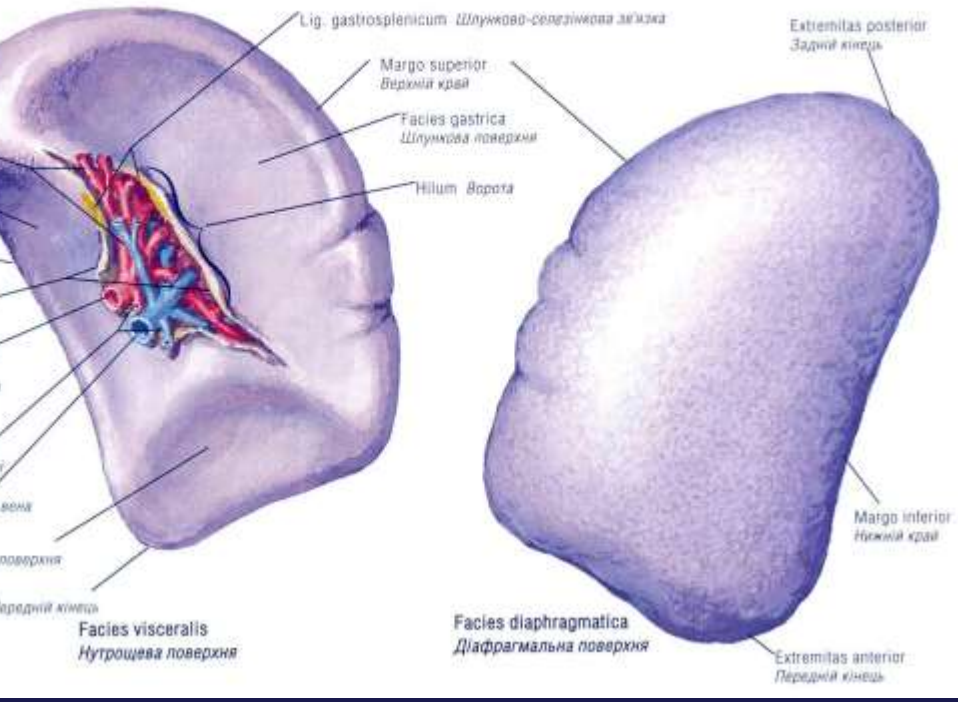
1) BREEDING CENTRE – IN-DEPENDENT ZONE

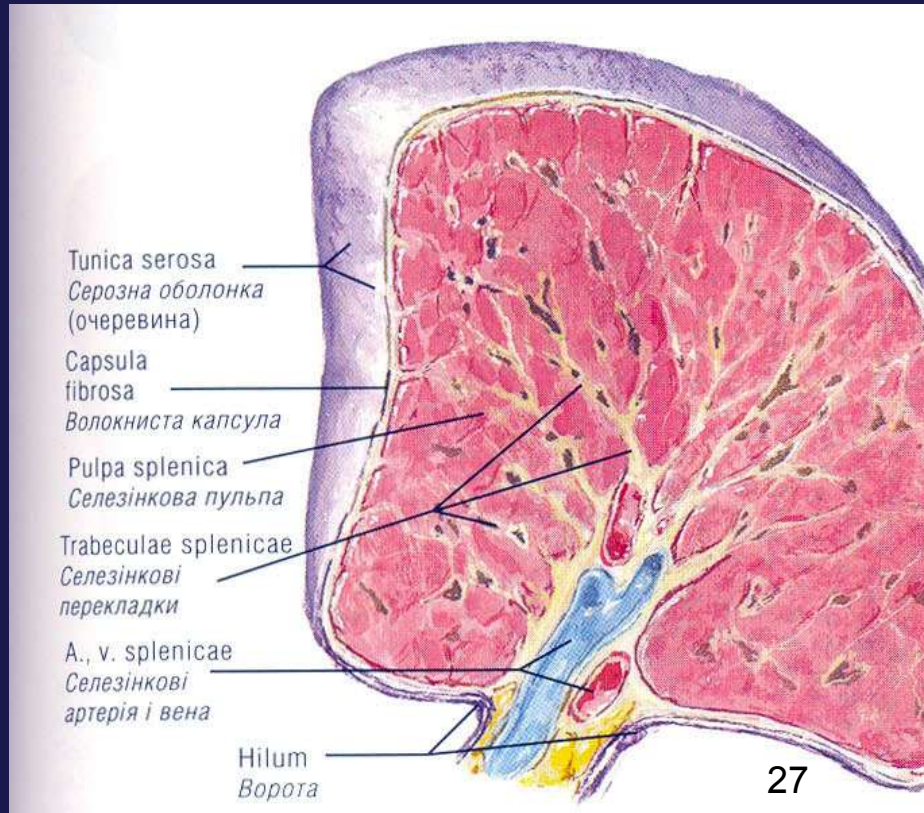
2) PERIARTERIAL ZONE - T-DEPENDENT ZONE

3) MANTLE LAYER - T- AND B-DEPENDENT ZONE

4) MARGINAL ZONE - T- AND B-SENSITIVE ZONE.

Селезінка (splen)





THE SPLEEN *DEVELOPS* FROM THE DORSAL MESENTERY AT 5-6 WEEKS OF FETAL DEVELOPMENT.

ANOMALIES OF SPLEEN

- **ALIYENIYA**
- **ANOMALIES FORMS OF SPLEEN - DUE TO A DEEP CUT AND FISSURES.**

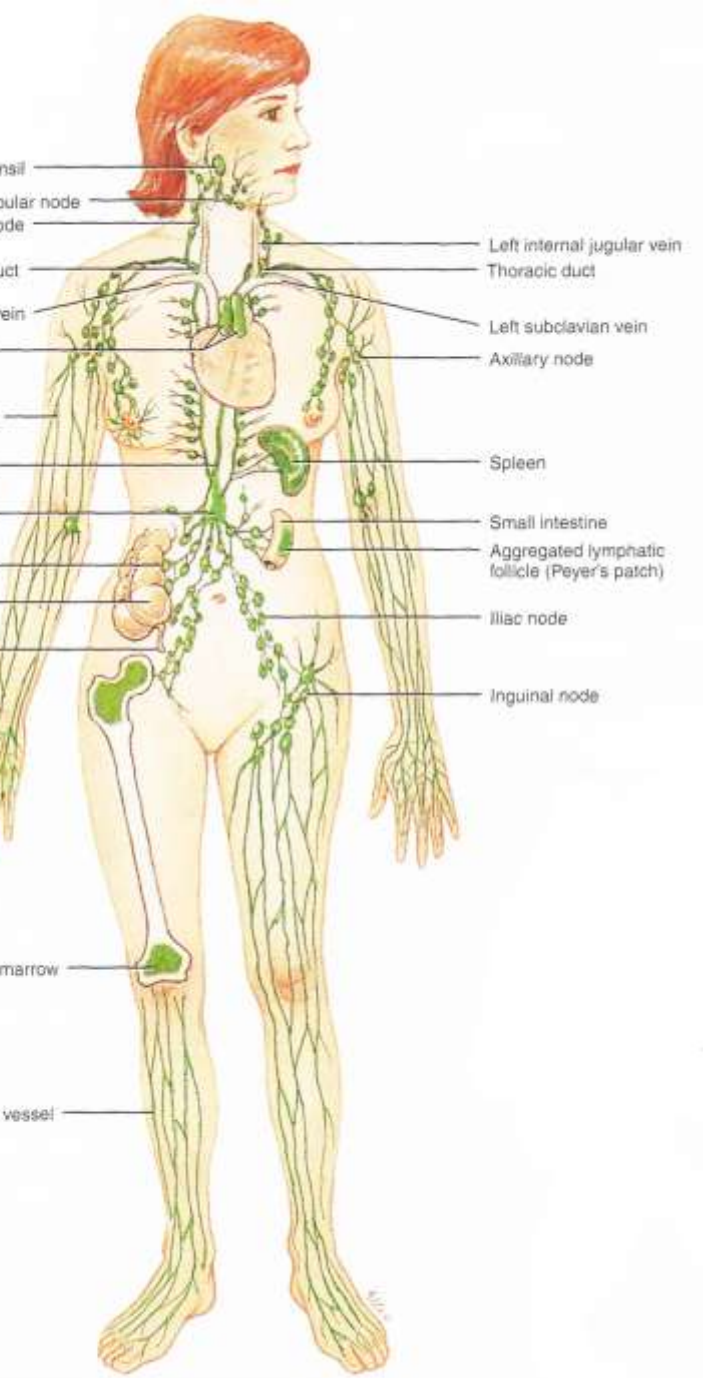
A) SPLEEN BLEEDING - SOMETIMES REACHES THE TESTES, IN WOMEN IT CAN REACH THE LEFT OVARY.

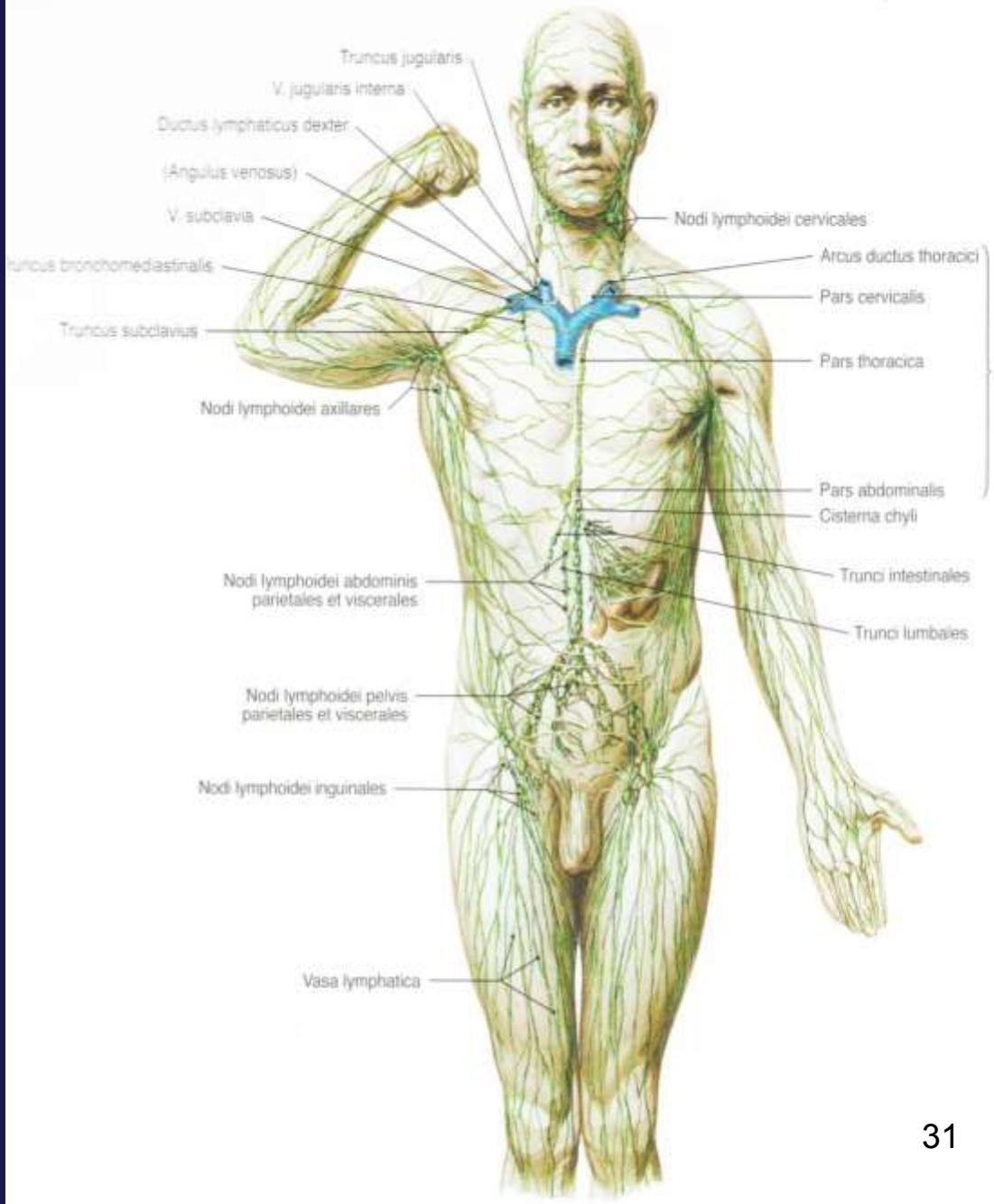
B) SPLEEN PART - DIVISION OF ORGANS BY DEEP GROOVES INTO SEVERAL SEPARATE PARTS, INDIVIDUAL PARTICLES ORGANS (2-4) ISOLATED STRATUM OF CONNECTIVE TISSUE.

- **HYPOPLASTIC SPLEEN (OR MIKROSPLENIYA) -** HYPOPLASIA OF THE SPLEEN, WHICH RETAINS, HOWEVER, ITS FUNCTIONS.
- **SPLEEN DOUBLE -** DOUBLING THE SPLEEN, IS RARE.
- **ADDITIONAL SPLEEN**
- **ECTOPIC SPLEEN**

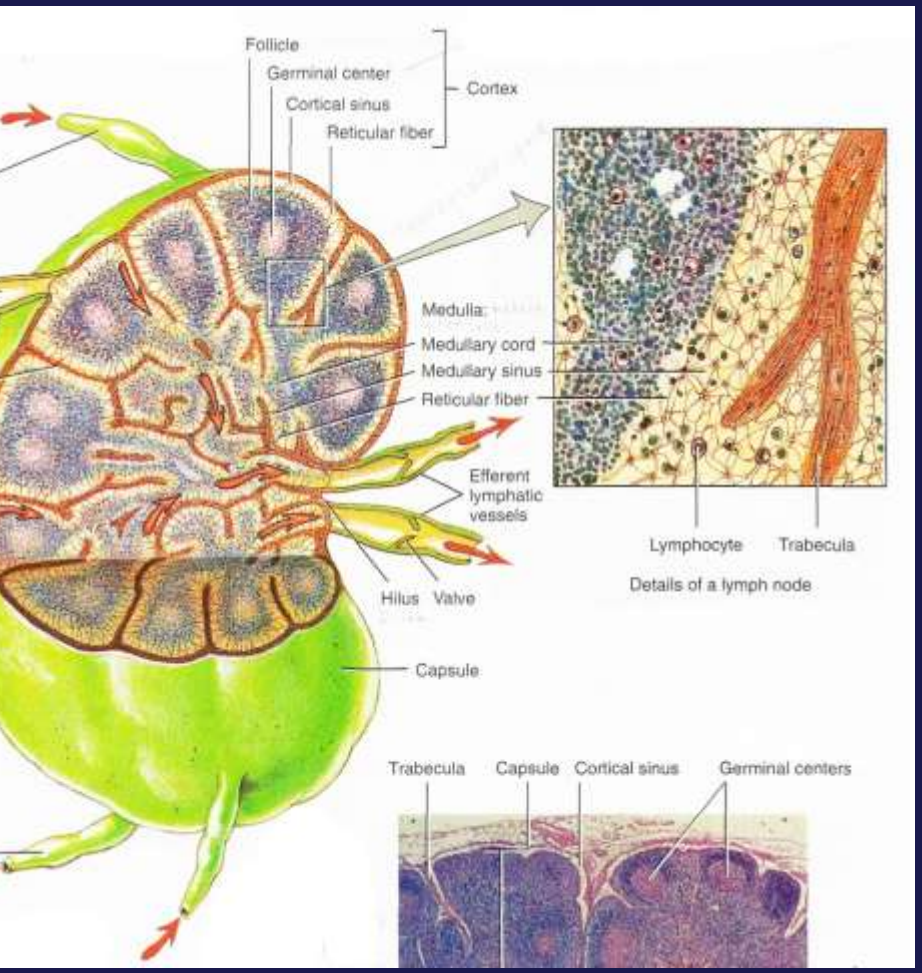
LYMPH NODES

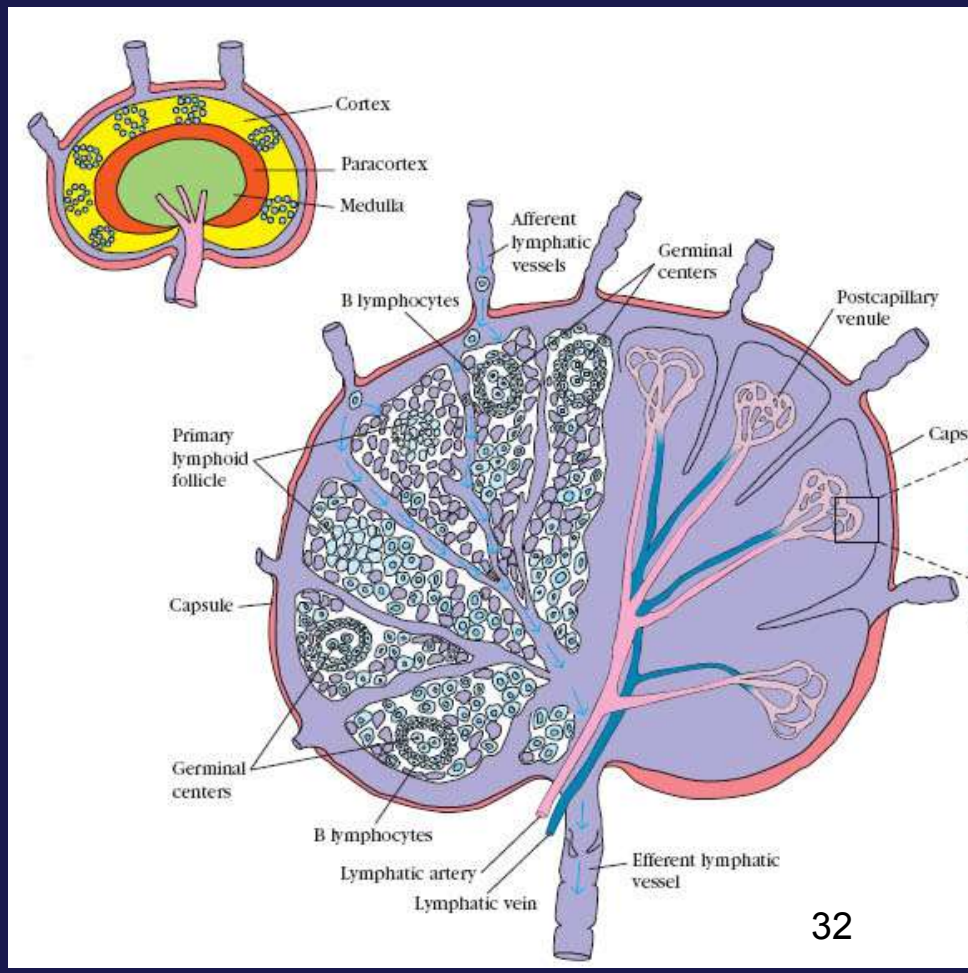
LYMPH NODES LIE ON THE PATH FOLLOWING THE LYMPHATIC VESSELS FROM ORGANS AND TISSUES TO LYMPH DUCTS AND TRUNKS.


nsil
ular node
ode
uct
ein
marrow
vessel
Left internal jugular vein
Thoracic duct
Left subclavian vein
Axillary node
Spleen
Small intestine
Aggregated lymphatic follicle (Peyer's patch)
Iliac node
Inguinal node

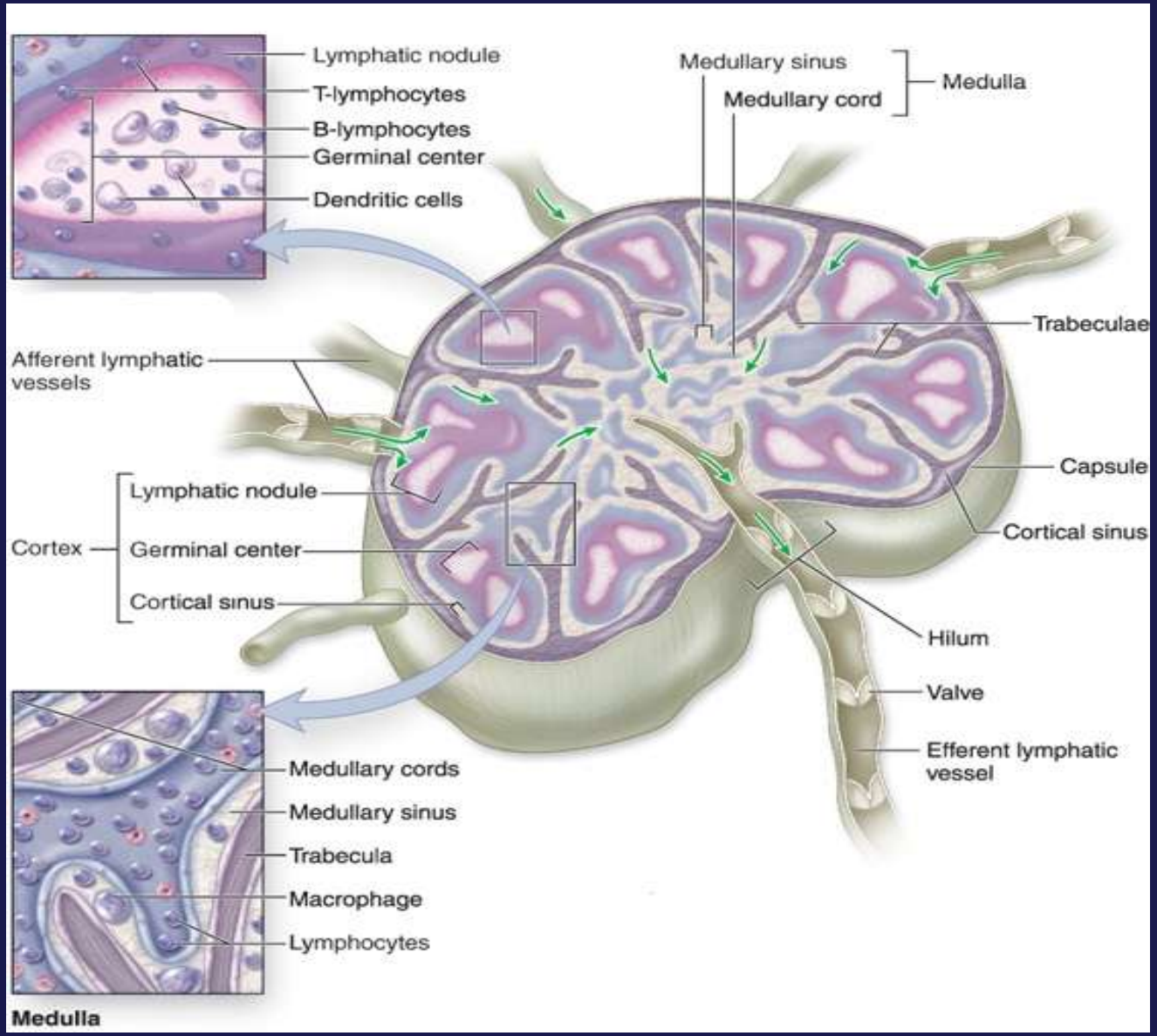

Truncus jugularis
V. jugularis interna
Ductus lymphaticus dexter
(Angulus venosus)
V. subclavia
Truncus bronchomediastinalis
Truncus subclavius
Nodi lymphoidei axillares
Nodi lymphoidei cervicales
Arcus ductus thoracici
Pars cervicalis
Pars thoracica
Ductus th
Pars abdominalis
Cisterna chyli
Trunci intestinales
Trunci lumbales
Nodi lymphoidei abdominis parietales et viscerales
Nodi lymphoidei pelvis parietales et viscerales
Nodi lymphoidei inguinales
Vasa lymphatica

LYMPH NODES HAS A DIFFERENT TYPES OF ROUND SHAPE. THEIR SIZES RANGE FROM 0.5-1.0 30-50 MM. EVERY LYMPH NODE COVERED WITH CONNECTIVE TISSUE OUTSIDE, WHICH MAKES CAPSULE FROM WHICH EXTENDS THIN SHIFTING INSIDE THE ORGAN.





LYMPH NODES LIE TOWARDS FLOW OF LYMPH FROM ORGANS AND TISSUES IN THE VENOUS SYSTEM. FOREIGN AGENT THAT REACHES THE LYMPH, DELAYED AND ELIMINATED IN THE LYMPH NODES.



LYMPH NODES COMPOSED OF:

- **CORTEX**
- **MEDULLA.**

BETWEEN CORTEX AND MEDULLA ARE PARAKORTIKALZONE ALSO CALLED T-DEPENDENT AREA.

TONSILS

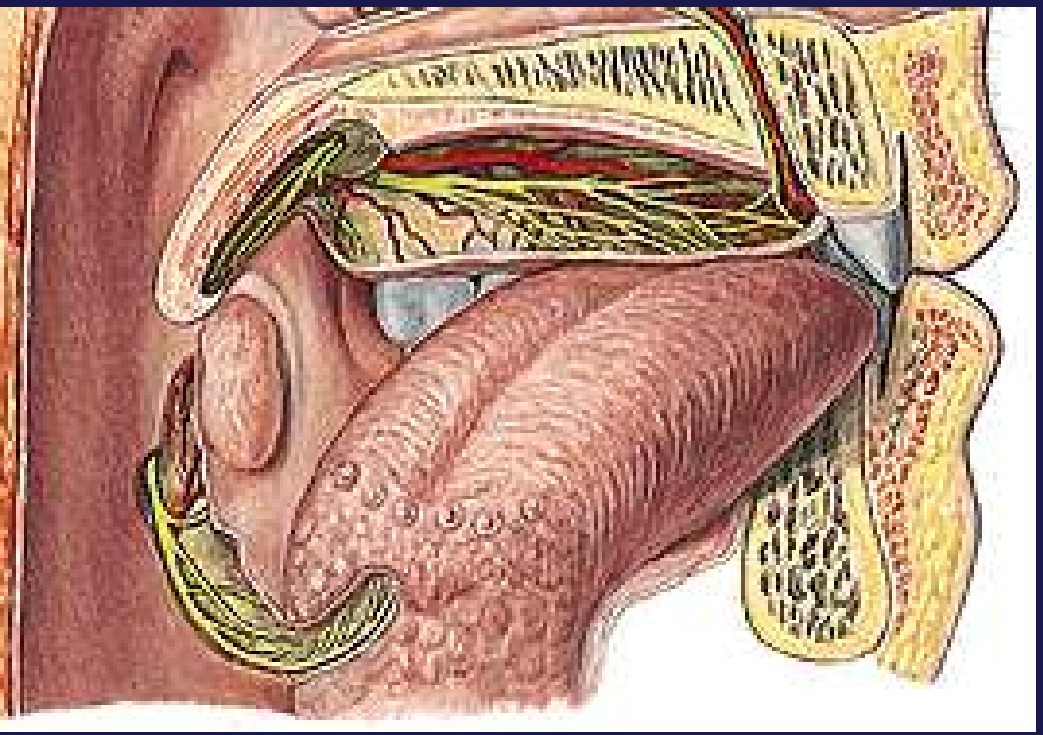
TONSILS ARE LOCATED IN THE WALLS OF INITIAL SECTION OF DIGESTIVE AND RESPIRATORY TRACTS, FORMING LYMPHOID RING PIROGOV-WALDEYER. TONSILLAR LYMPHOID TISSUE IS AT RISK OF ORAL CAVITY, NASAL CAVITY, ON THE ONE HAND, AND ORAL PHARYNX AND LARYNX, ON THE OTHER.

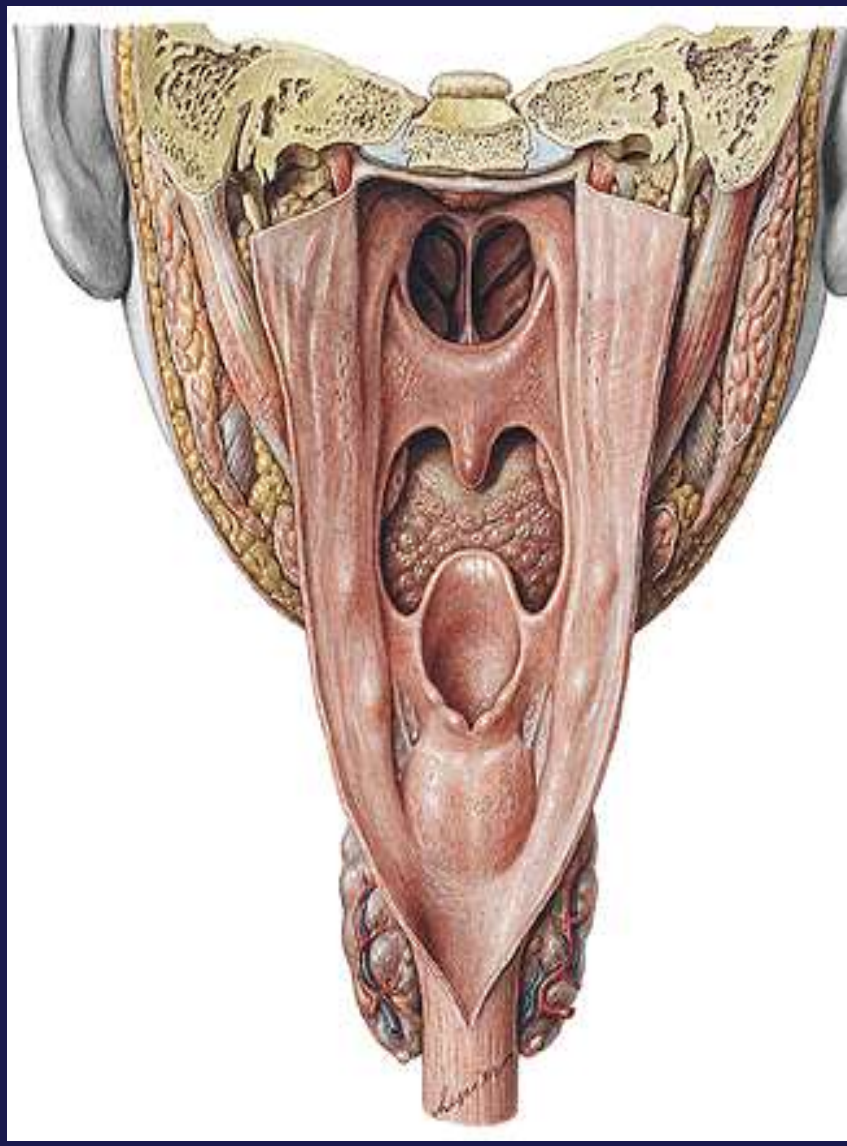
TONSILS:

- LINGUAL
- PHARYNGEAL
- PALATINE
- TUBAL

LOCATED IN THE AREA OF THE TONGUE, THROAT AND NASAL PART OF THE PHARYNX. THEY REPRESENT A DIFFUSE ACCUMULATION OF LYMPHOID TISSUE, CONTAINING SMALL SIZE DENSER CELL MASS - LYMPHOID NODULES.

TONSILS – IT IS T-INDEPENDENT ORGANS OF THE PERIPHERAL IMMUNE SYSTEM.





CLUSTERS OF LYMPHOID TISSUE

LYMPHOID NODULES OF APPENDIX, NODULI LYMPHOIDEI APPENDICIS VERMIFORMIS, DURING THE PERIOD OF MAXIMAL DEVELOPMENT (AFTER BIRTH UNTIL 16-17 YEARS) ARE LOCATED IN THE MUCOSA AND SUBMUCOSA IN THROUGHOUT THE BODY.

CLUSTERS OF LYMPHOID TISSUE

GROUP LYMPHOID NODULES (PEYYEROVI PLAQUE) IS A LONELY CLUSTER OF LYMPHOID NODES, WHICH ARE LOCATED IN THE WALL OF THE ILEUM. NUMBER OF LONELY LYMPHOID NODES IN PEYYEROVIY PLAQUE VARIES FROM 5-10 TO 100-150 AND MORE. DIMENSIONS LYMPHOID NODES IN PATCHES RANGE FROM 0.5 TO 2 MM.

CLUSTERS OF LYMPHOID TISSUE

GROUP LYMPHOID NODULES LOCATED IN THE ILEUM WALL END SMALL INTESTINE, NEAR THE CONFLUENCE OF THE ILEUM IN THE BLIND, AND THE SAME NODULE APPENDIX - BETWEEN DIFFERENT PARTS OF THE DIGESTIVE TUBE: SMALL AND LARGE INTESTINE.

TOTAL LYMPHOID NODES IN THE WALL IN CHILDREN AND TEENAGERS REACHES 600-800. NODULES OFTEN PLACED ONE ABOVE THE OTHER IN A 2-3 SERIES. AFTER 50-60 YEARS THE NUMBER OF LYMPHOID NODES IS REDUCED TO 100-150.

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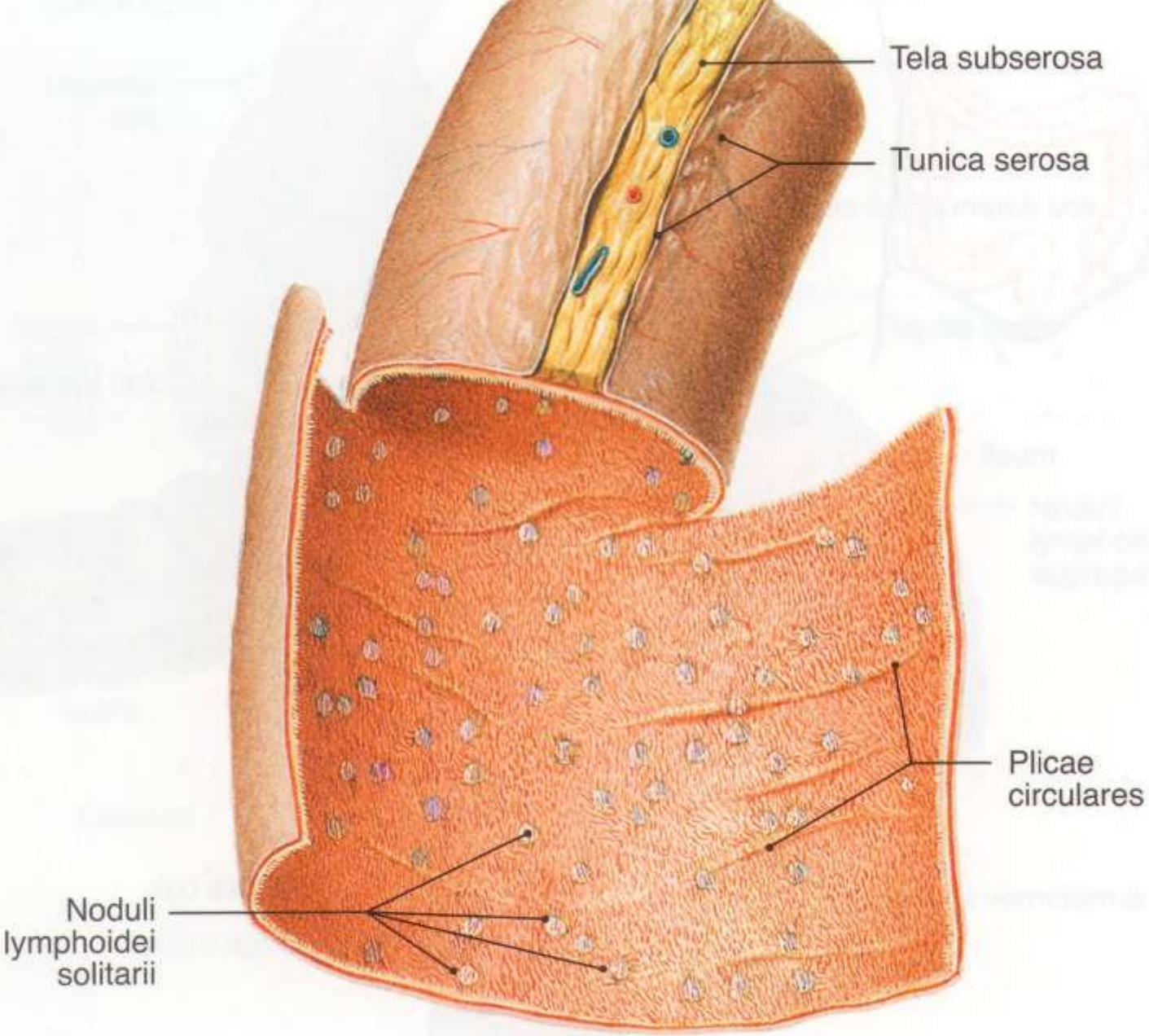


Fig. 997 Ileum, Ileum.

ANTIGENS

- ANY FOREIGN SUBSTANCE THAT ELICITS AN IMMUNE RESPONSE WHEN INTRODUCED INTO THE TISSUES OF A SUSCEPTIBLE ANIMAL AND CAPABLE OF COMBINING WITH THE SPECIFIC ANTIBODIES FORMED.
- GENERALLY HIGH MOLECULAR WEIGHT
- TYPICALLY, PROTEINS OR POLYSACCHARIDES.
- POLYPEPTIDES, LIPIDS, NUCLEIC ACIDS AND MANY OTHER MATERIALS ALSO CAN ALSO FUNCTION AS ANTIGENS
- MICROBES ARE ANTIGENIC AND THEY CONTAIN AND PRODUCE MANY ANTIGENS
- ANTIGENS HAVE SPECIFIC SITES THAT BIND TO ANTIBODIES CALLED “EPITOPES”

CLASSES OF ANTIBODIES (IMMUNOGHLOBULINS)

Class/ subclass	Heavy chain	Light chain	Molecular weight (kDa)	Structure	Function
IgA_1 IgA_2	α1 α2	λ or κ	150 to 600	Monomer to tetramer	Most produced Ig; protects mucosal surfaces; Resistant to digestion; secreted in milk
IgD	δ	λ or κ	150	Monomer	Function unclear; Works with IgM in B-cell development; mostly B cell bound
IgE	ε	λ or κ	190	Monomer	Defends against parasites; causes allergic reactions
IgG_1 IgG_{2a} IgG_{2b} IgG_3 IgG_4	γ1 γ2 γ2 γ3 γ4	λ or κ	150	Monomer	Major Ig in serum; good opsonizer; moderate complement fixer (IgG_3); can cross placenta
IgM	μ	λ or κ	900	Pentamer	First response antibody; Strong complement fixer; Good opsonizer

Components of the immune system

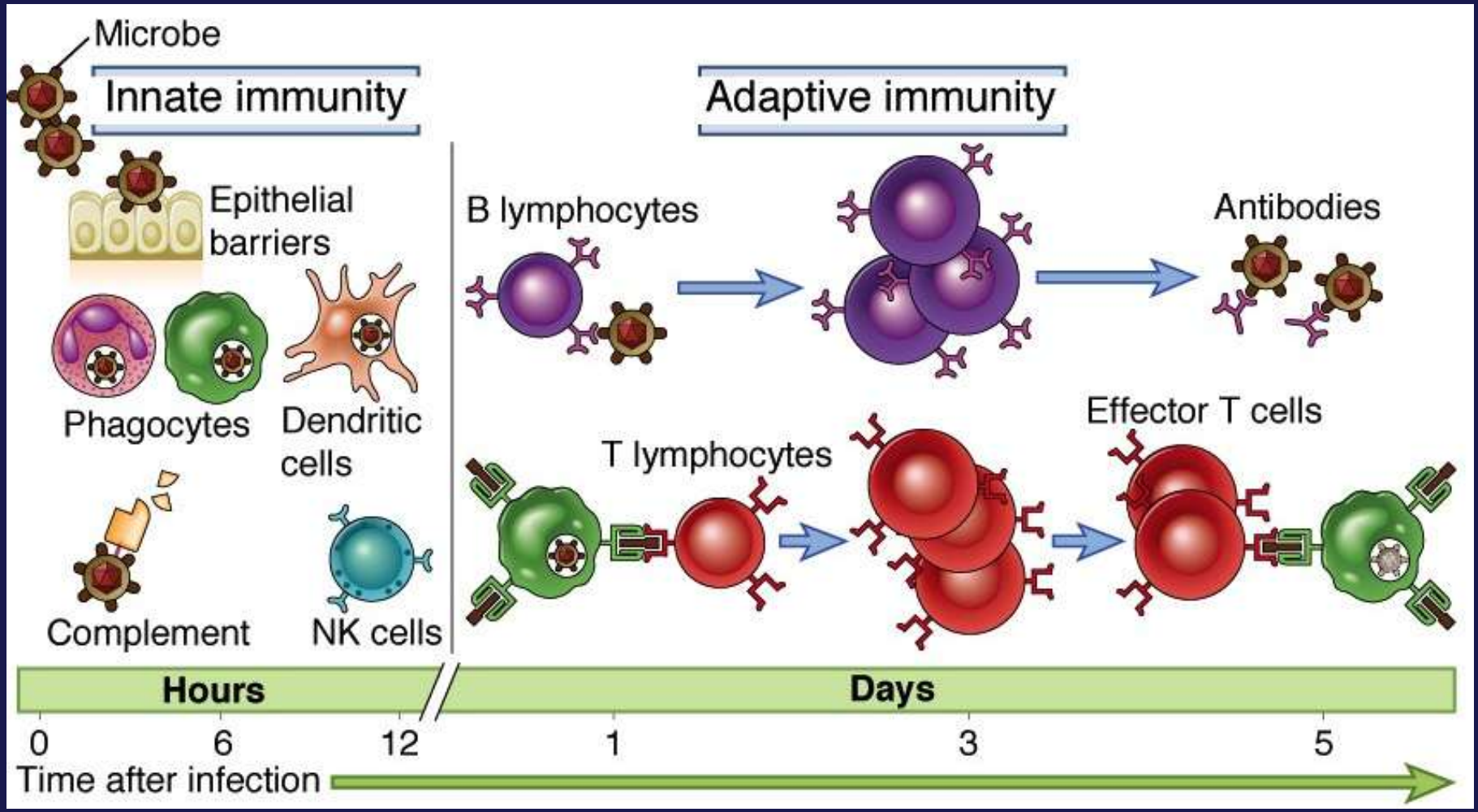
Innate immune system

- Response is non-specific
- Exposure leads to immediate maximal response
- Cell-mediated and humoral components
- No immunological memory
- Found in nearly all forms of life (plants & animals)

Adaptive immune system

- Pathogen and antigen specific response
- Lag time between exposure and maximal response
- Cell-mediated and humoral components
- Exposure leads to immunologic memory
- Found only in jawed vertebrates

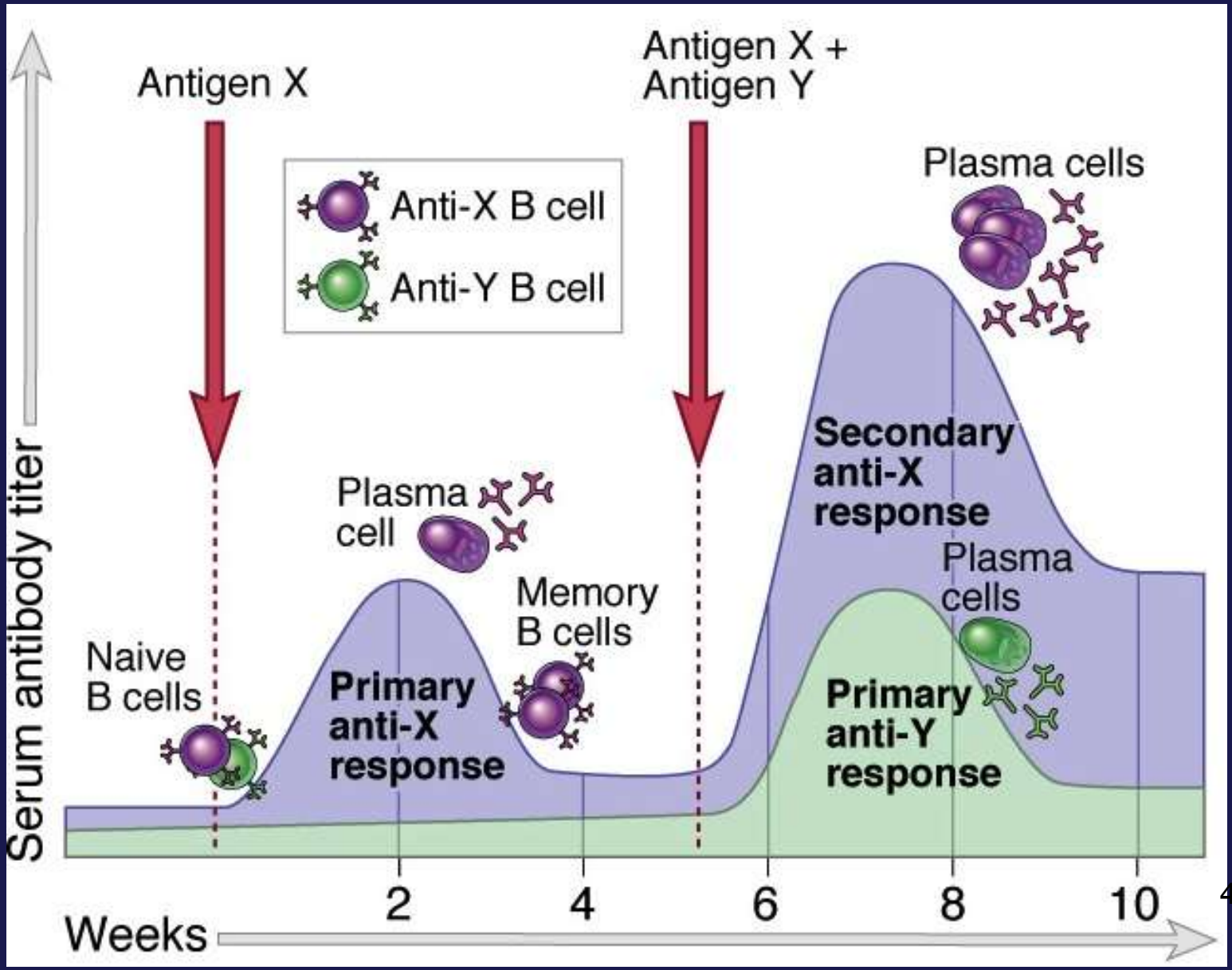
INNATE AND ADAPTIVE IMMUNITY



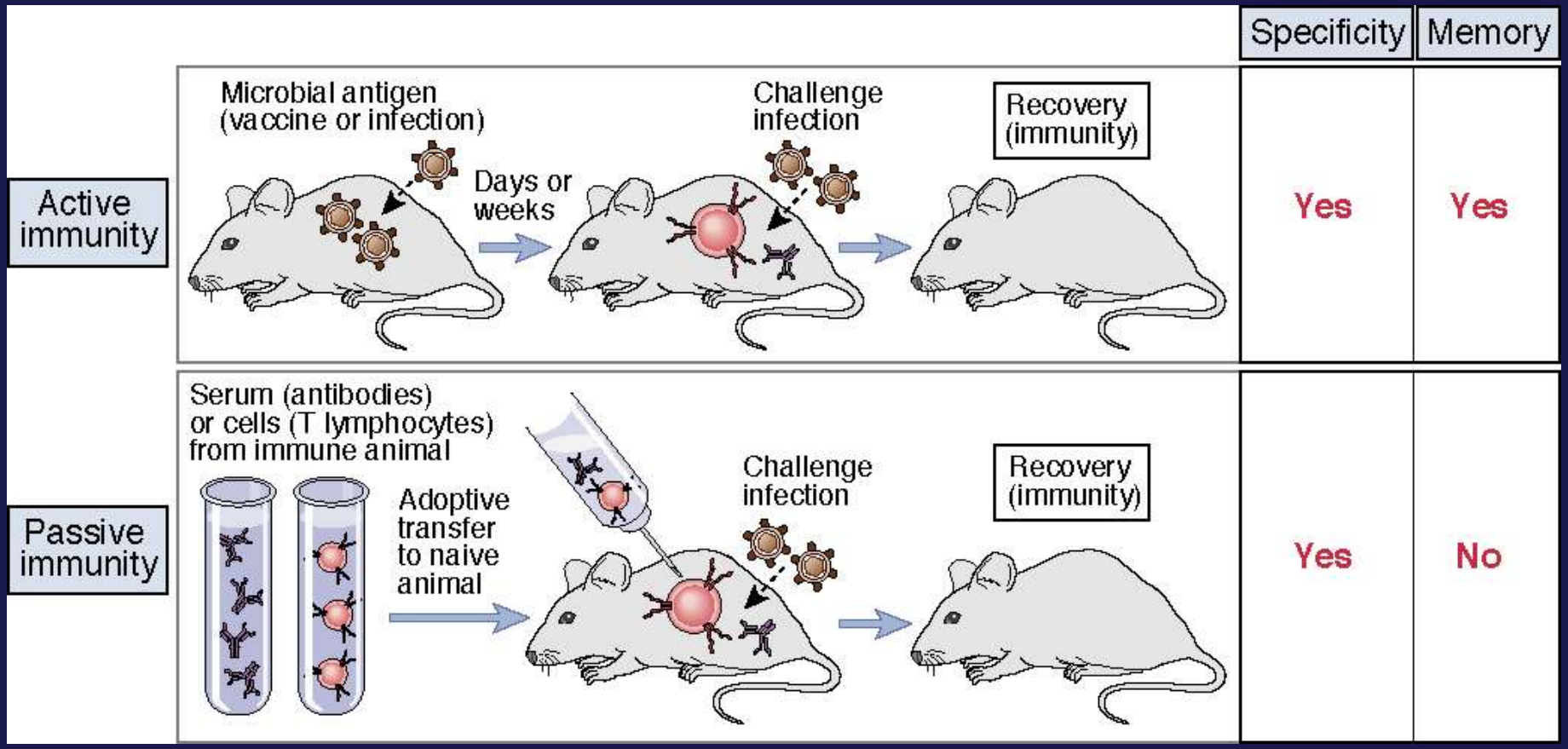
Innate immunity: always present (ready to attack); many pathogenic microbes have evolved to resist innate immunity

Adaptive immunity: stimulated by exposure to microbe; more potent

PRIMARY AND SECONDARY IMMUNE RESPONSES ILLUSTRATE SPECIFICITY AND MEMORY IN ADAPTIVE IMMUNITY



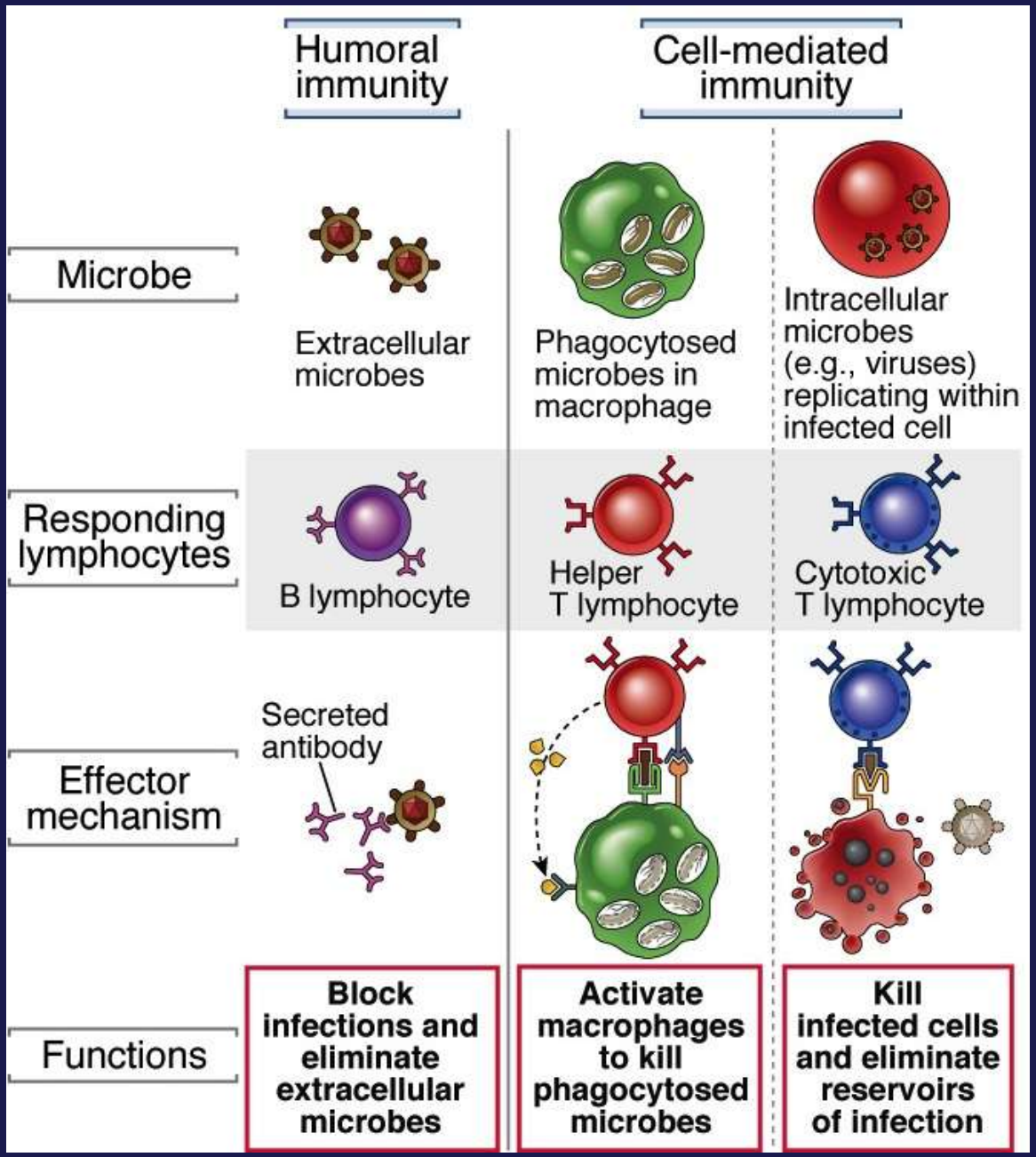
ACTIVE AND PASSIVE IMMUNITY



Active immunity: long-lasting protection (memory), multiple effector mechanisms activated, lag time

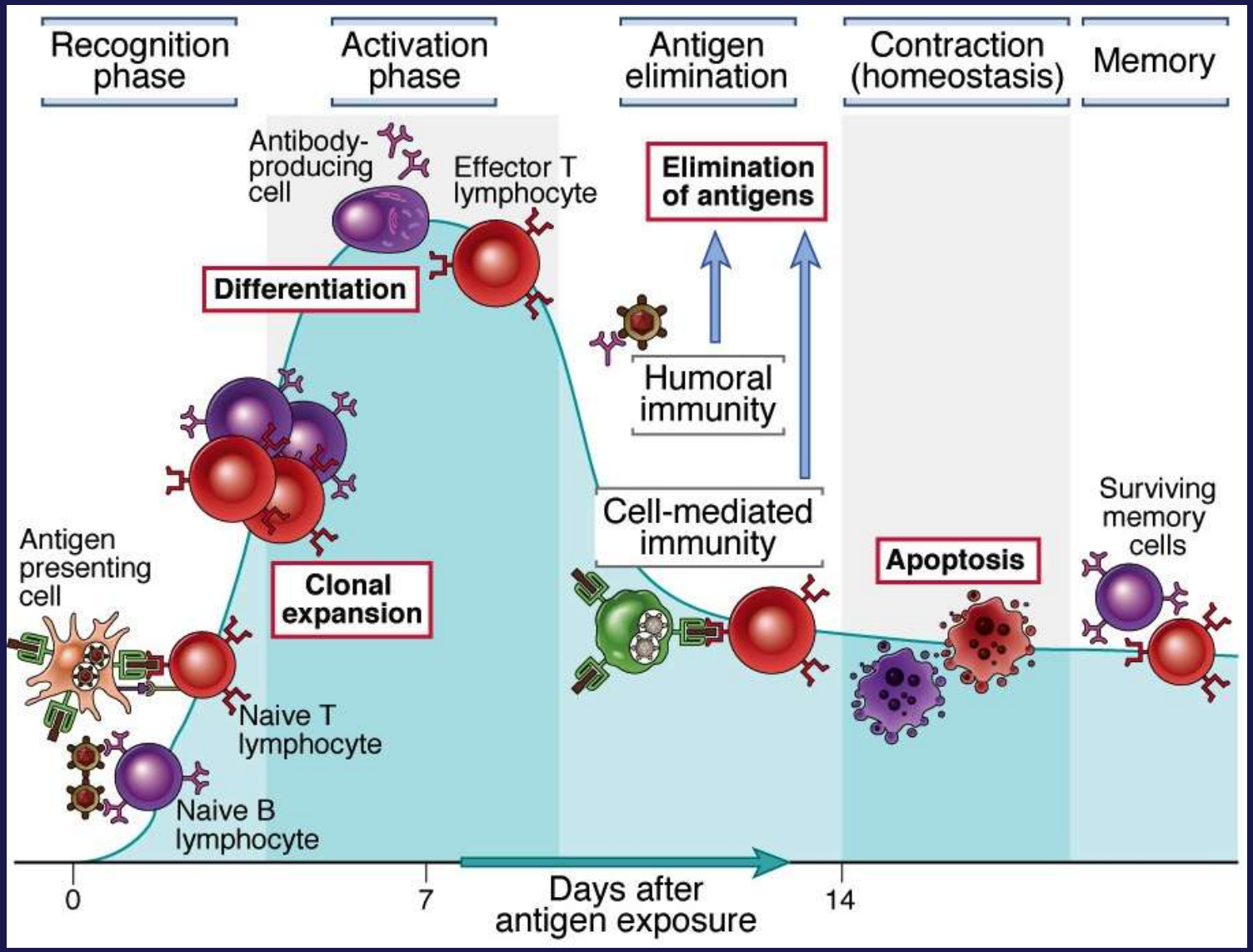
Passive immunity: rapid protection, short duration

TYPES OF ADAPTIVE IMMUNITY



Different types of immune responses are mediated by different classes of lymphocytes and defend against different types of microbes

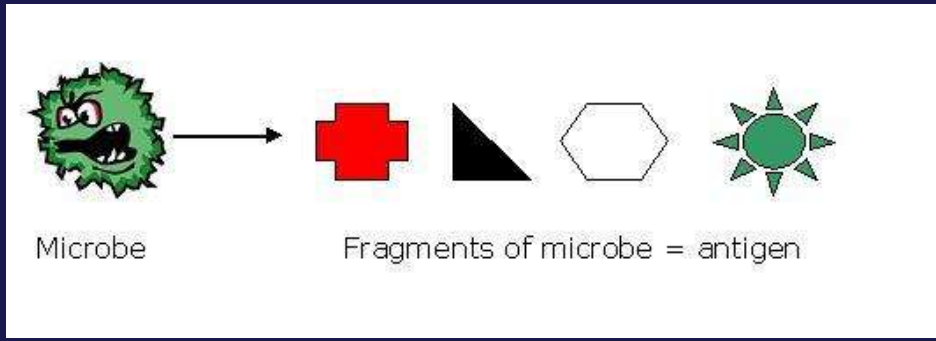
PHASES OF ADAPTIVE IMMUNE RESPONSES

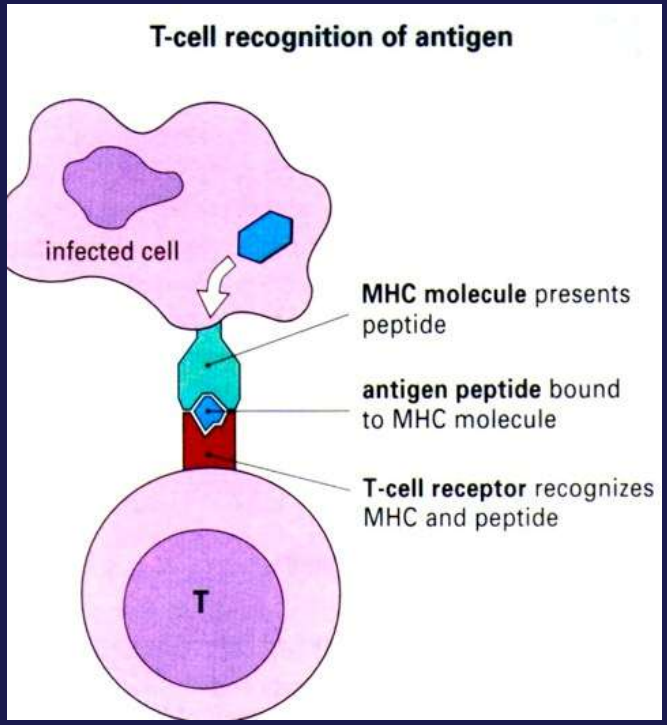


Need for proliferation and differentiation results in delay (typically 4-7 days) in the adaptive immune response

SPECIFIC IMMUNITY

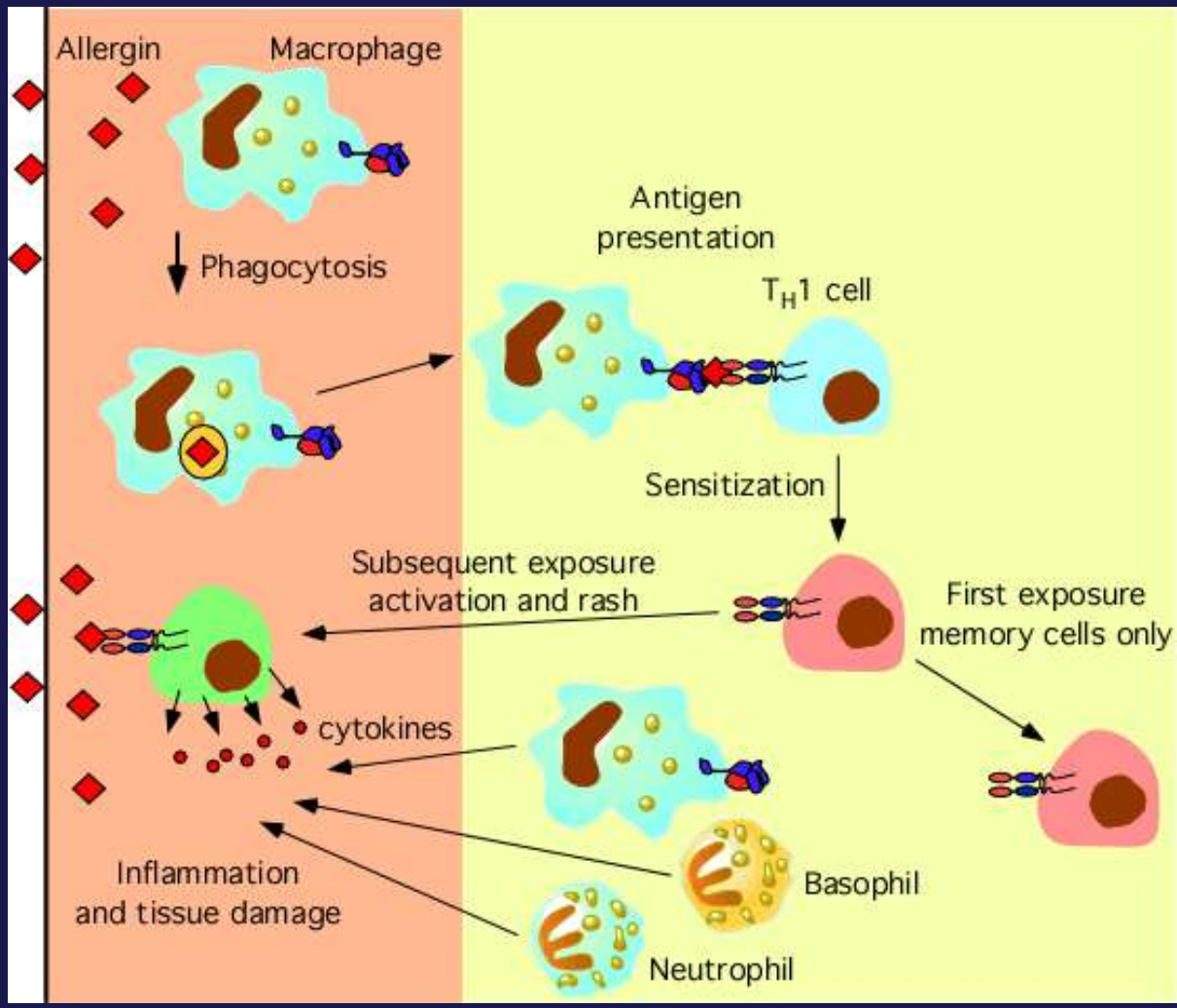
- Specificity: based on shape recognition of cell surface antigens
- Diversity: Any shape can be recognized by a B or T-lymphocytes and trigger an immune reaction
- Memory: once a pathogen has activated the immune system, memory cells remain and will protect against a secondary infection
- Self-tolerance: the immune system does not attack itself





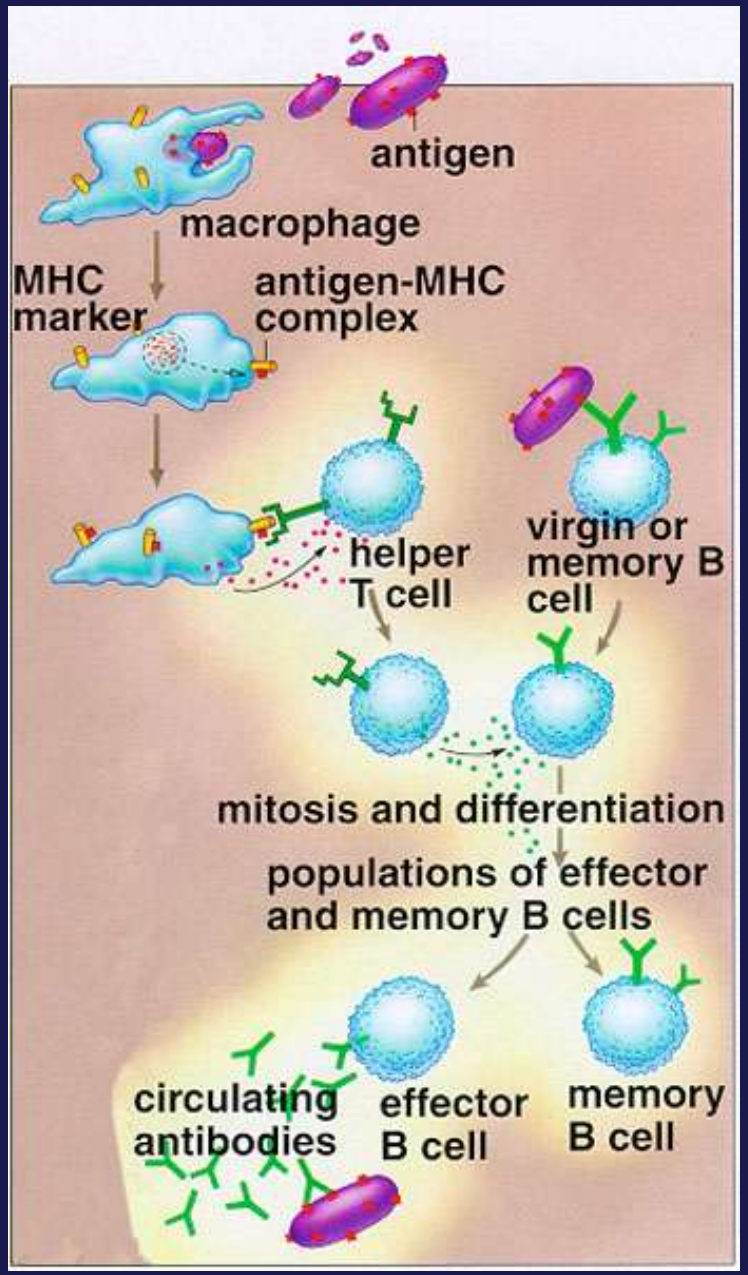
SPECIFIC IMMUNITY = THE PLAYERS

- Macrophages (antigen presenting cell = APC): phagocytize pathogens and present antigens to helper-T lymphocytes
- Helper-T lymphocytes: secrete lymphokines and activate B and killer T lymphocytes
- B-lymphocytes: multiply and specialize into plasma cells → secrete antibodies
- Killer-T lymphocytes: kill (through lysis) infected or cancerous cells



ANTIBODY-MEDIATED (HUMORAL) IMMUNITY = AMI

- 1- Macrophages phagocytize a pathogen and present an antigen to a matching helper-T cell
- 2- At the same time, some pathogens contact B-cells matching the pathogen's antigens
- The helper-T cells multiply, secrete lymphokines which stimulate the B-cells to multiply and specialize into plasma cells
- The plasma cells secretes antibodies



Thank you!