Basics of immunology

Blood

1. Plasma (~54.3%)

   Serum: Plasma without fibrin and fibrinogen (after coagulation)

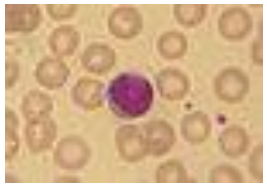
2. Cells: - Red blood cells = erythrocytes (~45%)

   - White blood cells = leukocytes

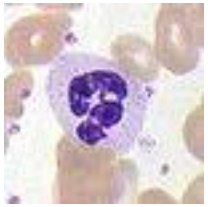
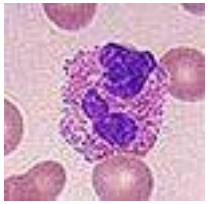
   - Platelets = thrombocytes

White blood cells

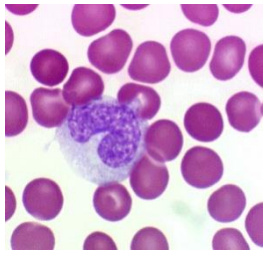
- Lymphocytes: - T-lymphocytes
  - B-lymphocytes



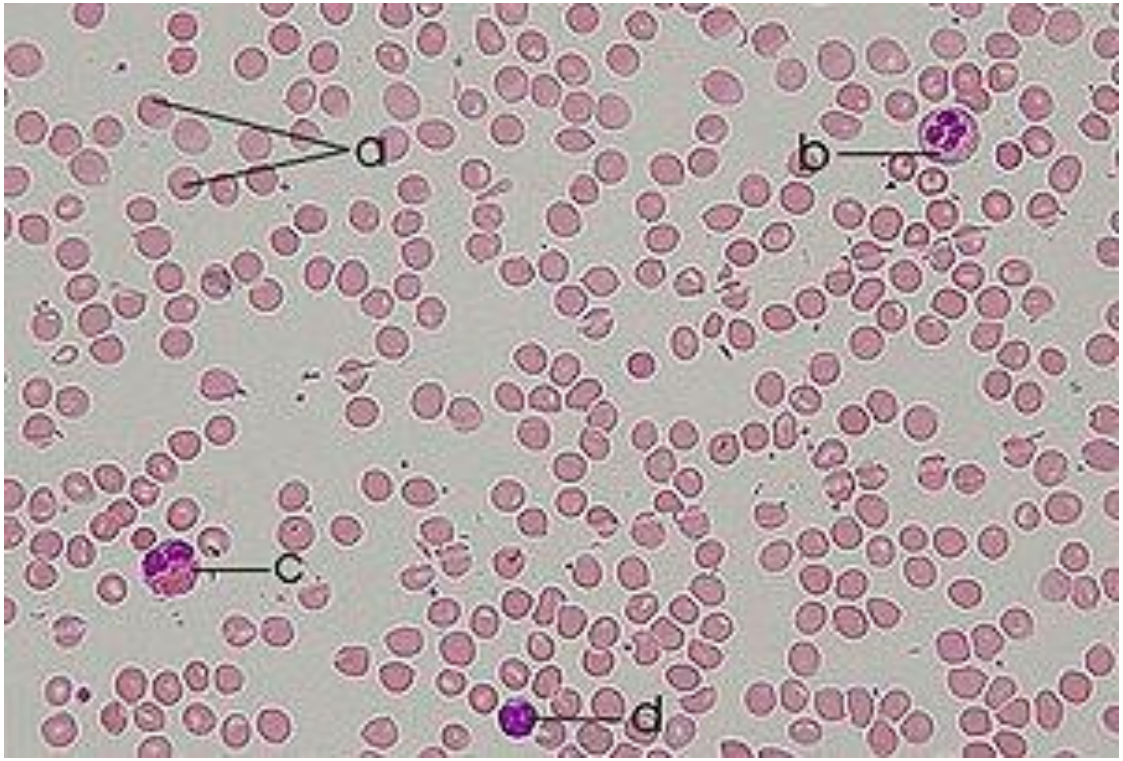
- Granulocytes: - Neutrophil (= Polymorphonuclear leukocytes)→ phagocytosis
  - Eosinophil
  - Basophil


- Monocytes: become macrophages in the tissues → phagocytosis



Blood smear



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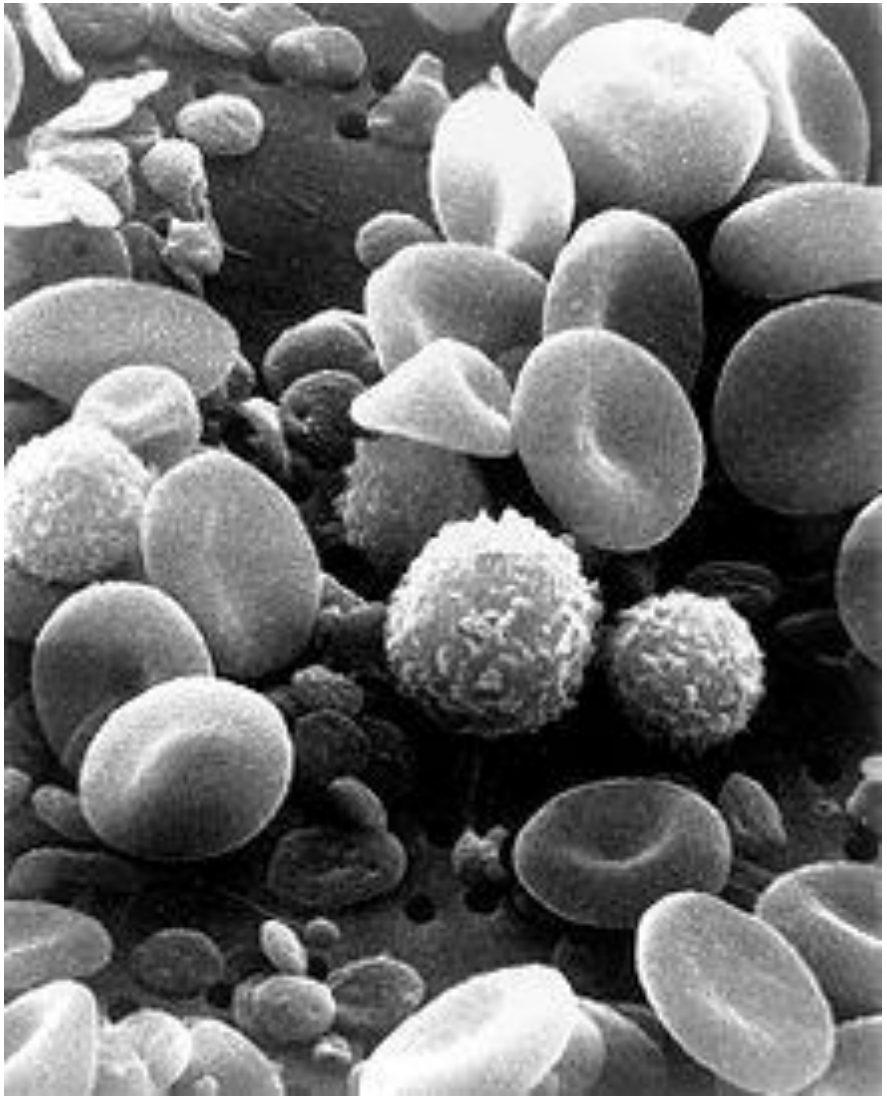
a) Red blood cells
b) Neutrophil granulocyte
c) Eosinophil granulocyte
d) Lymphocyte

Scanning electron microscope image



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Immune system

- Protects the body against pathogens (bacteria, viruses, parasites, fungi) and tumor cells
- Provides protection for self-antigens during immune response (prevents autoimmunity)

- Cells of the immune system
  = White blood cells

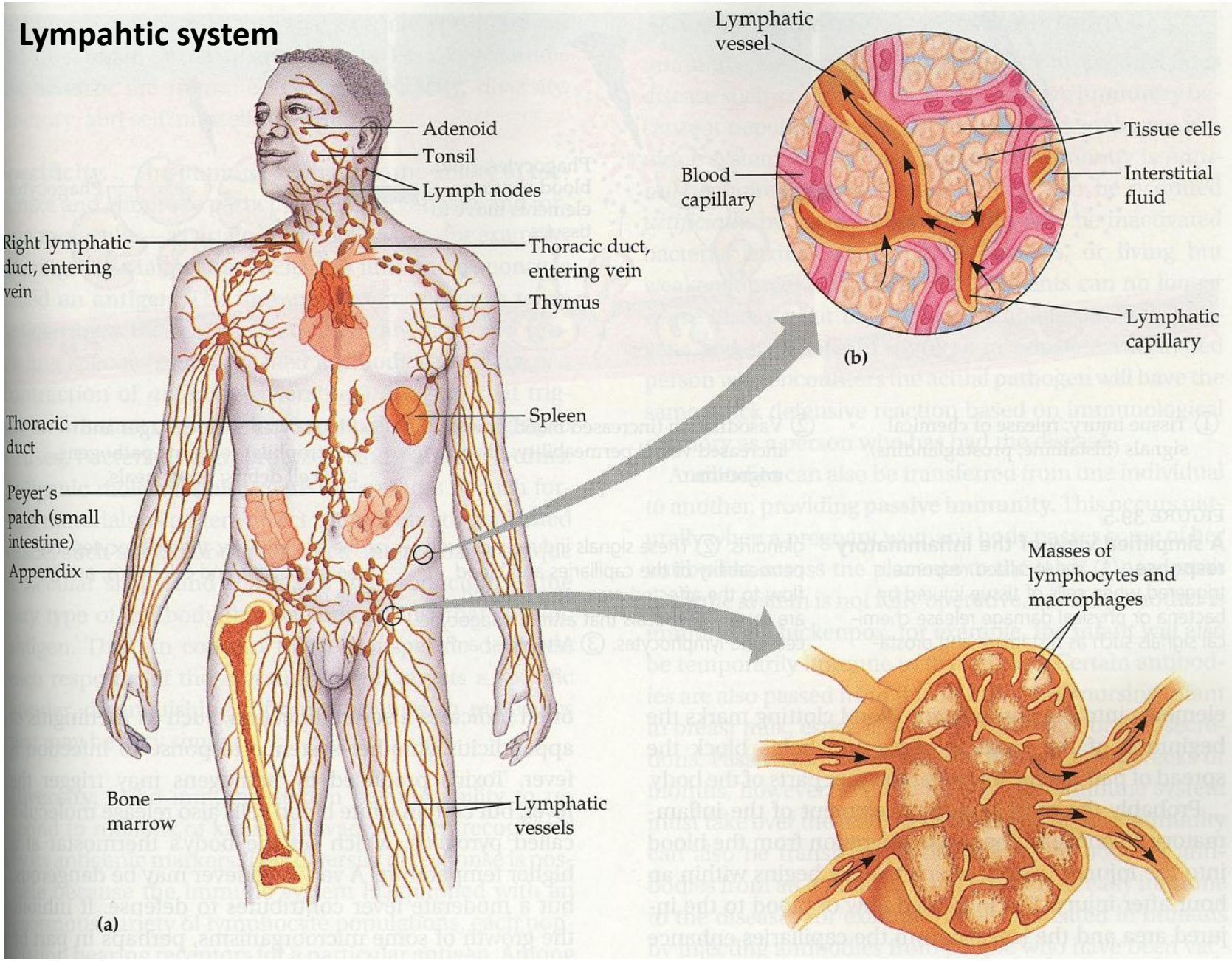
Organs of the immune system

1. Primary/Central: producing immune cells
   - Bone marrow
   - Thymus

   (- Embryonic liver)
2. Secondary/Peripheral
   - Spleen
   - Lymph nodes
   - MALT (Mucosa associated lymphatic tissue)

     /contains the Tonsils, Peyer`s patches in the small intestines and the appendix/
   - SALT (Skin associated lymphatic tissue)

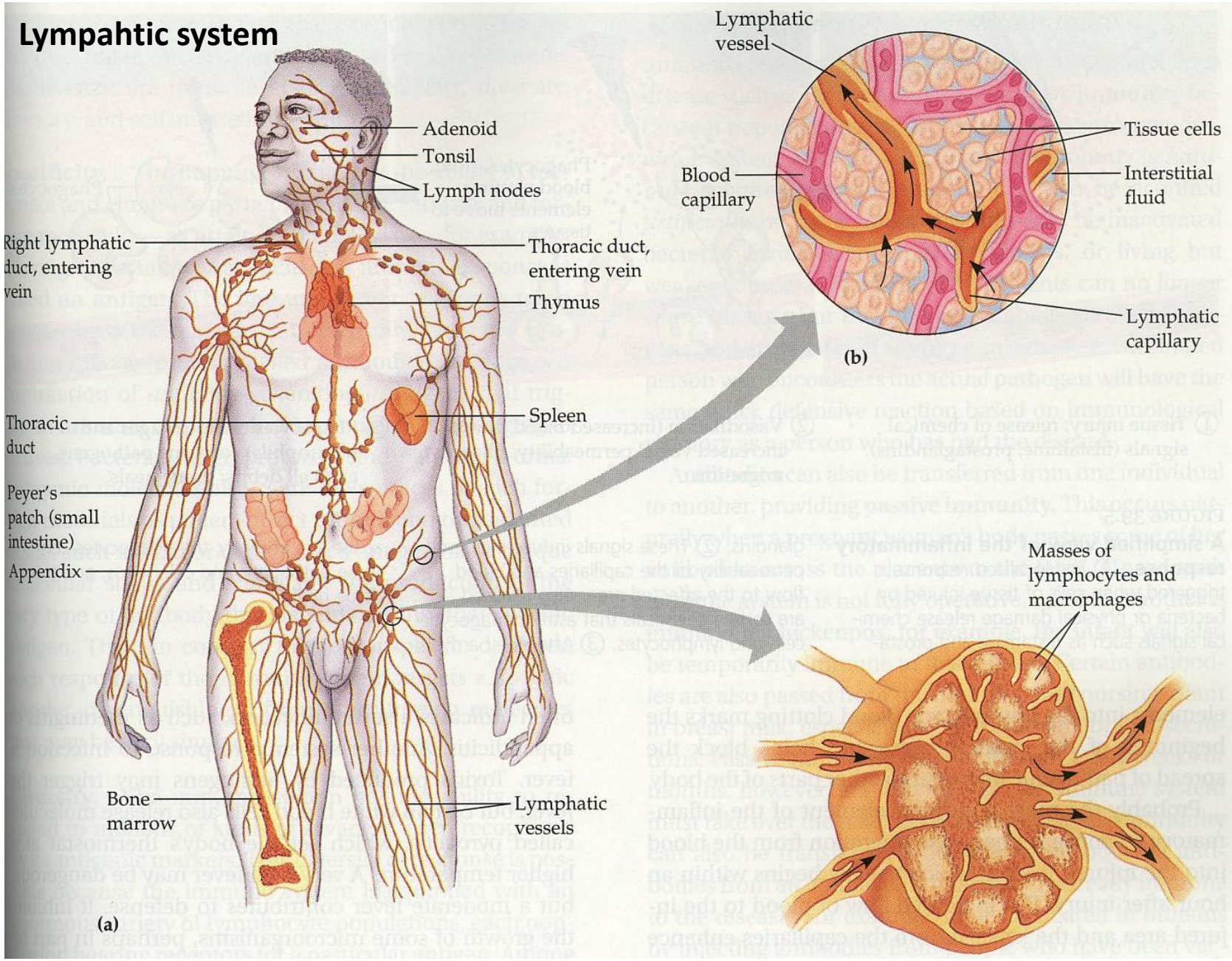
Lympahtic system



Lymph

- Tissue fluid (= Interstitial fluid)
- Comes from the blood through capillaries
- Contains materials produced by the cells
- Enters lymphatic capillaries → lymphatic vessels → lymph nodes → thoracic duct → big vein (blood)
- The lymphatic system provides important sites for the maturation, production, differentiation and storage of immune cells

Lympahtic system



Defense system of the body

1st line of defense

(non-specific, mechanical protection)

- Skin and mucous membrane
  - Tightly packed epithelial cells of the skin
  - Mucous membrane – pH 3-5
  - Saliva, tears wash away microorganism
  - Most microorganism taken up with food destructed by very acidic gastric juice
  - When skin injury occurs invasion of pathogens (microorganism, bacteria, viruses) is possible.

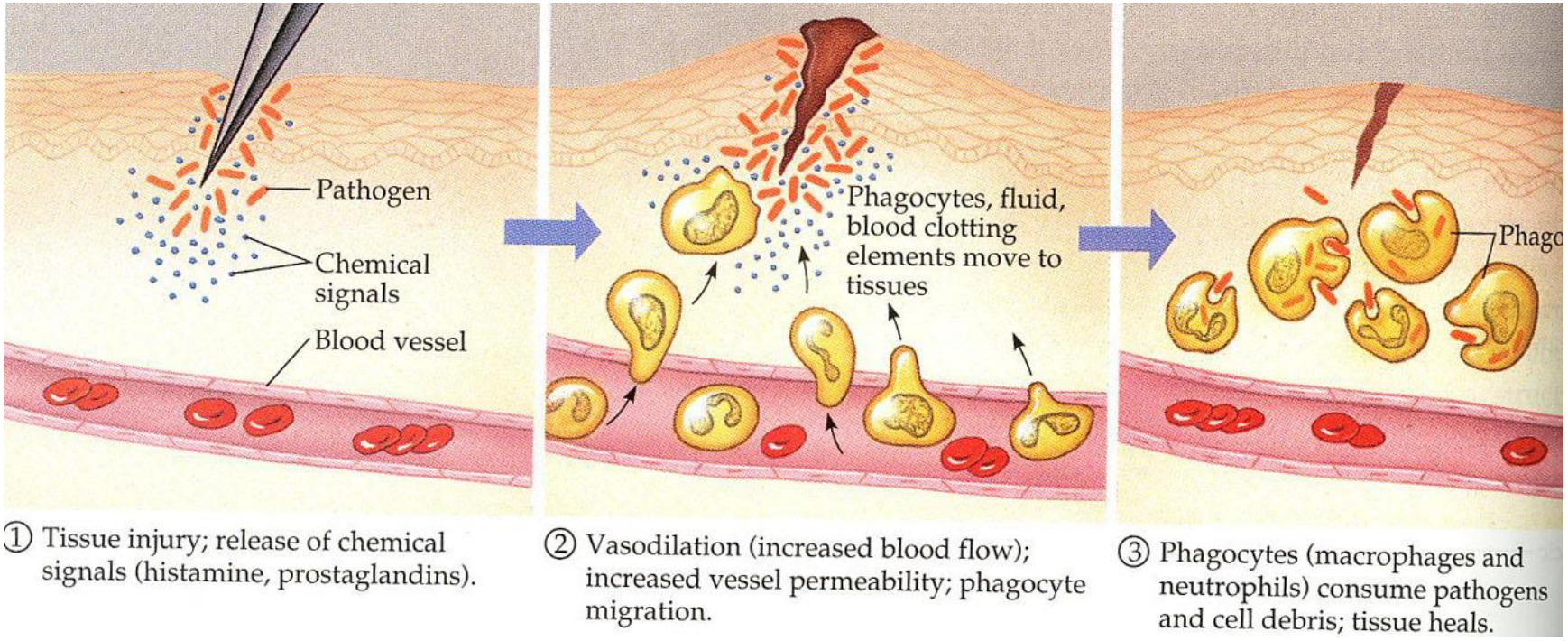
    This evokes second and third line of defense.

2nd line of defense

(non-specific, innate immunity)

- Phagocytic white blood cells
  - Granulocytes
    - They are generated in bone marrow.
    - They are normally in the blood but can leave the blood vessels, and enter the infected tissue with amoeboid movement.
    - They destroy micororganisms, and they tend to destroy themselves.
    - **Pus** is composed of dead micororganisms and the dead granulocytes .
    - They have short life-time.
  - Monocytes/Macrophages
    - They are generated in bone marrow.
    - They are “big eaters” and long-living cells.
    - They form pseudopodia and engulf microorganism.
    - Then they digest with lysosomal enzymes.

Immuno-response after tissue injury



① Tissue injury; release of chemical signals (histamine, prostaglandins).

② Vasodilation (increased blood flow); increased vessel permeability; phagocyte migration.

③ Phagocytes (macrophages and neutrophils) consume pathogens and cell debris; tissue heals.

3rd line of defense (specific, adaptive immunity)

- Lymphocytes
  - They belong to white blood cells
  - They are generated in bone marrow
  - Two major types of lymphocytes
    - B-lymphocytes (humoral immune response)
    - T-lymphocytes (cellular immune response and regulation of other immune responses)
  - Maturation of **B**-lymphocytes occur in **B**one marrow
  - Maturation of **T**-lymphocytes occur in **T**hymus
  - After their maturation both types of lymphocytes populate lymphatic organs such as lymph nodes, spleen, tonsils etc.
  - Lymphocytes can be also found in blood

Specific immune responses

1. Humoral immune response (B-lymphocytes produce **ANTIBODIES**= Immunoglobulins)

   → against extracellular pathogens (bacteria)

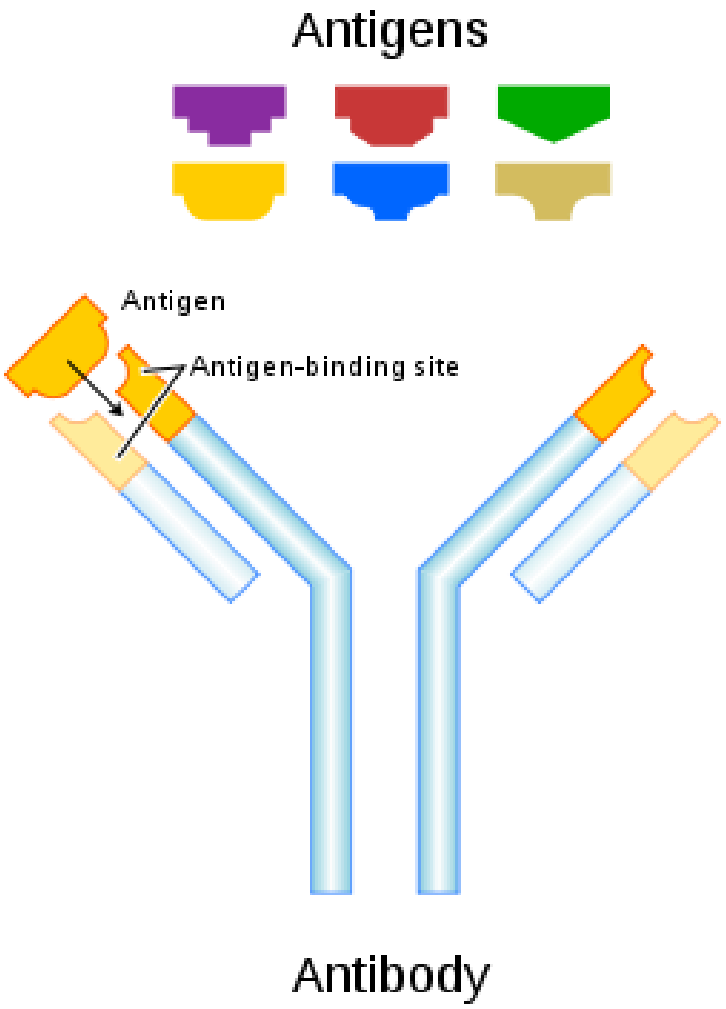
2. Cellular immune response (T-lymphocytes and other cells) → against intracellular pathogens (viruses) and tumor cells

Humoral immune response

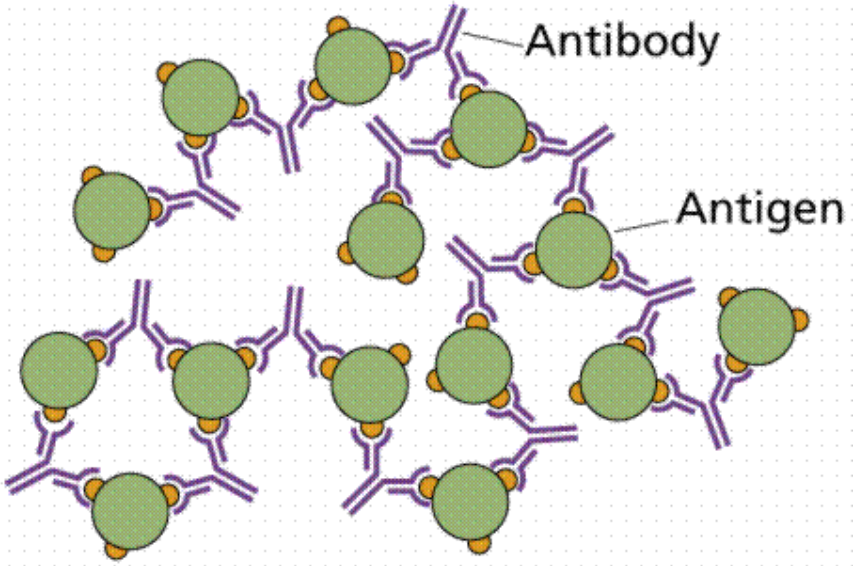
- Humoral immune response results in the production of **ANTIBODIES**
- Antibodies are produced and secreted by B lymphocytes.
- Antibodies circulate in body fluids (blood, lymph, EC fluid) that are called humors.
- Antibodies recognize antigens.
- T cells have an important role in the regulation of the humoral immune response

http://www.youtube.com/watch?v=hQmaPwP0KRI&feature=related

Antibody = Immunoglobulin



- Y-shaped proteins
- 2 **H**eavy and 2 **L**ight chains
- Disulphide bonds between them



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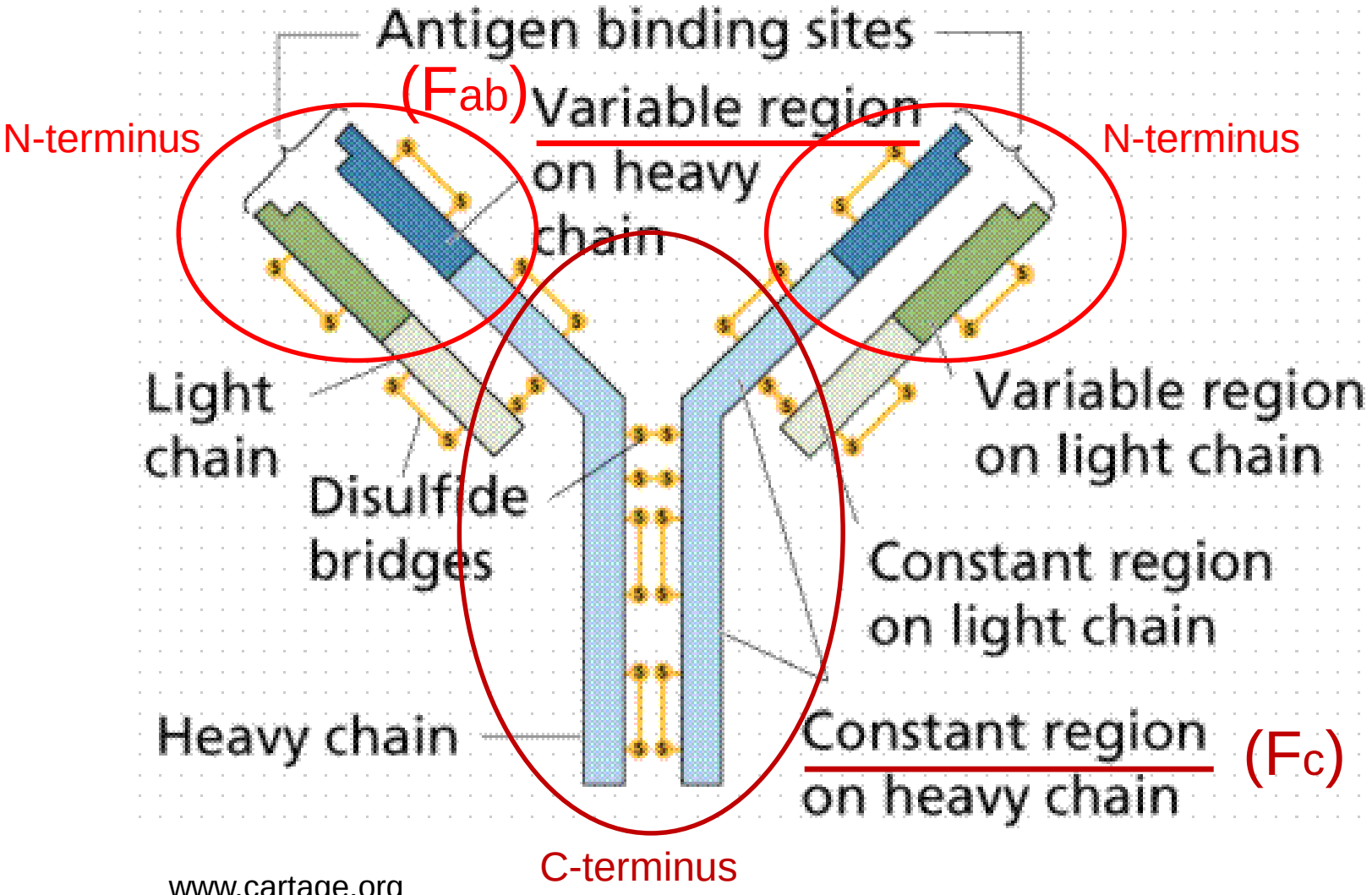
Antibody


Antigen binding sites
(Fab)
Variable region on heavy chain
N-terminus
N-terminus
Light chain
Disulfide bridges
Variable region on light chain
Constant region on light chain
Heavy chain
Constant region on heavy chain
(Fc)
C-terminus

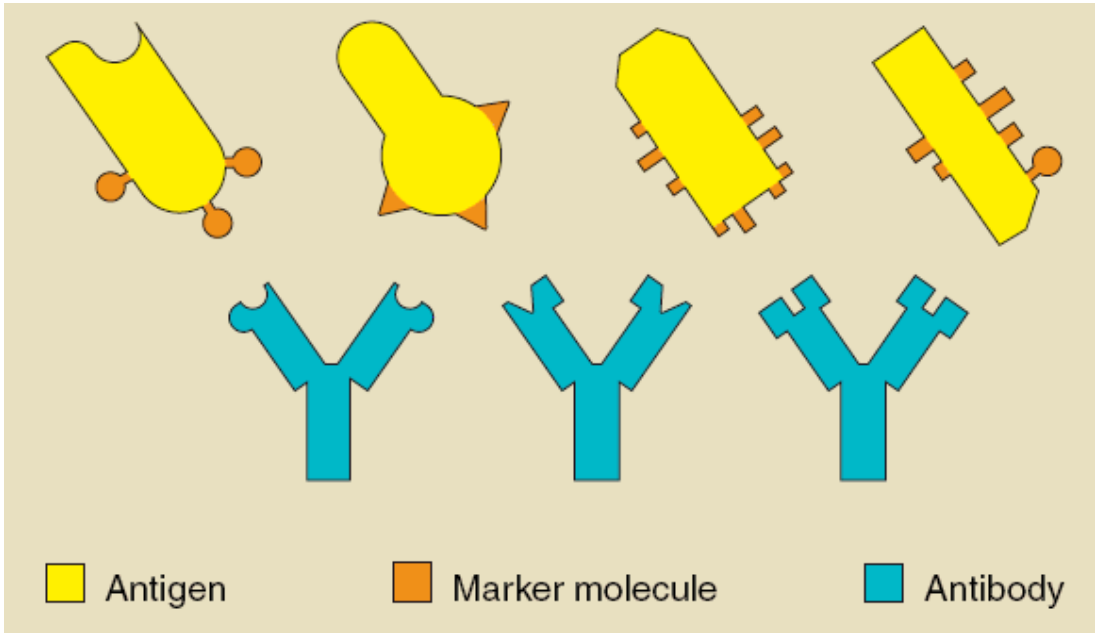
Antigen

- Antibody generator
- **All structures** (foreign or self) **which can be recognized by the immune system** is called antigen
- They induce immune response (elimination or tolerance)
- What can be an antigen?

-Proteins
- Polysacharides
- Lipids
- Nucleic acids

Antigen-antibody complex

- All antigens can be recognized by specific antibodies
- If an antibody binds to its antigen they form an antigen-antibody complex (immunocomplex)

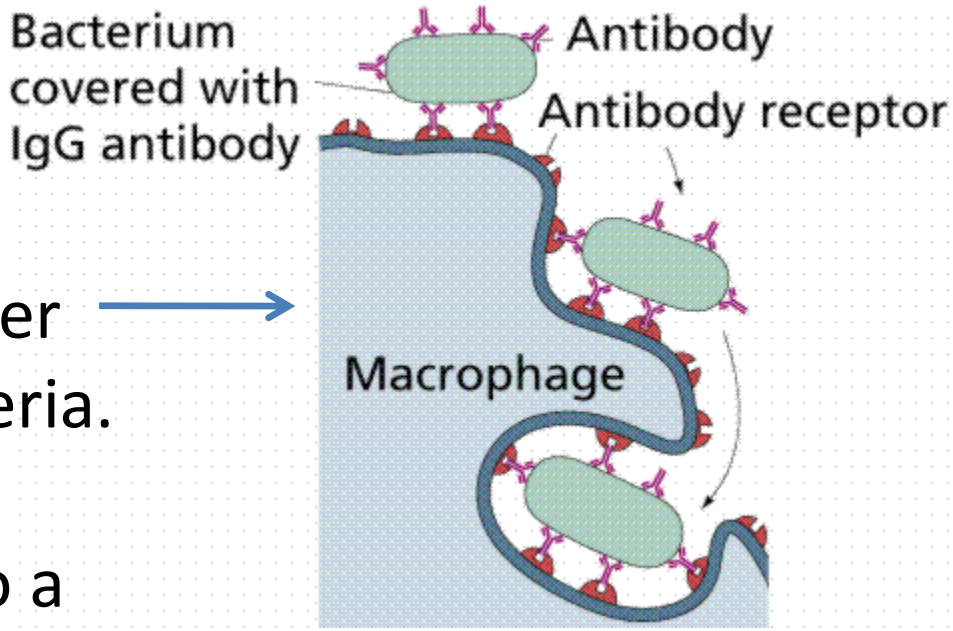


Consequence of antigen-antibody binding

– Antibody can block the antigen and make it ineffective.

– Antibody can clump antigens (e.g. bacterial antigens) and makes easier the phagocytosis of bacteria.

– After antibody binds to a bacterial antigen, a protein complex is formed that allows lysis (bursting) of the bacteria.



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Cellular immune response

- It is based on direct action of lymphocytes.
- T lymphocytes have important role in cellular immune response .
- In one form of cellular immune response, T lymphocytes directly act and destroy the cell containing the antigens (infected cell).

http://www.youtube.com/watch?v=1tBOmG0QMbA

Features of immune response

- Specificity
  - Antigen-antibody reaction is specific
- Diversity
  - Large variety of lymphocyte population
- Memory
  - Immune system has the capability to remember antigens
- Self/non-self recognition
  - Immune system distiguishes the body's own molecules from foreign molecules

BLOOD GROUPS (BLOOD TYPES)

- Determined by antigens (glycolipids, glycoproteins) on the surface of red blood cells and other cells. They could provoke an immune reaction in the recipient after transfusion or transplantation.
- There are 30 different blood type systems. 2 of them have major impact: AB0 and Rh systems.

AB0 transfusion chart

What matters is the antigen of the donor and the antibodies of the recipient

Recipient's blood group and antibodies present in his/her blood

Donor's blood group and antigens present on his/her red blood cells

	A	B	AB	0
A	OK	NOT	OK	NOT
B	NOT	OK	OK	NOT
AB	NOT	NOT	OK	NOT
0	OK	OK	OK	OK

AB0 blood types

- Because of the large size of the antibodies, which cannot penetrate the placenta, there is no reaction in the fetus during pregnancy.
- The inheritance is co-dominant.
- Recessive allele: i
- ii: 0 blood type
- dominant alleles: I^A, I^B
- I^AI^B: AB type,
- I^AI^A or I^Ai: A type,
- I^BI^B or I^Bi: B type

Rh blood type

- The D antigen is the most important:
- Rh+: DD or Dd
- Rh-: dd (no antigen)
- Rh- receiving Rh+ blood causes immune reaction
- Small antibodies→ immune reaction of mother (Rh-mother, Rh+ fetus)
- Distribution in the population:

O+	A+	B+	AB+	O-	A-	B-	AB-
36.44%	28.27%	20.59%	5.06%	4.33%	3.52%	1.39%	0.45%