Tikrit University
College of Veterinary Medicine

The blood

Subject name: physiology

Subject year:2nd

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Lecturers link

The blood:

Blood is a body fluid (connective tissue) in the circulatory system of humans and other vertebrates that delivers necessary substances such as nutrients and oxygen to the cells, and transports metabolic waste products away from those same cells.

The function of blood:

1. Respiration: transport of O2 and CO2
2. Transport: hormone, nutrients, metabolic waste.
3. Excretion of metabolic wastes to the kidney, lungs and skin.
4. Regulation of body temperature by distribution of body heat.
5. Defense against infections (WBCs, antibodies).
6. Maintenance of acid-base balance
7. Nutrition: transport of absorbed food material.

Blood Composition

1- Blood plasma contain:

•90% Water

•Proteins 8% w/v

–Blood proteins, also termed plasma proteins, are proteins present in blood plasma. They serve many different functions, including transport of lipids, hormones, vitamins and minerals in activity and functioning of the immune system.

–**Albumin (60 %):**

-Produced by the liver

-Maintain osmotic pressure

-Transport hormones and enzymes

-Globulins (36%) :

-Alpha and Beta Globulins: produced by the liver, transport lipids, metals and fat soluble vitamins

-Gamma Globulins: Antibodies released by plasma cells in response to immune response

–Fibrinogens (4%):

-Produced by the liver, form fibrin fibers of blood clots

Gas

•**Electrolytes:**

-Na+, K+, Ca2+, Mg2+, Cl-, SO4-, HCO3

-Maintain plasma osmotic pressure, and pH.

Organic Nutrients

–Carbohydrates

–Amino Acids

–Lipids

–Vitamins

•**Hormones:** Steroid and thyroid hormones are carried by plasma proteins

•**Metabolic waste**

–CO2, urea, uric acid, creatinin, ammonium salts

Buffy Coat < 1%

Platelets

•Leukocytes.

Formed Elements of the Blood - 45%

. Erythrocytes (red blood cells).

•Leukocytes (white blood cells).

•Platelets (thrombocytes).

Erythrocytes: (red blood cells).

•Diameter: 7.5 mm

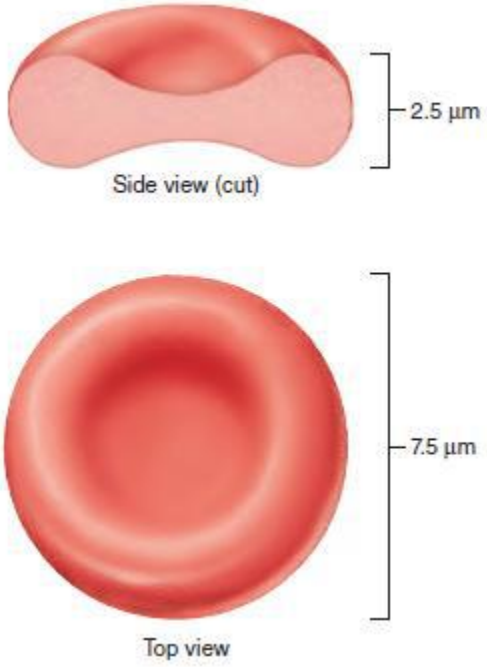
•Morphology: biconcave discs—flattened discs with depressed centers

•Anucleate and have essentially no organelles

•Contain 97% hemoglobin

•Contain antioxidant enzymes that rid the body of harmful oxygen radicals.

•Function- transport respiratory gases



•Hemoglobin- quaternary structure, 2 α chains and 2 β chains
•Lack mitochondria, because they generate ATP by anaerobic mechanisms, therefore they do not consume any of the oxygen they carry

•An RBC contains 280 million hemoglobin molecules

•Life span 100-120 days and then are destroyed in spleen (RBC graveyard).

RBC count:

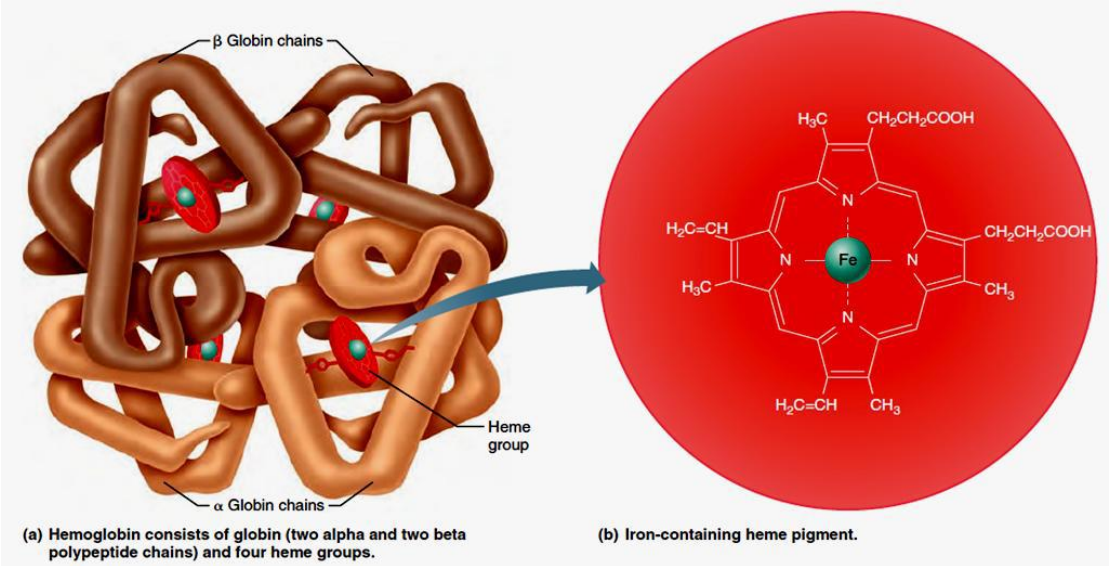
•Men: 4.7–6.1 million cells/ microliter

•Women: 4.2- 5.4 million cells/ microliter

•Erythrocytes are the major factor contributing to blood viscosity.

•When the number of Erythrocytes increases beyond the normal range, blood becomes more viscous and flows more slowly.

•When the number of Erythrocytes drops below the lower end of the range, the blood thins and flows more rapidly



(a) Hemoglobin consists of globin (two alpha and two beta polypeptide chains) and four heme groups.

(b) Iron-containing heme pigment.

Hemoglobin:

Normal values for hemoglobin are 13–18 g/100 ml in adult males, and 12–16 g/100 ml in adult females

•Hemoglobin is made up of the red heme pigment bound to the protein globin.

•Globin consists of four polypeptide chains: two alpha (α) and two beta (β)—each binding a ring-like heme

•Each heme group bears an atom of iron in its center

A hemoglobin molecule can transport four molecules of oxygen because each iron atom can combine reversibly with one molecule of oxygen.

•A single RBC contains about 250 million hemoglobin molecules, so each RBC can carry about 1 billion molecules of oxygen

Hematopoiesis

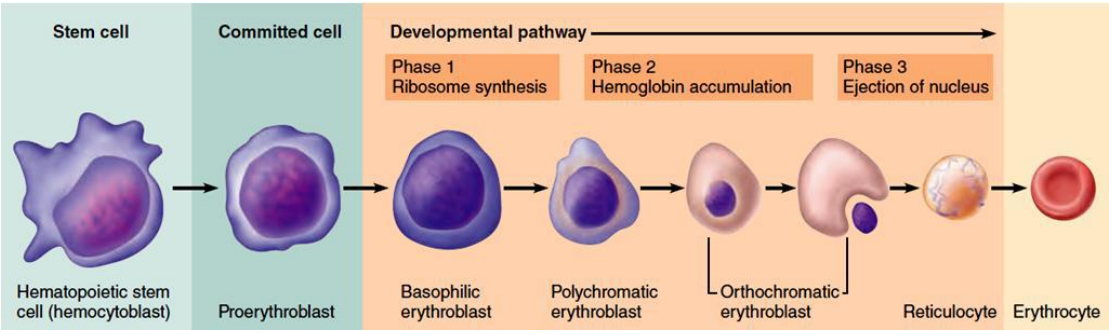
•Hematopoiesis (hemopoiesis): blood cell formation

•Occurs in red bone marrow of axial skeleton, girdles and proximal epiphyses of humerus and femur

•On average, the marrow turns out an 29.5 ml of new blood containing 100 billion new cells every day

Hemocytoblasts (hematopoietic stem cells) Give rise to all formed elements

•Hormones and growth factors push the cell toward a specific pathway of blood cell development



Erythropoiesis:

•Erythropoiesis: red blood cell production.

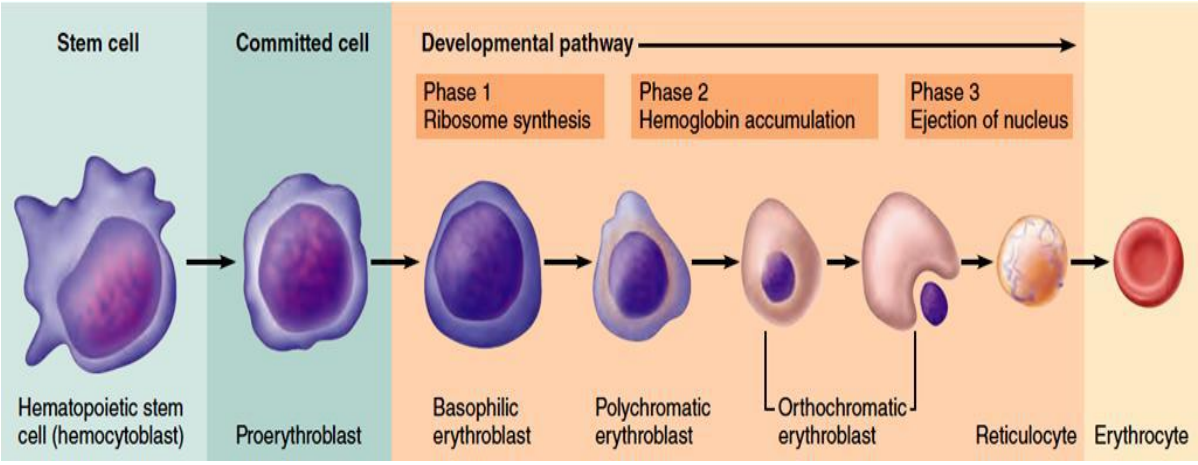
•A hematopoietic stem cell descendant called a myeloid stem cellmtransforms into a proerythroblast

•Proerythroblasts develop into basophilic erythroblasts.

-Hemoglobin is synthesized and iron accumulates as the basophilic erythroblast transforms into a polychromatic erythroblast and then an orthochromatic erythroblast.

•Reticulocytes (account for 1–2% of all erythrocytes) are formed after ejection all of the organelles and the nuclei

•Reticulocytes fully mature to erythrocytes within two days of release as their ribosomes are degraded by intracellular enzymes.



Regulation of Erythropoiesis

•Too few RBCs lead to tissue hypoxia

•Too many RBCs increases blood viscosity

•Balance between RBC production and destruction depends on

–Hormonal controls: Erythropoietin (EPO)

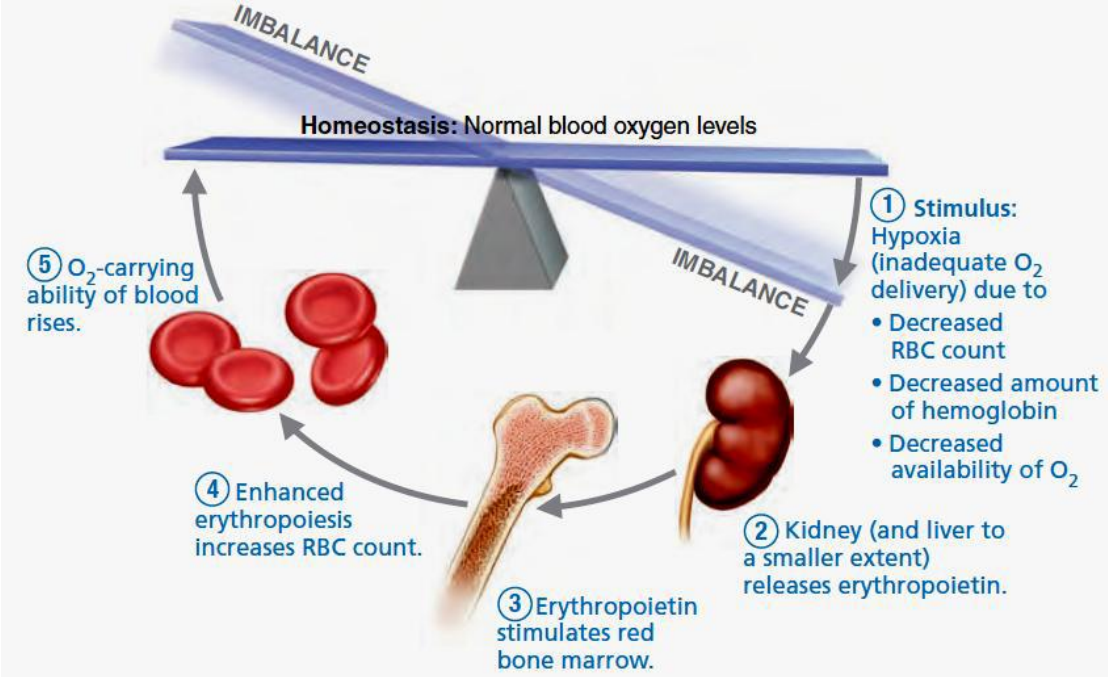
–Adequate supplies of iron, amino acids, and B vitamins.

Hormonal Control of Erythropoiesis

•Erythropoietin (EPO)

–Direct stimulus for erythropoiesis

–Released by the kidneys in response to hypoxia



Hormonal Control of Erythropoiesis

•Causes of hypoxia

–Hemorrhage or increased RBC destruction reduces RBC numbers

–Insufficient hemoglobin per RBC (e.g., iron deficiency)

–Reduced availability of O2 (e.g., high altitudes) or during pneumonia

•Effects of EPO

–More rapid maturation of committed bone marrow cells

•Increased circulating reticulocyte count in 1–2 days after erythropoietin levels rise in the blood

•hypoxia does not activate the bone marrow directly. Instead it stimulates the kidneys to provide EPO

•Testosterone also enhances EPO production, resulting in higher RBC counts in males.

Fate and Destruction of Erythrocytes

•Life span of RBC ranges from 100 to 120 days

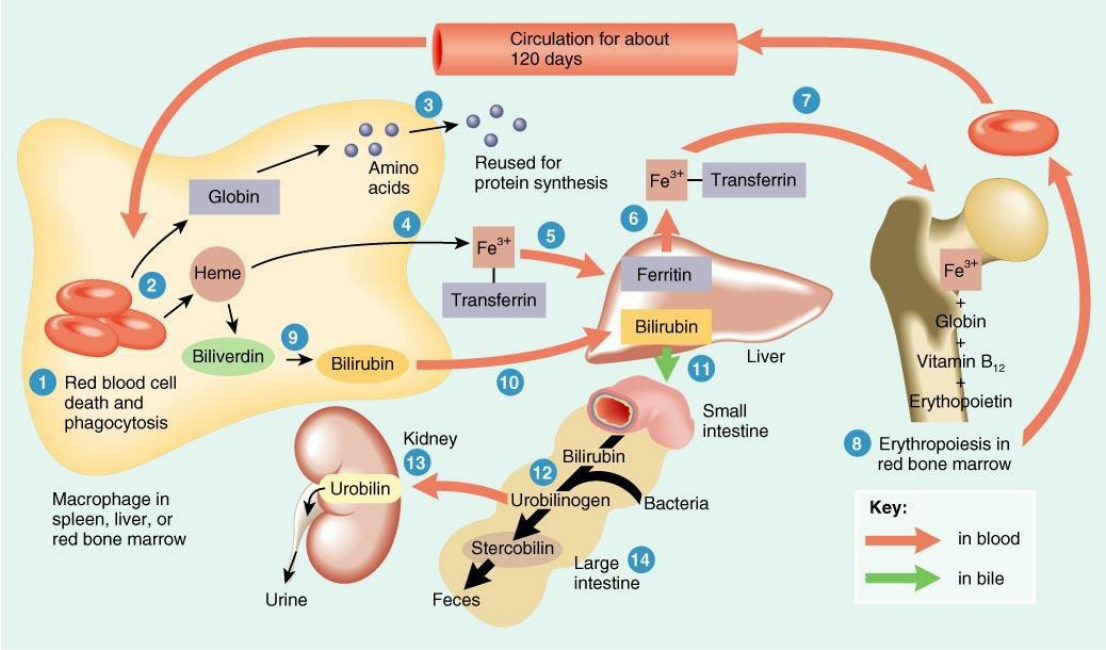
•Erythrocytes become "old" as they lose their flexibility, become increasingly rigid and fragile, and their hemoglobin begins to degenerate.

•They are trapped and fragmented by the spleen "red blood cell graveyard."

•Macrophages engulf and destroy dying erythrocytes.

•The heme is seperated from globin.

•Its core of iron is salvaged, bound to protein (as ferritin or hemosiderin), and stored for reuse.



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•Most of this degraded pigment leaves the body in feces, as a brown pigment called **stercobilin**.

•Some of **urobilinogen** (coloreless) is reabsorbed from the intestine, and converted into urobilin (yellow color) that is excreted by the kidneys.

•The protein (globin) part of hemoglobin is metabolized or broken down to amino acids, which are released to the circulation.

Leukocytes (White Blood Cells)

•On average, there are 4800–10,800 WBCs/µl of blood

•Leukocytes are grouped into two major categories on the basis of structural and chemical characteristics.

Granulocytes: contain obvious membrane-bound cytoplasmic granules, and

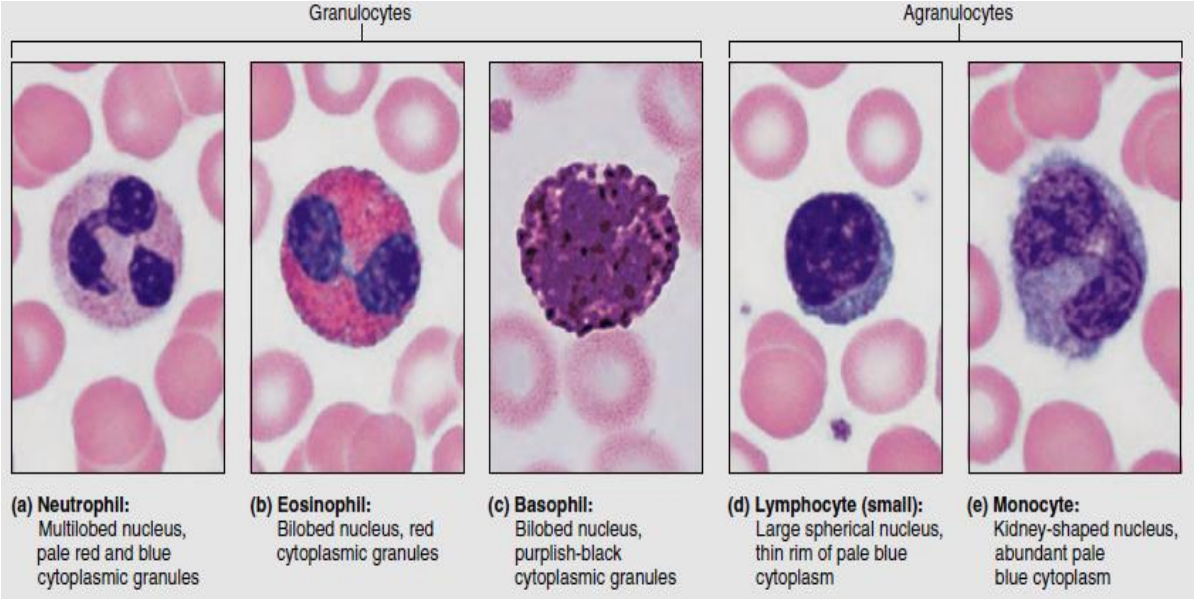
Agranulocytes: lack obvious granules .

Granulocytes

•Include: neutrophils, eosinophils, and basophils

•They have lobed nuclei

•Functionally, all granulocytes are phagocytes to some degree



Neutrophils

•Also called Polymorphonuclear leukocytes (PMNs)

•Account for 50–70% of the WBC population

•About twice as large as erythrocytes

•Their numbers increase explosively during acute bacterial infections.

•Some of their granules contain hydrolytic enzymes, and are regarded as lysosomes.

•Others, especially the smaller granules, contain a potent "brew" of antimicrobial proteins, called **defensins** that pierce holes in the membrane of the ingested pathogen**.**

•They also kill pathogens by respiratory burst (the cells metabolize oxygen to produce potent germ-killer oxidizing substances such as bleach and hydrogen peroxide.

•Neutrophils are chemically attracted to sites of inflammation and are active phagocytes.

Eosinophils

•Account for 2–4% of all leukocytes

•Their granules are lysosome-like and filled with a unique variety of digestive enzymes.

•They lack enzymes that specifically digest bacteria.

Eosinophils

•The most important role is to lead the counterattack against parasitic worms, such as flatworms (tapeworms and flukes) and roundworms (pinworms and hookworms) that are too large to be phagocytized

•They release the enzymes from their cytoplasmic granules onto the parasite's surface to digesting it

•Eosinophils have complex roles in many other diseases including allergies and asthma

Basophils

•The rarest white blood cells, accounting for only 0.5–1% of the leukocyte population

•Their cytoplasm contains large, coarse, histamine-containing granules

•Histamine is an inflammatory chemical that acts as a vasodilator (makes blood vessels dilate) and attracts other white blood cells to the inflamed site

•Granulated cells similar to basophils, called *mast cells, and are* found in connective tissues. They also release histamine.

Agranulocytes

•Include lymphocytes and monocytes

•Lack visible cytoplasmic granules.

Lymphocytes

•Accounting for 25% of the WBC population

•Few are found in the bloodstream, as they are closely associated with lymphoid tissues (lymph nodes, spleen, •etc.), where they play a crucial role in immunity.

•**T lymphocytes (T cells)** function in the immune response by acting directly against virus-infected cells and tumor cells.

•**B lymphocytes (B cells)** give rise to *plasma cells, which produce antibodies.*

Monocytes

•Account for 3–8% of WBCs

•When circulating monocytes leave the bloodstream and enter the tissues, they differentiate into highly mobile **macrophages**.

•Macrophages are actively phagocytic, and they are crucial in the body's defense against viruses, certain intracellular bacterial parasites, and chronic infections such as tuberculosis

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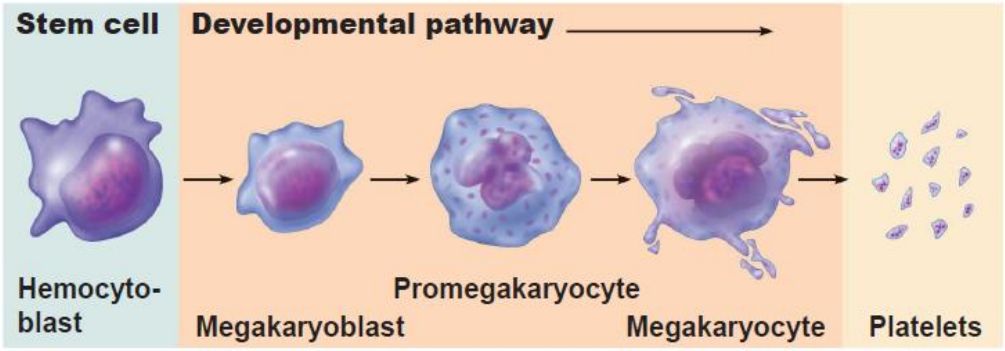
Platelets

•They are not cells in the strict sense

•they are cytoplasmic fragments of extraordinarily large cells called **megakaryocytes**

•Their granules contain lots of chemicals that act in the clotting process, (including serotonin, Ca2+, a variety of enzymes, ADP, and platelet derived growth factor (PDGF)).



Hemostasis

Step 1: Vascular spasm Smooth muscle contracts causing vasoconstriction Step 2:

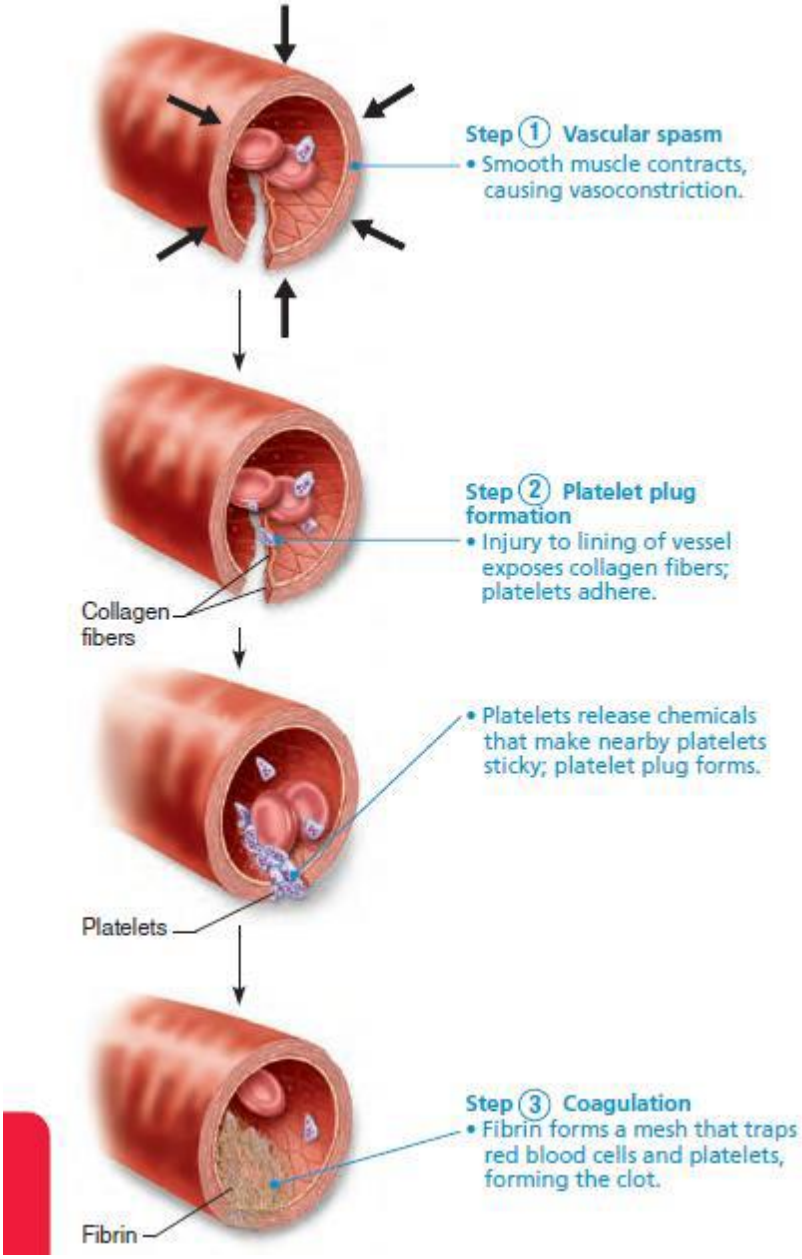
•Platelet plug formation Injury to lining of vessel exposing collagen fibers, platelets adhere.

•Platelets release chemicals that make nearby platelets sticky, platelet plug forms

Step 3: Coagulation

•Fibrin forms a mesh that traps RBCs & platelets, forming the clot.

direct injury to vascular smooth muscle, chemicals released by endothelial cells and platelets, and reflexes initiated by local pain receptors.



As a rule, platelets do not stick to each other or to the smooth endothelial linings of blood vessels.

•Intact endothelial cells release nitric oxide and a prostaglandin called prostacyclin (or PGI2).

•Both chemicals prevent platelet aggregation in undamaged tissue and restrict aggregation to the site of injury.

•However, when the endothelium is damaged and the underlying collagen fibers are exposed, platelets adhere tenaciously to the collagen fibers.

•A large plasma protein called von Willebrand factor stabilizes bound platelets by forming a bridge between collagen and platelets.

•Platelets swell, form spiked processes, become stickier, and release chemical messengers including the following:

Adenosine diphosphate (ADP)—a potent aggregating agent that causes more platelets to stick to the area and release their contents

Serotonin and Thromboxane A2 messengers that enhance vascular spasm and platelet aggregation.

Coagulation (blood clotting)

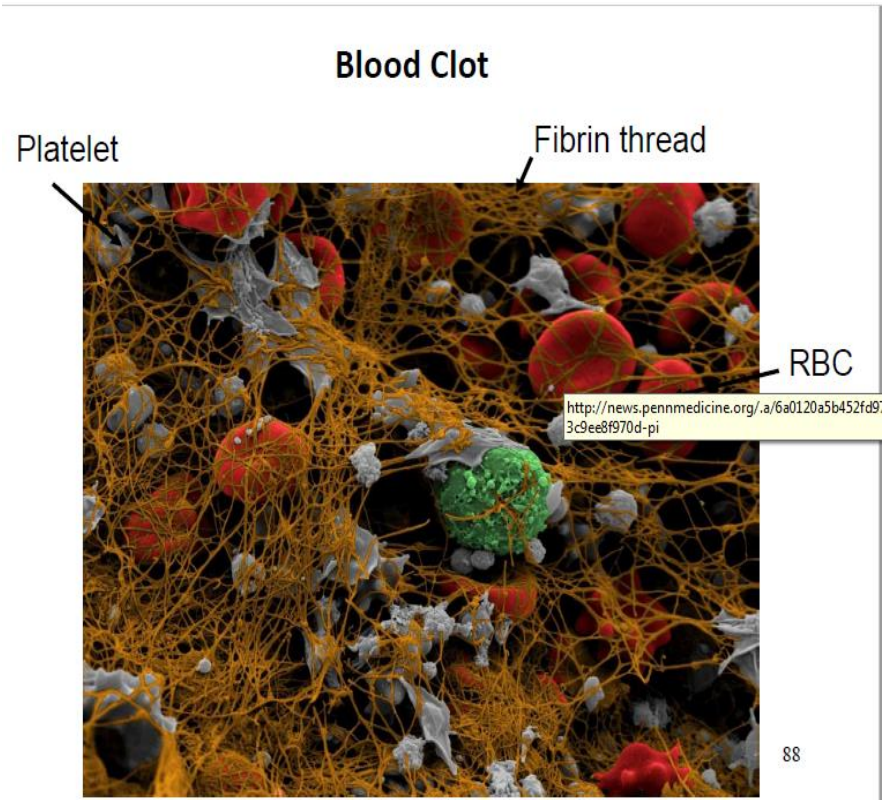
•Reinforces the platelet plug with fibrin threads that act as a "molecular glue" for the aggregated platelets

•Blood is transformed from a liquid to a gel in a multistep process hat involves a series of substances called clotting factors (procoagulants)

•Most clotting factors are plasma proteins synthesized by the liver. They are numbered I to XIII according to the order of their discovery

•Vitamin K (fat-soluble vitamin) is required for synthesizing four of the clotting factors

•In most cases, activation turns clotting factors into enzymes, except factor IV (Ca2+) and I (Fibrinogen)


Blood Clot
Platelet
Fibrin thread
RBC
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