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# Blood and Body Fluids

**Anatomy & Physiology**

Composition and functions of blood, plasma, blood cells, haemoglobin, blood groups, coagulation and immunity.

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## Blood as a transport and regulatory tissue

Blood is a fluid connective tissue consisting of plasma and formed elements: erythrocytes, leukocytes and platelets. It transports respiratory gases, nutrients, metabolic wastes and hormones; distributes heat; supports defence; and contributes to fluid and pH regulation. Adult blood volume depends on body size, pregnancy and clinical condition, so fixed textbook volumes are approximations rather than universal assessment targets.

Plasma contains water, electrolytes, nutrients, wastes and proteins. Albumin contributes strongly to plasma oncotic pressure and transports several substances. Globulins include transport proteins and immunoglobulins. Fibrinogen is a clotting precursor. Serum is the fluid remaining after blood clots, with fibrinogen and some clotting components removed or consumed. Plasma belongs to extracellular fluid and exchanges material with interstitial fluid across capillaries.

## Erythrocytes and haemoglobin

Mature erythrocytes are flexible biconcave cells lacking a nucleus and mitochondria. Their shape provides a large exchange surface and allows passage through narrow capillaries. Haemoglobin contains four globin chains with iron-containing haem groups. One haemoglobin molecule can bind up to four oxygen molecules. Binding is reversible, permitting oxygen loading in lungs and unloading in tissues.

Erythropoiesis occurs in red bone marrow. Reduced renal oxygen availability stimulates erythropoietin release, which promotes red-cell production. Iron, amino acids, vitamin B12 and folate support normal production. Erythrocytes circulate for approximately 120 days before macrophages remove ageing cells. Iron is recycled; haem breakdown produces bilirubin for hepatic processing and biliary excretion. Reticulocytes are recently released erythrocytes and help indicate marrow response.

## Leukocytes, platelets and immune function

| Element | Main function | Nursing connection |
|---|---|---|
| Neutrophils | Rapid phagocytic response, especially to bacterial infection | Interpret the differential count with symptoms |
| Lymphocytes | B-cell antibody responses, T-cell responses and natural killer activity | Connect adaptive responses with immune memory |
| Monocytes | Enter tissues and may develop into macrophages | Phagocytosis and antigen presentation |
| Eosinophils and basophils | Roles in parasite responses, allergy and inflammatory signaling | A raised count requires contextual interpretation |
| Platelets | Cell fragments from megakaryocytes; adhere and aggregate at injury | Observe mucosal bleeding, petechiae and procedure sites |

Innate immunity acts rapidly through barriers, phagocytes, complement and inflammatory responses. Adaptive immunity is antigen-specific and develops memory. B cells can become antibody-secreting plasma cells; T cells

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coordinate responses or destroy selected infected cells. Active immunity follows an individual's own response, whereas passive immunity transfers existing antibodies and is temporary. Inflammation is a protective process, but excessive or misdirected responses can injure tissues.

## Haemostasis and clot removal

Haemostasis limits blood loss while preserving flow elsewhere. Its linked phases are vascular spasm, platelet-plug formation and coagulation. Injury exposes adhesive surfaces; von Willebrand factor helps platelet adhesion. Activated platelets recruit others, producing a temporary plug. Coagulation reactions generate thrombin, which converts soluble fibrinogen into fibrin. Fibrin stabilizes the platelet plug, and clot retraction draws wound edges together.

The intrinsic and extrinsic pathways are useful laboratory teaching models that converge on a common pathway; actual clotting in vivo is a connected, cell-based process. Calcium and multiple clotting factors are required. Vitamin K supports synthesis of several hepatic clotting proteins. Anticoagulant mechanisms restrict clotting, and fibrinolysis uses plasmin to break down fibrin during repair. Haemostasis, thrombosis and fibrinolysis are related but distinct concepts.

## ABO and Rh blood groups

| Group | Red-cell ABO antigens | Usual plasma ABO antibodies |
|---|---|---|
| A | A | Anti-B |
| B | B | Anti-A |
| AB | A and B | Neither anti-A nor anti-B |
| O | Neither A nor B | Anti-A and anti-B |

Group A erythrocytes carry A antigen, and group A plasma usually contains anti-B antibodies. ABO incompatibility can cause antibody-mediated red-cell agglutination and haemolysis. Rh-positive usually indicates the presence of the D antigen. Anti-D antibodies generally develop after exposure to D-positive cells, rather than being naturally present. Maternal antibodies can cross the placenta and damage susceptible fetal erythrocytes. Red-cell and plasma compatibility rules differ; the familiar universal-donor shorthand never replaces identification, compatibility testing and local transfusion procedures.

## Nursing interpretation and examination approach

Review haemoglobin, haematocrit, red-cell indices, white-cell differential and platelet count together. Reference intervals differ with age, pregnancy, altitude and laboratory methods. A haemoglobin concentration does not by itself measure circulating volume; acute blood loss and fluid shifts can alter interpretation. Likewise, oxygen saturation measures the proportion of haemoglobin binding sites occupied, so apparently adequate saturation can coexist with reduced oxygen content in anaemia.

Connect pallor, fatigue, breathlessness, fever, bruising and bleeding with their possible physiological mechanisms. Document bleeding characteristics and relevant trends, and escalate unexpected deterioration using the clinical setting's pathway. For exams, organize blood under composition, functions, cell production, haemoglobin, immunity, haemostasis and grouping. A labelled clotting sequence and an ABO antigen-antibody table usually explain more clearly than a disconnected list of clotting factors.

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## Quick Revision

- Plasma is the extracellular fluid matrix of blood; serum remains after clotting.
- Haemoglobin reversibly transports oxygen and erythropoietin promotes erythrocyte production.
- Different leukocytes contribute to innate and adaptive defence.
- Platelets and fibrin cooperate to stabilize a haemostatic plug.
- ABO antigens and plasma antibodies determine major compatibility relationships.
- Blood results require clinical context and trends.

## Important Examination Questions

1. Describe plasma constituents and the functions of formed elements.
2. Explain erythropoiesis, erythrocyte destruction and haemoglobin function.
3. Compare innate, adaptive, active and passive immunity.
4. Explain haemostasis and distinguish it from fibrinolysis.
5. Construct an ABO antigen-antibody table and explain Rh sensitization.

## References and further reading

Newly written physiology study notes. Read the supporting textbook sections for diagrams, mechanisms and further explanation.

- OpenStax Anatomy and Physiology 2e: An Overview of Blood (https://openstax.org/books/anatomy-and-physiology-2e/pages/18-1-an-overview-of-blood)
- OpenStax Anatomy and Physiology 2e: Erythrocytes (https://openstax.org/books/anatomy-and-physiology-2e/pages/18-3-erythrocytes)
- OpenStax Anatomy and Physiology 2e: Leukocytes and Platelets (https://openstax.org/books/anatomy-and-physiology-2e/pages/18-4-leukocytes-and-platelets)
- OpenStax Anatomy and Physiology 2e: Hemostasis (https://openstax.org/books/anatomy-and-physiology-2e/pages/18-5-hemostasis)
- OpenStax Anatomy and Physiology 2e: Blood Typing (https://openstax.org/books/anatomy-and-physiology-2e/pages/18-6-blood-typing)
- OpenStax Anatomy and Physiology 2e: Barrier Defenses and the Innate Immune Response (https://openstax.org/books/anatomy-and-physiology-2e/pages/21-2-barrier-defenses-and-the-innate-immune-response)
- OpenStax Anatomy and Physiology 2e: B-lymphocytes and Antibodies (https://openstax.org/books/anatomy-and-physiology-2e/pages/21-4-the-adaptive-immune-response-b-lymphocytes-and-antibodies)

## Practice questions

Choose one best answer. The answer key and explanations follow the questions.

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**1. Which protein is converted to fibrin by thrombin?**

A. Albumin

B. Haemoglobin

C. Fibrinogen

D. Erythropoietin

**2. Which cells can differentiate into antibody-secreting plasma cells?**

A. Erythrocytes

B. B cells

C. Platelets

D. Neutrophils

**3. What ABO antibodies are usually present in group A plasma?**

A. Anti-A only

B. Anti-B

C. Anti-A and anti-B

D. Neither antibody

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## Answer key and explanations

**1. C - Fibrinogen**

Fibrinogen is the soluble precursor from which the stabilizing fibrin network forms.

**2. B - B cells**

Plasma cells are differentiated B lymphocytes responsible for antibody secretion.

**3. B - Anti-B**

Group A erythrocytes bear A antigen and plasma usually contains anti-B.

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