# Section 3
## Basic Blood Facts

### Aim

- To introduce the basic concepts of haematology, blood components and blood products and how they interlink with Intraoperative Cell Salvage (ICS) and blood conservation

### Learning Outcomes

- Describe the main functions of blood
- Identify the main components of blood and describe their individual functions
- Describe the basics of simple coagulation
- List the allogeneic (donor) blood components available for clinical use
- Identify the allogeneic (donor) blood products available for clinical use
- Identify the recombinant therapies available for clinical use

### Introduction

Before considering ICS it is important to understand the composition and function of whole blood as well as the functions of the main components of blood and how these components can be separated.

### 3.1 Functions of Blood

Human blood is a collection of cells suspended in liquid and has the following definable functions:

- Transport:
  - Dissolved gases (e.g. oxygen, carbon dioxide)
  - Waste products of metabolism (e.g. water, urea)
  - Hormones, enzymes and nutrients
  - Plasma proteins (associated with defence, such as blood clotting and antibodies)
  - Blood cells (including white blood cells and red blood cells)
- Maintenance of body temperature
- Control of pH:
  - The pH of blood must remain in the range 6.8 to 7.4 otherwise cells become damaged
- Removal of toxins from the body:
  - The kidneys filter all of the blood in the body (approximately 8 pints), 36 times every 24 hours. Toxins removed from the blood by the kidneys leave the body in the urine. Toxins also leave the body in the form of sweat.
- Regulation of body fluid electrolytes:
  - Excess salt is removed from the body

## 3.2 Composition of Blood

Blood has both cellular and non-cellular components, each accounting for approximately half of the total volume. The cellular components, which are produced in the bone marrow, include red blood cells (RBCs), white blood cells (WBCs) and platelets. The non-cellular component of blood is plasma which is primarily water. Plasma contains proteins such as albumin, clotting factors, immunoglobulin and electrolytes. Blood constitutes about 7% of body weight, which is 70ml/kg.

Haemoglobin (Hb) is a complex protein-iron compound in the blood that carries oxygen to the cells from the lungs and carbon dioxide away from the cells to the lungs. Each red blood cell contains 200 to 300 million molecules of haemoglobin. Each molecule of haemoglobin contains several molecules of haem, each of which can carry one molecule of oxygen. The normal concentration of haemoglobin is between 12.5 and 16g/dl.

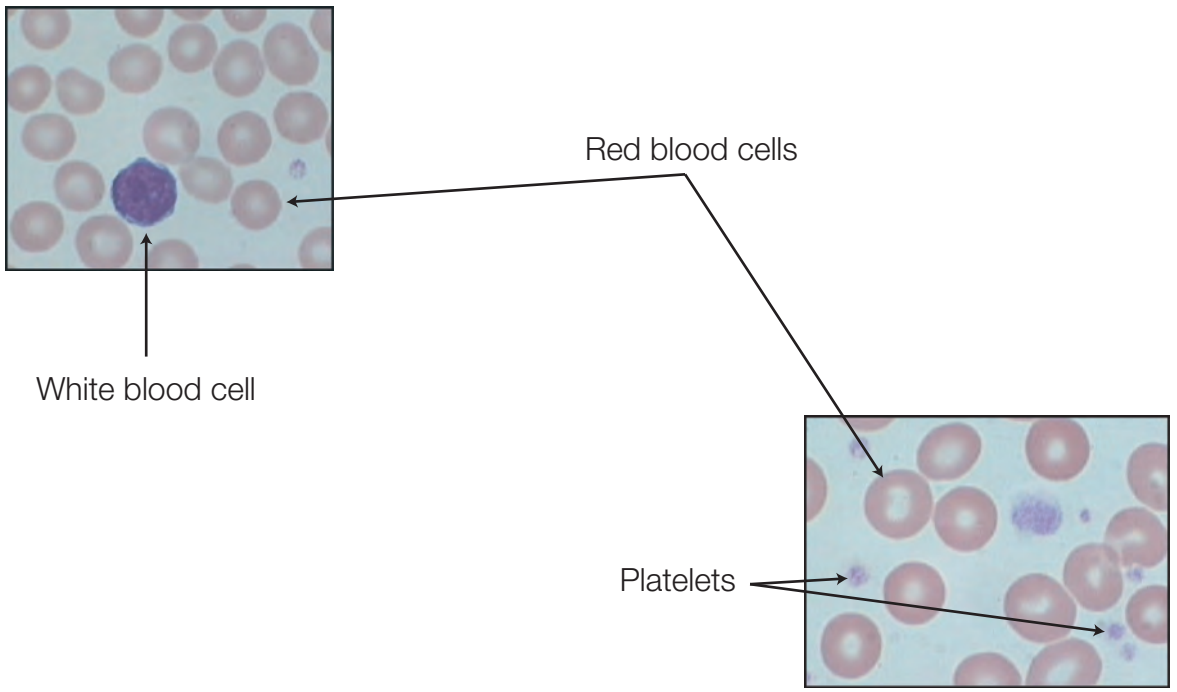
Haematocrit (Hct) is a measure of the number of red cells found in the blood, stated as a percentage of the total blood volume. The normal range is between 43 and 49% in men and between 37 and 43% in women.

### Table 1. Properties of the Main Components of Blood

| Properties | Red Blood Cells | White Blood Cells | Platelets |
|---|---|---|---|
| **Size** | 7 microns | 7 – 20 microns | 2 – 5 microns |
| **Survival** | 120 days | Hours – few days | 5 – 9 days |
| **Normal ranges*** | 4.5 – 5.8 million | 5,000 – 10,000 | 150,000 – 400,000 |
| **Function** | Transport of $O_2$ | Immune response, fight infection | Clotting |

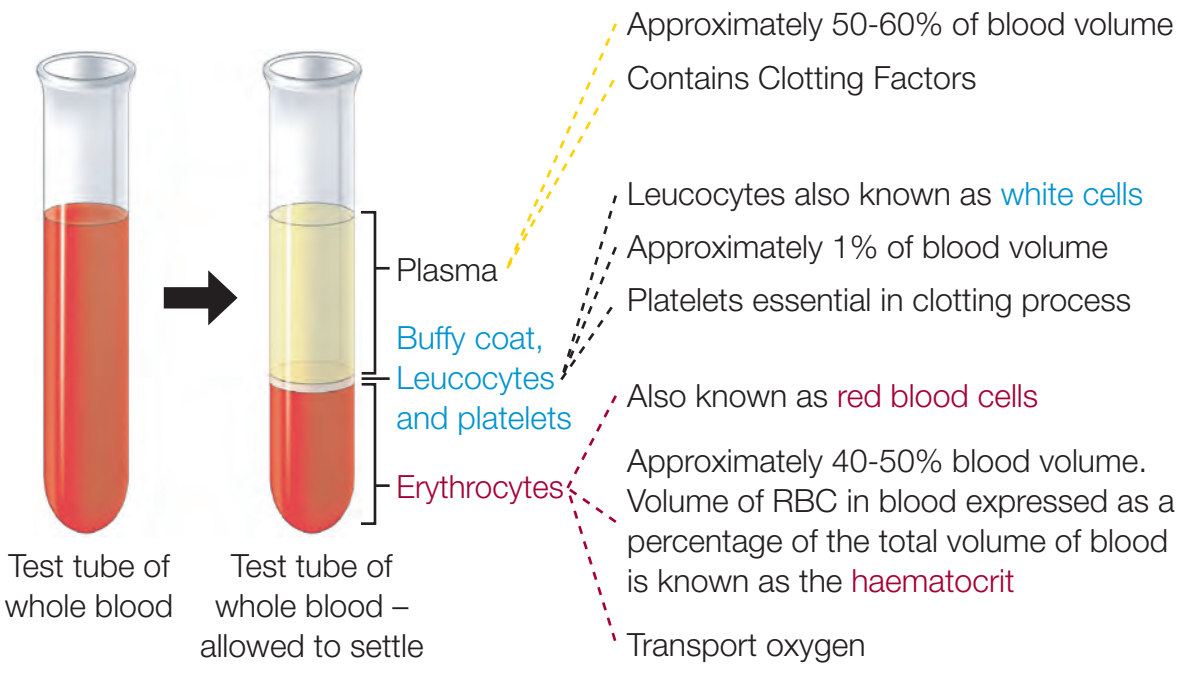
*Normal ranges will vary according to age and gender and also depending on the technology used to measure the cells.

## Figure 1. Red Blood Cells, White Blood Cells and Platelets




Because the components of blood have different densities, if they are allowed to settle in a test tube or spun in a centrifuge, they will separate according to their densities (Figure 2).

## Figure 2. Blood Separated into its Constituent Parts



## 3.3 Coagulation

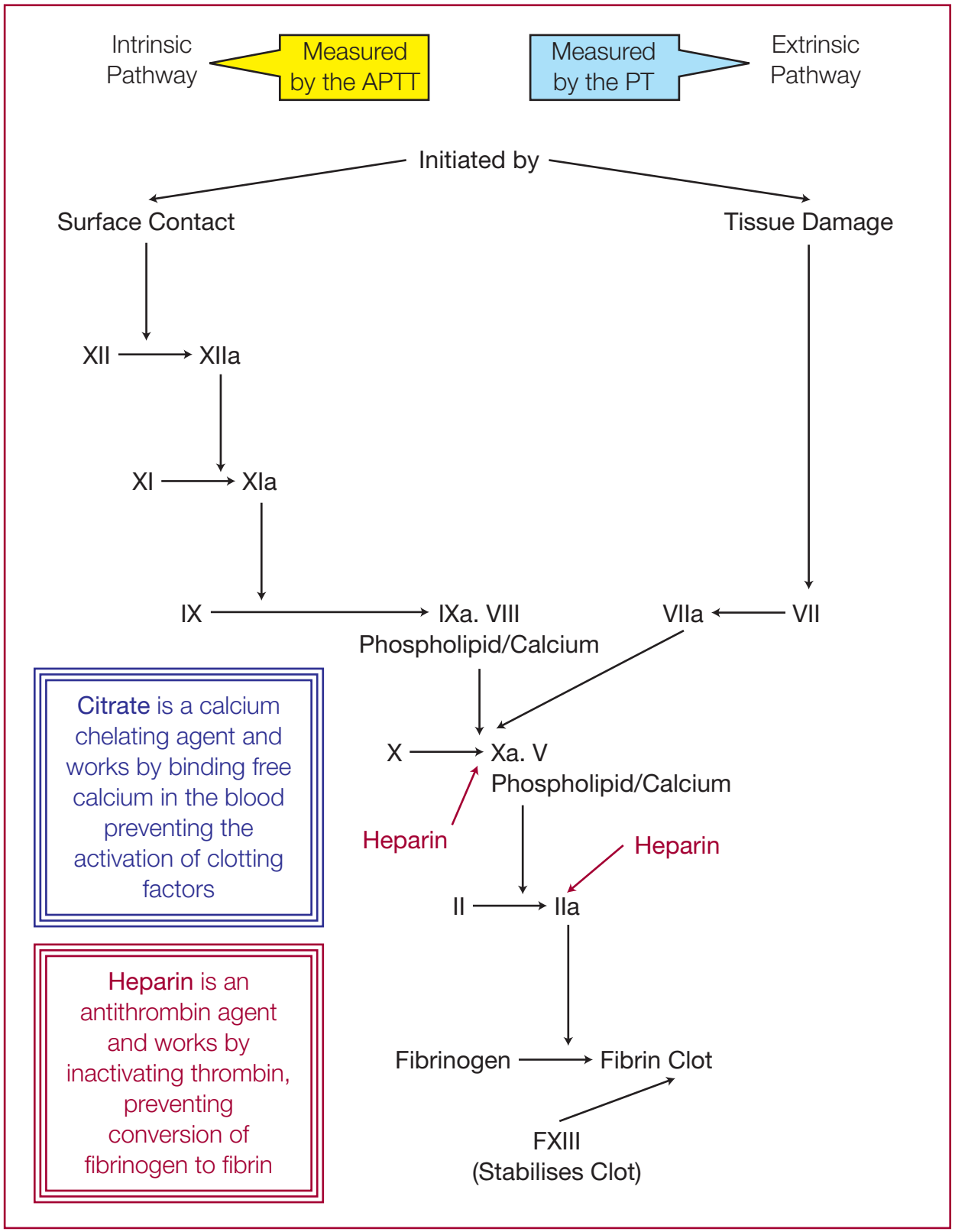
The clotting cascade is initiated by either the intrinsic or extrinsic pathway both leading to a series of coagulation events. The intrinsic pathway is initiated when blood comes into contact with a foreign (non-endothelial) surface such as tissue grafts or artificial heart valves, or when blood is removed from the body. The extrinsic pathway is normally activated by an external tissue injury such as a cut or ruptured vessel. Regardless of the origin, an amplification of the coagulation process leads to a common pathway where fibrinogen is converted to fibrin. During surgical procedures both the intrinsic and extrinsic pathway are stimulated.

### Coagulation tests

- The APTT is a test of the intrinsic pathway of coagulation. (Activated Partial Thromboplastin Time (APTT, KCCT, PTTK, KPTT, PTT)). All the above abbreviations refer to the same test and terminology varies between laboratories.
- The PT tests the extrinsic pathway of coagulation (One Stage Prothrombin Time (OSPT, PT))

## Figure 3. The Coagulation Cascade

*(Adapted from the American Association for Clinical Chemistry[1])*



## 3.4 Allogeneic (Donor) Blood Components

All blood components in the UK are collected from blood donors who are unpaid volunteers. They are very carefully selected and tested to make sure that the blood they donate is as safe as possible. Compared to other everyday risks, the likelihood of getting an infection from a blood transfusion is very low. All units supplied in the UK are leucodepleted (white blood cells removed) and have been since 1999. White blood cells are removed as a precaution against variant Creutzfeldt-Jakob Disease (vCJD). Table 2 lists the blood components available for clinical use.

### Table 2. Allogeneic (Donor) Blood Components

| Component | Volume | Storage | Clinical indications in the surgical setting |
|---|---|---|---|
| **Red cells** | 180-350ml | Designated temperature controlled fridge 2-6°C.<br><br>Shelf life: 35 days. | To raise the oxygen-carrying capacity of the blood when it is symptomatically reduced due to red cell loss or reduced red cell production. |
| **Platelets** | Apheresis 180-300ml<br><br>Pooled 250-400ml | Temperature controlled 'room temperature' (22°C +/– 2°C) – gentle agitation to ensure availability of oxygen.<br><br>Shelf Life: 5-7 days. | The prevention and treatment of bleeding due to:<br>• Thrombocytopenia associated with large volume blood transfusions<br>• Consumption due to disseminated intravascular coagulation (DIC), major surgery |
| **Fresh frozen plasma** | 240-300ml | Designated temperature controlled freezer –30°C.<br><br>Shelf life: 24 months. | • Clinically abnormal haemostasis following massive blood transfusion or major surgery<br>• Multiple coagulation factor deficiencies and disseminated intravascular coagulation (DIC)<br>• Immediate reversal of Warfarin effect if prothrombin complex concentrate (PCC) is unavailable<br>• Haemostatic defects associated with liver disease **if** bleeding/invasive procedure |
| **Cryo-precipitate** | | Designated temperature controlled freezer –30°C.<br><br>Shelf life: 24 months. | Bleeding associated with hypofibrinogenaemia This most commonly occurs in:<br>• DIC<br>• massive transfusion |

## 3.5 Risks of Allogeneic (Donor) Transfusion

The risk of getting hepatitis from a blood transfusion in the UK is currently about 1 in 850,000 for Hepatitis B, and 1 in 51,000,000 for Hepatitis C. The chance of getting Human Immunodeficiency Virus (HIV) is 1 in 5,000,000 and Human T-Lymphotropic Virus (HTLV) infection is 1 in 11,000,000. Although the risk of getting vCJD from a blood transfusion is probably low with a single blood transfusion, the risk of any infection will increase with additional blood transfusions. Within the UK there have been just a handful of cases where patients are known to have become infected with vCJD from a blood transfusion. The largest risk is from getting the "wrong blood" as evidenced by the Serious Hazards of Transfusion (SHOT) annual reports[2].


Blood and blood components must always be stored under controlled storage conditions in designated fridges, freezers etc.

## 3.6 Allogeneic (Donor) Blood Products

### Human Albumin 4.5%

4.5% human albumin is iso-oncotic with human plasma. It is usually supplied in a 400ml bottle which is stored at room temperature. The dosage should reflect circulating blood volume, rather than measures of albumin levels, and will vary according to patient size and the severity of the illness or fluid/protein losses. It is usually administered through a standard infusion set at rates of 5-15ml per minute, although this varies according to clinical need.

There is no firm evidence that the use of albumin is advantageous over the use of saline for fluid resuscitation in patients with trauma, burns or following surgery[3].


Simply raising a patient's albumin level does not improve outcome and other fluids may be effective for raising blood pressure: e.g. crystalloids or synthetic colloids.

### Human Albumin 20%

20% albumin has an oncotic pressure approximately 3-4 times higher than that of normal human plasma and infusion will therefore expand plasma volume by drawing in extravascular fluid. It is supplied in 100ml bottles and again is infused through a standard infusion set at rates of 1-2ml per minute.

20% albumin solutions are used in the management of:

- Hypoproteinaemic oedema associated with nephrotic syndrome (diuretic resistant oedema)
- Ascites in liver disease

### Immunoglobulin Products

Immunoglobulins are the antibodies produced by B-lymphocytes in response to infection. Immunoglobulins are important for the correct functioning of the immune system, fighting bacterial infections, neutralising viruses and activating the complement systems.

### Other Plasma Derivatives

Many other plasma derivatives are available for patient use, such as Factor VIII and IX concentrates and prothrombin complex concentrates. On the whole, their use is very specialised and outside the remit of this workbook. Their use is very specialised and should be guided by consultant haematologists.

## 3.7 Recombinant Therapies

### Recombinant Clotting Factors

Recombinant clotting Factors VIII and IX are used as a treatment for people with Haemophilia A and B, respectively.

### Recombinant Factor VIIa (NovoSeven®)

This was originally developed for use in haemophilia patients with inhibitors and is licensed for this indication. Other indications for use are still being established. Recombinant Factor VIIa works by activating coagulation and platelet adhesion, but only if tissue factor is exposed. It requires the presence of platelets and other coagulation factors. Case reports show it can be effective in stopping traumatic, surgical or obstetric haemorrhage, allowing a major bleeding source to be dealt with surgically. However, the product is not licensed for this indication. There may be risks of thrombotic complications and as the drug is currently extremely expensive, UK hospitals have special procedures for making it available. It must only be used according to local guidelines.

## Key Points

- Red cells are the heaviest component of blood and it is this property that allows the separation of washed red cells from the waste products in ICS.
- Heparin and citrate both inhibit coagulation and this allows for blood to be collected without clotting.
- Allogeneic blood and blood components are extremely safe and the greatest risk is in giving the wrong blood.

## References


1. The American Association of Clinical Chemistry (2003) The Coagulation Cascade *http://www.labtestsonline.org.au/images/coag_cascade.pdf* [Accessed on 15 July 2008]
2. Serious Hazards of Transfusion (1996 – 2007) Annual Reports *www.shotuk.org*
3. The SAFE Study Investigators (2004) A Comparison of Albumin and Saline for Fluid Resuscitation in the Intensive Care Unit. *N Engl J Med,* 350; 2247-56


## Further Reading

- Essential Haematology by A. V. Hoffbrand *(ISBN-13:978-4051-3649-5)*
- ABC of Transfusion (ABC Series) by Marcela Contreras *(ISBN 0-7279-1209-7)*
- Handbook of Transfusion Medicine *ed DBL McClelland (ISBN-10 0 11 322677 2)*