Your blood
– a textbook about blood and blood donation

Preface

“Your Blood” is a textbook about blood and blood donation. The purpose of the book is to convey to the reader a basic understanding of blood and blood donation and to create understanding and context in this field.

Three main themes
The first part of the book deals with *the history of blood donation*. Through the years countless experiments with blood and blood donation have been carried out and with varying degrees of success. Developments show how a greater understanding of blood and the functions of blood has brought about good blood donation results and there are many success stories to tell.

The second part is the main part, in which we focus on *blood and its functions* as well as on the requirements and standards behind correct and safe blood donation. The perception of blood as a fluid organ, in control of many different body functions, lies at the root of modern blood donation. Knowledge of blood’s constituent parts, blood types, antibodies, and antigens gives us an understanding of the significance of blood and thereby the importance of a well-functioning blood donor system such as the Danish, which is among the best in the world. The Danish system is characterised by high safety standards for donor as well as for recipient.

In the final part of the book we put blood donation into a *social context* and outline some ethical issues. The purpose of this part is to include personal and emotional aspects of blood donation as well as attitudes towards donating blood. The reader is invited to reflect on the matter and urged to form an individual opinion as to what blood donation means to him.

Many have supported and contributed to the making of this book. A large group of people has worked on the project on a voluntary and unpaid basis and they have therefore earned special thanks. For their medical advise we would like to thank Doctor Jan Jørgensen and Doctor Bjarne Møller, Klinisk Immunologisk Afdeling at Skejby Sygehus as well as Doctor Ellen Taaning, Klinisk Immunologisk Afdeling at Amtssygehuset in Herlev. Thank you also to Elisabeth Penninga, Birgitte Tusgaard Petersen, Helle Damgaard Sørensen, and Eva Rabing Christensen for their work on the script for the medical part. The students of 1. DU at Falkonergårdens Gymnasium receive thanks for their assessment of the layout of the book. Thomas Oldrup, Steffen Dalsgaard, and Signe Borup are thanked for their work on the historical and ethical parts.

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Blood donors in Denmark, 2002

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1. The history of blood

Throughout history blood has been ascribed many different meanings. Experiments with blood letting and blood transfusion have been carried out in countless ways and with much varying degrees of success. Some of the most important steps towards the successful transfusion of blood were the discovery of blood types and the founding of blood banks. This chapter tells the story of blood and blood transfusion.

(Caption/text 1)
Highlights from the history of blood transfusion:
1667: First transfusion from animal to human
1818: First transfusion from one person to another
1901: Landsteiner discovers the different blood types
1914: Fluids for blood keeping are developed
1932: The first blood bank is set up
1953: Bags made out of plastic are put into use
(End)

The power and symbolism of blood
Blood has always enjoyed special symbolism and power. People of many cultures have considered blood to possess religious and magical powers.

The prevalent view among primitive peoples was that – as with cannibalism – by drinking the blood of an animal or a person it was possible to transfer characteristics. After a gladiator fight in ancient Rome, it was common to see members of the audience hurry into the arena in order to drink the blood of the dying animals and gladiators.

Blood letting by live leeches
Accordingly, blood was believed to have an inherent kind of power, one which was respected and which was thought to have to do with the psyche as well as with the body. The idea to try and 'adjust' the amount of blood in a person emerged early. It was always clear that if a person lost too much blood, he would die.

(Caption/text 2)
Blood letting by attaching live, blood sucking leeches has been practised by doctors since 50 B.C. Leeches and the letting of blood was primarily used to cure various illnesses.
In this French illustration from a chapter of Boccaccio's work 'Dekameron' we are able to see how leeches were used in medicinal treatment. But not in the treatment of just anybody. In this case the patient is none other than Galerius, the Roman Emperor, who is confined to his bed with numerous leeches attached to his body. The text suggests that the emperor suffers from a special illness causing him to emit an atrocious smell. The three doctors by the bedside also clearly show this. Bloodsucking leeches were used far into the 20th century.
(End)

On this background the first blood letting experiments took place, in which a person was drained a certain amount of blood. These experiments were based on the theory of the four body fluids by Hippocrates, the father of modern medical science: the four body fluids were blood, urine, yellow bile, and black bile. Each one of these four fluids had a particular function and combined they would give a person characteristics and personality.

Many illnesses were thought to be caused by an imbalance in the distribution of these four fluids. Blood was the most important one of the four fluids – blood being where passion lay. Were someone insane, he could be cured through blood letting, thus removing some of the passion. Blood letting could take place either by means of clever machines making small incisions in the elbow bend or by attaching live blood sucking leeches. Blood lettings were not only used to adjust the four fluids and to treat diseases. The rural population also used it in the autumn to get a 'kick', because they felt it gave them extra energy. However, leeches and blood letting were primarily used to cure various diseases. It is not unimaginable that our grand parents had some of their diseases treated with the help from leeches.

(Caption/text 3)
Blood letting by leeches was not just a medieval phenomenon. It is not unimaginable that our grand parents had some of their diseases treated with the help from leeches. Today, at special pharmacies, it is still possible to buy leeches for treating some diseases. The leeches in the photo, *hirudo medicinalis*, are used to treat a haematoma, an accumulation of blood under the skin on the back of a patient.
(End)

The first transfusion of blood from an animal to a human being
It was really believed that a person's condition could improve, if his blood amount were to be 'adjusted' and some evidence suggests that the ancient Egyptians – as early as in the millennium before our calendar – tried to administer blood to people.

The first actual blood transfusion took place in the time around 1667. Nobody is entirely certain whether English or French scientists were first. Scientists fought among themselves to have their name and nation linked to the new discoveries that were so abundant in the late 17th century.

To the south of the English Channel the French scientist Denis was the Sun King's personal physician, among other things. He had carried out a good number of experiments with blood and had considered its functions and characteristics. In 1667 he found a 'guinea-pig'. It was the middle-aged arsonist and nudist Mauroy, a good-for-nothing, who was known for his brutality and for often beating his wife. In front of a number of distinguished gentlemen Denis drew 300 g of blood from the crude craftsman and afterwards administered to him a cup of blood, which he had drawn from a gentle calf. He believed that by transfusing the calf's blood he would also be able to transfer its mild character and thus to cure Mauroy of his brutality.

The experiment was a success – sort of. Mauroy did complain about burning pains in the arm that had been injected with the blood, lose his consciousness, and have his urine turn black, but he did also survive the transfusion, despite everything. However, he probably became more ill, than gentle as a calf.

At the same time in the Royal Society north of the English Channel noble gentlemen were discussing the discovery of blood's circulation by Harvey, an Englishman: blood is transported *from* the heart via arteries and *to* the heart via veins. The result of this discovery was that the heart -

which up until that point had been where to find love and faith, among other things – was now 'reduced' to a mere piece of vital machinery.
To the scientists this was a great discovery. Before then, they had experimented with transfusing blood from cattle, lambs, dogs, and horses and with administering all sorts of fluids: wine, milk, beer, and urine! If you are to insert a syringe – which was then made from silver - into a vein leading blood to the heart, there is no pressure and the blood clots inside the needle. If the same is attempted into an artery, there is plenty of pressure and blood spurts out. Obviously, the person who receives the blood needs the opposite to happen. Ironically, it is probably because of the lack of such knowledge that many people actually survived receiving blood from animals: because the blood simply never entered the patient's veins!

Back then, the pressure in the arteries was necessary in order to draw blood. Today, it is possible to draw blood from the veins by applying a stasis, which is far less dramatic. When the blood bag is placed beneath the donor, the blood flows by itself anyway.

(Caption/text 4)
Today we know that animal blood is very different from human blood. If animal blood enters human veins, the two types of blood will react with each other and begin to agglutinate, and the patient will most likely die. Some believe that the only reason it was possible to survive such transfusions was that the blood agglutinated inside the tiny tube between donor and patient. Much to the recipient's good fortune.
(End)

The first transfusion of blood involving two people
The first transfusion of blood from one person to another was carried out by the English doctor James Blundell. It took place in London in 1818 after experiments with blood had been at a standstill for 150 years. He injected small amounts of fresh blood – from a total of 20 different donors – into a patient who was suffering from a severe case of cancer of the stomach.Granted, the patient did not survive, but Blundell continued his work with scientific accuracy, which was unusual for his time. Over the next decade he carried out about ten transfusions with patients surviving half of them.

The question from where to obtain the blood also interested Blundell. The matter was about emergencies, which is why Blundell considered animal blood impractical, for as he said, "a dog may come when you whistle, but the creature is too small. A calf may seem appropriate for our purposes, but it hasn't been trained to climb stairs".

Beyond this, the concern in those days was not over who should donate the blood. In Germany a proposal was aired to pardon death sentenced prisoners if they were willing to donate their blood throughout the rest of their lives. It remains unknown whether this idea ever made it beyond a proposal.

(Caption/text 5)
This picture from about 1859 is from the US. It shows a doctor letting blood from a patient. Blood-letting – to cut open a vein in order to draw a certain amount of blood – was based on Hippocrates' theory that the body has four fluids: blood, urine, yellow bile, and black bile. Each of these fluids had a function and would give a person characteristics and personality. Passion, for instance, was in

the blood. What this patient suffers from is unknown, but he does not look too comfortable with the operation.
(End)

Landsteiner's tiger leap: A, B, AB, and 0 (zero)
The outcome of the transfusions was as predictable as the rolling of a dice – among other reasons because the fact was not yet known that people have different blood types. Hence, blood from two people may be incompatible. If donor and patient do not have matching blood types and their blood types are incompatible, the patient might die.

Consequently, the single most important tiger leap in the history of transfusion came in 1901 when the Austrian Karl Landsteiner discovered the different human blood types. In 1909 he classified human blood into the blood types A, B, AB, and 0 (zero) that are so well-known today, and he showed that mixing certain blood types has disastrous consequences.

In 1930 Landsteiner received the Nobel prize for medicine for the discovery of human blood types.

(Caption/text 6)
The single most important tiger leap in the more recent history of transfusion came in 1901, when the Austrian Karl Landsteiner discovered the different human blood types. It was the discovery of human blood types, which in 1930 earned him the Nobel prize in medicine.
(End)

Progress during the World Wars
Many bad things can be said about war, but the great wars have been the bleak background for experiments and progress in many fields, including the field of blood transfusion.

The first mobile blood bank was set up in connection with the First World War. It was established on the battlefield in France by the British Army. During the years 1914-16 several scientists had – more or less independent of each other – developed a fluid consisting of water, salt, citrate, and sugar, which could be added to donor blood to prevent it from agglutinating. This paved the way for a means of storing blood, which made it unnecessary to make direct transfusions from donor to patient. Consequently, on the battlefield in France it became possible to store blood for 10-26 days before use.

The first 'actual' hospital blood bank was set up in Leningrad in 1932, and in 1937 the term 'blood bank' was used for the first time, when one such was set up at Cook County Hospital in Chicago. It is worth noting that in this bank the blood was obtained by means of voluntary donation.

(Caption/text 7)
After the Second World War doctors returned home from the front where they had seen how much good blood transfusions could do, for instance for injured soldiers, who had had a leg amputated. Because of their experiences during the war they supported the use of blood as a means of treatment in the civilian world of doctors. Thus, in the years after the war blood banks were set up all over the world. In this dramatic photo an American physician administers blood plasm to an injured soldier in Sicily.
(End)

After the Second World War many doctors returned home from the front. They had seen how much good blood transfusions could do, for instance for injured soldiers, who had had a leg amputated. Because of doctors' experiences during the war, which they brought back into civil society, the post war period saw blood banks being set up all over the world.
In 1953 the storing of blood was made all the more straight forward by the introduction of the robust plastic blood bag. Up until then blood had been kept in glass bottles, which were difficult to transport and highly breakable. The use of plastic bags also made it practically possible to separate blood into its constituent parts inside a closed system.

Summary and questions
For the purpose of becoming able to adjust the amount of blood inside the human body, experiments with the letting and administering blood have been carried out for centuries. Among other things, blood lettings were used as a cure for insanity. It was thought that if some of the patient's blood was removed, blood being the body fluid containing passion, the patient would be cured. Blood lettings were also used in the autumn to give people a 'kick' if they felt they needed more energy.

Experiments were not only carried out with blood lettings, but also with blood transfusions between animals and humans as well as between people. It was thought that by transfusing the blood of an animal to a human it was possible to transfer some of the characteristics of that animal as well. That these experiments did not kill anyone is probably due to the fact that blood never actually entered the veins of the recipients.

The first transfusion between two people took place in 1818 and is attributed to the English doctor Blundell. As well as attempting to transfuse blood between two people Blundell was also interested in from where to obtain the blood.

One of the milestones in the history of blood donation was set in 1901 with Karl Landsteiner's discovery of human blood types. In 1909 he described and classified the AB0 blood type system into the blood types A, B, AB, and 0, which has been used since.

In connection with the two World Wars another step was taken towards the organisation of blood donation. During the First World War the idea came up to add to the blood a fluid consisting of water, salt, citrate and sugar in order to prevent the blood from agglutinating. From that moment on it was no longer necessary to transfuse blood directly from donor to patient. In the 1930s this led to the establishment of the first blood banks. In 1953 the storing of blood was made easier by replacing the glass bottles previously used for storing blood with blood bags made from plastic.

1. According to Hippocrates, which four fluids gave a person characteristics and personality?
2. Why did so many people survive transfusions between animals and humans?
3. What are the four blood types called that were discovered by Karl Landsteiner in 1909?
4. In what decade were the first real blood banks established?
5. How was blood stored before - and after - 1953?

2. The history of blood donation in Denmark

The history of blood donation in Denmark takes its beginning in 1848. It begins with the first transfusion from one person to another and continues with the founding of *Statens Serum Instituts Blodtypeafdeling* – the Blood Type Department of the National Serum Institute - and the founding of the national organisation for Danish blood donors. This chapter deals with the course of the history of blood donation in Denmark as well as its milestones.

The first transfusion of blood in Denmark
In Denmark the first transfusion of blood between two people took place in 1848. The location was *Almindeligt Hospital* in *Amaliegade*, Copenhagen's hospital for the poor. Partly fresh, untreated blood and partly whisked blood – to prevent it from agglutinating - were administered with a syringe. The patient was an officer, who had had a leg amputated and whom infections and blood poisoning was causing great suffering. Four days after the transfusion he died.

Transfusions from animals in the 19th century
Towards the end of the 19th century the use of animal blood for transfusions enjoyed a resurgence. The reason for its refound popularity, in Denmark as well as abroad, is not known. The preferred donors were lambs. There was no reason for choosing lambs, but one might suspect underlying religious motives: the mild lamb is an ancient symbol of Christ. It was very difficult to find sufficient numbers of human donors, and besides, lambs were not likely to say no. Some hospitals even set up sheep stables, so that donor lambs were always at hand.

(Caption/text 8)
Some Danish figures from the late 19th century
Out of 347 transfusions using human blood, 150 (43%) were succesful.
Out of 129 transfusions using animal blood, 42 (33%) were succesful.
One can only assume that 'succesful' means that the patient survived the transfusion.
(End)

One of the pioneers beating the drum against administering animal blood to humans was Professor Peter Ludvig Panum (1820-1885), who was later to lend his name to *Panum Instituttet* in Copenhagen. Towards the turn of the century the use of animal blood was abandoned, and the use of harmless salt water infusions was gradually adopted instead.

The period between the First and the Second World War
During the period between the First and the Second World War a number of blood transfusion experiments took place, particularly with women, who were bleeding heavily in connection with child births. Most often relatives donated the blood. In some cases, however, patients staying at the hospital anyway were used as donors. Some considered the use of patients, of whom some were likely to be carrying blood transmitted diseases, to have unfortunate consequences.

(Caption/text 9)
During the period between the First and the Second World War in Denmark a number of blood transfusion experiments took place, transfusing blood to women, who were bleeding heavily in connection with child births. Here, the beneficial effect of the transfusions was evident, but unfortunately sometimes also not so evident: in some cases the hospital's patients were used as donors, patients of whom some were likely to be carrying blood transmitted diseases. In other cases

patients' relatives were used as donors. Not until 1932 was the first corps of voluntary and medically examined donors set up.
(End)

The results of these many transfusions - along with Landsteiner's discovery of the AB0 blood types at the beginning of the century – formed a new attitude among doctors. Several doctors recommended that a professional corps of blood type specific donors be set up, members of which would receive payment in exchange for making themselves available to Copenhagen hospitals.

At the end of the 1920s a blood type department at the *Statens Serum Institut* was set up. Among other things, the task of this department was to determine the blood type of the donors and to offer counselling services on transfusion. Then, in 1932, *Spejdernes og Væbnernes Frivillige Bloddonorkorps* – The Blood Donor Association of Voluntary Guides and Boy Scouts – saw the light of day.

(Caption/text 10)
It looked dramatic, when a patient received a blood transfusion. The plastic blood bag, as a replacement for the bottles reminiscent of old-fashioned milk bottles, was not invented until the 50s. Often, the blood had to be constantly stirred in order to prevent it from agglutinating. It was difficult to store the blood, so now and again the donor was let, while the patient lay hidden behind a screen. This made it more plain to the donor that he was helping someone whose life was at risk. Incidentally, in this photo from around 1940, M.D. Jens Foged, who played an active role in establishing the donor corps, supervises a transfusion, deeply concentrated.
(End)

The Blood Donor Association of Voluntary Guides and Boy Scouts
In his youth and in his capacity of vice-chairman in the *Det Danske Spejderkorps (DDS)* - the Danish Guide and Scout Association - Tage H. Carstensen (1897-1985) visited boy scout associations abroad, because international scout work interested him. In 1930 the well-known scout leader, later to become barrister of the supreme court, returned from a trip to England with an idealistic idea: on his trip he had seen how adult English scouts – the so-called 'Rovers'- donated blood. This experience left a big impression on him and upon his return, he talked it over with some of his friends and then took the necessary initiative.

Two years later, when the first donor association *Spejdernes og Væbnernes Frivillige Bloddonorkorps* was set up in Copenhagen, Tage Carstensen really began his work. This happened in close co-operation with two other idealists: the then Senior Registrar at *Bispebjerg Hospital* Jens Foged, responsible for examining the donors, and the Director of *Statens Serum Institut*. Dr. Med. Thorvald Madsen, who took care of determining blood types and calling in donors.

(Caption/text 11)
The trio that began what today is *Bloddonorerne i Danmark (BiD)* – Blood donors in Denmark. To the left, the promoter of the initiative, the colourful scout leader and Barrister of the Supreme Court, Tage H. Cartsensen, who headed the organisation for many years. In the middle, Senior Surgeon and Professor M.D. at *Bispebjerg Hospital*, Jens Foged, who was responsible for examining the donors. To the right, the popular Director of *Statens Serum Institut* M.D. & J.D. Thorvald Madsen, who took care of determining blood types and calling in donors. The three gentlemen, together here in the mid-1950s, are the 'grand ol' men' of the donor cause.

(End)

According to the records Tage Christensen himself was the first to lie down on the couch. Thus, the first voluntary, unselfish and unpaid blood donation in Denmark took place on 21 May 1932.

From 50 to 250,000 donors
Soon independent local blood donor corps were organised across the country and affiliated with local hospitals.

In 1932 Denmark had 53 blood donors, and a corps of 200 was considered sufficient to meet future demands for blood! But in the course of time the number of blood transfusions increased, and hospitals needed more blood. It was therefore necessary to find more blood donors, which happened in close co-operation with other humanitarian organisations.

Before the Second World War the drawing took place at the hospital in need of the blood. Round the clock a doctor would call in a donor, draw the blood into a glass bottle and straight away transfer it to the patient who often lay just behind a screen. In Denmark the first actual blood bank opened on 2 April 1951 in a vacant hut from the tuberculosis examinations at Bisbebjerg Hospital. At this point in time, just 20 years after the first donor corps had been set up, the number of blood donors had risen to 25,000 nation-wide.

In 1952 everyone taking part in the donor work agreed to set up the nationwide organisation *Danmarks Frivillige Bloddonorer* - Denmarks Voluntary Blood Donors. Its task was to promote the donor cause and to monitor its development in Denmark. Today the name of this organisation is *Bloddonorerne i Danmark*, but it continues to rely on the principles of anonymous, voluntary, and unpaid donation. Today, around 236,000 Danish blood donors donate a good 355,000 portions of blood annually.

(Caption/text 12)
Dr Schmidt in front of the blood bank refrigerator. Behind him two doors are open. Blood type A Rh positive is on the top shelf and blood type A Rh negative is on the bottom shelf. As you are at risk of dying if you receive a blood type different from your own, it is extremely important to store the blood types separately and clearly marked. The photo was taken around 1960. In the 60s the number of blood donors increased dramatically. In 1960 there were 77,000 blood donors, and as the decade came to an end this number had nearly tripled to 232,000.
(End)

Structure and voluntary participation
Today blood donation is organised in a nationwide network of donation sites and voluntary donor corps, all of which are part of the nationwide organisation of the blood donors: *Bloddonorerne i Danmark.* The work upon which the Danish blood donor system is based is carried out by people who voluntarily and unpaid look after the interests of the around 236,000 Danish blood donors.

The blood banks and the local organizations
The work on drawing blood, conducting analyses, and distributing the donated blood is carried out in the same place where the blood is drawn. A distinction is made between the blood banks, which are hospital departments that are able to draw blood as well as carry out the necessary examinations vis-à-vis the donation sites where it is only possible to donate.

Donation can also take place at schools, work places etc. visited by mobile donation units, which then deliver on the blood to a blood bank.

(Caption/text 13)
They don't make lads like this anymore! Organisationally, the scout organisations were closely affiliated with the blood donors, especially during the early years, and they supplied many donors. Today, the chair is more comfortable, the hair cut looks different and the fashion has changed, but 40 years on the situation and the blood bag is actually much the same.
(End)

Regardless of where the donation takes place, EVERY donor belongs to a local donor corps. The 78 local corps are managed by particularly committed donors, and from the outset management has been based on voluntary work.

The local corps looks after the interests of the donors and are responsible for finding new donors, so that there is enough blood for the treatment of patients. Each donor corps is managed by an unpaid board of at least five members, who meet a couple of times annually. For each donation the corps receives a fee from the hospital, which is used to finance recruitment work, information, donor motivation, parties for the donors etc. Some times in the local areas small events like recruitment campaigns are organised.

Everybody can make a voluntary contribution to the local corps. The blood bank or the nationwide organization can help establish contact to the local corps.

The nationwide organization 'Blood Donors in Denmark'
In a county the local blood donor corps co-ordinate their work in a county committee. Through the 14 county committees the local corps are represented in the national committee with a total of 41 members. The national committee is the supreme management body of the nationwide organisation *Bloddonorerne i Danmark.*

All 78 local donor corps are affiliated with *Bloddonorerne i Danmark,* which serves as the interest organisation of the blood donors. It supports the corps with guidance and information material and represents Danish donors internationally. *Bloddonorerne i Danmark* also publish the magazine *Donor Nyt* – Donors' News - maintains press relations and organises nationwide campaigns in order to recruit and retain donors.

Summary and questions
In Denmark the first blood transfusion took place in 1848 at *Almindeligt Hospital* in Copenhagen. In the interwar years Karl Landsteiner's discovery of the AB0 blood types along with the use of patients and relatives as donors formed the idea that healthy and blood type specific donors ought to be used. Therefore, at the end of the 1920s a blood type department at the *Statens Serum Institut* was set up, and in 1932 Tage Carstensen founded *Spejdernes og Væbnernes Frivillige Bloddonorkorps* - the Voluntary Blood Donor Corps of Scouts and xxx. Also in 1932 he was the first to lie down on the couch voluntarily and unpaid in order to donate blood. On 2 April 1952 the first blood bank in Denmark opened at *Bispebjerg Hospital* in Copenhagen.

In 1952 local donors around the country agreed to organise nationally and the nationwide organisation *Danmarks Frivillige Bloddonorer* – Denmark's Voluntary Blood Donors – was founded. Today the name of this organisation is *Bloddonorerne i Danmark* – Blood donors in Denmark – and it still looks after the interests of the now approximately 236,000 Danish blood donors.

1) In the interwar years the attitude towards procedures concerning blood donation changed. Why?
2) Which two institutions were set up as a consequence of the new attitude towards blood donation?
3) From where did Tage Carstensen get his idea for *Spejdernes og Væbnernes frivillige bloddonorkorps* - The Blood Donor Association of Voluntary Guides and Boy Scouts?
4) When did the first voluntary and unpaid blood donation in Denmark take place?
5) In the period from 1932 until today, how many times has the number of donors in Denmark multiplied?

3. The functions and constituent parts of blood

Blood is an interesting part of the body. It consists of many billions of blood corpuscles in a fluid called plasma. It helps make sure that the body works. This chapter explains what functions blood has in the body and what it consists of.

The functions of blood
Blood constitutes about 7% of a person's weight. Inside the body a woman has on average five litres of blood and a man has on average 6½ litres of blood. Blood consists of four different parts: red blood corpuscles, white blood corpuscles, blood platelets, and plasma. Blood has three important functions: transport, defence and regulation.

Transport
Each cell in the body depends on the supply of nutrients and oxygen as well as the disposal of waste products and carbon dioxide. Blood does this. The circulation of blood in the blood stream makes it possible to transport matter from one part of the organism to another.

Blood and the blood stream, which are parts of the circulation, are therefore really responsible for the transportation of oxygen (O_2) to the organs as well as for the disposal of carbon dioxide (CO_2). Using the red blood corpuscles, the blood transports oxygen from the lungs to the organs, tissue, and muscles. At the same time the carbon dioxide produced by organs, tissue, and muscles is taken up and led back to the lungs. Blood can therefore be viewed as a transport organ making sure that all the organs of the body receive their supply of nutrients and oxygen and dispose of their waste products and carbon dioxide.

(Caption/text 14)
Together, the blood, the blood stream, the heart and the lungs make up the blood flow.
(End)

(Caption/text 15)
The blood is a transport organ carrying out transportation jobs between different parts of the body, e.g.:

- Oxygen from the lungs and carbon dioxide to the lungs
- Nutrients from the intestine to the liver
- Water between intestine, tissue, and kidneys (water balance)
- Waste products from matter to liver and kidneys
- Heat (regulation of temperature)
- Medicine from intestine out into the tissue
- Hormones and xxx
- White blood corpuscles and antibodies (immune defence)

(End)

Defence
Blood also helps to defend the body against intruding micro-organisms such as bacteria, virus, fungi, and parasites that can cause diseases. The white blood corpuscles floating with the blood through the whole body have the quality that they can attack and destroy the harmful micro-

organisms, which enter our body through the skin or through what we breathe and eat. As they are able to get to, attack, and destroy bacteria and virus, the white blood corpuscles defend the body against micro-organisms. Thus, the blood is also part of the body's defense against diseases.

Regulation

Regulation of the body temperature happens through regulating the circulation of blood. When the blood transfers heat from the internal organs to the cool skin, the body's temperature is regulated downwards. The surplus of body heat causes blood vessels to open, so that more blood is transported to the skin where it cools down. When the blood vessels in the skin open more blood runs close to the surface of the skin which then turns red and starts to give off heat. At the same time the blood releases fluid into the sweat glands which, when the sweat evaporates from the surface of the skin, also reduces the body temperature. If the body needs to stay warm, the blood vessels close up and blood is kept away from the skin, which then turns pale and cold. The blood is therefore an instrument of the body in regulating temperature.

Blood's constituent parts

As mentioned, blood consists of four different parts: red blood corpuscles, white blood corpuscles, blood platelets, and plasma. The blood consists of 45% blood cells, which are the red and the white blood corpuscles as well as the blood platelets. The blood cells are in a fluid called plasma. Plasma constitutes the remaining 55% of the blood.

(Caption/text 16)
Cells, 45%
Red blood corpuscles
Blood platelets
White blood corpuscles

Plasma, 55%
Salt water
Nutrients
Waste products
Proteins
(End)

Blood cells

The blood cells are divided into three groups, according to their appearance and their function. The blood's cells consist of around 25,000 billion red blood corpuscles, 35 billion white blood corpuscles, and 1,500 billion blood platelets and make up about two litres in total. The blood cells are formed in the bone marrow, and the exact ratio among the three different types of cells is maintained on a constant basis.

Red blood corpuscles (erythrocytes)

Red blood corpuscles (erythrocytes) make up the greater part of the blood's cells. Red blood corpuscles are red, disc-shaped cells that measure about 7.5 µm (0.0075 millimetres) in diameter, and they are almost in the shape of a dried apricot. The average life-span of a red blood corpuscle is 120 days, after which it perishes. Every second around two million red blood corpuscles are formed and destroyed.

(Caption/text 17)
Red blood corpuscles, enlarged about 1,800 times and artificially coloured. The red blood corpuscles are on their way through an artery branch. A red blood corpuscle may travel up to 15 kilometres every day.
(End)

The red blood corpuscles contain a protein called haemoglobin. Among other things, haemoglobin consists of iron. Iron is the matter that colours haemoglobin red, and thus also gives colour to the red blood corpuscles. Iron is important to the formation of both haemoglobin and red blood corpuscles. If you lack iron, haemoglobin is not formed, and in the end a lack of haemoglobin leads to a lack of blood. Iron is therefore indispensable to the formation of haemoglobin and thereby to the formation of red blood corpuscles.

Haemoglobin is also necessary for the blood to be able to transport oxygen (O_2) from the lungs to the tissue and to the organs where it is constantly consumed. Haemoglobin also transports carbon dioxide (CO_2) from the tissue and the organs back to the lungs where it is exhaled. Thus, haemoglobin is a precondition for blood being able to function as a transport organ.

Lack of red blood corpuscles may arise as a consequence of the loss of blood following an operation or an accident, but it may also result from corpuscles being destroyed faster than the rate at which they are formed. Due to a decrease in production, many diseases - including some forms of cancer – will cause a lack of red corpuscles, and patients suffering from these diseases may therefore need a blood transfusion.

White blood corpuscles (leucocytes)
White blood corpuscles (leucocytes) are an important part of the immune defence. White blood corpuscles are ball-shaped cells with a diameter of 10-30 µm (0.010-0.030 millimetres). Some types have bulges resembling and functioning as tentacles. The life span of the white blood corpuscles – from a few hours up to a week – is considerably shorter than that of the red blood corpuscles. Moreover, there is far fewer of them.

The white blood corpuscles are mostly found outside the blood stream. When found in the blood stream, they are being transported round in the body. Other than that, they can be found in the body tissue - connective tissue, skin, and organs – where they help to defend the body from attacks by micro-organisms. Besides defending the body, the white blood corpuscles also function as the body's 'dustmen' who take up and remove dead cells. The white blood corpuscles have one final important characteristic: they recognise the body's own cells and distinguish them from foreign micro-organisms. This fundamental characteristic prevents them from attacking the body's own cells.

(Caption/text 18)
A white blood corpuscle, enlarged about 3,500 times and artificially coloured. There are different kinds of white blood corpuscles. This is a so-called T-lymphocyte, characterised by its long 'bulges' protruding from the cell.
(End)

White blood corpuscles are divided into three groups, according to their functions and characteristics: lymphocytes, monocytes/macrophages, and granulocytes.

Lymphocytes are the cells 'responsible' for the immune defence system. Immune defence refers to the phenomenon that in case of an attack by a micro-organism with a different surface or structure than those of the body's own, the lymphocytes react specifically against this foreign structure. The lymphocyte goes through a development process in which matter is formed that reacts with and destroys the micro-organisms with the foreign structure. This is explained in greater detail in the section on antigens and antibodies.

Lymphocytes are divided into T- and B-lymphocytes. A T-lymphocyte identifies or points out the cells which have been invaded by the foreign organism. In addition to these there are special T-lymphocytes referred to as killer-cells. They help to destroy or kill the infected cells. A B-lymphocyte forms the matter which reacts with the organism and the foreign structure. Furthermore, some of the B-lymphocytes are memory cells that remember and recognise an earlier infection. Because of the B-lymphocytes the immune defence is then able to react quickly in case of a similar infection. The memory cells therefore help to ensure that in a new encounter with a foreign organism, which has a different structure, the body is able to react much more quick and powerfully, so that the infection is cured straight away.

Monocytes are the type of white blood corpuscles that function as 'dustmen'. They are active both in the blood and in other tissue, where they take up and destroy micro-organisms and worn-out cells. In the event of an infection a greater number of monocytes will enter the tissue, where they are transformed into **macrophages**, capable of breaking down the intruding micro-organisms. This ability to break down micro-organisms makes the macrophages an important part of the body's defence against infection.

Granulocytes contain matter, which, for instance, is capable of breaking down tissue. Granulocytes can take up destroyed tissue and micro-organisms and break down the material it has taken up. There are three kinds of granulocytes: neutrophils, eosinophils, and basophils.

- Neutrophilic granulocytes are involved in the body's fight against different bacterial infections. When tissue is damaged, the neutrophilic granulocytes rush to the area where they destroy and consume the remains of the damaged cells and bacteria. In the destruction process the granulocytes themselves will perish and produce the yellow fluid (pus), which can be observed in festering tissue.

- Eosinophilic granulocytes contain matter released during allergic reactions triggered e.g. by allergy to worms or house dust mites. The matter intensifies the allergic reaction.

- Basophilic granulocytes are the rarest and contain matter released during allergic reactions (reactions of hypersensitivity). This matter extends the small blood vessels in e.g. the nasal cavity, which shows itself as hay fever.

Apart from the red corpuscles and the white blood corpuscles, the blood's cells also consist of blood platelets. The blood platelets set themselves apart from the other blood cells through their size and their greater numbers, among other things.

Blood platelets (thrombocytes)
Blood platelets (thrombocytes) are the smallest cells in the blood. There is, however, a lot of them – around 300,000 per mm^3 blood. They are shaped like little round discs and when they are activated

they change into balls that look like sea urchins. The blood platelets have a diameter of approximately 0.003 mm, and they live for about nine days.

(Caption/text 19)
A blood platelet, enlarged about 6,800 times and artificially coloured. The blood platelet is the white cell among the red blood corpuscles.
(End)

The blood platelets are formed in the bone marrow, and under normal circumstances they simply float with the blood. But if there is a cut or a scratch in your skin, the first to arrive on the scene to stop the bleeding are the blood platelets. The blood platelets are attracted by matter in the damaged tissue. The matter makes them swell, stick together, and cling, so that the hole is sealed quickly. The scab, which subsequently forms, is a combination of red blood corpuscles and a plasma protein and it seals the hole ultimately.

If the body's internal organs are damaged, the blood platelets activate substances – coagulation factors – which cause the blood to clot and heal the internal tissue. Put differently, the blood platelets are responsible for the release of those substances that make the blood clot, so that the body's internal organs will heal.

Plasma
Apart from cells the blood also consists of plasma. Plasma makes up 55% of the blood and is the fluid in which blood cells are found. Plasma is a yellowish fluid consisting of 90% salt water with a salt concentration similar to that of sea water. Apart from salt water plasma also contains fatty substances, hormones, vitamins, waste products, carbohydrates, and many different proteins (albumen), which are all transported around along with the blood.

(Caption/text 20)
Proteins (albumen) supply building materials, among other things, for the growth and maintenance of the body's tissue.
(End)

One of the proteins is albumen, the function of which it is to transport different kinds of matter around along with the blood. Albumen is not able to penetrate the vessel walls, and it therefore stays in the blood stream where it helps to sustain a high concentration of matter, which keeps plasma in the blood stream. Were it not for albumen, water would seep through the vessel walls, because the pressure is higher inside the vessel than in the tissue surrounding it.

Usually, the amount of plasma ensures an appropriate ratio between the number of blood cells and the amount of fluid. Too many blood cells increase the blood's thickness, which leads to a steep increase in the amount of work that the heart has to perform in order to pump blood around in the blood stream. If the heart fails to do this, it fails to function and you will show the symptoms of coronary thrombosis.

Apart from albumen and other transportation proteins, plasma contains antibodies produced by the immune system and coagulation factors that will cause the blood to clot.

Summary and questions

Our blood has overall three important functions: it transports oxygen, nutrients etc. around in the body and out to the organs and into the tissue. Blood defends our body against micro-organisms attacking us from the outside. All blood’s constituent parts take part in this defence – both blood cells and plasma. Blood also regulates the body temperature.

With the help from haemoglobin, the red blood corpuscles – the erythrocytes – transport oxygen to the body’s organs. Haemoglobin’s content of iron gives the red blood corpuscles and the blood its red colour. Together with the blood platelets the red blood corpuscles form the scab, which seals a scratch or a cut in your skin.

In the body’s immune defence the white blood corpuscles – the leucocytes – are the main responsible cells. They can also be found outside the blood stream where they defend the body against infections. The white blood corpuscles are divided into three different kinds: lymphocytes, monocytes/macrophages, and granulocytes, each with its own function: lymphocytes are responsible for the immune defence. They are the ones that recognise or identify and react against foreign organisms and ‘kill’ them. Monocytes and macrophages break down and destroy worn-out or dead cells. Granulocytes contain enzymes that break down destroyed tissue. In this way dead cells or other micro-organisms are removed from the body. The white blood corpuscles are therefore both the ‘dustmen’ and the ‘killers’ of the body.

The blood platelets – the thrombocytes – become active when we get a scratch in the skin and blood vessels and tissue break. The blood platelets quickly seal the hole and activate the coagulation factors that cause the blood to clot and form a scab. Beneath the scab new tissue forms, and the hole is sealed.

Plasma consists primarily of salt water and helps transport nutrients and fluid waste products around with the blood. Furthermore, plasma makes sure that the blood does not become too thick, so that the heart is able to pump it around effortlessly inside the body.

1) Give an example of the way in which blood functions as a transport organ.
2) Name the three types of blood cells.
3) What gives blood the colour red?
4) What are the two types of lymphocytes called? What are their respective functions?
5) What are the functions of blood platelets?
6) Name some of the matter found in plasma.

4. The body's immune defence

The body's defence against infections, and thereby against infectious diseases, is a complicated process. Defending the body involves the blood and, in particular, it involves the white blood corpuscles, which contribute to the body's defence in different ways, as briefly described in chapter 3. The antibodies that are found in the blood are part of the defence against and destruction of micro-organisms and they are pointed at the corresponding antigens that are found on the surface, among other places, of the bacteria and viruses, which make us ill. This chapter is about antigens, antibodies, and immunity. Moreover, it briefly touches on HIV infection and AIDS, which are both linked to our immune system.

Antigens and antibodies

Antigens
Antigens are matter which causes the formation of antibodies. An antigen is therefore a kind of generator of antibodies. Antigens can be part of the surface of a cell (e.g. a micro-organism), or they can be free and unbound. They can be found everywhere in nature, also the human body. Some antigens are familiar to the body. These are the ones that are part of ourselves, of our own bodies, and with which we are born. Other antigens are foreign to us and to our immune system, because they do not belong to our bodies and therefore are not known to us beforehand. A foreign antigen, for instance, can be found in the surface of a bacterium or a virus.

(Caption/text 21)
A gene and an antigen are two different things
Genes you inherit from your parents, and they are found in the chromosomes. Here, all information about every single person is stored, including information on what antigens the person is able to form.

Antigens are matter, often of a protein character, which is found everywhere in humans as well as in nature.

When the body defends itself against foreign antigens, it happens by forming antibodies to match exactly those antigens that are foreign to the body. The antibodies make sure that the body's immune system is activated, so that the micro-organisms are destroyed, and one does not fall ill.
(End)

Foreign antigens enter our bodies in different ways, for instance through food, water, and the air we breathe. When our immune system discovers foreign antigens in our bodies, it will attack them and thereby fight the bacterium or virus, in the surface of which the antigen is found.

(Caption/text 22)
Antibody molecule 1) with a surface that fits the antigen 2) like a key fits into a lock.

Here, antigen 2) and antibody 1) surfaces do not match very well.
(End)

The immune system's fight against foreign antigens at the same time releases matter from the cells involved – matter that makes us feel ill, e.g. because our body temperature increases.

Antigen and gene
An antigen should not be mistaken for a gene. Genes and antigens are two very different things. There is, however, one important correlation between them, as it is the gene, which determines the kind of antigens that are to be found in an organism. Genes are found in the chromosomes, which we inherit from our parents. Genes contain the basic information, which is crucial in determining a person's characteristics. Among other places antigens are found in the cell surfaces, and they are one of the characteristics determined by the genes.

Antibodies
Antibodies are matter formed by the organism's immune system when coming across an antigen that does not belong to the organism. An antibody binds itself to antigens with the same structure as the antigen that once brought about the formation of the antibody itself. An antibody does not bind itself to other types of antigens. An antigen and the corresponding antibody are therefore a unique match. They only react with each other and not with others. They are said to fit each other like a key fits into a lock.

Antibodies are formed from parts of the white blood corpuscles called B-lymphocytes. The antibodies fight the foreign micro-organisms by binding themselves to their antigens. An antibody bound to an antigen will attract white blood corpuscles of the neutrophilic type, and these will begin to surround and take up the micro-organism, so that it is destroyed.

As antibody is produced by the white corpuscles, blood becomes an important part of the body's defence against infections and diseases.

Antibodies are protein bodies. They are found everywhere in tissue and in plasma. They continuously circulate with the blood inside the body and are bound to the type of antigens they are formed to react with. As a principal rule you only have antibodies against the antigens you have come across before and to which you are therefore immune.

Immunity
The word immunity implies resistance and in this context it refers to resistance to micro-organisms that the body has not come across before. When you are immunised against an antigen, a specific reaction takes place between the antigen and the B-lymphocytes, which form the antibody. This reaction leads to the development of memory cells, among other things, which make sure that the body in future recognises and reacts against the antigen and thereby becomes resistant to the micro-organism.

(Caption/text 23)
Graphic illustration of the Y-shaped antibody. In the background: tuberculosis bacteria.
(End)

A distinction is made between the first and the subsequent immunisations. The first immunisation happens when the body comes across a foreign antigen for the first time. The reaction against the antigen is relatively slow because the lymphocytes need to be activated first and produce antibody, memory cells, etc. At the subsequent immunisations the lymphocytes are already activated, and in the blood, both circulating antibodies and memory cells already exist. The reaction at the subsequent immunisations is therefore much swifter and much more vigorous. Antibody is formed in larger amounts and of a kind, which binds itself to the matching antigen both more quickly and more firmly. Repeated immunisations therefore increase immunity against the foreign antigen to a considerable extent.

(Caption/text 24)
The graph shows the amount of antibody formed at the first and subsequent immunisations.

First encounter with an antigen. Later encounter with the same antigen.
(End)

Immunisation is used in vaccination. An antigen is administered which is then isolated from the disease-inducing micro-organism, against which the patient then forms antibodies. Later, when the person encounters the antigen as part of a bacterium or a virus, the body will react very swiftly and vigorously, which will prevent the person from falling ill. In this way, people can be made immune to a wide range of diseases e.g. small pox, German measles, whooping cough and influenza.

(Caption/text 25)
Through vaccination, it is ensured that a person forms antibodies against various diseases.
(End)

HIV/AIDS
AIDS is a disease directly linked to the body's immune defence. AIDS is an abbreviation for Acquired Immune Deficiency Syndrome. The disease is caused by an infection of Human Immune defect Virus (HIV). HIV infection develops after a shorter or longer symptom free period (5-15 years) into AIDS. HIV breaks down the body's immune defence, because the virus attacks and destroys some of the blood's white blood corpuscles, the so-called T-lymphocytes, which normally help to defend the body against invading micro-organisms. In other words, HIV breaks down the immune defence, which finds it increasingly difficult to fight foreign micro-organisms. After a number of years, the immune defence is so damaged that the body is incapable of fighting infections, which under normal circumstances would be perfectly harmless. When the HIV-carrier contracts such infections and consequently falls ill, the person in question is said to have AIDS. Most AIDS patients die from basic infectious diseases, such as diarrhoea or pneumonia.

Summary and questions
Collectively, the body's defence against micro-organisms is called the immune defence. The immune defence is constituted by antibodies and by a part of the white blood corpuscles, called T-lymphocytes

Antigens are protein-like matter, which are found either unbound in e.g. plasma or bound e.g. as part of the surface of a cell. Foreign antigens, which are not part of our own body, are discovered and recognised by the body's immune defence, because they have a structure that is foreign to the body. When the immune defence discovers a foreign antigen, it is instructed to form antibodies, i.e. the foreign antigen triggers a message to form antibodies matching exactly the antigen in question.

Antibodies are formed by the B-lymphocytes. Antibodies fight the foreign antigens by binding themselves to them and attracting white neutrophilic blood corpuscles, which then surround and destroy the bacterium and the foreign antigen.
Immunisation takes place in two ways: at the first immunisation, the body comes across the antigen for the first time, and because the body first has to initiate the production of antibody and memory

cells, the forming of antibody at the first immunisation only happens slowly. The subsequent immunisations happen the following times the body encounters the antigen. Now there are antibody and memory cells in the blood to begin with, and the process of forming the antibody is therefore very swift and vigorous. Micro-organisms will therefore be killed before they cause a disease. Immunisation is used in vaccination where the antigen is injected isolated from disease-inducing micro-organisms.

HIV and AIDS are linked to the body's immune defence. HIV is a virus, which destroys human immune defence. After a number of years with an HIV infection, the immune defence is weakened to such an extent that the patient is no longer able to fight basic infections from which he consequently dies. The patient is said to have developed AIDS.

1) What does *immunity* mean?
2) What are *antigens*?
3) What are *antibodies*?
4) What type of blood cells produce antibody?
5) Describe the difference between antibody formed at the first immunisation and antibody formed at subsequent immunisations.

5. Blood groups

This chapter covers blood types and blood type determination. People have different blood types the same way we have different eye and hair colours. The different blood types are characterised by each having a special antigen in the surface of the red blood corpuscles. A blood type is therefore determined by showing which antigens characterise the blood type. The antigens become evident through their reaction with their matching antibody. Thus, ‘A’ antigens are shown through their reaction with ‘anti-A’. This test is called ‘blood type determination’.

(Caption/text 26)
Are you the boring type?
The more common your blood type is, the more the blood banks need your blood. So, to the blood banks no types are boring!
(End)

In the human body, there are no less than approximately 300 different blood type antigens distributed across 26 different blood type systems. A blood type system is a collection of blood type antigens that belong together. The blood type antigens can be combined in so many ways that it is almost impossible within all blood type systems to find two unrelated people carrying the same blood type.

The system of blood groups
Of all the blood type systems, the blood type systems AB0 – known as A B zero – and Rhesus are particularly important when transfusing blood. A blood type therefore usually implies the specification of the AB0 and Rhesus types, e.g. 0 Rhesus positive or A Rhesus negative, possibly further shortened to 0 pos and A neg.

The AB0 blood group system
The AB0 blood type system’s antigens are part of the surface of all cells in the body. The AB0 blood type system is characterised by two AB0-antigens called A-antigen and B-antigen. Whereas type AB has both A and B-antigens, type 0 has neither A nor B-antigens.

The AB0-antigens are hereditary qualities determined by the genes A, B, and 0. While the 0-gene does not cause the formation of any antigen, the A-gene forms A-antigens and the B-gene forms B-antigens. The two AB0-genes you inherit from your parents, e.g. A and 0, are found in each their chromosome and constitute what is referred to as the AB0-genotype. The phenotype is what the genes generate. It might be blonde hair, brown eyes, or an AB0-blood type. Using the example of the A0 genotype the phenotype is A, because whereas the 0-gene does not form any antigen, the A-gene forms A-antigens. When there are only A-antigens, the phenotype is A, and the AB0 blood type is therefore A.

(Caption/text 27)

Father's gene	Mother's gene	Genotype	Antigen	Phenotype	Incidence	Antibodies
0	0	00	Neither	0	41%	anti-A and anti-B
A 0 A	A A 0	AA 0A A0	A	A	44%	anti-B
B 0 B	B B 0	BB 0B B0	B	B	11%	anti-A
B A	A B	BA AB	A and B	AB	4%	Neither

The table shows the interrelationship among the AB0-genes inherited from your parents; the AB0-genotype; the incidence of AB0-antigens in the different AB0-types; the AB0-phenotype; the incidence of AB0-types in the Danish population; and the incidence of the AB0-blood type system's antibodies anti-A and anti-B in the four different AB0 blood types.
(End)

The AB0-blood type system's antigens A and B have matching antibodies, anti-A and anti-B. Anti-A- and anti-B are formed because we are affected by foreign A and B-antigens from Coli Bacilli. Coli Bacilli are bacteria which are found in the bowel of all humans, among other places, without causing disease. They are not inborn, but can be found approximately three months after you are born. When you're infected with Coli Bacilli during the first months of your life, you come across the A and B antigens. If you already have these antigens yourself, they are not foreign to you and you are not immunised to form AB0-antibody. If, however, you do not have them already, the immune apparatus will be affected by the foreign antigen, and you will form antibody against it. If, for instance, you do not have an A-antigen, you will become immunised by the foreign A-antigen and form anti-A, and similarly with B-antigen and the formation of anti-B. Alternatively put, you will always form AB0-antibody against any AB0 antigen(s) not present in your body. (see table)

When you always have AB0-antibody against the AB0-antigens you do not have, it means that mixing blood from two people with different AB0-types will result in a mixture, which always includes AB0-antibody from the one person directed against AB0-antigens from the other person. If one person is type 0 and another person is type A and you mix the two, the 0-blood will include anti-A, which will then react with the A-antigens in the A-blood. The two types of blood are said to be incompatible.

Today, when a blood transfusion with red blood corpuscles is administered, only red blood corpuscles with added salt water are used, not whole blood (xxx). Most plasma containing antibody, and thereby also AB0-antibody, has been filtered out. Therefore, when a transfusion is administered with red blood corpuscles and no plasma, a few more combinations of AB0-types can be used. It is possible to administer 0-blood to all AB0-types, A-blood to types A and AB as well as B-blood to types B and AB.

If you administer red blood corpuscles with antigens that are able to react with the antibody in the patient's blood, you get a so-called haemolytic transfusion reaction. This is caused by the reaction between the transfused red blood corpuscles and the patient's blood type antibody. This reaction releases matter into the blood, which makes the blood pressure go down and causes the red blood corpuscles to break (haemolysis). Serious haemolytic reactions may cause death.

In practise, a patient would normally only receive blood of the patient's own AB0 blood type, so as to avoid transfusion complications due to the fact that there is always some plasma left in the mixture of red blood corpuscles and fluid consisting of salt water and residual plasma. However, as suggested by the figure, in cases of shortage it is possible to administer red blood corpuscles.

The Rhesus blood group system

Unlike the antigens of the AB0-system, the antigens of the Rhesus blood type system are only found in the surface of the red blood corpuscles and not in the surface of other cells. Altogether, there are about 50 different Rhesus antigens of which usually only five are important when a blood transfusion is administered. The most important antigen by far is the D-antigen. Therefore, when the Rhesus type is determined, only this antigen is taken into consideration. If you have the D-antigen, you are Rhesus positive (RhD pos). If you do not have the D-antigen, you are Rhesus negative (RhD neg). Around 85% of the Danish population is Rhesus positive, and around 15% is Rhesus negative (see table below).

(Caption/text 28)

Father's gene	Mother's gene	Genotype	Antigens	Phenotype	Incidence	Antibodies
D	D	DD	D	RhD pos	85%	Not able to form anti-D
d	D	dD				
D	d	Dd				
d	d	dd	Not D	RhD neg	15%	Able to form anti-D

The table shows the connection between the D-genes inherited from the parents, the D-genotype, the incidence of D-antigens in the different Rhesus types, the D-phenotype or the Rhesus blood type, the incidence of Rhesus types in the Danish population, and the incidence of the antibody anti-D in the Rhesus blood type system, in case of influence by other people's RhD positive red blood corpuscles.
(End)

The Rhesus blood type system is important because the D-antigen is very immunogenic (xxx), which means it easily induces the formation of antibody for those who need it. Normally, within the Rhesus system there are no blood type antibodies, unless previously exposed to red blood corpuscles from another person, because Rhesus antigens are only found in the surface of these. Under normal circumstances it is therefore possible to administer a blood transfusion without consideration for the Rhesus blood type system.

(Caption/text 29)
The characteristics of blood were first discovered in the Rhesus-monkey and were later named after it. The discovery was made during the years just prior to the Second World War.
(End)

(Caption/text 30)
If the foetus is Rhesus positive, pregnant women who are Rhesus negative can form Rhesus antibody.
(End)

If RhD positive blood is transfused to an RhD negative person, who has anti-D antibody in his plasma, the Rhesus antibody anti-D can cause some very serious haemolytic transfusion complications. The Rhesus antibody anti-D is also the main cause for the serious disease 'congenital jaundice of the newborn', in which case the antibody anti-D of the mother's Rhesus negative immunised plasma of the mother passes through the placenta into the Rhesus positive foetus where it binds itself to the red blood corpuscles of the foetus, which then become damaged and break apart.

To avoid immunisation and formation of the dangerous antibody anti-D, patients who are Rhesus-D negative can only receive Rhesus-D negative blood. In case of RhD negative blood shortage exceptions to this rule can be made, if the patient does not already have anti-D, and there is no likelihood that the patient will become pregnant in future (i.e. males and females older than the childbearing age).

The first time an RhD negative person encounters the D-antigen – the first immunisation – that person's immune system will react slowly as there are no antibodies against the anti-D circulating in the plasma already. It therefore takes some time before the lymphocytes become active and develop any further. If antibody is formed, it does not happen until months after the transfusion or the pregnancy.

Next time the body is exposed to the D-antigen – the subsequent immunisation – an immunisation has already happened. Therefore, a reaction will take place between the D-antigen and the memory cells in the immune system, and between the anti-D and the foreign red blood corpuscles, which will be destroyed quickly.

(Caption/text 31)
My mum has always had too little blood, and having blood type AB neg in addition hasn't made her pregnancies any easier. At every birth she's lost a lot of blood. I'm the youngest out of four and if she hadn't been able to receive blood, I wouldn't have been born. That's the reason why I've become a donor. On behalf of myself and my mum, I want to give something back.
Maja Sparre, 19
(End)

(Caption/text 32)
The distribution of blood types across the Danish population.
(End)

Summary and questions

The two most important blood type systems are the AB0 and the Rhesus systems. The antigens of the AB0 blood type system are found in the surface of all the cells in our body, in bacteria, and in plants. Rhesus antigens are only found in the surface of red blood corpuscles.

You inherit the AB0- and Rhesus-genes from your parents. You inherit one gene from each of your parents, and these two genes determine which genotype you have. The genotype indicates which genes you have inherited. The genes determine which blood type antigens you have. The antigens determine which blood type (also known as phenotype) you have. Thus, the blood type becomes an expression of the blood type antigens your body has formed. In the same way as the body forms antibodies against foreign antigens, the body also forms blood type antibodies against foreign blood type antigens.

As the AB0-blood type antigens are not only found in humans, but also elsewhere in nature – e.g. in coli bacillus - we are all in contact with these 'foreign' AB0-blood type antigens at an early stage in life. In our blood we therefore have AB0-antibodies against the AB0 antigens we do not have. In a blood transfusion, blood of the same AB0-blood type as the patient's own blood type is administered. If not, the reaction between e.g. the patient's AB0-antibody and the donor's AB0-antigens on the red blood corpuscles will cause a haemolytic transfusion complication, in which the transfused red blood corpuscles are rapidly destroyed. This may cause a life threatening situation.

Among other things, the Rhesus system consists of the antigen D which induces the antibody anti-D. As the Rhesus-D antigen is only found in the red blood corpuscles, the only way for the antigen to enter the body is through blood transfusion or pregnancy, in case of which a small amount of foetus blood is transferred to the mother. Due to the D-antigen's great ability to induce the formation of antibody, the risk of immunisation is great if a person who is Rhesus negative gets the D-antigen into his body.

1. What do you call the antigens that determine your AB0-type?
2. Why do you get A and B-antibodies in your blood already when you are very small?
3. In what ways can you become immune to the formation of anti-D?
4. Describe the interrelationship between genotype, phenotype and blood type.
5. What is a haemolytic transfusion complication?

6. Blood donor eligibility

(Caption/text 33)
"Any person is considered a blood donor, whose blood – or parts thereof – is collected at one of the country's blood banks or at one of the mobile blood collection units of the blood banks for the purpose of administration to others in treatment of disease or for the purpose of producing blood derivatives or reagents for diagnostic or other purposes. According to laws on procurement and application of human blood and blood products for pharmaceutical purposes etc., the collection of human blood can only be made from voluntary and unpaid blood donors."
Source: De Transfusionsmedicinske Standarder
(End)

Anyone who is in good health, aged between 18 and 60, and whose weight exceeds 50 kg can register as a blood donor. The standard amount of blood collected per portion is 450 ml +/– 10%. A donor cannot weigh less than 50 kg because the ½ litre of blood collected will make up too great a part of his total amount of blood – also known as the blood volume. These figures have been worked out based on the estimate that no more than 13% of the total blood volume can be collected. As the standard withdrawal is 450 ml, there is a risk that the percentage of blood collected from people weighing less than 50 kg might be too high.

Within minutes the body replaces the 450 ml of collected blood with fluid from the tissue, under the precondition that the donor has no fluid deficiency. It is therefore important that the donor has had plenty to eat and drink before the collection, and that donor has something to drink in connection with the collection. After the collection, it is also important that the donor rests for 10 minutes, so that the blood volume has time to equilibrate itself again. If you donate blood on a regular basis, you can continue until you turn 65.

(Caption/text 34)
To become a donor, you must weigh more than 50 kg.
(End)

A blood donor is called in for collection up to four times a year. At least three months have to pass between every two collections. This ensures that the donor's blood has been replenished. It is not necessary everywhere in the country to call in a donor for collection four times a year. That is because it is the bigger cities with hospitals carrying out many blood demanding operations and treatments that need a lot of blood. In the smaller cities the amount of blood necessary is not quite as vast, and a donor therefore usually does not need to make donations more than once or twice a year.

(Caption/text 35)
In the future you could be called in for collection by means of an SMS-text message.
(End)

Not all the different blood types are in equal demand. 0 Rhesus Negative (0 RhD neg), which can be administered to all patients immediately, regardless of their own blood type, is in great demand, whereas the AB type is in less demand. Regardless of their blood type, however, everyone should register as a donor, so that they are available and can be called in e.g. in an emergency situation.

Donor approval
Before a donor is approved, a number of considerations has to be made – for the donor as well as for the recipient of the blood. A prospective donor therefore has to answer a number of questions as well as be made aware of a great deal of information. The blood bank makes sure that a donor receives the information required and that the relevant questions are asked. And the blood bank staff is available as well, if the donor has additional questions or requires more information.

The questions asked are about the donor's general state of health, potential risky conduct, and other circumstances that may disqualify him as blood donor. This chapter deals with safety issues concerning blood donation and throws light on the kinds of conduct that may cause temporary or permanent exclusion as a donor.

Consideration for donor as well as recipient
Questions are not only asked out of consideration for the donor. Questions are also asked as part of the safety measures that need to be in place in order to prevent the recipient of the blood from becoming ill or infected by the blood. Therefore, when deciding if a person qualifies as a donor, both donor and recipient have to be taken into consideration. Through information and questions, it is attempted to exclude donors who either themselves may be harmed by donating blood, or who may cause a disadvantage to the recipient of the blood – or expose him to a risk. For safety reasons it is therefore important that the answers to the questions are both correct and honest and that the donor receives the necessary information.

(Caption/text 36)
The diseases among others that may render a donor unfit for donation:

- Heart diseases
- Circulatory diseases
- Epilepsy
- Asthma
- Diabetes

The diseases among others that can be transmitted to the recipient:

- Cancerous diseases
- Infectious diseases

(End)

Safety
The Danish blood supply is one of the safest in the world. In order to maintain the high safety standards, various safety measures are in place, each of which helping to make sure that neither the donor nor the recipient of the blood is harmed in any way. One measure is a health questionnaire accompanied by the relevant information. Screenings and tests of the donated blood are a different safety measure. We return to the screenings in the section on donor blood examination. To increase safety, blood is never collected from a donor at his first visit to the blood bank. Instead, a blood sample is taken, which is then examined for blood type, haemoglobin value, and infection markers. In Denmark we have a corps of permanently affiliated donors, who donate blood on a regular basis, which ensures that donors are well-informed, examined regularly, and always at hand and thus that blood is readily available.

Health questionnaire
When you turn up in the blood bank, you are asked to fill in a health questionnaire, and you receive written information on conduct that may lead to permanent or temporary exclusion.

(Caption/text 37)
Written information is handed out on conduct that may lead to exclusion as a donor.
(End)

Usually there is no need to perform actual health examinations, but donors do have to be thoroughly questioned – particularly about possible previous and current diseases, vaccinations, possible medicine ingestion as well as stays in regions with increased risk of infection, e.g. with HIV and malaria.

View an example of a donor questionnaire in the following pages.

Name: Personal registration number:

All health information will be treated confidentially.

Have you ever	**Yes**	**No**
- suffered from serious diseases or undergone surgery?	☐	☐
- suffered from serious infectious diseases?	☐	☐
- suffered from allergies? (e.g. asthma, hay fever, allergy to medicine etc.)	☐	☐
- experienced fits?	☐	☐
- suffered from anaemia?	☐	☐
- suffered from too high or too low blood pressure?	☐	☐
- suffered from epilepsy (fits or spasms) after puberty?	☐	☐
- suffered from heart or circulatory disturbances?	☐	☐
- suffered from kidney diseases?	☐	☐
- suffered from diabetes?	☐	☐
- suffered from cancer tumours?	☐	☐
- experienced growth disturbances treated with growth hormones?	☐	☐
- suffered from other extraordinary diseases?	☐	☐
- had sexual intercourse with another male? (only to be answered by males)	☐	☐
- worked as a prostitute?	☐	☐

Within the past year, have you		
- experienced prolonged periods of fever?	☐	☐
- experienced unintended weight loss?	☐	☐
- had sexual intercourse with	☐	☐
- a bisexual male?	☐	☐
- a prostitute in Denmark or abroad	☐	☐
- a person from Africa, India, South-East Asia or or South America?	☐	☐
- a person who was HIV positive?	☐	☐
- an intravenous drug addict?	☐	☐
- a person who has been treated for haemophilia?	☐	☐
- been pregnant? (to be answered by females only)	☐	☐
- travelled outside Europe or North America?	☐	☐
- received a blood transfusion?	☐	☐
- had your ears or another part of your body pierced?	☐	☐
- received acupuncture, tattoos, or scarification?	☐	☐

(Turn page)

Within the past two months, did you…	**Yes**	**No**
- take any medication?	☐	☐
- receive a vaccination?	☐	☐

Additional information

➢ Have you been a blood donor before?	☐	☐
➢ Do you weigh less than 50 kg?	☐	☐
➢ Are you aware of incidents of the Creutzfeldt-Jakob's disease within your family?	☐	☐
➢ Have you ever sniffed cocaine, injected, or shared a syringe or a needle with others?	☐	☐
➢ Have you received a corneal graft or a meninx transplant?	☐	☐
➢ Are you born or raised in an area affected by malaria?	☐	☐
➢ Is anyone within your household infected by hepatitis?	☐	☐
➢ Do you consider yourself in good health?	☐	☐
➢ Have you suffered from infectious jaundice, infectious hepatitis, malaria, or syphilis?	☐	☐
➢ Did you read the recent leaflet on AIDS?	☐	☐
➢ Could you have been exposed to an HIV infection?	☐	☐
➢ Do you wish to speak privately to a nurse or a doctor?	☐	☐

The above questions have been answered to the best of my knowledge. I have read the information material I have received. I have had the opportunity to ask questions and these have been answered to my satisfaction.

_______________ ____

Date Signature

Further information about ____
that may have bearing on my blood donation or on the administration of my blood to other patients can be obtained from my private doctor/specialist or hospital.

To be filled in by the blood bank

Collection number:

Remarks:

Interview conducted by:

Approved by:

The questions are answered in a questionnaire given to the donor and filled in without interference by others. However, the blood bank doctor or another authorized member of staff must be near by in case the questions need to be explained or elaborated on – or in case the donor himself has further questions. In other words, before a collection is made, the donor can have a confidential and personal conversation with an authorized member of the blood bank staff. This, however, requires that the donor is able to communicate directly and without an interpreter, and that the donor is able to read and understand the questions in the questionnaire. Because of the requirement for confidentiality between the blood bank staff and the donor, it is therefore not possible to become a donor if you have moved to the country and have yet to learn how to read and speak Danish.

The questionnaire is meant to help sorting out donors who would be harmed by donating blood or whose conduct or general condition of health would result in an increased risk of donating infected blood or blood containing medicine residues.

Exclusion – temporary or permanent

As a consequence of the information brought out by the questionnaire, the donor may be excluded from donating blood. The exclusion may be temporary or permanent depending on the condition of health or the conduct, which led to the exclusion. Clear rules exist as to when someone is excluded from donating blood on a temporary basis and therefore put in quarantine, and when someone is permanently excluded from being a blood donor.

(Caption/text 38)

"The first time I really became alive to the idea of being a blood donor was about five years ago. I'd heard about blood donation before, but even so, it hadn't really stuck in my mind very well.
I was 20 years old then – and it was a colleague at the time who made me decide to do something about it. What she said was that it is just one little pinprick, which to others could make life a whole lot easier. This tallied with the thoughts about blood donation I'd had up until then. Still, it was only then that I was able to get myself together and become a blood donor". Martin Nørgaard Larsen, 25
(End)

(Caption/text 39)

Quarantine – the most common reasons for TEMPORARY exclusion

A number of circumstances leads to temporary exclusion as a donor, including risky conduct, diseases and medicine use:

Acupuncture

If the acupuncture is performed by a doctor (not just supervised by a doctor), there is no need for quarantine. If the acupuncture is performed by others, this leads to one year of quarantine.

Allergies

Donors suffering from seasonal hay fever (pollen) can donate blood in symptom-free periods if they are not undergoing a desensitization process. In cases of acute allergies,
these lead to an exclusion period without symptoms, depending on the individual case.

Amoebiasis

This type of enteritis, which is contracted e.g. through travelling in the tropics, leads to one month of quarantine, after the donor has reported himself fit.

Appendicitis

This leads to at least three months of quarantine.

Borreliosis
Forest tick bites causing suspicion of a borreliosis infection lead to one month of quarantine.
Diarrhoea
If diarrhoea is caused by an acute infection on an otherwise healthy individual, it leads one month of quarantine.
Pregnancy/breast-feeding
Pregnants are not allowed to donate blood. After having given birth, nine months have to pass before a woman is allowed to donate blood again. Collections are not made while regular breast-feeding takes place.
Yellow fever
This leads to one month of quarantine, after the donor has reported himself fit.
Jaundice
Normally, this leads to permanent exclusion. However, jaundice which is certain to have been caused by blocked biliary ducts due to e.g. gallstone only leads to at least six months of quarantine. If a donor has suffered from jaundice as a new born, he will not be excluded.
Hashish
Use leads to 24 hours of quarantine.
Herpes
As herpes is not transmitted through blood, it does not lead to quarantine.
Skin diseases/eczema
The needle should not be inserted in or around an area with active skin disease (e.g. eczema, infection etc.). If eczema is found near the place of needle entry, a collection cannot be made before the donor has showed no symptoms for three months. In cases of widespread skin diseases which are treated with steroids or another active substance, no collections are made for a period of four weeks without treatment.
Infectious diseases/colds
After the end of an acute infectious disease, at least two weeks should pass before a collection is again allowed. Colds and the like lead to one week of quarantine, after the fever has disappeared.
Bone fractures
These lead to at least three months of quarantine.
Cancerous diseases
Cancerous diseases lead to permanent exclusion, yet with the following exceptions: a year after the last hospital department check-up or visit with a gynaecology specialist, women donors who have had abnormal cells in the cervix may donate. A year after his last treatment, a donor who has been treated against basal cell carcinoma (a special kind of skin cancer) may donate.
Malaria
People born and/or raised in a malaria area can become donors three years after their last stay in the malaria area – at the earliest – and only if they are tested negative for malaria at this point. If the malaria area is revisited the quarantine comes into force again – even if the trip was just a short visit.
Someone who has stayed in a malaria area can remain a donor for six months after returning home, on the condition that there has been no spells of fever during the stay abroad and no prolonged periods of fever after returning home.

(Caption/text 40)
The tiny malaria mosquito is one of the world’s greatest carriers of disease.
(End 40)

Medication
Taking certain kinds of medication for a period may lead to temporary exclusion (see page xxx)
Glandular fever
Glandular fever, popularly referred to as ‘kissing disease’, leads to six months of quarantine, after the donor has reported himself fit.
Operation
The exclusion period after an operation is subject to an individual medical assessment, but as a main rule, bigger operations lead to an exclusion period of six months, and smaller ones lead to three months of exclusion. If the donor has received a transfusion in connection with a surgical operation, this leads to an exclusion period of one year.
Piercing
Due to the risk of hepatitis infection and the like, holes for jewellery will lead to a one year quarantine. This also applies to scarification, etc.
Psoriasis
This only leads to exclusion if present in both elbow bends, spread all over the body and/or treated with steroids (adrenal cortex) or another active substance in large skin areas.
Travelling
Travelling in areas with an increased risk of blood transmitted infections (e.g. malaria) leads to an exclusion of six months after returning. However, if you are born and/or raised in one of these areas, it will lead to three years of quarantine after returning to Denmark.
Sexual conduct
Sexual conduct with an increased risk of HIV-infection leads to one year of quarantine.
Dental treatment
After a visit to the dentist, 48 hours must pass – yet one week in case of extraction – before a blood donor can donate again.
Tattoos
Due to the risk of a hepatitis infection and the like, a tattoo leads to one year of exclusion.
Transfusion
A transfusion of blood or blood products leads to one year of quarantine for the recipient.
Vaccination
Depending on the type of vaccine, a vaccination leads to either four weeks or two days of exclusion.
(End 39)

(Caption/text 41)
No withdrawal – common reasons for PERMANENT exclusion
In the same way as different kinds of risky conduct lead to temporary exclusion, there are also types of conduct, diseases and other circumstances that lead to permanent exclusion. If you fall into one or more of the categories below, it is not possible for you to become a blood donor:

Allergies
Allergies that are pronounced and chronic (including asthma).
Autoimmune diseases
E.g. chronic muscular, rheumatic, skin and connective tissue diseases.
Thromboses
Thromboses in deep-lying vessels.
Bronchitis

Creutzfeldt-Jacob’s Disease (CJD) and variant Creutzfeldt-Jacob’s Disease (vCJD)
CJD in the close family, cornea or cerebral cortex transplant as well as treatment with a growth hormone of human origin.
Epilepsy (convulsive fits)
Treated as well as untreated epilepsy.
Too high haemoglobin value
Caused by polycythaemia vera, which is a disease that leads one to forming too many red blood corpuscles. The haemoglobin content therefore becomes too high. Blood’s haemoglobin content is estimated based on haemoglobin colour. The limit is about 10-11 millimole per litre for women and men, respectively.
Too high blood pressure
The blood pressure is measured by placing a cuff around the upper part of the arm. The cuff is inflated until the vessels are under so much pressure that the blood is unable to pass. Then the pressure is slowly lifted, and the blood pressure is measured at which the blood in the artery of the upper arm is able to pass through the artery (systolic), and again, by listening above the vessel, below the cuff, when the vessel is again fully open (diastolic). The blood pressure should not be more than 180 mm mercury systolic and 100 mm diastolic. However, if the pressure drops to less than 165/100 after a 10-minute rest, it is allowed to make a collection anyway. If, without medical treatment, but because of weight loss and exercise, the blood pressure should drop from too high to normal values, collection is allowed.
Too low blood pressure
Here, the limit is at 100/50 (systolic/diastolic). If, without medical treatment, the blood pressure is normalised again, collection is allowed.
Rheumatic fever
If it has caused a heart disease.
HIV
Someone who has been tested HIV-positive, or someone who either has had or continues to have considerable risky sexual conduct, e.g. intravenous drug users, prostitutes, and homosexual males.
Cerebral Haemorrhage (Apoplexy)
Heart diseases
E.g. symptom-producing stricture of coronary arteries, heart valve abnormalities, oversized heart, and medicinal treatment of heart disease.
Cancer
Someone who either has or has had cancer. See also circumstances simply leading to temporary exclusion.
Hepatitis (infectious jaundice)
Malaria
Whether or not someone either has or has had symptom-producing malaria or has been tested positive for malaria.
Drug addiction by injection
Only one injection many years ago is sufficient for exclusion.
Metabolic disorders/Diabetes
E.g. diabetes (except light forms, which do not require medicinal treatment) and an irregular metabolism. Exclusion is meant to protect the donor against losing too many hormones and regulating medicine. Moreover, the regulating medicine may affect the patient.
Syphilis
Weight

Less than 50 kg. If the donor weighs less than 50 kg, the loss of blood will be too severe compared to the total body weight. This will increase the risk of the donor feeling unwell or fainting. Because the size of the blood bag corresponds to a certain amount of blood, it is not possible to simply collect less blood.
(End)

Medicine and exclusion
Certain types of medicine lead to temporary or permanent exclusion. In a number of cases, donors who take medication have to be excluded as a consequence of the illness which has put them on medication. An example is hypotensive medicine. If you take such medicine, you cannot donate blood, not even if your blood pressure is normal. If a disease is treated with medicine, medicine residues may still be in the blood and may harm the person who receives the blood. An example is penicillin. If the person, who receives the blood is allergic to penicillin, residual penicillin in the blood can be dangerous.

(Caption/text 42)
Medicine you CANNOT take before donating blood:

Acetyl-salicyclic acid and other analgesics
For up to seven days before making a blood donation, you cannot take the agent acetyl-salicyclic acid, which is contained in drugs such as *Kodimagnyl*, *Albyl*, *Treo*, and *Idotyl*. The same applies to the so-called *Ibuprofen*-preparations *Brufen*, *Nurofen*, and *Ibumetin*, among others, as well as to a long series of other commonly used remedies against arthralgia and myalgia. These common pain-relieving drugs affect the blood platelets' ability to lump together and thereby the blood's ability to clot. Even a small dosage of acetyl-salicyclic acid, e.g. *Magnyl*, which is taken to prevent thromboses, affects the blood platelets so that they cannot be used for transfusion. Sometimes, however, a donor who *has* taken acetyl-salicyclic acid will be allowed to donate blood anyway. In such cases, the blood platelets will not be used, but the rest of the portion will.

Antibiotics
Due to the risk of an allergic reaction from the recipient of the blood, donor blood cannot contain penicillin or similar drugs. Depending on the preparation, you cannot donate blood for up to 4-6 weeks after your last dose.

Hypotensive medicine
If you are undergoing treatment with hypotensive medicine, you cannot donate blood. Not even if your blood pressure is normal.

Hormones
Some hormones, e.g. growth hormones, lead to permanent exclusion. Other hormones lead to a brief period of quarantine, some to no quarantine at all.

Psychoactive drugs
Drugs that affect a person's conduct or psyche must have left the body completely before donating blood. The drugs can cause unwanted reactions from the recipient of the blood, not least if he is already on medication.

Vaccination
Standard vaccinations lead to a period of quarantine for either two days or four weeks – provided, of course, that you are having no discomforts as a result of the vaccination. If you have been vaccinated recently, ask your blood bank to which of the two types of quarantine your vaccine belongs.
(End)

Ideally, all blood should contain no medicine residues at all. In practice, however, there are several common drugs, which have no significant bearing on a blood donation and which are therefore accepted.

(Caption/text 43)
Medicine you CAN take before donating blood:

Paracetamol
If you are a blood donor and you need an analgesic, you can use *Panodil*, *Pamol* or *Pinex*. In normal doses these drugs are not harmful to the blood recipient.

Other agents
A normal intake of contraceptive pills, laxatives, and most drugs against acid indigestion do not harm the blood recipient, But, *OF COURSE*, you cannot donate blood unless, you are overall fit and well.
(End)

Summary and questions
Anybody who is fit and well, between the age of 18 and 60 years old and who weighs more than 50 kg can register as a blood donor. Moreover, the prospective donor should be able to read and understand Danish at such a level that he is able to fill in a health questionnaire and maintain a dialogue with the blood bank staff without an interpreter present. This is due to a requirement for confidentiality between the donor and the blood bank staff, which is meant to ensure that people intending to become donors respond honestly and satisfactorily to questions about their health and conduct.

Being a donor, you are called in for collection up to four times a year, at the most, and +/– 450 ml are collection per portion. If you weigh less than 50 kg, the 450 ml is more than the allowed 13% of a person's total blood volume and therefore you cannot donate. After a collection the blood is quickly replaced by plasma. However, this is provided that the donor has no fluid deficit.

Before a donor is approved a number of safety considerations have to be made – for the blood recipient as well as for the donor himself. No-one should be caused any harm as a consequence of either donating or receiving blood, and before a donation is made, a lot of information concerning the donor's health therefore needs to be interchanged between the donor and the blood collection staff. The donor must have the necessary information and in addition fill in a health questionnaire, the purpose of which is to shed light on the donor's general condition of health, potentially risky conduct, and other safety issues.

Medicine intake may lead to exclusion as a donor, either temporarily or permanently, but the donor's condition of health and/or conduct do the same.

1) What demands are made as to the donor's language proficiencies – and what are their purpose?
2) Name the four areas it is particularly important to ask a donor about.
3) What is the purpose of the questionnaire?
4) Which circumstances and what conduct leads to exclusion due to the risk of transmitting an HIV infection?
5) How often, at the most, is it allowed to donate blood?

7. Donating Blood

My tenth donation
Inside it's nice and warm. It's probably a combination of the cold outside and the fact that I'm all warm from 'rolling'. Since the blood bank doesn't mind paying, I could, of course, also have taken a cab? No, I may just as well go on skates for the sake of the good cause.

In the waiting room there's juice, biscuits, crisps, magazines, and a relaxed atmosphere. There always is. I only just about manage to munch a biscuit and open the latest edition of *Donor Nyt,* Donor News, before it's my turn to see the blood bank doctor. He watches me over the rim of his glasses while I tick off my answers in the questionnaire. He looks nice enough, so I ask him whether it's a problem that I'm going to run a 15 km race over the weekend. He allows himself time to answer and explain. It is no problem. As long as I take it easy for about 10 minutes after the collection, I can run as much as I want to. I return to the waiting room.

I always worry a bit when the nurse takes me to the couch: what if I begin to feel unwell, become afraid and panic and aargh… well, I never really do. And she sits right next to me most of the time too. But actually, I do frighten a little bit to see the bin, knowing it's full of needles. Yuk! But never mind, I don't need to get into contact with that, anyway. I lie down on the couch and calm down straight away. The nurse disinfects the place on my arm where the needle is about to enter with iodine or alcohol. And then she pricks!

(Caption/text 44)
Susanne Høgh in the 'soft couch' – collection at the *Danmarks Farmaceutiske Højskole.*
(End)

The blood immediately begins to run through the transparent tube connecting the needle with the blood bag. The tube turns completely red. It didn't hurt, actually, and I don't feel the blood leaving my arm. At first it runs fast, but after a while it slows down and I'm given a rubber heart to keep up the pace.

While I lie here, the nurse asks me my name and my civil registration number. She has to make absolutely sure that I'm the right person and that I match 'my bag'. She also has a different nurse check my name and civil registration number as well as the donation number in my papers linking me with my portion of blood. And the she asks me what I'd like to drink: coke, juice, or a beer! I prefer a coke.

(Caption/text 44)
The blood bank staff double-checks that the donor and the blood portion 'match'.
(End)

While I wait for the blood bag to fill up, I sip from my coke. I look around to watch the other donors and listen to what they chat about with the nurses. There is one other donor who is about my age. While she lies there and waits, she rocks her one foot. And then there is this man who's about my father's age. Today there are six people having blood collected at the same time as me. There's also a good number of nurses, either sitting with the others donating blood, walking up and down to check names, putting away blood bags, serving beer and soft drinks, or doing all sorts of other things. There’s a calm atmosphere, but lots of activity. And I’m just lying here, watching it all, thinking: ‘someone needs this blood leaving my arm right now’.

The bag is full now. It took about seven minutes. The nurse bends the tube to stop the blood. She welds it from the bag. Through a sort of tap in the bag she sucks a little blood into a test tube. This is the blood sample, which is to be tested for virus and which is to be used for blood type and haemoglobin value control. The name and the number on the test tube have also been checked – by my nurse as well as the other one. It doesn’t take many seconds before I’m done. She carefully removes the needle from my arm, puts a little wad of cotton wool across the hole, straightens my arm up into the air, and places my thumb on the cotton. I’m done. I don’t feel anything, but I’m supposed to stay on the couch for a while, finish my coke, and rest.

(Caption/text 45)
After 10 donations you receive a bronze needle
(End)

I watch the nurse as she leaves with the blood bag and the test tube. A bit later she returns and lets me know my haemoglobin value. It’s usually 8.4. And it is today too, which is good. The nurse also has a little bronze needle with a red blood droplet for me. She congratulates me and tells me that it is because I’ve donated blood 10 times, which is about five litres of blood, altogether. Cool.

As I finish my coke, swing my legs off of the couch, and leave for my jacket, the nurse sends me a smile.

Side effects – positive as well as negative ones

(Caption/text 46)
For approximately every 3,000 collections, one accident occurs.
(End)

The side effects from donating blood are quite few. And very few donors experience negative side effects at all! Statistically, a donor can make 3,000 donations without an accident occurring. In Denmark this roughly equals 100 accidents per year.

But accidents may happen, and side effects may appear. It may be discomfort leading to a fainting fit, symptoms from a nerve that has been in contact with the syringe, or a small collection of blood (haematoma) at the place of needle entry.

The blood banks try to prevent any discomfort by urging donors to drink and eat before making a donation. Moreover, it is a good idea to rest for 10 minutes after a collection. It is attempted to avoid accumulations of blood and injured nerves through the exertion of extreme caution and by training the staff performing the collections in the techniques very thoroughly. At the same time it is important that the donor informs the staff, while the syringe is in the arm, if there is the slightest feeling of discomfort.

However, within a short period of time, most accidents by far have been taken care of, which fortunately means that the number of serious accidents is very small.

In addition to the negative side effects, you often also learn about donors who experience positive side effects following a blood collection. Some feel more lively and full of energy after a collection. Others experience a quiet satisfaction having made a blood donation and thereby helping another person.

Sikringsfonden (the Protection Fund)

If an accident were to happen in connection with a blood collection, a safety net indemnifies the donor financially. In case something does go wrong, the donor is covered by the *Patientforsikringsloven* (the Patient Insurance Act) and the *Bloddonorernes Sikringsfond* (the Blood Donors' Protection Fund). The purpose of *Sikringsfonden* is to offer support to blood donors who have met with accidents in connection with their efforts as donors. Donors can claim damages for injuries that are a direct consequence of the collection, but accidents in connection with transport to a scheduled collection and back are also covered unless damages can be claimed from a third party.

(Caption/text 47)
In the following cases *Bloddonorernes Sikringsfond* and *Patientforsikringen* will pay damages:

- Health expenses, e.g. medicine, physiotherapeutic treatment, and aids and appliances.
- Lost earnings.
- Pain and suffering
- Permanent injuries, 5% or more
- Lost ability to work, 15% or more
- Funeral costs
- Loss of provider

However, the last two categories have never been subject to payment. Furthermore, the fund will cover material damages under special circumstances.
(End)

The *Bloddonorernes Sikringsfond* and the *Patientforsikringen* co-operate closely. According to the rules of the Danish Patient Insurance Act and the Danish Act on Damages for Pharmaceutical Injuries, the *Patientforsikringen* assesses whether a donor should receive compensation and, if so, how much it should amount to.

(Caption/text 48)
"I became a donor shortly after I turned 20. I don't remember exactly what made me sign up, but I really think it's a duty, like voting at an election.
To me, it's logic that, if you want blood to be available in the hospitals in case you or your dear ones are unfortunate enough to need it, then somebody has to donate it. And as long as I'm in good health and it doesn't take more than a little of my time, it's a huge satisfaction to be able to help people. And it doesn't cost me anything…
In addition, donating blood makes me feel physically well. It gives me renewed energy, but of course that may be a mental placebo effect." Karin Møller Jensen, 26
(End)

Summary and questions
The donor always fills in a health questionnaire before a blood collection. If necessary, it is also possible to talk to the responsible staff at the blood bank and ask further questions. Conversations between the donor and the blood bank staff are confidential. It is important that the donor has eaten and drunk before a collection, which is why e.g. biscuits, juice, soft drinks, and beer are served at the blood bank.

Before the needle is put into the arm, the skin is disinfected, either with ethanol or iodine. A blood collection takes between 5 and 10 minutes. The blood bag and the blood sample are labelled with a number linking the donor to his portion of blood. It is checked by two nurses. When the blood bag is full, the nurse takes a blood sample that is screened for infections and used to check the blood group and the haemoglobin value. If the haemoglobin value is too low, the staff tells the donor how to increase it. After the collection, the donor must rest for about 10 minutes while the blood that has been collected is replaced by liquids from the body.

The side effects from blood collection are very few. The most frequent kinds of accidents range from common indisposition to fainting fits, accumulations of blood in the area of needle entry, or symptoms from a nerve that has been struck by the needle. In case of an accident in connection with a blood collection, the *Bloddonorernes Sikringsfond* and the public patient insurance will indemnify the donor. Compensation is only given for injuries that are connected with the effort of being a donor.

1. Which safety measures always precede a collection?
2. Who checks whether the donor and his blood portion match?
3. How long does the collection take?
4. Which side effects might occur in connection with a collection?

8. Examining donor blood

The examination or screening of donor blood contributes to the safety of the Danish blood donor system. In addition to the health questionnaire mentioned in chapter 7, and as a further safety measure, a blood sample is taken at every collection. The blood sample is screened and subsequently used to verify the blood group, determine the haemoglobin value, and identify possible risks of infection.

(Caption/text 49)
All donor blood is checked for blood group and haemoglobin value and screened for infection markers.
(End)

At the donor's first visit to the blood bank, only a test sample is taken, i.e. not the 450 ml. At the second and future visits, the donor fills in a questionnaire, the blood is collected, and a small amount of additional blood is collected for the test sample. This chapter elaborates on the examination of the haemoglobin value and on the screening.

Haemoglobin value
The haemoglobin value (formerly known as the haemoglobin percentage) expresses the amount of haemoglobin in the blood. Haemoglobin gives the red blood corpuscles their red colour. The haemoglobin value is supposed to be between 7 and 11 millimoles per litre – lower for women than for men. If your haemoglobin value is low, it is recommended that you eat a lot of food containing iron. Iron helps rebuild haemoglobin in the red blood corpuscles. In order to regenerate red blood corpuscles, it is important that the donor has sufficient iron in his body.

Certain foods supply iron to the body. Meat, offal, and vegetables like beetroots and broccoli are examples of recommendable kinds of food if your haemoglobin value is low. Some foods promote the absorption of iron; other foods hamper it. Foods and drinks containing vitamin C, e.g. orange (juice) and other citrus fruits, promote the absorption of iron, whereas tea and coffee are not recommendable. If iron rich foods are insufficient, supplementary iron tablets may be a solution.

(Caption/text 50)
These types of food contain iron and are recommended if your haemoglobin value is low:

- Meat
- Fish
- Black pudding and offal, e.g. liver and cod roe
- Eggs
- Bread and cereals
- Vegetables, e.g. beetroots, broccoli, and borecole
- Dried fruit, e.g. raisins, apricots, and figs
- Fresh fruit, e.g. oranges and kiwis

(End)

Screening the blood
Besides checking the haemoglobin value, the blood banks screen the blood for various infectious diseases. Before the blood is released for transfusion, it is screened for a number of so-called infection markers. These are often antibodies against viruses.

(Caption/text 51)
The viruses, against which the blood is screened, may infect in the following ways:
- Through blood transfer (e.g. by reusing needles and syringes that are not sterile)
- Through sexual intercourse
- From mother to child before or during birth, and in connection with breast-feeding

(End)

(Caption/text 52)
The blood is only released if the results of the mandatory screenings for infection markers are negative.
(End)

Blood screenings take place at the blood banks where specialists in clinical immunology are responsible for the screenings. The health authorities have drawn up strict guidelines on how to screen the blood and for which infection markers to screen it. This is why they are called the mandatory screenings for infection markers.

The mandatory screenings for infection markers currently include HIV types I and II, hepatitis types B and C, and HTLV types I and II. The results of the mandatory screenings for infection markers must be negative. If no infection markers are found, the blood can be released for transfusion. If, however, infection markers are found at the screening, the screening process is repeated twice using the same technique. If just one of the two repeated screenings turns out positive, the conclusion on the entire screening is that an infection marker was found, and that the test was positive. This means that the blood portion from this collection of blood cannot be used.

(Caption/text 53)
At the mandatory screenings for infection markers, the blood is screened for the following infections:

HIV types I and II
As mentioned, HIV stands for Human Immunodeficiency Virus. After a shorter or a longer period (5-15 years), an HIV infection will cause AIDS. The method used by the blood banks to screen for HIV is also used by general practitioners. Due to safety, it is very important that screenings performed by the blood banks are not considered an “HIV test” and that people exposed to possible infections risks refrain from donating blood. Blood cannot be collected from a person if there is the slightest risk of him being infected by HIV. Instead, he should see his practitioner or one of the many HIV clinics across the country. You can see any doctor you want, and you can be tested anonymously if you want to. The test is free.

Hepatitis type B
If an adult is infected with hepatitis type B, he will usually develop hepatitis with jaundice about three to four months after the infection. After an additional three to six months, you usually recover, and the virus leaves the blood. In some cases, you hardly get ill, but the virus stays in your body and, eventually (in 20-30 years), you may develop cirrhosis and cancer of the liver. This particularly concerns the infection of adults with a reduced immune defence system and children.

Hepatitis type C
Most often, you do not show any symptoms in the first part of the course of the disease; however, the virus stays in your body and increases your risk of developing cirrhosis and cancer of the liver 20-30 years after the infection has taken place.
Hepatitis C is very likely to infect through a blood transfer, which is why this virus is very common among injecting drug addicts sharing syringes because residual blood is often found on the needles. On the other hand, it has only exceptionally been noticed to be transferred sexually or from a mother to her unborn child.

HTLV types I and II
New donors, donors who have not made a donation for 5 years, and donors who have been exposed to the risk of infection are also tested for HTLV types I and II.

HTLV stands for Human T cell Lymphocytotrop Virus. The HTLV screening is only carried out at the donor's first visit to the blood bank. The risk of being infected later is very small because HTLV is very uncommon in Denmark. Usually, an HTLV I infection does not cause illness. In exceptional cases, after 30-50 years, it might lead to the development of leukaemia or myelitis followed by paralyses. HTLV II does not cause any known diseases.
(End)

Test result: positive
If a blood screening turns out positive, the donor will be informed. The blood bank doctor contacts the donor and informs him of the positive test result and of the help available to him. Besides further examination, the donor is offered to see a specialist about psychological help and treatment for the disease that may be present according to the blood screening.

Fortunately, in Denmark it is not very common to come across a donor carrying a disease. But when infections are this rare, people may forget the problem. That is why it is important to emphasise the importance of answering the questions in the health questionnaire to the best of your knowledge and not considering the blood donor system a replacement for the doctor's virus screening.
If you are worried that you may be infected, you can have confidential advice and guidance from the blood bank doctor – over the phone prior to a collection, if necessary. If you are worried that you may be infected with HIV, you can also see any general practitioner or one of the many HIV hospital clinics across the country, or you can call the anonymous telephone hot line.

The window period or the seronegative period
As mentioned, the use of health questionnaires and blood screenings are complementary safety precautions intended to identify donors whose blood may infect recipients with fatal vira. The screenings detect donors who have formed antibodies against viruses. The answers to the questions asked in the questionnaire increase the chances of identifying the donors who have not been

infected recently (and therefore carry significant amounts of virus in their blood) but have yet to form antibodies against the virus.

The window period is a term referring to those weeks when the donor is carrying virus in his blood, but has yet to form antibodies. The term is used because of the gap (an empty window) in the virus screening process. The period is also called the seronegative period, i.e. the period during which the screening for antibodies in the plasma is negative.

The weeks when the donor has a virus in his blood but has still not formed the antibody against it are called the window period because there is a hole (an open window) in the virus screening technique. The period is also referred to as the seronegative period, i.e. the period during which the screening for antibodies in the plasma will come out negative.

The first time the donor encounters the foreign virus (the primary immunisation), the process of immunization and formation of antibodies makes slow progress. When the formation of antibody gets under way, the amount increases from nothing to maximum level within a few days. Actually, the donor is most infectious in the first period when the virus concentration is high, and no antibodies exist to neutralise the virus.

(Caption/text 54)
The donor has virus in his blood, but has yet to form antibodies.
(End)

(Caption/text 55)
I became a donor because two of my friends, both a couple of years older than me, were donors, and when I turned 18, they dragged me along. More have joined us since then, and it is a good way to meet and afterwards have a good time, go shopping or see a movie.

Anne Samsøe-Petersen, 22

(End)

It takes 3-12 weeks from when a donor is infected with HIV to when a screening process is able to detect the antibodies and thereby show that the donor is infectious. The risk of contracting an HIV infection through a blood transfusion in Denmark is estimated to be 1 in 2-4 million transfusions, i.e. 1 every 4-8 years.

Regarding hepatitis B, it takes 3-16 weeks from infection to when the virus can be detected in the blood. The same applies if the hepatitis has turned chronic. Because the donor is infectious during this period, you might risk collecting infected blood. An infection through a blood transfusion with hepatitis is estimated to occur once in 200,000 portions of blood, i.e. scarcely twice a year. Hepatitis type C has a seronegative, but infectious window until 8-24 weeks after the infection. Until then, it is not possible to detect antibodies against the virus.

Because of the window period, it is insufficient only to screen the blood for infections. This is why it is of utmost importance that the donor informs his blood bank about conduct, so-called risky conduct, that might have lead to an infection. In this way, the health questionnaire and the screening complement each other.

False alarm – false reaction
Experiencing false alarm is no joke. False alarm – a false reaction in a screening for infections – occurs when a donor without infection markers gets a higher screening value than that of a definitely negative result and a lower screening value than that of a definitely positive result.

The screening techniques currently used are so sensitive that they might show a slight reaction although there are no antibodies in the blood. You could compare these techniques to an extremely sensitive burglar alarm triggered by a curious mouse. The alarm sounds, but you cannot tell by the noise it makes whether it was just triggered by a mouse or if there really is a burglar in the house.

When performing the mandatory screening for infection markers, all reactions estimated to be stronger than the definitely negative results are then screened again using more accurate techniques (confirmatory tests). These techniques are able to determine the reaction in a more accurate way. The result of the second test is known within a few weeks.

The test has three possible outcomes: it is either positive, if infection markers are detected; it is negative, if no infection markers are detected; or it is inconclusive, if it is impossible to say for sure if the reaction has been caused by infection markers in the blood. If the new confirmatory test is inconclusive, it has not been shown with certainty that the blood carries antibodies against infection. However, neither has it been shown that the blood is free of infection markers.

If your mandatory screening for infection markers does not turn out definitely negative, and your new confirmatory test turns out inconclusive, the reason may be that you are infected, but have yet to form enough antibodies to produce a conclusive test result. Alternatively, the screening may have given a false reaction.

A few months later, at another blood collection, the blood is screened once again. If the donor is infected with a virus, the amount of antibody will have increased so much in the intervening period that the reaction from the new screening turns out definitely positive. This result will show that antibodies were present in the blood at the first collection. If the donor is not infected with a virus, the reaction from the screening may remain inconclusive, or it may be definitely negative. However, as it is still not possible eliminate the possibility of the donor being infected and having formed antibodies between the two blood collections, it is still not possible to say for sure that the test result is negative.

When the test results from three collections are available, and at least one year has passed between the first and the third collection, and the test results continue to show an inconclusive reaction, it may be concluded that

- This condition will most likely not change for the donor concerned.
- The donor’s blood will therefore most likely be discarded at every collection.
- The donor is not infectious, but this cannot be proven until several months after each blood collection.

In order to find a solution to this precarious situation, the blood bank doctor will explain the situation to the donor. Often it is agreed to wait and see for about a year and then try to see if the testing techniques have improved.

(Caption/text 56)
250 a year
“In the Copenhagen Hospital Association, we identify 30-40 donors a year who have to stop giving blood temporarily due to “false alarm”. We are in contact with approximately 30-40,000 donors a year, i.e. about 1 in 1,000 donors are affected” says Ebbe Dickmeiss, Senior Hospital Physician at the *Rigshospitalets Blodbank*. Ebbe Dickmeiss emphasises that this is only a technical problem regarding the screening techniques. Thus, the donor is neither infected nor infectious.

In all of Denmark, the frequency of false reactions correspond to about 250 donors a year.
(End)

It may be difficult for a donor to understand that as long, as an HIV test shows this false reaction, safety precautions require that his blood is not used although it is proven that he is NOT infectious. Despite any concern a false reaction may cause the donor, it is often possible to convince him that he is not infected. The donor is informed that if he were infectious, the blood bank would be obliged to let him know about the risk of infecting others and to refer him to an HIV clinic for treatment. When neither step is taken, it is because the donor is not infected.

(Caption/text 57)
“I signed up as a donor when I turned 18 because both of my parents are donors. That is why it was completely natural to me to sign up for this good cause. I saw an ad in a *Donor Nyt* magazine with a registration form and I sent it in, so it wasn’t as hard as many people might think. It’s probably a very normal way to become a donor, but I guess it can never become too normal! I’ve donated four times…

Peter Thøgersen, 20

(End)

Summary and questions
In connection with every collection, a blood sample is taken. It is used to verify the blood group, check the haemoglobin value, and screen for infections.

The haemoglobin value (or the haemoglobin percentage) expresses the amount of haemoglobin existing in the red blood corpuscles. The haemoglobin value is between 7 and 11 millimoles per litre. As iron is necessary in order to regenerate red blood corpuscles, iron rich foods are recommended.

The blood is screened for a number of infection markers, often antibodies against a virus. The health authorities decide for which infection markers the blood should be screened. Currently, all donor blood is screened for HIV and hepatitis B and C. Furthermore, new donors are screened for HTLV.

If the mandatory screening does not detect infection markers in the blood, it can be released for transfusion. If the screening turns out positive, the test is repeated twice. If just one of these tests does not turn out 100% negative, the blood cannot be released, and a new test has to be carried out using a different kind of screening technique. The test result is either positive, i.e. infection markers are detected in the blood, or negative, i.e. no infection markers are detected. A third possible result may be that the test result cannot be determined because the reaction is inconclusive. This means that this screening technique is unable to determine definitely whether infection markers exist in the blood. The inconclusive reaction is caused by screening techniques so sensitive that they sometimes react although no infection markers exist in the blood.

In the window period, the screening may show a negative result despite the fact that the blood IS infected. The window period is a term referring to those weeks when the donor carries the virus in his blood, but has yet to form the antibodies against which the blood is screened. To achieve the highest level of safety possible, also during the window period, it is of utmost importance that the questions regarding infections in the health questionnaire are answered carefully and honestly. The questionnaire and the screening are complementary. Although the blood is infected, the screening result may be negative in the window period. The questionnaire, however, may perhaps indicate that there is a risk of infection.

A final possibility is that a screening result is positive, i.e. that it shows that the blood is infected. When this happens, the blood bank doctor informs the donor of the positive result, and the donor is offered to see a specialist or a psychologist and to receive treatment for the disease of which the blood screening has shown signs.

1. The blood sample taken in connection with a collection is used to check three different things. Which?
2. For which infection markers is the blood screened?
3. What do you call the period, during which a donor carries infected blood, but not sufficient amounts of antibody to detect the infection?
4. What is a donor offered when tested positive?
5. What does it mean that a test is false positive?
6. When would you normally resume collecting blood from a donor who has had an inconclusive reaction as a result of a screening for infection markers?

9. The manufacture and storage of blood components

The collected donor blood has to be used for the patients in the most beneficial and safe ways possible.

The Danish Medicines Agency considers the manufacture of blood and blood components a manufacture of medicine. This is why very precise rules have been laid down regarding the way donor blood (also known as whole blood) is transformed into blood components and how these must be stored. The rules take the shelf life of the blood into account and ensure that it is stored safely. The shelf life is very dependent on the temperature. The safety is particularly dependent on the blood being handled hygienically in closed containers, away from anything that might transmit infections to the blood, and being labelled and kept in a way that no mistakes are made when issuing the blood.

The manufacture of blood components
At the collection, the donor's blood is collected into a plastic bag (the main bag), a part of a set consisting of three plastic bags connected with plastic tubes. The whole set is sterile and has never been used before. The tubes enable the transfer of parts of the blood from one bag to another without breaking the chain of sterility. The main bag contains matter preventing the blood from coagulating.

After the collection, the blood is centrifuged so that it is divided into three layers in the main bag, according to the density of each part. After the centrifugation, the plasma, which is on top, is pressed into an empty plastic bag (the plasma bag) through a plastic tube in the top of the bag. The red blood corpuscles, which are on the bottom, are lead into another plastic bag (the SAG-M bag), containing liquid with nutrients for the red blood corpuscles, through a tube in the bottom of the bag. The layer in between, which remains in the main bag, is called the buffy coat. It contains large amounts of blood platelets and white blood corpuscles, and it is used for producing concentrates of blood platelets. Thus, the collected whole blood is split into three different components in each their plastic bag. In this way, it is possible to store the components separately under optimum conditions, depending on their respective requirements.

All blood components are labelled with a unique and clear collection number that makes it possible to trace where the blood has been collected, where it has been stored, and to which patient it has been administered. All this information is registered in the blood bank's computer system.

(Caption/text 58)
It's not only the thought that counts! A spare can of fuel is <u>your</u> safety.
Oh no! There may be empty shelves in the blood bank, but we only collect <u>1</u> portion!
(End)

Storing the blood components
Distinct rules have been laid down regarding the storage of the individual blood components. The rules take the storage temperature into special account because the shelf life is particularly dependent on the temperature. The requirement for correct and constant temperature when storing blood is due to the fact that the blood has to stay as fresh as possible. When storing blood, the temperature must be measured all the time and registered continuously so that the storage temperature can be documented.

Cooling cabinets and rooms for storing blood components must be carefully cleaned and should not be used for storing food, urine samples, tissue samples, or other items that may transfer bacteria or vira to the blood components.

If red blood corpuscles are stored at 4°C they will keep for up to five weeks. Blood platelets made from the buffy coat are stored at 22°C and will then keep for up to five days. Provided that the bacteria content is checked regularly, the storage time may be increased to a week. During storage, the blood platelets must be in constant motion in order to achieve a sufficient exchange of oxygen (O_2) and carbon dioxide (CO_2) through the plastic bag. Plasma (fresh, frozen plasma) is stored frozen at temperatures below –30°C and will then keep for several months.

Releasing the blood components

Before the blood components can be used for transfusion, double-check analyses have to be performed on each collection. Until the results of these analyses are available, the blood components are put in special quarantine areas. When the results are available and approved, the blood components will be released from the quarantine storeroom and moved to the storeroom with blood for patients.

Ensuring the quality

To check that the quality of the blood components is good, a few portions are sampled to check the quality – a random check. The components are tested in various ways, and the results of these tests must meet the quality requirements that have been laid down.

In order to avoid the occurrence of errors, all procedures are accurately described. Altogether, these instructions take up several shelves in the bigger blood banks. Any procedural deviation from these instructions is described in special deviation reports. Based on these deviation reports, it is possible to assess whether some working procedures hold too many deviations or perhaps even errors. Subsequently, any such working procedures will be revised so that the risk of errors can be reduced. In this way, the whole production is subject to a continuous process of quality assurance.

Summary and questions

At the collection, the blood is collected into a plastic bag, a part of a set consisting of three plastic bags connected with plastic tubes. After the collection, the blood is centrifuged so that it is divided into three layers in the main bag, according to density. Each layer is then transferred into its own plastic bag each. The bags are separated, making it possible to store the contents separately under optimum conditions, according to the respective requirements. Each of the three blood components is stored in its own way so that it stays as fresh as possible. The shelf life is especially dependent on the temperature.

Before the blood components can be used, analyses have to be carried out, e.g. verifying the haemoglobin value and screening for infection markers. To find out whether the quality of the blood components is good, random checks are made.

1. Name the blood components made from whole blood.
2. How are they made?
3. What is the shelf life of each component?
4. How is the blood tested before it can be used for patients?

10. Using blood

The blood collected from donors in the blood banks is used for many different purposes, but always to the benefit of the patients. This chapter elaborates on how the blood is used; which patients in particular receive it; the indications upon which it is administered; and the complications that might result from a blood transfusion.

How is donor blood used?
Donor blood is mainly used directly in the treatment patients. A smaller part, however, is used to check the production quality. A few portions are used as normalising material for adjusting apparatuses in hospital laboratories. With the consent of the Blood donors in Denmark and the individual donor, a few portions are used for research.

Usually, donor blood is used after being separated into components. The separation increases the quality of the blood and makes it possible for each collected portion to help more than one patient.

Last, but not least, there is the absolutely indirect “use” of donor blood; the patients do not receive any blood, but the doctors would not have dared starting a complicated examination or a surgery if blood had not been ready for the patient in the rare case of a complication causing a haemorrhage.

(Caption/text 59)
Donor blood is used in connection with accidents and surgery as well as for the treatment of a series of medical diseases.
(End)

Which types of patients receive the blood?
Blood transfusion is often associated with blue lights, accidents, and surgery. But donor blood is often used in connection with a series of non-acute diseases as well. In particular, these include the treatment of cancerous diseases or diseases of the blood. Notably many blood components are used for patients who receive bone marrow transfusions.

A survey of the use of blood components at a Danish university hospital has shown the following distribution of blood components to patients:

- 39% for treating cancer
- 20% for treating cardiovascular and pulmonary diseases
- 41% for treating other groups of patients

The last group includes patients with injuries caused by accidents (12%), patients with diseases in the organs of digestion (11%), and patients with diseases of the blood (5%).

(Caption/text 60)
Diseases of the blood and of blood producing organs and certain diseases relating to the immune system, 5%

Diseases in the organs of digestion, 11%

Injuries, poisonings, and certain other consequences of external influence, 12%

Diseases in circulatory organs, 20%

Cancer (incl. leukaemia), 39%

Others*, 13%

*Others includes, among others, diseases in urologic and sexual organs, bone, muscles, connective tissue, respiratory organs, the nervous system, eyes, ears, skin, and cases of pregnancy, birth etc.
(End)

Cancer patients (39%)
At the biggest hospitals in the country, approximately 39% of all donor blood is used for cancer patients. The cancer patients very often have anaemia as their production of red blood corpuscles in the bone marrow is impeded because of chemotherapy. The symptoms of anaemia are paleness, fatigue, dizziness, and dyspnoea when physically exerted.

(Caption/text 61)
Cancer patients' anaemia may result from a number of causes:

- *Chemotherapy* and radiation treatment may destroy the bone marrow or temporarily cause it to malfunction. The cells (stem cells), which are the preliminary stage of blood cells, are found in the bone marrow. If your bone marrow is destroyed, you will lack blood cells.
- *Nutrition disorders* are often observed with cancer patients because nausea and reduced appetite prevent the patients from getting the nutrients, vitamins, and iron that are necessary for the blood cells and all the other cells in order to function at their optimum.

(End)

Patients with cardiovascular and pulmonary diseases (20%)
20% of the blood is used for patients with sclerosis in the coronary arteries of the heart or in the big main artery (aorta). Normally, these diseases are treated with surgery. Usually, only a few portions of red blood corpuscles are used at an operation for sclerosis in the coronary arteries of the heart. Thus, it is not the amount per operation that causes the great blood requirements, but the fact that so many operations are carried out – 15-25 per day, nationwide. In case of sclerosis in the aorta, the vascular wall may brake. This will cause a haemorrhage, often resulting in the need for 20-50 portions of red blood corpuscles, blood platelets, and plasma.

Patients with great losses of blood (41%)
Among others, this patient group includes patients who have been injured in accidents, e.g. road accidents. Others might be patients with bleeding stomach ulcers, intestinal haemorrhages, or haemorrhages after giving birth. The loss of blood need not always be replaced by donor blood If a bleeding is less severe,; salt water is sufficient. In case of severe haemorrhages, it is necessary to administer red blood corpuscles corresponding to the amount of lost blood and supplement with plasma and blood platelets.

How is each blood component used?
Of all the cells in the blood, only the red blood corpuscles and the blood platelets are used for treating patients. Usually, the white blood corpuscles are not used. On the contrary, the amount of

white blood corpuscles is often reduced as much as possible, e.g. through filtration. This is done because they often do the patients more harm than good.

(Caption/text 62)
»When I was 15-16 years old, I had my tonsils removed surgically. After the operation, the wound in my neck began to bleed, and I threw up for hours before the bleeding stopped. For several days, I was tired and apathetic. Completely colourless and my lips had turned to white. When the nurses finally measured my haemoglobin percentage, it turned out to be 3.7!

Then I had blood immediately, and I felt every drop, and my energy and power came back. I'd thought I'd kick the bucket, but after receiving four portions of blood, I totally cheered up. I then decided to give blood myself when I was old enough. You see, now I know what dimensions it's all about. I learned that it is important to help.«

Susanne Knudsen, 28

(End)

The red blood corpuscles are used in connection with haemorrhages, operations, and for treating anaemia. Blood platelets are administered in case of haemorrhages or if the patient's own production is insufficient, e.g. because of cancer. Plasma is used for patients in lack of the factors that are part of the coagulation process of the blood.

The manufacture and use of plasma derivatives
The plasma that is not used for patients immediately is used for manufacturing concentrates of the proteins that are found in the blood (plasma derivatives), e.g. globulin and albumin. This takes place in medicine factories such as the Statens Serum Institut. In the manufacture, 10,-100,000 portions of plasma are mixed in a big vessel. Then they are exposed to various chemical and physical processes causing it the proteins to precipitate. The proteins are taken out for further processing. The process includes killing viruses, partly by heat treatment and partly by chemicals.

(Caption/text 63)
Among other things, plasma is used for manufacturing different kinds of plasma derivatives:

- Globulins, used for treating and preventing infectious diseases
- Anti-thrombin, preventing the blood from coagulating
- Albumin, used for treating shocks and at operations
- Factor 8 and Factor 9, assuring that the blood coagulates; used for treating haemophiliac patients. Today in Denmark, however, most haemophiliac patients are treated with genetically engineered factor preparations.

(End)

When should blood or blood components be administered?
Prior to the transfusion of a blood component, the doctor must write the indication for administering blood to the patient in the patient's medical record. That is, the doctor must consider the following before prescribing a blood transfusion:

- Could the patient manage with something other than blood, e.g. salt water, a glucose solution, or albumin?
- What part of the blood does the patient actually need?

A lot of people, especially young people with a normal heart function are perfectly alright losing more than one litre of blood (20% of an adult's blood volume) without having it replaced with red blood corpuscles. Instead of a blood transfusion, the doctor should choose to ordinate a salt solution because this has the ability to keep up the total blood volume. In return, you avoid some of the complications that may occur in connection with the transfusion of blood from other people.

Complications when transfusing blood components
Complications in connection with blood transfusion do not occur as often as they used to. Especially fever and skin eruption are avoided because, today, only blood components are used instead of whole blood. This way, you avoid giving the patients blood with high contents of white blood corpuscles causing this kind of complication.

There are three groups of complications that may occur when performing a blood transfusion:

Immunologic complications
The immunologic complications are caused by incompatibility between the donor's and the patient's blood. When the donor's and the patient's blood do not match, it is because antibody in the blood of one of them reacts with antigens in the blood of the other one.

Infection
Complications with infections concern the transmission of bacteria, parasites, or virus by the donor's blood. You may e.g. have bacteria in your blood the first 24 hours after you have had a scaling at the dentist's. They could also appear when manufacturing blood components. It is especially seen when manufacturing blood platelets because they are stored at 22°C afterwards, a nice temperature for the growth of human bacteria.

A virus may be transmitted with donor blood if the donor has it in his blood. It particularly concerns hepatitis and HIV viruses. To avoid this, the donor is questioned on conduct causing the risk of infection so that an infection in the window period can be ruled out, and every portion of blood is screened for infection markers.

Errors
An error could be a blood transfusion to a wrong patient, i.e. the portion was labelled with another patient's data and destined for him, but it still ended up being administered to a wrong patient. It also concerns the transfusion of a blood portion to the patient it was destined for, but of a wrong blood group or a wrong blood component.

I Denmark, four transfusion complications occur in every 100,000 used blood components. Half of these are immunological, and half is infections or wrong transfusions.

(Caption/text 64)
I'd often thought that I should also sign up, and I was then inspired by an ad for blood donation. I don't remember if it was on TV or at the cinema… The ad showed a number of people, and one person at the time stepped forward. They'd saved a life that day by giving blood. At that time, that particular ad really spoke to me, and I finally pulled myself together and called the blood bank. It was as simple as that.

Vivian Hesselberg Lundfold, 28

(End)

Summary and questions

Donor blood is mainly used directly for the treatment of patients. A smaller part is used for checking the quality of the production, as normalising material for adjusting apparatuses in hospital laboratories, and for research. Plasma surplus is used for plasma derivatives such as globulin and albumin. The store of blood in the blood bank also acts as a safety net in cases when smaller operations are complicated by unexpected haemorrhages.

The blood components are especially used for cancer patients (about 40%) and patients with cardiovascular and pulmonary diseases (about 20%). The rest is used for treating injuries and diseases of the digestion organs and of the blood.

The blood components are used so that the red blood corpuscles are given in case of haemorrhage and when treating anaemia. Blood platelets are given in case of haemorrhages or lack of blood platelets, whereas plasma is given to patients lacking the factors that enter into the coagulation process of the blood.

Before transfusing a blood component, the doctor must consider whether the patient could manage with something other than blood, e.g. salt water or albumin, and which part of the blood the patient actually needs.

Transfusion complications are rare. They can be divided into immunologic complications, caused by incompatibility between the donor's and the patient's blood; infection complications, caused by the transmission of bacteria and viruses; and complications caused by errors.

1. State the four main areas where blood components are used.
2. For what patients are the blood components particularly used?
3. For which particular condition is the individual blood component used?
4. What could be used instead of blood components?
5. Which kinds of complications occur when transfusing blood components?

11. Blood donor – yes or no?

In most West European countries, the number of blood donors adds up to 5-10% of the population aged between 18 and 65 years. It just about covers the need for blood donors. The more donors help covering the need, the smaller the burden is to the individual donor. Blood donors, however, like to give blood at least once a year in order to feel that they are doing an effort and that they are related to the blood bank. This chapter elaborates on some of the considerations behind being a blood donor and on possible reasons for not being a blood donor.

Should or shouldn't I?
Knowledge of the donor cause is the first step towards becoming a donor. When Danes are asked whether they know anything about the cause of blood donation, their answers are mostly affirmative. Many people who know of it have considered becoming blood donors, but it has not come off. There may be various reasons for this. They can be divided into emotional and more practical reasons.

The emotional reasons may be the dislike of being in hospital or the feeling that the contribution you can make is so small compared to the size of the entire problem that it is pointless. Donor or not, you would not feel a perceptible change in general.

The dislike of being in the blood bank might result from a fear of being in contact with the hospital services, the fact that many people are afraid of needles because they are connected to pain, or of the situation regarding the collection. You may be afraid of panicking during the collection or in some other way lose control of yourself.

The practical reasons may be that it is impossible to find convenient time, that the blood bank is too far away, or that you do not know where it is or when it is open.

It may also be a mixture of reasons so that you have a convenient explanation for not being a blood donor (»I haven't had time«), but in fact, it covers up a fear of being exposed to pain in connection with the prick of a needle.

Society cannot force you to become a blood donor. Whether you want to be a blood donor is your own choice.

Reasons for becoming a blood donor
There is a great need for donor blood for treating patients. That is why it is a necessity that everybody makes up his mind about wanting to become a blood donor or not. The purpose of the Blood donors in Denmark is to ensure a sufficient and accurate knowledge on being a blood donor so that you do not refrain from becoming one because of faulty or insufficient knowledge.

Some of the motives for becoming a blood donor are caused by moral considerations. These concern the following among others:

- You think that giving blood is a really good cause that helps saving other people's lives.
- You want to help your fellow human beings (altruism)

Other motives are more selfish:

- You want other people to consider you a good person.
- You want enough blood to be available if one of your loved ones or yourself might need it.
- You feel physically and mentally better after donating blood.
- Your health is checked (haemoglobin value and infection markers).
- You want to return the amount of blood to the blood banks that you or one of your loved ones has received.

(Caption/text 65)
Being a donor means giving, giving to another person
Having energy for others, others than your self
Living life a little more, more marvellous
Offer your hand, hand it to someone who needs it
– One day it might be you…

Mette Bank, 21

(End)

From time to time, blood donors declare that they started giving blood because they or one of their loved ones had a blood transfusion, i.e. because of a mixture of moral and selfish reasons. Having donated blood many times, however, the motive changed to wanting to help others.

Meanwhile, not everybody who wants to can become a blood donor. In order to protect the donor from getting sick because of the collection and to protect the patient from getting sick by receiving the blood, there are strict rules stating when you are allowed to donate blood and when you are excluded because of risky conduct, diseases, taking medication, etc. These rules have been laid down by the health authorities on the assessment of the factors that may affect the security when collecting and transfusing blood.

Voluntary and unpaid
Besides stating that being a blood donor should be voluntary, the Danish law on blood supply states that it should be non-remunerated so that money and finances will not become a reason for being a blood donor.

There are several reasons for this. Paying for blood may lead to the donor, because of the money, not giving accurate information about his health, conduct that might result in the risk of infection, or taking medication. A fee might tempt a donor to give blood too often or in another way act irresponsible towards himself or the patient who gets the blood.

Blood donors should be non-remunerated, and they should give blood out of their own free will.

In other words, using remunerated donors would increase the risk of the recipient being infected by the blood and of the donor being hurt by giving it. To avoid these risks, it is an internationally acknowledged principle, respected by still more countries, that donors should be non-remunerated, and that they should give blood out of their own free will.

(Caption/text 66)
Resolution R(95)14 of the European Council recommends that all member countries should try to achieve self-sufficiency from voluntary and non-remunerated donations.

Non-remunerated blood donation is defined as follows:
Giving blood, plasma, or cell elements is considered voluntary and non-remunerated if the person gives it of his own free will without pay; in cash, or in kind that might be considered cash. This also includes the time that is taken off work besides the period that is reasonably necessary for the collection and transport. However, smaller acknowledgements, refreshments, and reimbursements of direct transport expenses are consistent with voluntary and non-remunerated blood donation.
(End)

Helping others and showing humanity.

Altruism
Altruism means unselfishly helping others and showing humanity. When you give blood without pressure from without and without expecting to be paid, but because you think it is right, being donor is an act of altruism. Altruism is crucial for keeping up the voluntary, non-remunerated blood donor system.

Altruism is partly connected with the view of human nature that considers everybody equal and partly with values such as humanity, common responsibility, and solidarity.

(Caption/text 67)
1. It hurts.
2. You don't get any money.

(End)

The choice is yours
Being a blood donor, the blood collected from you over the years would usually not correspond to the amount of blood you could receive from transfusions. Most people probably hope that they shall not end up in a situation needing donor blood. However, since there are always patients who need donor blood, it is also crucial that blood is always available for critical and potentially fatal situations.

That is why collecting blood from blood donors is all about ensuring that other people's lives can be saved if at risk.

Almost 5% of the Danes give blood today, and that is just about enough to keep up the necessary blood supply. However, as blood donors fall away all the time because of age, sickness, and other things, it is necessary that new donors enter the system. Nationwide, approximately 30,000 new donors are needed every year; especially young people, who are able to give blood for many years in the future, are urged to sign up.

30,000 new donors a year

Summary and questions
Since everybody is in charge of his own life, society cannot force anyone to donate blood. In other words, blood donation must be voluntary and without pressure from anyone else.

Blood donors should be non-remunerated because paid collections may lead to the risk of the donor being tempted to have blood collected in spite of a disease or a failing health. This would affect the quality of the blood and increase the recipient's risk of being infected by the donor blood.

The reasons why people do not volunteer as donors are partially emotional, e.g. when fear (of needles or in general) plays a part, and partially the fact that practical circumstances are in the way of signing up.

In the same way as there are various arguments for not giving blood, there are various reasons for doing it. The moral reasons are connected to the whish of doing what is right and good and unselfishly helping your fellow human beings. This argument is connected with altruism, i.e. unselfishly wanting to help others and show humanity. The non-moral reasons are connected with getting something out of donating blood.

Approximately 5% of the Danish population are donors. About 30,000 new donors are needed every year. That is why it is important that each individual makes up his mind and volunteer as a donor if he wants to, provided, of course, being in the best of health.

1. State two important, unchangeable principles for blood donation in Denmark.
2. Which motives are there for being a donor, and how could you group them?
3. Which are the reasons for not being a blood donor, and how could you group them?
4. What does altruism mean?
5. How many new blood donors are needed in Denmark annually?