

Blood type

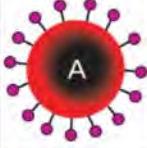
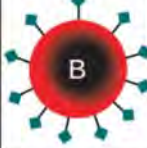
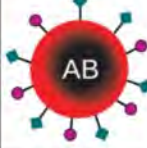







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A **blood type** (also called a **blood group**) is a classification of blood based on the presence and absence of antibodies and also based on the presence or absence of inherited antigenic substances on the surface of red blood cells (RBCs). These antigens may be proteins, carbohydrates, glycoproteins, or glycolipids, depending on the blood group system. Some of these antigens are also present on the surface of other types of cells of various tissues. Several of these red blood cell surface antigens can stem from one allele (or an alternative version of a gene) and collectively form a blood group system.^[1]

Blood types are inherited and represent contributions from both parents. A total of 35 human blood group systems are now

recognized by the International Society of Blood Transfusion (ISBT).^[2] The two most important ones are ABO and the RhD antigen; they determine someone's blood type (A, B, AB and O, with +, − or Null denoting RhD status).

Many pregnant women carry a fetus with a blood type which is different from their own, which is not a problem. What can matter is whether the baby is RhD positive or negative. Mothers who are RhD- and carry a RhD+ baby can form antibodies against fetal RBCs. Sometimes these maternal antibodies are IgG, a small immunoglobulin, which can cross the placenta and cause hemolysis of fetal RBCs, which in turn can lead to hemolytic disease of the newborn called erythroblastosis fetalis, an illness of low fetal blood counts that ranges from mild to severe. Sometimes this is lethal for the fetus; in these cases it is called hydrops fetalis.^[3]

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

Blood type (or blood group) is determined, in part, by the ABO blood group antigens present on red blood cells.

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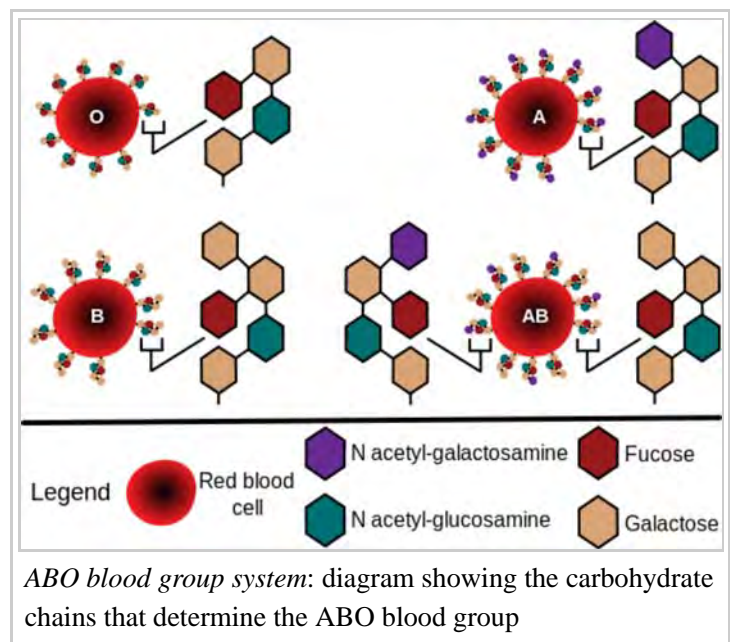
Blood group systems

A complete blood type would describe a full set of 30 substances on the surface of RBCs, and an individual's blood type is one of many possible combinations of blood-group antigens.^[4] Across the 35 blood groups, over 600 different blood-group antigens have been found,^[5] Almost always, an individual has the same blood group for life, but very rarely an individual's blood type changes through addition or suppression of an antigen in infection, malignancy, or autoimmune disease.^{[6][7][8][9]} Another more common cause in blood type change is a bone marrow transplant. Bone-marrow transplants are performed for many leukemias and lymphomas, among other diseases. If a person receives bone marrow from someone who is a different ABO type (e.g., a type A patient receives a type O bone marrow), the patient's blood type will eventually convert to the donor's type.

Some blood types are associated with inheritance of other diseases; for example, the Kell antigen is sometimes associated with McLeod syndrome.^[10] Certain blood types may affect susceptibility to infections, an example being the resistance to specific malaria species seen in individuals lacking the Duffy antigen.^[11] The Duffy antigen, presumably as a result of natural selection, is more common in ethnic groups from areas with a high incidence of malaria.^[12]

ABO blood group system

The *ABO system* is the most important blood-group system in human-blood transfusion. The associated anti-A and anti-B antibodies are usually *immunoglobulin M*, abbreviated IgM, antibodies. ABO IgM antibodies are produced in the first years of life by sensitization to environmental substances such as food, bacteria, and viruses. The **original terminology** used by Dr. Karl Landsteiner in 1901 for the classification is A/B/C; in later publications "C" became "O".^[13] "O" is often called *0* (*zero*, or *null*) in other languages. The Austrian Federal Ministry of Health (<http://bmg.gv.at/home/EN/Home>) claims the **original terminology** used by Dr. Karl Landsteiner in 1901 for the classification is 0(Zero)/A/B/AB and that in later publications "0" became "O" in most of English language countries.^{[13][14]}



Phenotype	Genotype
A	AA or AO
B	BB or BO
AB	AB
O	OO

Rh blood group system

The Rh system (Rh meaning *Rhesus*) is the second most significant blood-group system in human-blood transfusion with currently 50 antigens. The most significant Rh antigen is the D antigen, because it is the most likely to provoke an immune system response of the five main Rh antigens. It is common for D-negative individuals not to have any anti-D IgG or IgM antibodies, because anti-D antibodies are not usually produced by sensitization against environmental substances. However, D-negative individuals can produce IgG anti-D antibodies following a sensitizing event: possibly a fetomaternal transfusion of blood from a fetus in pregnancy or occasionally a blood transfusion with D positive RBCs.^[15] Rh disease can develop in these cases.^[16] Rh negative blood types are much less common in Asian populations (0.3%) than they are in White populations (15%).^[17] The presence or absence of the Rh(D) antigen is signified by the + or − sign, so that, for example, the A− group is ABO type A and does not have the Rh (D) antigen.

ABO and Rh distribution by country

As with many other genetic traits, the distribution of ABO and Rh blood groups varies significantly between populations.

Other blood group systems

33 blood-group systems have been identified, including the ABO and Rh systems.^[18] Thus, in addition to the ABO antigens and Rh antigens, many other antigens are expressed on the RBC surface membrane. For example, an individual can be AB, D positive, and at the same time M and N positive (MNS system), K positive (Kell system), Le^a or Le^b negative (Lewis system), and so on, being positive or negative for each blood group system antigen. Many of the blood group systems were named after the patients in whom the corresponding antibodies were initially encountered.

Clinical significance

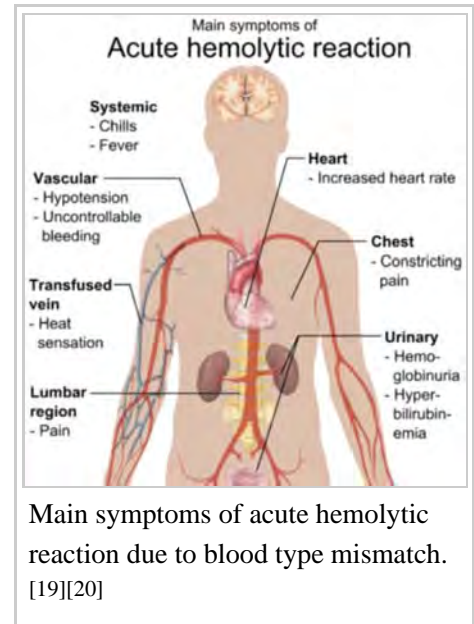
Blood transfusion

Transfusion medicine is a specialized branch of hematology that is concerned with the study of blood groups, along with the work of a blood bank to provide a transfusion service for blood and other blood products. Across the world, blood products must be prescribed by a medical doctor (licensed physician or surgeon) in a similar way as medicines.

Much of the routine work of a blood bank involves testing blood from both donors and recipients to ensure that every individual recipient is given blood that is compatible and is as safe as possible. If a unit of incompatible blood is transfused between a donor and recipient, a severe acute hemolytic reaction with hemolysis (RBC

destruction), renal failure and shock is likely to occur, and death is a possibility. Antibodies can be highly active and can attack RBCs and bind components of the complement system to cause massive hemolysis of the transfused blood.

Patients should ideally receive their own blood or type-specific blood products to minimize the chance of a transfusion reaction. Risks can be further reduced by cross-matching blood, but this may be skipped when blood is required for an emergency. Cross-matching involves mixing a sample of the recipient's serum with a sample of the donor's red blood cells and checking if the mixture *agglutinates*, or forms clumps. If agglutination is not obvious by direct vision, blood bank technicians usually check for agglutination with a microscope. If agglutination occurs, that particular donor's blood cannot be transfused to that particular recipient. In a blood bank it is vital that all blood specimens are correctly identified, so labelling has been standardized using a barcode system known as ISBT 128.



The blood group may be included on identification tags or on tattoos worn by military personnel, in case they should need an emergency blood transfusion. Frontline German Waffen-SS had blood group tattoos during World War II.

Rare blood types can cause supply problems for blood banks and hospitals. For example, Duffy-negative blood occurs much more frequently in people of African origin,^[21] and the rarity of this blood type in the rest of the population can result in a shortage of Duffy-negative blood for these patients. Similarly for RhD negative people, there is a risk associated with travelling to parts of the world where supplies of RhD negative blood are rare, particularly East Asia, where blood services may endeavor to encourage Westerners to donate blood.^[22]

Hemolytic disease of the newborn (HDN)

A pregnant woman can make IgG blood group antibodies if her fetus has a blood group antigen that she does not have. This can happen if some of the fetus' blood cells pass into the mother's blood circulation (e.g. a small fetomaternal hemorrhage at the time of childbirth or obstetric intervention), or sometimes after a therapeutic blood transfusion. This can cause Rh disease or other forms of hemolytic disease of the newborn (HDN) in the current pregnancy and/or subsequent pregnancies. If a pregnant woman is known to have anti-D antibodies, the Rh blood type of a fetus can be tested by analysis of fetal DNA in maternal plasma to assess the risk to the fetus of Rh disease.^[23] One of the major advances of twentieth century medicine was to prevent this disease by stopping the formation of Anti-D antibodies by D negative mothers with an injectable medication called Rho(D) immune globulin.^{[24][25]} Antibodies associated with some blood groups can cause severe HDN, others can only cause mild HDN and others are not known to cause HDN.^[3]

Blood products

To provide maximum benefit from each blood donation and to extend shelf-life, blood banks fractionate some whole blood into several products. The most common of these products are packed RBCs, plasma, platelets, cryoprecipitate, and fresh frozen plasma (FFP). FFP is quick-frozen to retain the labile clotting factors V and VIII, which are usually administered to patients who have a potentially fatal clotting problem caused by a condition such as advanced liver disease, overdose of anticoagulant, or disseminated intravascular coagulation (DIC).

Units of packed red cells are made by removing as much of the plasma as possible from whole blood units.

Clotting factors synthesized by modern recombinant methods are now in routine clinical use for hemophilia, as the risks of infection transmission that occur with pooled blood products are avoided.

Red blood cell compatibility

- Blood group AB** individuals have both A and B antigens on the surface of their RBCs, and their blood plasma does not contain any antibodies against either A or B antigen. Therefore, an individual with type AB blood can receive blood from any group (with AB being preferable), but cannot donate blood to any group other than AB. They are known as universal recipients.
- Blood group A** individuals have the A antigen on the surface of their RBCs, and blood serum containing IgM antibodies against the B antigen. Therefore, a group A individual can receive blood only from individuals of groups A or O (with A being preferable), and can donate blood to individuals with type A or AB.
- Blood group B** individuals have the B antigen on the surface of their RBCs, and blood serum containing IgM antibodies against the A antigen. Therefore, a group B individual can receive blood only from individuals of groups B or O (with B being preferable), and can donate blood to individuals with type B or AB.
- Blood group O** (or blood group zero in some countries) individuals do not have either A or B antigens on the surface of their RBCs, and their blood serum contains IgM anti-A and anti-B antibodies. Therefore, a group O individual can receive blood only from a group O individual, but can donate blood to individuals of any ABO blood group (i.e., A, B, O or AB). If a patient in a hospital situation needs a blood transfusion in an emergency, and if the time taken to process the recipient's blood would cause a detrimental delay, O negative blood can be issued. Because it is compatible with anyone, O negative blood is often overused and consequently is always in short supply.^[26] According to the American Association of Blood Banks and the British Chief Medical Officer's National Blood Transfusion Committee, the use of group O RhD negative red cells should be restricted to persons with O negative blood, women who might be pregnant, and emergency cases in which blood-group testing is genuinely impracticable.^[26]

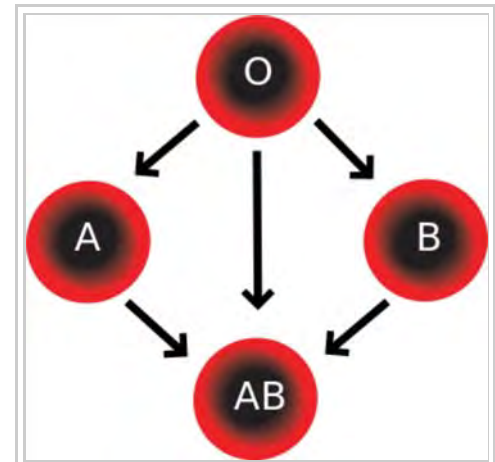
Red blood cell compatibility table^{[27][28]}

Recipient ^[1]	Donor ^[1]							
	O−	O+	A−	A+	B−	B+	AB−	AB+
O−	✓	✗	✗	✗	✗	✗	✗	✗
O+	✓	✓	✗	✗	✗	✗	✗	✗
A−	✓	✗	✓	✗	✗	✗	✗	✗
A+	✓	✓	✓	✓	✗	✗	✗	✗
B−	✓	✗	✗	✗	✓	✗	✗	✗
B+	✓	✓	✗	✗	✓	✓	✗	✗
AB−	✓	✗	✓	✗	✓	✗	✓	✗
AB+	✓	✓	✓	✓	✓	✓	✓	✓

Table note

1. Assumes absence of atypical antibodies that would cause an incompatibility between donor and recipient blood, as is usual for blood selected by cross matching.

An Rh D-negative patient who does not have any anti-D antibodies (never being previously sensitized to D-positive RBCs) can receive a transfusion of D-positive blood once, but this would cause sensitization to the D antigen, and a female patient would become at risk for hemolytic disease of the newborn. If a D-negative patient has developed anti-D antibodies, a subsequent exposure to D-positive blood would lead to a potentially dangerous transfusion reaction. Rh D-positive blood should never be given to D-negative women of child bearing age or to patients with D antibodies, so blood banks must conserve Rh-negative blood for these patients. In extreme circumstances, such as for a major bleed when stocks of D-negative blood units are very low at the blood bank, D-positive blood might be given to D-negative females above child-bearing age or to Rh-negative males, providing that they did not have anti-D antibodies, to conserve D-negative blood stock in the blood bank. The converse is not true; Rh D-positive patients do not react to D negative blood.



Red blood cell compatibility chart

In addition to donating to the same blood group; type O blood donors can give to A, B and AB; blood donors of types A and B can give to AB.

This same matching is done for other antigens of the Rh system as C, c, E and e and for other blood group systems with a known risk for immunization such as the Kell system in particular for females of child-bearing age or patients with known need for many transfusions.

Plasma compatibility

Blood plasma compatibility is the inverse of red blood cell compatibility.^[29] Type AB plasma carries neither anti-A nor anti-B antibodies and can be transfused to individuals of any blood group; but type AB patients can only receive type AB plasma. Type O carries both antibodies, so individuals of blood group O can receive plasma from any blood group, but type O plasma can be used only by type O recipients.

Plasma compatibility table^[28]

Recipient	Donor ^[1]			
	O	A	B	AB
O	✓	✓	✓	✓
A	✗	✓	✗	✓
B	✗	✗	✓	✓
AB	✗	✗	✗	✓

Table note

1. Assumes absence of strong atypical antibodies in donor plasma

Rh D antibodies are uncommon, so generally neither D negative nor D positive blood contain anti-D antibodies. If a potential donor is found to have anti-D antibodies or any strong atypical blood group antibody by antibody screening in the blood bank, they would not be accepted as a donor (or in some blood banks the blood would be drawn but the product would need to be appropriately labeled); therefore, donor blood plasma

issued by a blood bank can be selected to be free of D antibodies and free of other atypical antibodies, and such donor plasma issued from a blood bank would be suitable for a recipient who may be D positive or D negative, as long as blood plasma and the recipient are ABO compatible.

Universal donors and universal recipients

With regard to transfusions of packed red blood cells, individuals with type O Rh D negative blood are often called universal donors, and those with type AB Rh D positive blood are called universal recipients; however, these terms are only generally true with respect to possible reactions of the recipient's anti-A and anti-B antibodies to transfused red blood cells, and also possible sensitization to Rh D antigens. One exception is individuals with hh antigen system (also known as the Bombay phenotype) who can only receive blood safely from other hh donors, because they form antibodies against the H antigen present on all red blood cells.^{[30][31]}

Blood donors with exceptionally strong anti-A, anti-B or any atypical blood group antibody may be excluded from blood donation. In general, while the plasma fraction of a blood transfusion may carry donor antibodies not found in the recipient, a significant reaction is unlikely because of dilution.

Additionally, red blood cell surface antigens other than A, B and Rh D, might cause adverse reactions and sensitization, if they can bind to the corresponding antibodies to generate an immune response.

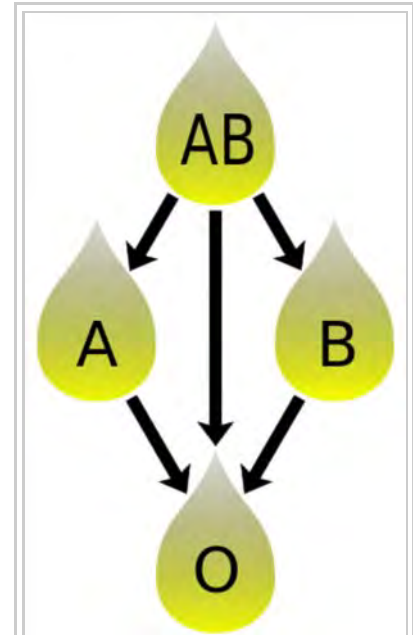
Transfusions are further complicated because platelets and white blood cells (WBCs) have their own systems of surface antigens, and sensitization to platelet or WBC antigens can occur as a result of transfusion.

With regard to transfusions of plasma, this situation is reversed. Type O plasma, containing both anti-A and anti-B antibodies, can only be given to O recipients. The antibodies will attack the antigens on any other blood type. Conversely, AB plasma can be given to patients of any ABO blood group due to not containing any anti-A or anti-B antibodies.

Blood group genotyping

In addition to the current practice of serologic testing of blood types, the progress in molecular diagnostics allows the increasing use of blood group genotyping. In contrast to serologic tests reporting a direct blood type phenotype, genotyping allows the prediction of a phenotype based on the knowledge of the molecular basis of the currently known antigens. This allows a more detailed determination of the blood type and therefore a better match for transfusion, which can be crucial in particular for patients with needs for many transfusions to prevent allo-immunization.^{[32][33]}

History



Plasma compatibility chart

In addition to donating to the same blood group; plasma from type AB can be given to A, B and O; plasma from types A, B and AB can be given to O.



A hospital corpsman with the Blood Donor Team from Naval Medical Center Portsmouth takes samples of blood from a donor for testing

Two blood group systems were discovered by Karl Landsteiner during early experiments with blood transfusion: the ABO group in 1901^[34] and in co-operation with Alexander S. Wiener the Rhesus group in 1937.^{[35][36]} Development of the Coombs test in 1945,^[37] the advent of transfusion medicine, and the understanding of ABO hemolytic disease of the newborn led to discovery of more blood groups, and now 33 human blood group systems are recognized by the International Society of Blood Transfusion (ISBT),^[4] and in the 33 blood groups, over 600 blood group antigens have been found;^[5] many of these are rare or are mainly found in certain ethnic groups.

Czech serologist Jan Janský is credited with the first classification of blood into the four types (A, B, AB, O) in 1907, which remains in use today. Blood types have been used in forensic science and were formerly used to demonstrate impossibility of paternity (e.g., a type AB man cannot be the father of a type O infant), but both of these uses are being replaced by genetic fingerprinting, which provides greater certainty.^[38]

According to the Austrian Federal Ministry of Health (<http://www.bmg.gv.at/home/EN/Home>) the original terminology used by Karl Landsteiner in 1901 for the classification is A, B and 0 (*zero*); the "O" (*oh*) you find in the ABO group system is actually a subsequent variation occurred during the translation process, probably due to the similar shape between the number 0 and the letter O.

Society and culture

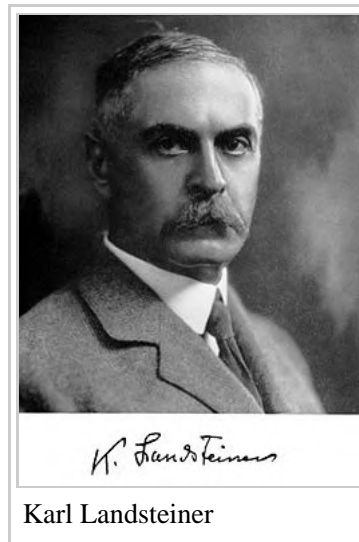
A popular belief in Japan is that a person's ABO blood type is predictive of their personality, character, and compatibility with others. This belief is also widespread in South Korea^[39] and Taiwan. Deriving from ideas of historical scientific racism, the theory reached Japan in a 1927 psychologist's report, and the militarist government of the time commissioned a study aimed at breeding better soldiers.^[39] The fad faded in the 1930s due to its lack of scientific basis and ultimately the discovery of DNA in the following decades which it later became clear had a vastly more complex and important role in both heredity generally and personality specifically. No evidence has been found to support the theory by scientists, but it was revived in the 1970s by Masahiko Nomi, a broadcaster with a background in law who had no scientific or medical background.^[39] Despite these facts, the myth still persists widely in Japanese and South Korean popular culture.^[40]

See also

- hh blood group
- Blood type (non-human)

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Further reading

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External links

- www.BloodGroupBank.com Know Blood Group Information of your friends (<http://bloodgroupbank.com/>)
- BGMUT (<http://www.ncbi.nlm.nih.gov/gv/mhc/xslcgi.cgi?cmd=bgmut/home>) Blood Group Antigen Gene Mutation Database at NCBI, NIH has details of genes and proteins, and variations thereof, that are responsible for blood types
- Online Mendelian Inheritance in Man (OMIM) ABO Glycosyltransferase; ABO -110300 (<https://omim.org/entry/110300>)
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- "Molecular Genetic Basis of ABO". Retrieved July 31, 2008.
- Blood types (<http://www.pleacher.com/mp/mlessons/stat/blood2.html>) – intuitive explanation using Venn diagrams

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