Apheresis

*For the linguistic term, see*[*Apheresis (linguistics)*](https://en.wikipedia.org/wiki/Apheresis_(linguistics))*.*

*"Pheresis" redirects here. It is not to be confused with [Phoresis](https://en.wikipedia.org/wiki/Phoresis" \o "Blood).*

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| **Apheresis** | |
| [Apheresis.svg](https://en.wikipedia.org/wiki/File:Apheresis.svg)  Whole blood enters the centrifuge (1) and separates into plasma (2), leukocytes (3), and erythrocytes (4). Selected components are then drawn off (5). | |
| [**MeSH**](https://en.wikipedia.org/wiki/Medical_Subject_Headings) | [D016238](https://www.nlm.nih.gov/cgi/mesh/2016/MB_cgi?field=uid&term=D016238) |
| [[edit on Wikidata](https://www.wikidata.org/wiki/Q618446)] | |

**Apheresis** ([ἀφαίρεσις](https://en.wiktionary.org/wiki/%E1%BC%80%CF%86%CE%B1%CE%AF%CF%81%CE%B5%CF%83%CE%B9%CF%82" \o "wikt:ἀφαίρεσις) (*aphairesis*, "a taking away")) is a [medical technology](https://en.wikipedia.org/wiki/Medical_technology) in which the [blood](https://en.wikipedia.org/wiki/Blood) of a person is passed through an apparatus that separates out one particular constituent and returns the remainder to the circulation. It is thus an [extracorporeal](https://en.wikipedia.org/wiki/Extracorporeal) therapy.

The apheresis machine was invented by American medical technologist Herb Cullis in 1972.[[1]](https://en.wikipedia.org/wiki/Apheresis#cite_note-1)

One of the uses of apheresis is for collecting stem cells.[[2]](https://en.wikipedia.org/wiki/Apheresis#cite_note-2)

Method

Depending on the substance that is being removed, different processes are employed in apheresis. If separation by [density](https://en.wikipedia.org/wiki/Density) is required, [centrifugation](https://en.wikipedia.org/wiki/Centrifugation) is the most common method. Other methods involve absorption onto beads coated with an absorbent material and filtration.

The centrifugation method can be divided into two basic categories:

**Continuous flow centrifugation**

Continuous flow centrifugation (CFC) historically required two [venipunctures](https://en.wikipedia.org/wiki/Venipunctures) as the "continuous" means the blood is collected, spun, and returned simultaneously. Newer systems can use a single venipuncture. The main advantage of this system is the low extracorporeal volume (calculated by volume of the apheresis chamber, the donor's [hematocrit](https://en.wikipedia.org/wiki/Hematocrit), and total blood volume of the donor) used in the procedure, which may be advantageous in the elderly and for children.

**Intermittent flow centrifugation**

Intermittent flow centrifugation works in cycles, taking blood, spinning/processing it and then giving back the unused parts to the donor in a [bolus](https://en.wikipedia.org/wiki/Bolus_(medicine)). The main advantage is a single venipuncture site. To stop the blood from [coagulating](https://en.wikipedia.org/wiki/Coagulation), [anticoagulant](https://en.wikipedia.org/wiki/Anticoagulant) is automatically mixed with the blood as it is pumped from the body into the apheresis machine.

**Centrifugation variables**

The centrifugation process itself has four variables that can be controlled to selectively remove desired components. The first is spin speed and bowl diameter, the second is "sit time" in centrifuge, the third is solutes added, and the fourth is not as easily controllable: plasma volume and cellular content of the donor. The end product in most cases is the classic sedimented blood sample with the [RBC's](https://en.wikipedia.org/wiki/Red_blood_cells) at the bottom, the [buffy coat](https://en.wikipedia.org/wiki/Buffy_coat) of platelets and [WBC's](https://en.wikipedia.org/wiki/White_blood_cells) ([lymphocytes](https://en.wikipedia.org/wiki/Lymphocytes)/[granulocytes](https://en.wikipedia.org/wiki/Granulocytes), [PMN's](https://en.wikipedia.org/wiki/Polymorphonuclear_leukocytes), [basophils](https://en.wikipedia.org/wiki/Basophils), [eosinophils](https://en.wikipedia.org/wiki/Eosinophils)/[monocytes](https://en.wikipedia.org/wiki/Monocytes)) in the middle and the plasma on top.

Types

[](https://en.wikipedia.org/wiki/File:Blood_donation_needle.jpg)

Disinfect, insert the cannula, pull out the cannula, dress the wound. The blue pressure cuff is controlled by the platelet apheresis machine in newer models.

There are numerous types of apheresis.

**Donation**

Blood taken from a healthy donor can be separated into its component parts during [blood donation](https://en.wikipedia.org/wiki/Blood_donation), where the needed component is collected and the "unused" components are returned to the donor. [Fluid replacement](https://en.wikipedia.org/wiki/Fluid_replacement) is usually not needed in this type of collection. In many countries, apheresis donors can donate blood more often than those donating whole blood. There are large categories of component collections:

* [Plasmapheresis](https://en.wikipedia.org/wiki/Plasmapheresis) – [blood plasma](https://en.wikipedia.org/wiki/Blood_plasma). Plasmapheresis is useful in collecting FFP (fresh frozen plasma) of a particular ABO group. Commercial uses aside from FFP for this procedure include immunoglobulin products, plasma derivatives, and collection of rare WBC and RBC antibodies.
* [Erythrocytapheresis](https://en.wikipedia.org/wiki/Erythrocytapheresis) – [red blood cells](https://en.wikipedia.org/wiki/Red_blood_cells). Erythrocytapheresis is the separation of [erythrocytes](https://en.wikipedia.org/wiki/Erythrocytes) from whole blood. It is most commonly accomplished using the method of centrifugal sedimentation. This process is used for red blood cell diseases such as sickle cell crises or severe malaria. The automated red blood cell collection procedure for donating erythrocytes is referred to as 'Double Reds' or 'Double Red Cell Apheresis.'[[3]](https://en.wikipedia.org/wiki/Apheresis#cite_note-3)
* [Plateletpheresis](https://en.wikipedia.org/wiki/Plateletpheresis) (thrombapheresis, thrombocytapheresis) – [blood platelets](https://en.wikipedia.org/wiki/Platelet). Plateletpheresis is the collection of platelets by apheresis while returning the RBCs, WBCs, and component plasma. The yield is normally the equivalent of between six and ten random platelet concentrates. Quality control demands the platelets from apheresis be equal to or greater than 3.0 × 1011 in number and have a pH of equal to or greater than 6.2 in 90% of the products tested and must be used within five days.
* [Leukapheresis](https://en.wikipedia.org/wiki/Leukapheresis) – [leukocytes](https://en.wikipedia.org/wiki/Leukocytes) (white blood cells). Leukopheresis is the removal of [PMNs](https://en.wikipedia.org/wiki/Granulocyte), basophils, eosinophils for transfusion into patients whose PMNs are ineffective or where traditional therapy has failed. There is limited data to suggest the benefit of [granulocyte transfusion](https://en.wikipedia.org/wiki/Granulocyte_transfusion). The complications of this procedure are the difficulty in collection and short shelf life (24 hours at 20 to 24 °C). Since the "buffy coat" layer sits directly atop the RBC layer, HES, a sedimenting agent, is employed to improve yield while minimizing RBC collection. Quality control demands the resultant concentrate be 1.0 × 1010 granulocytes in 75% of the units tested and that the product be irradiated to avoid graft-versus-host disease (inactivate lymphocytes). Irradiation does not affect PMN function. Since there is usually a small amount of RBCs collected, ABO compatibility should be employed when feasible.
* Stem cell harvesting – circulating [bone marrow](https://en.wikipedia.org/wiki/Bone_marrow) cells are harvested to use in [bone marrow transplantation](https://en.wikipedia.org/wiki/Bone_marrow_transplantation).

**Donor safety**

* Single use kits – Apheresis is done using single-use kits, so there is no risk of infection from blood-contaminated tubing or centrifuge. Blood does not contact the device and during the separation, blood does not exit the kit.
* Reinfusion – At the end of the procedure, the remaining blood in the kit is given back to the donor with a process called 'reinfusion'.
* Immune system effects – "the immediate decreases in blood lymphocyte counts and serum immunoglobulin concentrations are of slight to moderate degree and are without known adverse effects. Less information is available regarding long-term alterations of the immune system"[[4]](https://en.wikipedia.org/wiki/Apheresis#cite_note-4)

**Kit problems**

Two apheresis kit recalls were:

* Baxter Healthcare Corporation (2005), in which "pinhole leaks were observed at the two-omega end of the umbilicus (multilumen tubing), causing a blood leak."[[5]](https://en.wikipedia.org/wiki/Apheresis#cite_note-5)
* Fenwal Incorporated (2007), in which there were "two instances where the anticoagulant citrate dextrose (ACD) and saline lines were reversed in the assembly process. The reversed line connections may not be visually apparent in the monitor box, and could result in excessive ACD infusion and severe injury, including death, to the donor."[[6]](https://en.wikipedia.org/wiki/Apheresis#cite_note-6)

**Donor selection**

People who do not use a drug that may prevent blood donation, who do not have the risk of the carrier of a disease, and who have suitable vascular structure may be apheresis donors. For apheresis platelet donation the donor’s pre platelet count should be above 150 x 10^9/L. For apheresis plasma donation, the donor’s total protein level should be greater than 60 g/L. For double red cell apheresis, donors of either gender require a minimum hemoglobin level of 14.0 g/dl.[[7]](https://en.wikipedia.org/wiki/Apheresis#cite_note-7)

**Plasticizer exposure**

Apheresis uses plastics and tubing, which come into contact with the blood. The plastics are made of [PVC](https://en.wikipedia.org/wiki/PVC) in addition to additives such as a [plasticizer](https://en.wikipedia.org/wiki/Plasticizer), often [DEHP](https://en.wikipedia.org/wiki/DEHP). DEHP leaches from the plastic into the blood, and people have begun to study the possible effects of this leached DEHP on donors as well as transfusion recipients.

* "current risk or preventive limit values for DEHP such as the RfD of the US EPA (20 μg/kg/day) and the TDI of the European Union (20–48 μg/kg/day) can be exceeded on the day of the plateletpheresis. . . . Especially women in their reproductive age need to be protected from DEHP exposures exceeding the above mentioned preventive limit values."[[8]](https://en.wikipedia.org/wiki/Apheresis#cite_note-8)
* "Commercial plateletpheresis disposables release considerable amounts of DEHP during the apheresis procedure, but the total dose of DEHP retained by the donor is within the normal range of DEHP exposure of the general population."[[9]](https://en.wikipedia.org/wiki/Apheresis#cite_note-9)
* The Baxter company manufactured blood bags without [DEHP](https://en.wikipedia.org/wiki/DEHP), but there was little demand for the product in the marketplace
* "Mean DEHP doses for both plateletpheresis techniques (18.1 and 32.3 μg/kg/day) were close to or exceeded the reference dose (RfD) of the US EPA and tolerable daily intake (TDI) value of the EU on the day of the apheresis. Therefore, margins of safety might be insufficient to protect especially young men and women in their reproductive age from effects on reproductivity. At present, discontinuous-flow devices should be preferred to avert conceivable health risks from plateletpheresis donors. Strategies to avoid DEHP exposure of donors during apheresis need to be developed."[[10]](https://en.wikipedia.org/wiki/Apheresis#cite_note-10)

**Therapy**

[](https://en.wikipedia.org/wiki/File:Platelet_apheresis.jpg)

The assembly (A-D), operation (E) and disassembly (F) of the platelet apheresis machine which can be configured to separate other components as well.

The various apheresis techniques may be used whenever the removed constituent is causing severe symptoms of disease. Generally, apheresis has to be performed fairly often, and is an invasive process. It is therefore only employed if other means to control a particular disease have failed, or the symptoms are of such a nature that waiting for medication to become effective would cause suffering or risk of complications.

* [Plasma exchange](https://en.wikipedia.org/wiki/Plasma_exchange) – removal of the liquid portion of blood to remove harmful substances. The plasma is replaced with a replacement solution.
* [LDL apheresis](https://en.wikipedia.org/wiki/LDL_apheresis) – removal of [low density lipoprotein](https://en.wikipedia.org/wiki/Low_density_lipoprotein) in patients with [familial hypercholesterolemia](https://en.wikipedia.org/wiki/Familial_hypercholesterolemia).
* [Photopheresis](https://en.wikipedia.org/wiki/Photopheresis) – used to treat [graft-versus-host disease](https://en.wikipedia.org/wiki/Graft-versus-host_disease), [cutaneous T-cell lymphoma](https://en.wikipedia.org/wiki/Cutaneous_T-cell_lymphoma), and [rejection in heart transplantation](https://en.wikipedia.org/wiki/Transplant_rejection).
* Immunoadsorbtion with Staphylococcal [protein A](https://en.wikipedia.org/wiki/Protein_A)-agarose column – removal of allo- and autoantibodies (in autoimmune diseases, transplant rejection, hemophilia) by directing plasma through protein A-agarose columns. Protein A is a cell wall component produced by several strains of Staphylococcus aureus which binds to the Fc region of IgG.
* [Leukocytapheresis](https://en.wikipedia.org/wiki/Leukoreduction) – removal of malignant white blood cells in people with leukemia and very high white blood cell counts causing symptoms.
* [Erythrocytapheresis](https://en.wikipedia.org/wiki/Erythrocytapheresis) – removal of erythrocytes (red blood cells) in people with [iron overload](https://en.wikipedia.org/wiki/Iron_overload) as a result of [Hereditary haemochromatosis](https://en.wikipedia.org/wiki/Hereditary_haemochromatosis) or [transfusional iron overload](https://en.wikipedia.org/wiki/Transfusion_hemosiderosis" \o "Transfusion hemosiderosis)
* [Thrombocytapheresis](https://en.wikipedia.org/wiki/Thrombocytapheresis) – removal of platelets in people with symptoms from extreme elevations in platelet count such as those with [essential thrombocythemia](https://en.wikipedia.org/wiki/Essential_thrombocythemia) or [polycythemia vera](https://en.wikipedia.org/wiki/Polycythemia_vera).

Indications

[](https://en.wikipedia.org/wiki/File:Platelets_collected_by_using_apheresis.jpg)

Platelets collected by using apheresis at an [American Red Cross](https://en.wikipedia.org/wiki/American_Red_Cross) donation center.

**ASFA categories**

In 2010, the [American Society for Apheresis](https://en.wikipedia.org/wiki/American_Society_for_Apheresis) published the 5th Special Edition(1)[[11]](https://en.wikipedia.org/wiki/Apheresis#cite_note-11) of [evidence based guidelines](https://en.wikipedia.org/wiki/Evidence-based_medicine) for the practice of Apheresis Medicine. These guidelines are based upon a systematic review of available scientific literature. Clinical utility for a given disease is denoted by assignment of an **ASFA Category** (I – IV). The quality and strength of evidence are denoted by standard [GRADE](https://en.wikipedia.org/wiki/Evidence-based_medicine#GRADE_working_group) recommendations. ASFA Categories are defined as follows:

* **Category I** for disorders where therapeutic apheresis is accepted as a first line treatment,
* **Category II** for disorders where therapeutic apheresis is accepted as a second-line treatment,
* **Category III** for disorders where the optimal role of therapeutic apheresis is not clearly established and
* **Category IV** for disorders where therapeutic apheresis is considered ineffective or harmful.

**Diseases and disorders**

Only diseases (or mentioned special conditions thereof) with ASFA category I or II are displayed in **bold**, with category I being underlined in addition.

Fluid replacement during apheresis

When an apheresis system is used for therapy, the system is removing relatively small amounts of fluid (not more than 10.5 mL/kg body weight). That fluid must be replaced to keep correct intravascular volume. The fluid replaced is different at different institutions. If a [crystalloid](https://en.wikipedia.org/wiki/Volume_expander#Types) like [normal saline](https://en.wikipedia.org/wiki/Normal_saline) (NS) is used, the infusion amount should be triple what is removed as the 3:1 ratio of normal saline for plasma is needed to keep up [oncotic pressure](https://en.wikipedia.org/wiki/Oncotic_pressure). Some institutions use [normal serum albumin](https://en.wikipedia.org/w/index.php?title=Normal_serum_albumin&action=edit&redlink=1), but it is costly and can be difficult to find. Some advocate using [fresh frozen plasma](https://en.wikipedia.org/wiki/Fresh_frozen_plasma) (FFP) or a similar blood product, but there are dangers including citrate toxicity (from the anticoagulant), [ABO incompatibility](https://en.wikipedia.org/wiki/ABO_incompatibility), [infection](https://en.wikipedia.org/wiki/Infection), and cellular [antigens](https://en.wikipedia.org/wiki/Antigen).