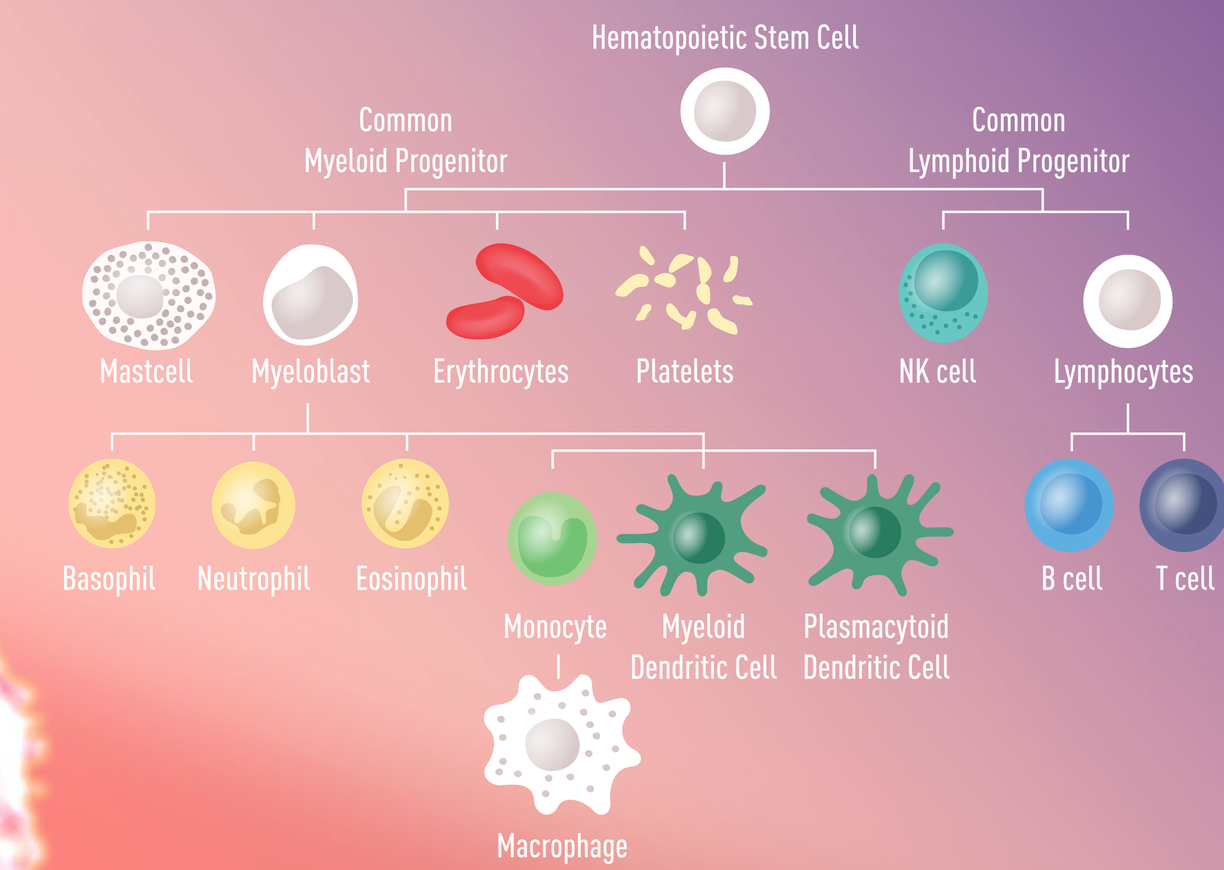
Sponsored by
THE HUMAN PROTEIN ATLAS
Knut och Alice Wallenbergs Stiftelse
Produced by the Science/AAAS Custom Publishing Office
Science AAAS

www.proteinatlas.org

The Human Blood Atlas

Blood cell types

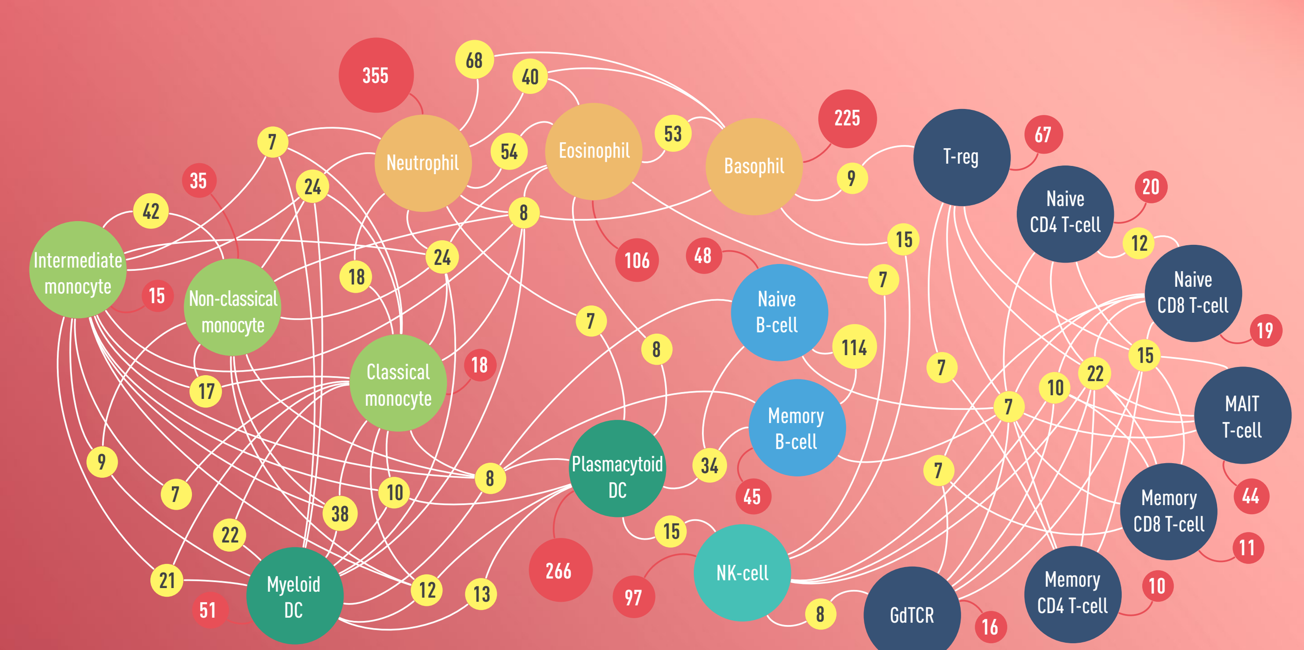
Blood cells make up approximately 40% of the blood volume and originate from stem cells in the bone marrow, where they mature into erythrocytes (red blood cells), platelets, and a large number of white blood cell populations that circulate throughout the body.



- **Erythrocytes** (red blood cells) are small non-nucleated cells that transport oxygen and represent the most numerous cell type in the blood.
- **Platelets** circulate in the blood until they are activated by tissue damage, where they aid in blood clot formation.
- **Granulocytes** are a category of white blood cells involved in defending against bacteria and parasites. They are characterized by the presence of granules in their cytoplasm that contain, e.g., defensins, lysozymes and histamines. Cell types include **neutrophils** (most common), **eosinophils**, and **basophils**.
- **Monocytes** are the largest of the white blood cells and are involved in immune responses to bacteria, viruses, and fungi. They can differentiate into **macrophages** that can penetrate into tissues and perform defense functions.
- **Dendritic cells** are regulators of immune responses. They engulf and present fragments of pathogens to T cells in lymph nodes, enabling the adaptive immune response.
- **Natural killer (NK)** cells are involved in innate immunity and release cytotoxic granules to fight tumors and cells infected by a virus.
- **B cells** produce antibodies to fight infections as part of the adaptive immune response.
- **T cells** regulate the adaptive immune response and consists of many different cell types.

Introduction to the Human Protein Atlas

The Human Protein Atlas (www.proteinatlas.org) is an open access database with RNA and protein profiles of all genes across cells, tissues, and organs in the human body. A subsection of this database, the Human Blood Atlas, focuses on the expression levels of all human protein-coding genes in major blood immune cell populations. In addition, the proteins actively secreted to blood (the Human Secretome) are described.

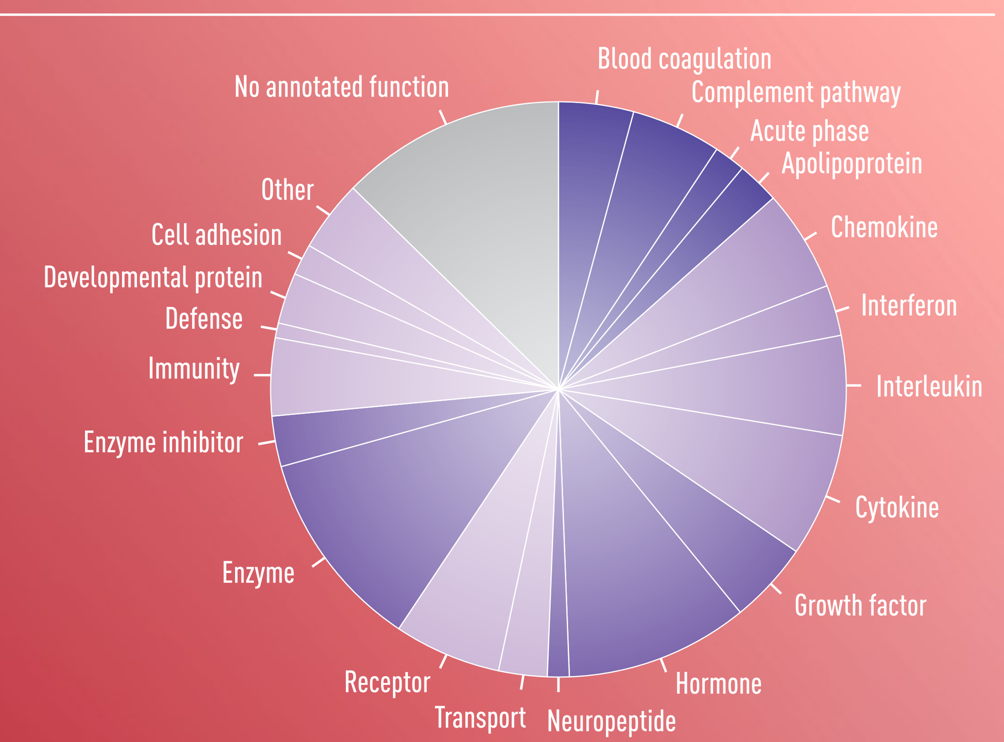


The genes in human blood cells

Each node in this network shows the number of genes that are active in a specific immune cell population—both the number of genes enriched (high relative abundance of the protein) in a single cell type (red) and the number of genes enriched in several related cell types (yellow). For details and list of genes, see www.proteinatlas.org/blood.

Function of blood proteins

The liquid portion of blood is called plasma. It contains a complex mixture of proteins including clotting factors, antibodies, hormones, and enzymes, as well as sugars and fat particles. The abundance of blood proteins varies considerably, with only 10 proteins making up more than 90% of the total protein mass. Albumin is the most abundant, while signaling proteins like cytokines and hormones appear at much lower concentrations. The Human Blood Atlas lists the functional role of all proteins predicted to be actively secreted into the blood (figure on right) as well as their concentrations as determined by mass spectrometry and/or immunoassays (www.proteinatlas.org/blood).



Blood disease and immune activation

Certain proteins are essential for activating immune cells upon infection and their dysfunction leads to infectious disease susceptibility. Other proteins play critical roles in regulating immunity. Proteins with such activating or inhibiting functions are interesting targets for drug development. Examples of pharmaceutical drugs include anti histamines that control allergic reactions and biopharmaceuticals used to lower the levels of cytokines in autoimmune diseases, such as multiple sclerosis (TNF-α) and psoriasis (IL-17). In addition, targeting proteins that limit immune responses—so called checkpoint inhibitors such as PD-L1 and CTLA4—can boost the efficacy of immune cells, leading to dramatic improvements in patients with certain blood cancers, as well as showing promise in the treatment of solid tumors.

A century of advances in immunology

reflected in Nobel prizes awarded for discoveries involving blood cells and proteins

1908
Paul Ehrlich
Side-chain theory about how antibodies tackle invaders
Ilya Ilyich Mechnikov
Identification of phagocytic cells that engulf intruders

1913
Charles Richet
Discovery of anaphylaxis, a life-threatening allergic reaction to toxins

1919
Jules Bordet
Discovery of complement factors in blood serum

1926
The Svedberg
for his studies of proteins using analytical ultracentrifuge methods

1930
Karl Landsteiner
Discovery of human blood groups and the system for typing blood

1945
Alexander Fleming, Ernst Boris Chain, Howard Walter Florey
for the discovery of penicillin and making it into an antibiotic to cure infectious diseases

1948
Arne Tiselius
for his research on electrophoresis and the complex nature of serum proteins

1952
Selman Waksman
for discovering streptomycin, the first antibiotic to work against tuberculosis

1955
Vincent du Vigneaud
for the first synthesis of a polypeptide hormone

1957
Daniel Bovet
for his work on antihistamine

1958
Fred Sanger
the structure of insulin

1960
Frank MacFarlane Burnet and Peter Medawar
Concept of immunological tolerance

1962
Max Ferdinand Perutz and John Cowdery Kendrew
Structure of hemoglobin

1972
Gerald Edelman and Rodney Porter
Elucidating the structure of antibodies

1977
Rosalyn Yalow
for the development of radioimmunoassays of peptide hormones
Roger Guillemin and Andrew V. Schally
for their discoveries of peptide hormone production

1980
Baruj Benacerraf, Jean Dausset, and George Snell
Regulation of immune response by proteins on the surface of cells

1984
Georges Kohler and César Milstein
Techniques for producing monoclonal antibodies
Nils Jerne
Network theory for the immune system

1987
Susumu Tonegawa
Genetic mechanism for the construction of antibodies

1996
Peter Doherty and Rolf Zinkernagel
How the immune system recognizes virus-infected cells

1999
Günter Blobel
for the discovery of the signal peptide that directs the transport of proteins in the cell

2011
Ralph M. Steinman
Discovery of the dendritic cell and its role in adaptive immunity
Bruce A. Beutler and Jules A. Hoffmann
Activation of innate immunity

2015
William C. Campbell and Satoshi Ōmura
for a novel therapy against infections by roundworm parasites
Tu Youyou
for a novel therapy against Malaria

2018
James P. Allison and Tasuko Honjo
Discovery of cancer therapy by inhibiting immune regulators (checkpoint inhibition)