A Look inside the Lab: Flow Cytometer
The Scientist's Sorting Machine

Part 1

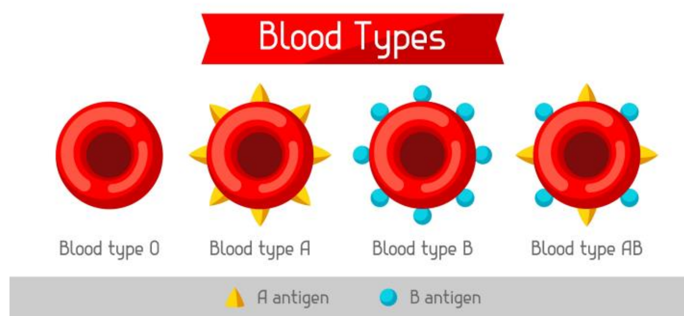
What do A, B, AB, and O have to do with each other? While they are all letters or combinations of letters from our alphabet, you may also recognize them as different blood types. Typically, blood types are described by one of these sets of letters as well as "positive" or "negative," referring to whether the person's blood cells have a marker known as rhesus, or Rh, factor. Blood type comes from your parents; it is inherited through genetics. Do you know what blood type you have? Do your classmates know their blood type?

Until the 1900s, people thought that all human blood was the same; however, we now know there are distinct blood groups. But what makes the blood groups different? The proteins and sugars found on the surface of red blood cells. These proteins and sugars are typically referred to as cell surface markers. These markers help other cells identify and communicate with blood cells. In fact, all cells — not just blood cells — have cell surface markers, and scientists use these markers to conduct experiments that allow us to learn more about how our bodies work. Let's take a closer look.

Cell surface markers and blood cells

A cell surface marker is either a protein or carbohydrate (a type of sugar molecule) found on the outside surface of a cell. The surface markers on a particular cell depend on the cell type and function.

In the example of blood types, cell surface markers on red blood cells distinguish between types. For example, people with the type A positive blood have type A and Rh factor antigens on their red blood cells. If they are type A negative, their red blood cells have the A antigen marker, but not the Rh factor marker. People with type B blood have type B antigens and can be positive or negative for Rh factor. Those with type AB blood have both type A and B antigens on the surface of their red blood cells. Those with type O blood have neither. Similarly, those with AB and O blood can also be positive or negative for Rh factor.



These two surface markers (blood type and Rh factor) are directly related to which types of donated blood can be used for which patients. Specifically, because our immune systems react against blood type surface markers that are different from our own, people getting blood transfusions can only receive blood that either has no surface markers or the same surface markers as their own. Because people with type O negative blood do not have any of the antigens (A, B or Rh factor) on their cells, they can only get type O negative blood, but their blood donations can be used for the greatest number of patients. For this reason, people with type O negative blood are often referred to as "universal donors." Conversely, people with type AB positive blood can get any other blood type (A, B, O and Rh positive or negative), but their blood donations can only be used in people with type AB positive blood, so they are often referred to as "universal recipients."

In the U.S. population in 2023, about 7% of the population has O negative blood and about 3% had AB positive blood. The most common type of blood was O positive (38%), and the least common was AB negative (1%). Want to find out more? [Check out this graph from Statista.com](https://www.statista.com/statistics/1112664/blood-type-distribution-us/) (https://www.statista.com/statistics/1112664/blood-type-distribution-us/).

Part 2

Cell surface markers and cells of our immune system

Immune system cells also have cell surface markers. Cells of the immune system typically have multiple markers at the same time and can even change which markers they display at different phases of their lifespan. Some of the markers are known as "Cluster of Differentiation" or "CD" markers. Hundreds of CD markers have been identified.

Here are a couple of more common examples of cell surface markers in the immune system:

- T cells: We have two main types of T cells in our immune system, known as CD4 and CD8 T cells. CD4 T cells are known as "helper" T cells. Once CD4 cells recognize a harmful antigen or pathogen, they signal other cells to its presence, causing a variety of different parts of the immune system, including B cells, to become activated. CD8 cells are known as "cytotoxic" or "killer" T cells because they destroy cells that have been infected.
- B cells: We have different types of B cells in our immune system based on whether they are specific for a pathogen (memory B cells), secrete antibodies (plasma cells) or have yet to mature (naïve B cells). These different groups of B cells have different surface markers. Some markers are CD markers (e.g., CD19, CD27, CD45R) and others are proteins related to the cell's immunoglobulin type (e.g., IgG, IgA, IgM and IgD).

These are only a couple of examples of how surface markers on cells indicate the role of the cell in the immune system. Some scientists spend their whole career studying when cell surface markers appear and what role they play in immune responses.

Understanding and learning from cell surface markers

Because surface markers can provide information about cells and their role in immunity, scientists have figured out ways to use these markers to conduct experiments that help us continue learning about our immune system. Sometimes, these studies require isolating a specific sub-group of cells. To separate and classify cells, scientists use a flow cytometer. Flow cytometers allow researchers to analyze a cell population based on their surface markers or to separate the cells into their distinct subpopulations for further experimentation.

Scientists can treat their samples with antibodies that will bind to particular cell surface markers. If these antibodies also contain a fluorescent label, they can determine what percent of the cells in their sample contain that marker. For example, if a scientist wants to determine if their sample has CD8 T cells, they can incubate the cells with a fluorescently labeled antibody that will attach to the CD8 surface marker and analyze the sample using flow cytometry. If they want to use those CD8 cells for another experiment, they could use the flow cytometer to sort the cells; this is called fluorescence-activated cell sorting (FACS). Because the machine can process about 10,000 or more cells per second, it offers an efficient way to get a purified sample of the cells needed for an experiment.

By using cell surface markers and flow cytometers, scientists have an are incredibly useful tool for conducting scientific research. Flow cytometers can help diagnose and monitor cancer, conduct genetic and molecular research, or identify infectious or autoimmune diseases and blood cell disorders, among other uses.