

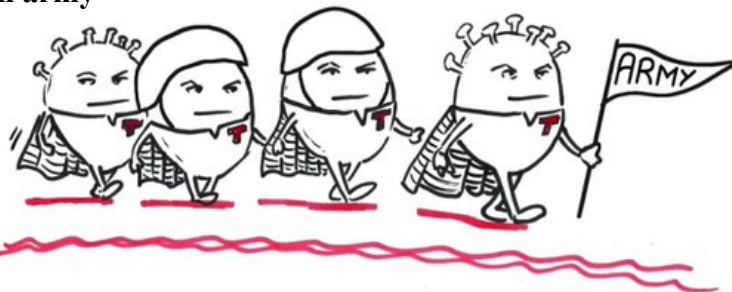
Why We Need CAR-T!

By Taylor Moore

In 2014, a new cancer treatment made headlines after it was stated to be a *breakthrough treatment* by the Food and Drug Administration (FDA): CAR-T cell therapy! This revolutionary treatment is widely known as the new way to treat blood cancers. But what is a CAR-T cell, and why is this treatment so groundbreaking?

First, let's discuss how our immune system takes care of us. Our blood is made up of three types of cells: red blood cells, white blood cells and platelets. Red blood cells are what folks often think of when they think of the blood, as they give the liquid its notorious color. However, their lesser known relative, the white blood cells, serve a very important function. White blood cells can be thought of as a miniature army living within us. These troops are entrusted with protecting our body against infection and disease. There are multiple types of white blood cells comprising our army, filling the different positions needed to have a secure defense. But for our purposes, we will only be focusing on the cell type known as a lymphocyte. In our miniature army, lymphocytes are tasked with destroying things in the body that could pose a risk. There are two main types of lymphocytes present in our body: B-cells and T-cells. Our T-cells focus on removing infected cells that can no longer serve their purpose. This can include cells infected by a virus, as well as cancer cells.

Figure 1: Our T-cell army

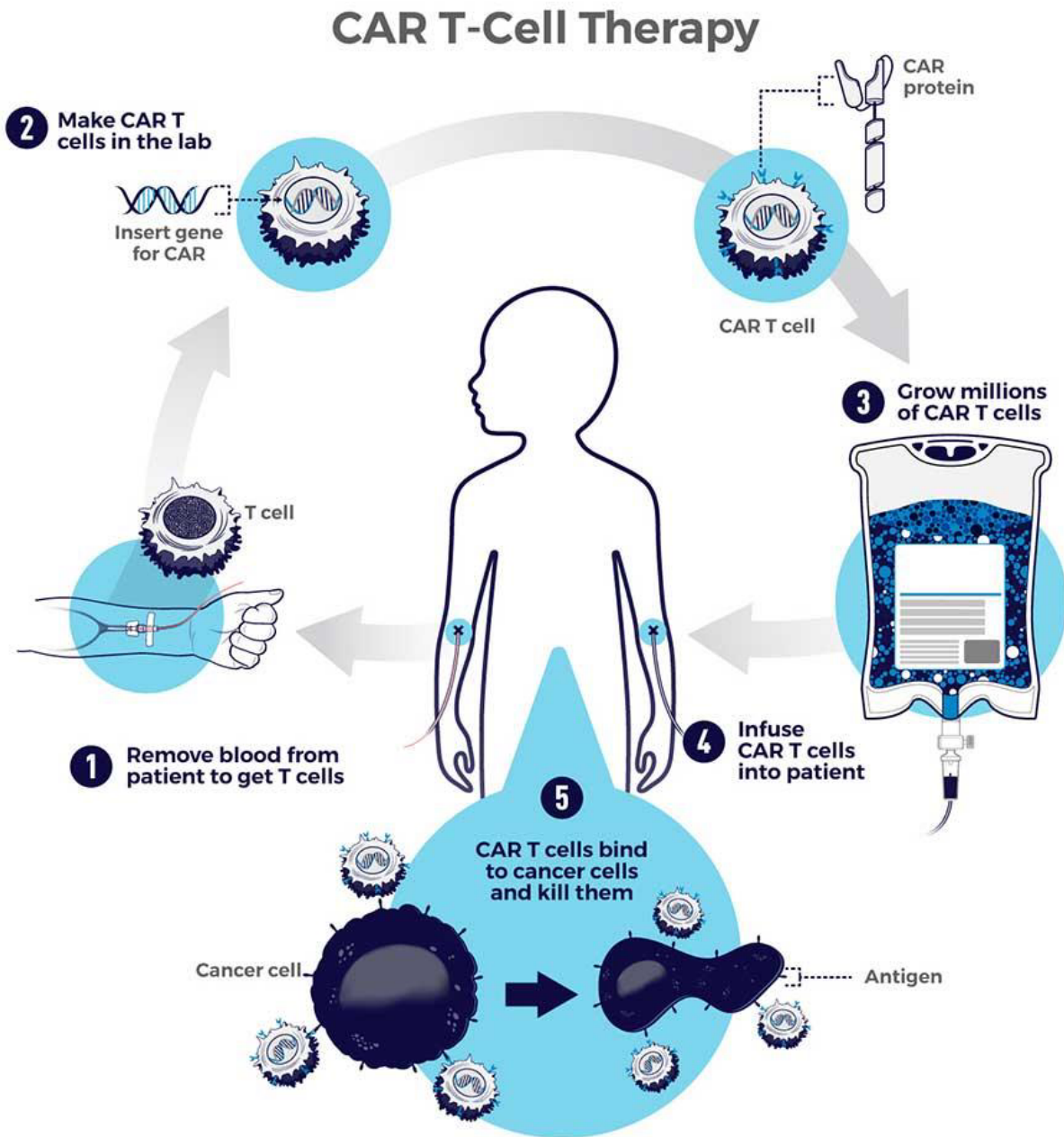


Source: Roche

Now that we know what a T-cell is, let's talk about what a CAR is and how they work. On the outside of our cells, we have molecules known as receptors. Our T-cells use their receptors to communicate with each other, communicate with other cell types within the body, and to locate diseased cells. While these cells are proficient at their jobs, they are sometimes unable to locate cells that need to be eliminated. That's where CARs come in! CARs, also known as chimeric antigen receptors, are man-made receptors that researchers created in the early 2000's. These are special receptors that will allow the T-cells in our bodies to recognize the diseased cells that they could not locate before. In our mini-army analogy, the scientists are giving our T-cell troops special weapons to fight opponents they previously could not defeat. Wow, that's so cool!

So how are CAR-T cells created? A patient who is hoping to go through CAR-T cell therapy will first have their blood drawn (Fig. 2.1). The scientists will then separate the T-cells out from the blood taken. The T-cells will be given a set of instructions, known as a gene, for how to make the CAR (Fig. 2.2). The cells will be given time to grow in the laboratory so that they can create the CAR on their outside surface. Over time they multiply, increasing the number of troops we have carrying these specialized weapons (Fig. 2.3). Once we have enough trained troops for the battle, the CAR-T cells are inserted back into the patient's blood stream (Fig. 2.4), where they can use their new tools to track down and eliminate the diseased cells (Fig 2.5). Go get 'em!

Figure 2: How CAR-T cells are made



CAR T-cell therapy is a type of treatment in which a patient's T cells are genetically engineered in the laboratory so they will bind to specific proteins (antigens) on cancer cells and kill them. (1) A patient's T cells are removed from their blood. Then, (2) the gene for a special receptor called a chimeric antigen receptor (CAR) is inserted into the T cells in the laboratory. The gene encodes the engineered CAR protein that is expressed on the surface of the patient's T cells, creating a CAR T cell. (3) Millions of CAR T cells are grown in the laboratory. (4) They are then given to the patient by intravenous infusion. (5) The CAR T cells bind to antigens on the cancer cells and kill them.

cancer.gov

Source: National Cancer Institute

Finally, we discussed that T-cells target and eliminate cancer cells, but what is cancer and why does it need to be removed from the body? Throughout our lives, the cells within our body divide, splitting from being one cell into being two. This allows us to replace old or diseased cells once they are removed from the body. Our cells are kept on a strict schedule, known as the cell cycle, so that they only divide when the body needs them to. Cancer is a disease that occurs when a cell strays from the cell cycle and begins dividing uncontrollably. This creates an excess number of cells, known as a tumor. This tumor becomes cancerous when the rapid division begins to spread to multiple areas of the body. Cancer can become life threatening because the excess amount of cells present will prevent the organ that the tumor is in from functioning how it is intended. They can destroy healthy cells around them, prevent nutrients from flowing through the body, and prevent the body from removing unnecessary waste in the organs.

Currently, the most common treatment used for cancer found in the blood is chemotherapy. Chemotherapy is a medicine that uses a series of chemicals to kill the cancerous cells, hopefully removing the cancer from the body. This treatment has been shown to be successful, however, there are many downsides that come with using this therapy. One downside is that the chemicals used also target healthy cells. Because of this, the treatment reduces the patient's immune system, making the patient more vulnerable to other illnesses. As we discussed, CAR-T cell therapy works to support the immune system, protecting patients from additional diseases while fighting cancer. Since they are specially designed in a laboratory, they can be individualized to the patient's needs, helping their T-cells find the cancer faster. CAR-T cell therapy has shown great success in patients that chemotherapy had no effect. Since its headline debut in 2014, there have been six CAR-T cell therapies approved by the FDA. We hope that there will be many more to come.