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Vaccines, Autoimmunity and Allergies

Vaccines

Understanding immunological memory has led to the development of **vaccinations** or **immunizations** that can help prevent a person from getting a certain disease. A vaccine is made of a collection of antigens that will stimulate an immune response, but won't cause the individual to get the disease. Some vaccines are made by killing pathogens or treating them so that they can't reproduce in the body. Other vaccines are made of collections of antigens or toxins that have been rendered harmless. When a patient receives the vaccine, the helper T-cells, cytotoxic T-cells, and B-cells can become activated and produce many memory cells. Then if the person gets infected by the actual pathogen at a later time, the memory cells can generate a secondary response to protect the patient before they ever get the disease caused by the pathogen.

Autoimmunity

Under normal circumstances, the immune response is only generated against antigens that enter the body through the physical barriers and evade being destroyed by the nonspecific internal defenses for several days. Occasionally the helper T-cells, cytotoxic T-cells, and B-cells make mistakes and become activated by normal body proteins. When this occurs, the immune system can cause damage to normal body tissues resulting in an **autoimmune** reaction, or **autoimmunity.** Several diseases have been discovered that are caused by autoimmunity such as; rheumatoid arthritis, lupus, multiple sclerosis, type 1 diabetes, celiac disease and Grave's disease (just to name a few).

Transplant Rejection

If cells from another human are placed into a patient's body, there is a chance that the patient's white blood cells will reject them. Recall that antigens can activate cytotoxic T-cells and then move through the body looking for cells expressing those antigens on their surface. If a patient receives a kidney transplant, there is a very good chance that the proteins on the transplanted kidney cells will not be a perfect match of the proteins on the recipient's cells. As a result, there is a high likelihood that the recipient's cytotoxic T-cells will become activated and try to destroy the "foreign" cells of the transplant. Whenever a transplant is performed there are 2 important things that can be done to try to reduce the risk of rejection. First, the cell surface markers on the donor organ or tissue are matched as closely as possible to the recipient's cell surface markers. Recall the importance of blood type matching before giving a blood transfusion. Cell surface markers are determined by genes, so with the exception of blood donation, it is usually most beneficial to look for donors in the same family as the recipient since they would share many genes and would have fairly similar cell surface markers. The second thing that can be done to reduce the risk of rejection is to give the transplant recipient immunosuppressive drugs. These drugs will reduce the activity of the white blood cells so they will be less likely to react to the transplanted organ or tissue. This will lessen the likelihood of rejection, but it actually puts the patient at a much higher risk of infection. Therefore, transplant recipients usually have to avoid groups of people and take other medications to help prevent infections. Eventually the dose of the immunosuppressive drugs will be reduced and the patient can return to normal activity. If the transplanted tissue/organ can remain in the body for a year without being rejected, there is a good chance that rejection will not occur.

Allergies

Allergies are often referred to as an exaggerated immune response to a harmless antigen. (Antigens resulting in allergic reactions are commonly referred to as *allergens*). For example, if a person suffers from hay fever, they have an allergy to plant pollen. When plant pollen enters into their upper respiratory system, their body initiates an immune response, but rather than just removing the antigen, the allergic response leads to the release of excessive amounts of inflammatory substances like histamine. As the mucous membranes in the upper respiratory system undergo excessive inflammation, the linings of the nasal cavities swell, the eyes become red and irritated, and the individual will begin to sneeze (as a result of irritation of the nasal cavity). All of these signs and symptoms result from the release of large amounts of histamine and other inflammatory chemicals. In a person who doesn't suffer from hay fever, an immune response to pollen can be generated, but the resulting inflammation is minimal. Therefore, they would not suffer from the same signs and symptoms and their body would effectively remove the pollen without suffering from an allergic reaction.

Scientists have discovered that individuals who suffer from severe allergies have much higher levels of IgE in their blood than people without allergies. A very small amount of IgE release from activated B-cells is normal during an immune response, but for some unknown reason, the B-cells in some individuals can begin to produce many times the normal amounts of IgE when they are exposed to an otherwise harmless antigen. IgE functions as an antigen receptor on mast cells and basophils (types of white blood cells). Once IgE is released into the blood, it can bind to the surface of mast cells and basophils. When antigens bind to these IgE molecules, the mast cell or basophil is stimulated to release inflammatory chemicals such as histamine, which promotes inflammation, and heparin that will prevent clots from forming and also increase inflammation. This is a normal process that occurs during the immune response, and can actually help fight an infection. As long as the IgE levels are relatively low, the inflammation caused by the mast cells or basophils will be limited to normal, protective levels. If the amount of IgE in the blood is high, mast cells and basophils will release large amounts of inflammatory chemicals and the inflammation can become excessive.

Some children will grow up without suffering from hay fever and then as adults they can develop an allergy to plant pollen. This can occur when the individual's B-cells only produce normal levels of IgE to plant pollen when they are a child. However, if a single B-cell begins to produce excessive amounts of IgE, it can produce memory cells that will also produce increased levels of IgE. Once these IgE-producing memory cells are formed, the person will most likely have progressively worse allergic responses with continued exposure to the allergen. Each time the memory cells become activated, they will release more IgE and more memory cells causing more and more severe allergies.

An allergic response at the mucous membranes of the upper respiratory system will produce the typical hay fever signs and symptoms, but what if an allergen were to get into the body tissues either by ingestion or injection through the skin? Allergic reactions to bee stings or certain foods are potentially life threatening since they can stimulate systemic inflammation. Bees actually produce venom that is injected into the skin by the stinger when a person gets stung. The first time a person is exposed to the venom, a primary immune response will result, taking several days for antibody to be produced. If the individual's B-cells begin producing large amounts of IgE, the person becomes *sensitized* to the allergen. This means that the venom-binding IgE will bind to mast cells and basophils, setting the stage for an allergic response upon a second exposure to the venom. If the person gets stung again, the mast cells and basophils can release inflammatory chemicals directly into the blood. As inflammation is stimulated simultaneously in many parts of the body, the blood vessels dilate and capillaries begin leaking fluid into the tissues. This can cause extreme swelling in various body tissues and also cause the person's blood pressure to drop to dangerous levels. This severe type of allergic response is called **anaphylactic shock** and can cause death if not treated promptly! One of the most common treatments is the use of an "epi-pen". This special hypodermic needle can be used to inject epinephrine into the body if anaphylactic shock is occurring. The epinephrine will cause the blood vessels to constrict as well as increase heart rate, countering the low blood pressure caused by the allergic response.