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Physical Barriers: First Wall of Defense

Physical barriers are the body's first wall of defense against pathogens and consist of the epidermis and the mucous membranes that line the digestive, respiratory, and urinary tracts. The epidermis that makes up the covering of the skin is composed of many layers of tightly packed cells. The most superficial layers of the epidermis are made of dead cells filled with a protein called keratin. These cells are almost impervious to the effects of any bacteria or virus. As a result, as long as the epidermis is intact, it is almost impossible for pathogens to get to deeper tissues and cause an infection. In addition to layers of dead cells, the epidermis is coated with secretions that limit the growth of many bacteria. Sebum, the oily substance found on the epidermis, is toxic to many bacteria and the acids found on the skin can cause the pH to drop to less than 5, which is too acidic for many bacteria to grow. Finally, there are many relatively harmless bacteria that normally inhabit the skin that can actually protect us from infections. These non-pathogenic bacteria, sometimes called *normal flora*, take up space and use up nutrients, essentially out-competing the bad pathogens.

Mucous membranes are composed of tightly packed cells, but one weakness with these barriers is that the cells making up these membranes are living cells. They do restrict the entry of pathogens into our deeper tissues, but since they are living cells, pathogenic bacteria and viruses can directly affect them. This actually explains why some of the most common infections in humans are acquired through the respiratory and digestive tracts (i.e. the common cold, the flu, food poisoning, COVID 19, etc.). In order to make these barriers better at repelling pathogens, there are special cells in the mucous membranes called goblet cells, which produce mucus. Sticky mucus can trap pathogens that enter the digestive, respiratory or urinary tracts and stop them from gaining access to and damaging the mucous membrane cells. Tears can also help wash pathogens from the mucous membranes associated with the eyes. Saliva can have a similar effect in the mouth. Stomach acid (reaching a pH of as low as 1) can destroy any bacteria or viruses that enter the digestive tract. Apparently, this protective function is the main reason we produce stomach acid since it has little effect on food digestion.

Normal flora bacteria can also be extremely important in protecting humans from certain types of infections at the mucous membranes. For example, if the normal flora of the large intestine become disrupted by prolonged antibiotic use, a patient can develop a severe infection of the large intestine caused by *Clostridium difficile* (commonly referred to as *C. diff*), but this type of infection is extremely rare in people who have healthy levels of normal flora bacteria. A common treatment for *C. diff* infections is giving the patient a fecal transplant. In other words, fecal matter from a healthy person (containing large numbers of normal flora bacteria) is injected into the large intestine of the patient in order to repopulate the large intestine with normal flora. This treatment is sometimes referred to as a "stool enema" or "fecal enema". Another interesting example of the protection normal flora can give to humans is seen in the relationship between the bacteria that live in the vagina and the mucous membrane cells lining the vagina. The cells lining the vagina actually release nutrient-rich secretions into the vagina. The nutrients from these secretions support the growth of certain *Lactobacillus* and *Streptococcus* bacteria. These bacteria primarily carry out fermentation of carbohydrates to produce ATP. A waste product of this fermentation is lactic acid. The lactic acid released from the bacteria accumulates in the vagina and creates a very acidic environment that discourages the growth of most pathogens in the vagina. If the acid-producing bacterial populations are disrupted, the pH of the vagina begins to rise, allowing pathogenic yeasts to flourish. This can lead to the development of a vaginal yeast infection.

Besides physical and chemical barriers of defense, our body also uses several reflexes to remove pathogens. You may have experienced these the last time you had the flu or ate food that was spoiled. The memories are probably still sharp! Coughing, sneezing, vomiting and diarrhea are some of the ways our body tries to rid itself of disease.

Potential pathogens are constantly coming in contact with our physical barriers, but these barriers are extremely effective and rarely fail to give us complete protection. If there is a break in the epidermis or if the mucous membranes are not able to prevent an infection, the next wall of defense will become very important in protecting our health.



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