The Biochemical Basis of Allergies: Why does the immune system react to harmless substances?

Stanford Medicine's Sean N. Parker Center for Allergy and Asthma Research states, "30% to 40% of the global population suffers from one or more allergic conditions."

Ranging from mild to severe, allergies are overreactions of the immune system to typically harmless substances known as allergens. These reactions can cause symptoms ranging from sneezing, hives, and itchy eyes to more severe conditions like hay fever and asthma. Allergic reactions can be triggered through direct contact, ingestion, or inhalation of allergens. Some allergies develop over time, while others are present from birth; some persist throughout life, while others are temporary.

Our body's primary line of defense—the immune system—is a complex network of organs, cells, and tissues. It serves as a powerful shield, protecting us from diseases as severe as cancer. However, it can sometimes mistakenly react to harmless substances, resulting in harmful responses to our own bodies. This raises an important question: why do such benign substances trigger severe reactions, and how do these immune responses cause allergies?

The immune system produces an antibody called immunoglobulin E (IgE), which triggers the release of chemicals involved in reacting to allergens. However, IgE antibodies are specific to particular substances. For instance, the IgE in one person's body may react to pollen but not to dust, while another person's IgE may react to dust but not to pollen.

Among allergic reactions, anaphylaxis is the most severe. Even a tiny concentration of a triggering substance can result in hospitalization or, in extreme cases, death. Anaphylaxis occurs when the immune system releases a surge of chemicals that cause a sudden, severe reaction. This reaction can cause a rapid drop in blood pressure, constriction of the airways, and difficulty breathing. Common triggers include foods like nuts, insect stings, and certain medications.

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Understanding the biochemical mechanisms behind anaphylaxis is crucial for effective treatment and prevention. When the immune system encounters an allergen, it triggers the release of various chemicals, including histamine, from immune cells such as mast cells and basophils. This cascade of chemical reactions causes inflammation, dilation of blood vessels, and constriction of airways. While mild allergic reactions may result in localised itching or swelling, anaphylaxis involves a rapid, systemic response that can be life-threatening. Immediate intervention, usually through an injection of adrenaline, is essential to counteract the severe symptoms and prevent fatal outcomes.

A quick fall in blood pressure causes our airways to tighten, making breathing difficult. Skin rashes can develop, and pulses can go haywire. Common anaphylaxis allergens are nuts and bee stings. Anaphylaxis can occur in a matter of mere minutes, which is why it is high risk and must be treated at once.

My mother is a medical mystery. Every month, she develops an allergy to something new. So far, the list includes a chemical found in her mattress, milk, Vitamin C, soy, millet–you name it, and she will have been allergic to it at some point in her life. From putting a sheet of plastic over her mattress to staying locked up in her room for days, she takes her treatments, which might seem unusual to others, very seriously. My mother is a medical mystery, but she's not the only one. Allergies are becoming increasingly common, with around 30% of India's population suffering from at least one allergic disease.

Allergies, though often dismissed as mere inconveniences, can be life-threatening and demand urgent attention. As their prevalence continues to rise globally, understanding their underlying mechanisms and improving methods of prevention and treatment are more important than ever. Whether through developing advanced diagnostic tools, enhancing accessibility to life-saving interventions like adrenaline injectors, or raising awareness about allergic conditions, tackling this growing health concern requires both scientific progress and public education. Ultimately, recognising allergies as a serious medical issue rather than a trivial discomfort is essential to ensuring the well-being of those affected.

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CITATIONS

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