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Review Article

Immunology, toxicology, and immunotoxicology: An overview

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ABSTRACT: Immunology, toxicology, and immunotoxicology are three different fields of science. Immunology is the branch of science that deals with the studies of the immune system. On the other hand, toxicology is the branch of science that deals with chemicals, toxic substances, or polluted environments and their ill effect on living creatures as well as the environment. Immunotoxicology deals with both fields of immunology and toxicology. Immunotoxicology is an active area of toxicology, but this is still a relatively small area. Over the past 30 years, the main focus of immunotoxicology has been the aspects of immunotoxicity from a mechanistic or regulatory process.

KEYWORDS: immune system; toxic effect; immunotoxicology; immunology; toxicology

1. Introduction

Immunology is the field of science that discusses the immune system. The immune system plays a very important role in our body. It protects our body from external poisonous agents, attacks of viral and bacterial cells, or any kind of defense act. The toxic agents may be chemicals, drugs, or any antigens. Therefore, studies in immunology are very important in the medical and biological fields of science. Prevention is better than cure, so for everybody we desire a healthy immune system[1,2]. A strong immune system can protect us from any kind of external toxicity, but if the immune system has not worked properly, then flu diseases and cancers can happen. If the immune system attacks your own body part instead of foreign viral or bacterial cells, then autoimmune disease occurs, which has no cure yet. So, studies of the immune system have been very important in recent decades. Immunity is of three different types (**Figure 1**).

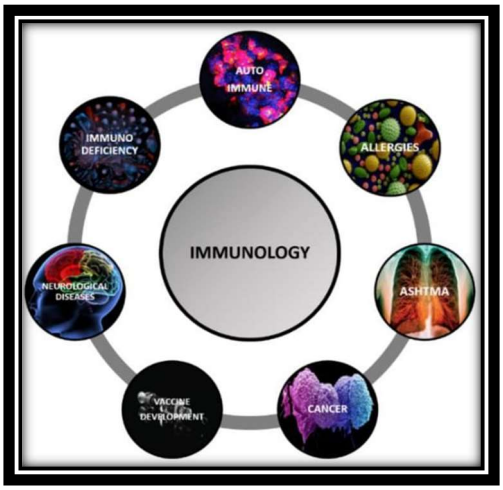

Figure 1. Types and domains of immunology[1].

Innate, adaptive, and passive. Innate immunity refers to inborn immunity, and adaptive immunity means the immunity that is acquired and is mainly found in vertebrates. Passive immunity forms when a person is given antibodies from the outer sources and not generated by their own body (**Figure 2**).

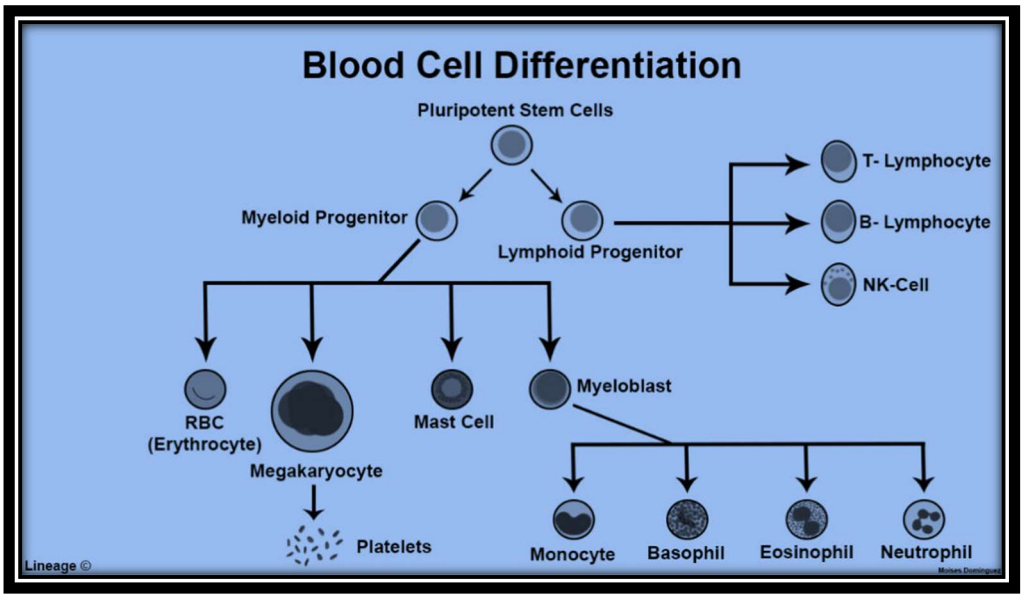

Figure 2. The cells which are responsible for immunity in the human body[3].

In contrast to immunology, toxicology is the knowledge of the harmful effect of man-made chemicals on natural creatures or nature. Toxicology has been divided into many segments[4–6]. These are toxicogenomics, aquatic toxicology, chemical toxicology, clinical toxicology, ecotoxicology, environmental toxicology, forensic toxicology, and medical toxicology.

Toxicogenomic[7] is the field of science that deals with the toxic effects of genes or particular cells in response to poisonous substances. Aquatic toxicology, as the name implies, is the toxic effect of the chemicals on aquatic substances. Chemical toxicology studies the effect of chemical agents on biological systems. Clinical toxicology is the field of toxicology that studies the research, precaution, and treatment of studies due to chemicals, drugs, or toxins. Ecotoxicology deals with the adverse effects of toxic chemicals or drugs on the ecosystem. Environmental toxicology is the field that studies the effect of chemical, biological, and physical substances on the environment's organisms. Forensic toxicology is the analysis of biological samples for poisonous substances or drugs. Medical toxicology is the study of different drugs for the prevention and treatment of toxic effects on human beings.

Immunotoxicology is made of two different types of poisonous effects. The first one is based on the immune system's ability to fight against the effect of a foreign chemical and minimize the toxic effect in the biological system. In contrast, the other one is the negative effects of chemicals on the immune system. The chemicals sometimes impair the immune ability of the body to resist infections. It is about the harmful effects of different drugs, such as immunosuppressives, immunostimulants, and chemicals, on the immune system, which can disturb the normal immune system. There are different types of immune toxic effects. Immunosuppression, immunostimulation, hypersensitivity, and autoimmunity.

The first one, immunosuppression, deals with the decrease of the efficacy of the immune system. In contrast, immunostimulants are substances that stimulate the immune system. Hypersensitivity deals with the abnormal response of the immune system to the guest's viral or bacterial cell. whereas autoimmunity is the effect of the immune system on the body's own healthy part (**Figure 3**).

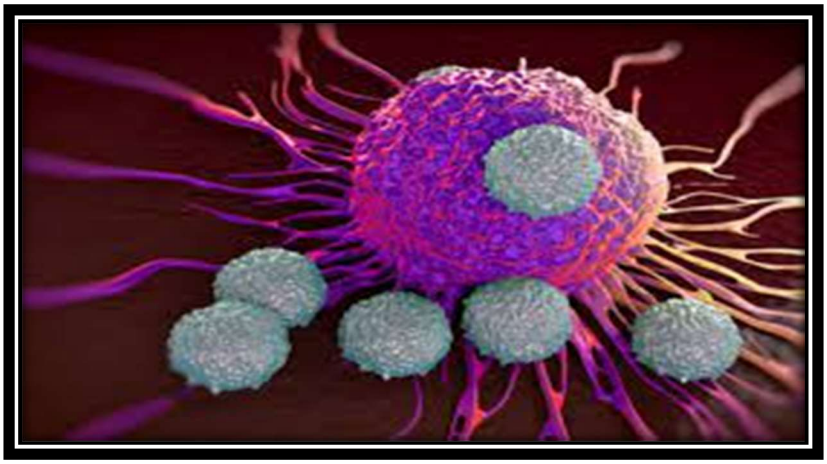

Figure 3. Schematic diagram for immunotoxicology[8].

2. Background of the fields

Immunology is a new field of science. The field was generated when Jenner invented vaccinia (1880), which protects the human body from human smallpox. On the other hand, the field of toxicology was developed by Paracelsus, who linked chemistry to medicines. The immunotoxicology field was generated in the early 1970s. The field discussed altered immune function and changes in body immunity after exposure to chemicals and drugs or any type of antigens.

3. Parts of the immune system

The immune system is like a defense system in the human body. The organs that take part in it are the thymus gland and spleen, and the tissues are like lymph nodes, vessels, bone marrow, and skin.

3.1. Bone marrow

Bone marrow generates all types of immune cells. It is generally composed of stem cells, which generally change in our body from day to day. Stem cells form lymphocytes, and two different types of cells are generated from the lymphocytes. B and T cells. B cells are mature cells, and T cells are immature and travel from bone marrow to thymus, and they get mature there.

3.2. Thymus gland

The thymus gland is present just above the heart and behind breastbones. It is the main organ of the body to form the immune cells.

3.3. Lymph nodes

Lymph nodes contain a large number of immune cells. Lymph nodes are present in the opening door of the body, like in the mouth and in the genital part. Such as tonsils, adenoids, and Peyer's patches. Throughout the body, lymph nodes are there, and after infection, they start to swell and generate immune cells.

3.4. Vessels

Vessels are two different types: blood vessels and lymphatic vessels. Blood vessels contain lymph, which is full of immune cells. If the body is attacked by pathogens, then the immune system is activated to fight against it. The lymphatic fluid generates lymph nodes for filtering the blood. Lymphatic vessels contain filtered blood and carry it forward to the heart via the thoracic cage.

3.5. Spleen

The spleen is the largest immune organ in the body. It contains immune cells, which can filter pathogens, especially bacterial cells.

3.6. Skin

Skin is also a protective part of our body that protects us from infections and covers the entire body part.

3.7. Chemical toxicity

There are some chemicals that are highly toxic in nature, such as arsenic trioxide, chlorine, hydrogen cyanide, nitrogen oxide, phosphate, potassium cyanide, sodium arsenate, and sodium cyanide. Some solvents that are also highly toxic are toluene, benzene, and all chloro solvents like chloroform, dichloromethane, methanol, etc.

3.8. Drug toxicity

Some drugs have maximum side effects but have to be provided in need. People should be aware of it to minimize its use. Allergic medicines like diphenhydramine have severe side effects like dry mouth, cough, and constipation. Some medicines, like warfarin, create problems in bleeding complications. Other medicines like lisinopril (Prinivil), captopril (Capoten), enalapril (Vasotec), and ramipril (Altace) have side effects like kidney failure and ultimate death.

Biguanides such as metformin are common medicines for patients with diabetes with side effects of low blood pressure and low body temperature.

Antibiotics levofloxacin and ciprofloxacin are fluoroquinolones. These medicines were to treat urinary tract infections and bronchitis. The side effects are severe, like tendon injuries, ruptures, or tears of the aorta.

Painkillers such as acetaminophen (Tylenol) and non-steroidal anti-inflammatory drugs such as ibuprofen (Motrin, Advil) and naproxen (Aleve) are used commonly. The common side effects are bleeding in the stomach, ulcers, kidney damage, high blood pressure, and chances of heart attack.

4. Conclusion

Immunology and toxicology relations are very significant in today's date. The autoimmune diseases[9–11] (164 diseases, to the best of our knowledge) are increasing day by day, which are caused by misleading of the immune system. The immune system is the police force of the body. If any foreign cell attacks the body immediately, the immune system starts working to protect it, and if the immune system stops reacting, then the body will soon be attacked by several diseases and cause ultimate death. So, a healthy immune system is very important to leading a healthy life. Therefore, the study of immunology, toxicology, and immunotoxicology has tremendous importance in present and future days; otherwise, the existence of human lives is in danger in the future era of modern technologies.

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Conflict of interest

The author declares no conflict of interest.

References

1. Pandya S, Thakur A, Saxena S, et al. A study of the recent trends of immunology: Key challenges, domains, applications, datasets, and future directions. *Sensors* 2021; 21(23): 7786. doi: 10.3390/s21237786
2. Kaufmann SHE. Immunology's coming of age. *Frontiers in Immunology* 2019; 10. doi: 10.3389/fimmu.2019.00684
3. Li D. Cells of the immune system. Available online: https://step1.medbullets.com/immunology/105042/cells-of-the-immune-system (accessed on 20 December 2023).
4. Marshall JS, Warrington R, Watson W, et al. An introduction to immunology and immunopathology. *Allergy, Asthma & Clinical Immunology* 2018; 14(S2). doi: 10.1186/s13223-018-0278-1
5. Kimber I. Toxicology and the immune system: A perspective. *Human & Experimental Toxicology* 1991; 10(6): 445–449. doi:10.1177/096032719101000614
6. Garg AD. The dynamic interface of genetics and immunity: Toward future horizons in health & disease. *Genes & Immunity* 2023; 24(4): 155–158. doi: 10.1038/s41435-023-00213-y
7. Wang X, Li F, Chen J, et al. Integration of computational toxicology, toxicogenomics data mining, and omics techniques to unveil toxicity pathways. *ACS Sustainable Chemistry & Engineering* 2021; 9(11): 4130–4138. doi: 10.1021/acssuschemeng.0c09196
8. Labcorp. Assessing immunotoxicology during drug development: Highlights from a webinar. Available online: https://www.labcorp.com/assessing-immunotoxicology-during-drug-development-highlights-webinar (accessed on 20 December 2023).
9. Kalfa TA. Warm antibody autoimmune hemolytic anemia. *Hematology* 2016; 2016(1): 690–697. doi: 10.1182/asheducation-2016.1.690
10. Fairweather D, Rose NR. Women and autoimmune diseases1. *Emerging Infectious Diseases* 2004; 10(11): 2005–2011. doi: 10.3201/eid1011.040367
11. Canamary AM, Takahashi WY, Sallum JMF. Autoimmune retinopathy: A review. *International Journal of Retina and Vitreous* 2018; 4(1). doi: 10.1186/s40942-017-0104-9