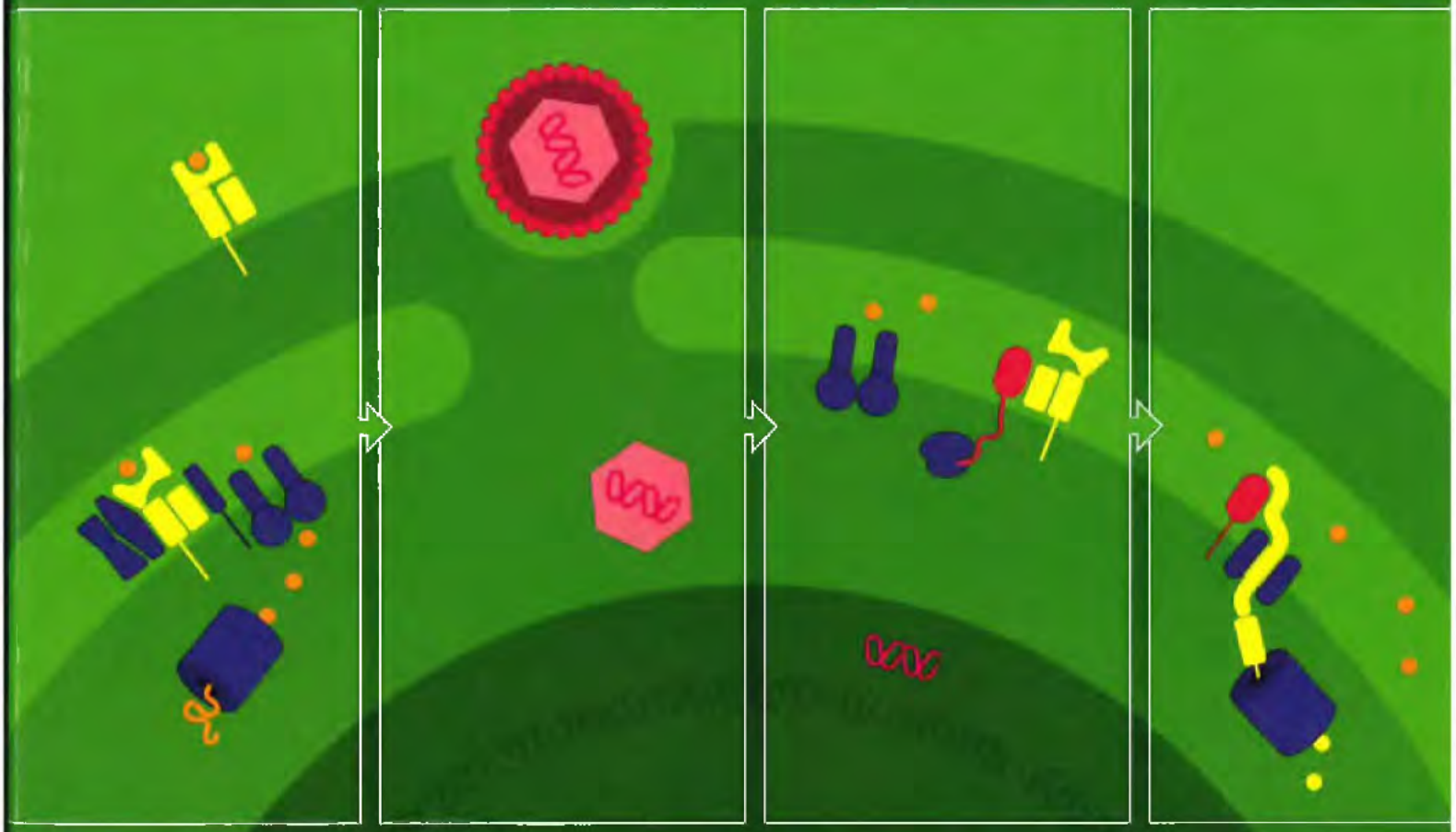
Janeway's

immuno biology

SEVENTH EDITION



Kenneth Murphy • Paul Travers • Mark Walport

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Kenneth Murphy
Washington University School of Medicine, St. Louis

Paul Travers
Anthony Nolan Research Institute, London

Mark Walport
The Wellcome Trust, London

With contributions by:

Michael Ehrenstein
University College London, Division of Medicine

Claudia Mauri
University College London, Division of Medicine

Allan Mowat
University of Glasgow

Andrey Shaw
Washington University School of Medicine, St. Louis

Garland Science
Taylor & Francis Group

Vice President:	Denise Schanck
Assistant Editor:	Sigrid Masson
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Production Editor and Layout:	Georgina Lucas
Copy Editor:	Bruce Goatly
Illustration and Design:	Matthew McClements, Blink Studio, Ltd.
Permissions Coordinator:	Mary Dispenza
Indexer:	Merrall-Ross International Ltd.

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Storyboards by:	Kenneth Murphy, Paul Travers, and Peter Walter
Narrated by:	Julie Theriot
Animations, Interface Design, and Programming:	Matthew McClements, Blink Studio, Ltd.
Senior Media Editor:	Michael Morales

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Principles of innate and adaptive immunity.

The body is protected from infectious agents and the damage they cause, and from other harmful substances such as insect toxins, by a variety of effector cells and molecules that together make up the **immune system**. In this part of the chapter we discuss the main principles underlying immune responses and introduce the cells and tissues of the immune system on which an immune response depends.

1-1 Functions of the immune response.

To protect the individual effectively against disease, the immune system must fulfill four main tasks. The first is **immunological recognition**: the presence of an infection must be detected. This task is carried out both by the white blood cells of the innate immune system, which provide an immediate response, and by the lymphocytes of the adaptive immune system. The second task is to contain the infection and if possible eliminate it completely, which brings into play **immune effector functions** such as the complement system of blood proteins, antibodies, and the destructive capacities of lymphocytes and the other white blood cells. At the same time the immune response must be kept under control so that it does not itself do damage to the body. **Immune regulation**, or the ability of the immune system to self-regulate, is thus an important feature of immune responses, and failure of such regulation contributes to conditions such as allergy and autoimmune disease. The fourth task is to protect the individual against recurring disease due to the same pathogen. A unique feature of the adaptive immune system is that it is capable of generating **immunological memory**, so that having been exposed once to an infectious agent, a person will make an immediate and stronger response against any subsequent exposure to it; that is, they will have protective immunity against it. Finding ways of generating long-lasting immunity to pathogens that do not naturally provoke it is one of the greatest challenges facing immunologists today.

When an individual first encounters an infectious agent, the initial defenses against infection are physical and chemical barriers that prevent microbes from entering the body; these are not generally considered as part of the immune system proper and it is only when these barriers are overcome or evaded that the immune system comes into play. The first cells that respond are phagocytic white blood cells, such as macrophages, that form part of the innate immune system. These cells are able to ingest and kill microbes by producing a variety of toxic chemicals and powerful degradative enzymes. Innate immunity is of ancient origin—some form of innate defense against disease is found in all animals and plants. The macrophages of humans and other vertebrates, for example, are presumed to be the direct evolutionary descendants of the phagocytic cells present in simpler animals, such as those that Metchnikoff observed in the invertebrate sea stars.

Innate immune responses occur rapidly on exposure to an infectious organism. Overlapping with the innate immune response, but taking days rather than hours to develop, the adaptive immune system is capable of eliminating infections more efficiently than the innate immune response. It is present only in vertebrates and depends on the exquisitely specific recognition functions of lymphocytes, which have the ability to distinguish the particular pathogen and focus the immune response more strongly on it. These cells can recognize and respond to individual antigens by means of highly specialized **antigen receptors** on the lymphocyte surface. The billions of lymphocytes

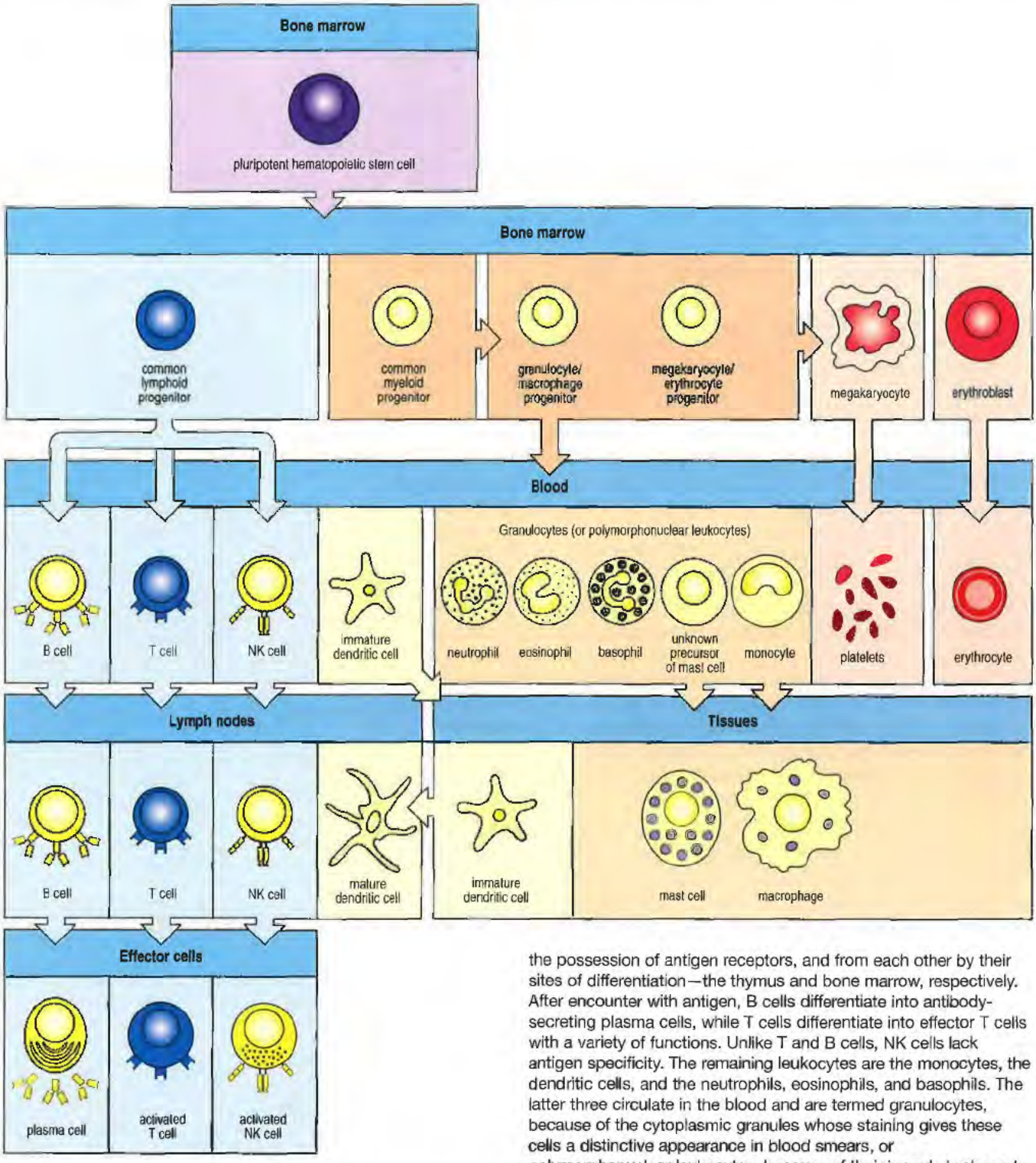

Fig. 1.3 All the cellular elements of the blood, including the cells of the immune system, arise from pluripotent hematopoietic stem cells in the bone marrow. These pluripotent cells divide to produce two types of stem cells. A common lymphoid progenitor gives rise to the lymphoid lineage (blue background) of white blood cells or leukocytes—the natural killer (NK) cells and the T and B lymphocytes. A common myeloid progenitor gives rise to the myeloid lineage (pink and yellow backgrounds), which comprises the rest of the leukocytes, the erythrocytes (red blood cells), and the megakaryocytes that produce platelets important in blood clotting.

the possession of antigen receptors, and from each other by their sites of differentiation—the thymus and bone marrow, respectively. After encounter with antigen, B cells differentiate into antibody-secreting plasma cells, while T cells differentiate into effector T cells with a variety of functions. Unlike T and B cells, NK cells lack antigen specificity. The remaining leukocytes are the monocytes, the dendritic cells, and the neutrophils, eosinophils, and basophils. The latter three circulate in the blood and are termed granulocytes, because of the cytoplasmic granules whose staining gives these cells a distinctive appearance in blood smears, or polymorphonuclear leukocytes, because of their irregularly shaped nuclei. Immature dendritic cells (yellow background) are phagocytic cells that enter the tissues; they mature after they have encountered a potential pathogen. The common lymphoid progenitor also gives rise to a minor subpopulation of dendritic cells, but for simplicity this developmental pathway has not been illustrated. However, as there are more common myeloid progenitor cells than there are common lymphoid progenitors, the majority of the dendritic cells in the body develop from common myeloid progenitors. Monocytes enter tissues, where they differentiate into phagocytic macrophages. The precursor cell that gives rise to mast cells is still unknown. Mast

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