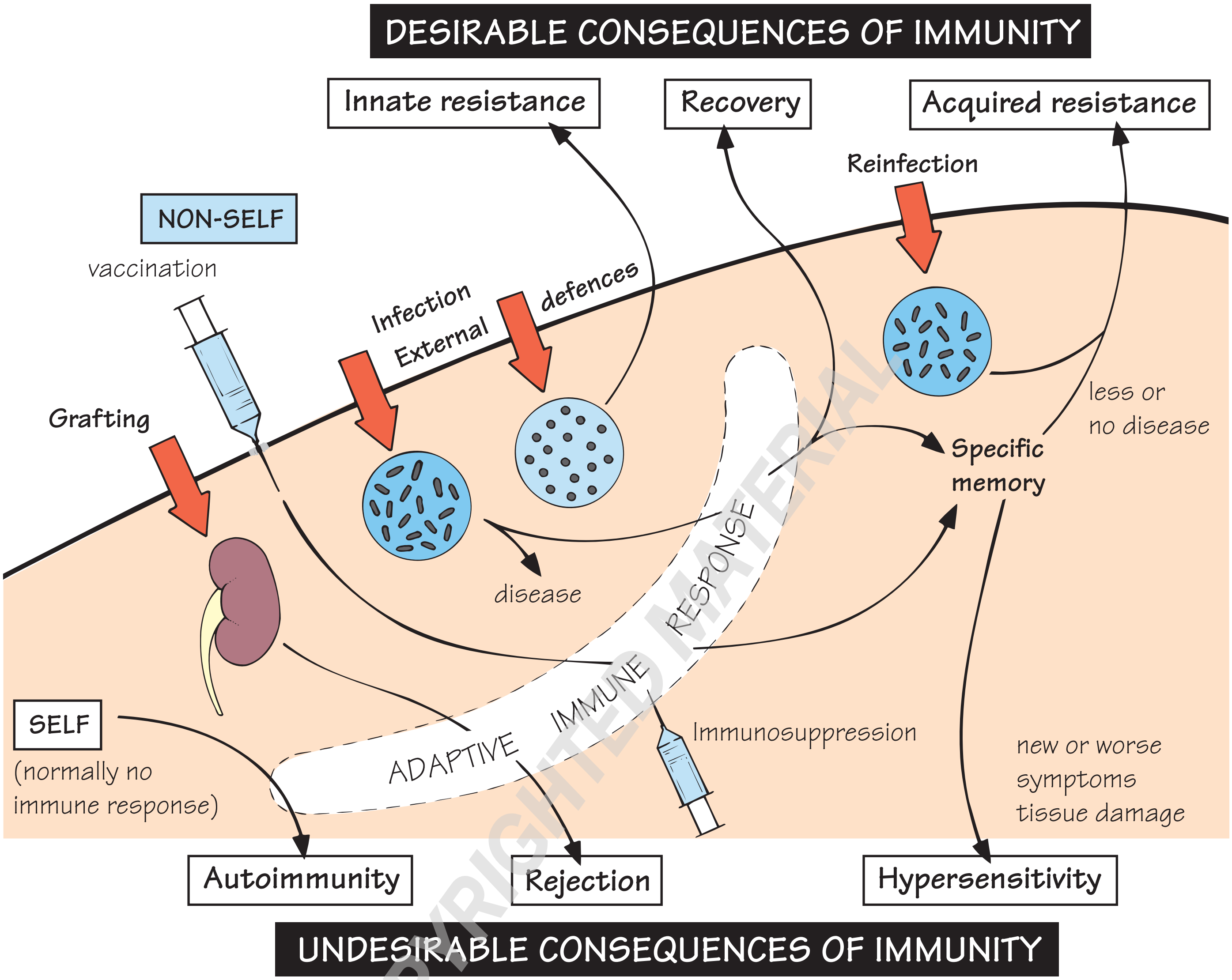
1 The scope of immunology



Of the four major causes of death – injury, infection, degenerative disease and cancer – only the first two regularly kill their victims before child-bearing age, which means that they are a potential source of lost genes. Therefore any mechanism that reduces their effects has tremendous survival value, and we see this in the processes of, respectively, **healing** and **immunity**.

Immunity is concerned with the recognition and disposal of foreign or 'non-self' material that enters the body (represented by red arrows in the figure), usually in the form of life-threatening infectious microorganisms but sometimes, unfortunately, in the shape of a life-saving kidney graft. Resistance to infection may be '**innate**' (i.e. inborn and unchanging) or '**acquired**' as the result of an **adaptive immune response** (centre).

Immunology is the study of the organs, cells and molecules responsible for this recognition and disposal (the 'immune system'), of how they respond and interact, of the consequences – desirable (top) or otherwise (bottom) – of their activity, and of the ways in which they can be advantageously increased or reduced.

By far the most important type of foreign material that needs to be recognized and disposed of is the microorganisms capable of causing infectious disease and, strictly speaking, immunity begins at the point when they enter the body. But it must be remembered that the first line of defence is to keep them out, and a variety of **external defences** have evolved for this purpose. Whether these are part of the immune system is a purely semantic question, but an immunologist is certainly expected to know about them.

Non-self A widely used term in immunology, covering everything that is detectably different from an animal's own constituents. Infectious microorganisms, together with cells, organs or other materials from another animal, are the most important non-self substances from an immunological viewpoint, but drugs and even normal foods, which are, of course, non-self too, can sometimes give rise to immunity. Detection of non-self material is carried out by a range of **receptor** molecules (see Figs 5, 10–14).

Infection Parasitic viruses, bacteria, protozoa, worms or fungi that attempt to gain access to the body or its surfaces are probably the chief *raison d'être* of the immune system. Higher animals whose immune system is damaged or deficient frequently succumb to infections that normal animals overcome.

External defences The presence of intact skin on the outside and mucous membranes lining the hollow viscera is in itself a powerful barrier against entry of potentially infectious organisms. In addition, there are numerous antimicrobial (mainly antibacterial) secretions in the skin and mucous surfaces; these include lysozyme (also found in tears), lactoferrin, defensins and peroxidases. More specialized defences include the extreme acidity of the stomach (about pH 2), the mucus and upwardly beating cilia of the bronchial tree, and specialized surfactant proteins that recognize and clump bacteria that reach the lung alveoli. Successful microorganisms usually have cunning ways of breaching or evading these defences.

Innate resistance Organisms that enter the body (shown in the figure as dots or rods) are often eliminated within minutes or hours by inborn, ever-present mechanisms, while others (the rods in the figure) can avoid this and survive, and may cause disease unless they are dealt with by adaptive immunity (see below). These mechanisms have evolved to dispose of pathogens (e.g. bacteria, viruses) that if unchecked can cause disease. Harmless microorganisms are usually ignored by the innate immune system. Innate immunity also has a vital role in initiating the adaptive immune response.

Adaptive immune response The development or augmentation of defence mechanisms in response to a particular ('specific') stimulus, e.g. an infectious organism. It can result in elimination of the microorganism and recovery from disease, and often leaves the host with specific memory, enabling it to respond more effectively on reinfection with the same microorganism, a condition called acquired resistance. Because the process by which the body puts together the receptors of the adaptive immune system is random (see Fig. 10), adaptive immunity sometimes responds to harmless foreign material such as the relatively inoffensive pollens, etc., or even to 'self' tissues leading to **autoimmunity**.

Vaccination A method of stimulating the adaptive immune response and generating memory and acquired resistance without suffering the full effects of the disease. The name comes from vaccinia, or cowpox, used by Jenner to protect against smallpox.

Grafting Cells or organs from another individual usually survive innate resistance mechanisms but are attacked by the adaptive immune response, leading to rejection.

Autoimmunity The body's own ('self') cells and molecules do not normally stimulate its adaptive immune responses because of a variety of special mechanisms that ensure a state of self-tolerance, but in certain circumstances they do stimulate a response and the body's own structures are attacked as if they were foreign, a condition called autoimmunity or autoimmune disease.

Hypersensitivity Sometimes the result of specific memory is that re-exposure to the same stimulus, as well as or instead of eliminating the stimulus, has unpleasant or damaging effects on the body's own tissues. This is called hypersensitivity; examples are allergies such as hay fever and some forms of kidney disease.

Immunosuppression Autoimmunity, hypersensitivity and, above all, graft rejection sometimes necessitate the suppression of adaptive immune responses by drugs or other means.