# 1 Introduction to Pharmacodynamics

*Pharmacodynamics* is often described as 'what the drug does to the body'. It is the study of how the drug interacts with a particular body system, and how it affects this system to bring about a therapeutic effect. The pharmacodynamic properties of a drug can help us to predict what side effects, adverse effects, and drug interactions we might expect to see when a drug (or combination of drugs) is used in practice.

## Sites of drug action

The site of drug action within the body can be broadly divided into receptors, enzymes, and transmembrane transporters and channels. Many drugs will have an effect at more than one site, one of which may be the intended target to mediate the therapeutic effect. However, the other could be a different site, or a similar site located in a different part of the body, and which mediates a completely different effect from that intended. This forms the basis for some of the side effects that patients may experience. Competition between two or more drugs for a particular target may result in an increased or decreased effect, and is the basis for pharmacodynamic drug interactions.

## Receptors

Receptors are specific sites, typically located on cell membranes, which are bound to by the body's endogenous signalling molecules (such as hormones and neurotransmitters). When these signalling molecules bind to the receptor, they bring about or mediate an effect. Drugs have been discovered which, due to their chemical structure, will also bind to these receptors within the body. Once bound, the drug may mimic the effect of the endogenous signalling molecule and bring about a physiological response. Alternatively, it may have no effect and prevent the action of the endogenous signalling molecule, blocking the normal response. Examples include salbutamol (which mimics the effect of endogenous adrenaline) and atenolol (which blocks the effect of endogenous adrenaline), used in the treatment of asthma and hypertension, respectively.

## Enzymes

Enzymes are proteins that catalyse (facilitate) chemical reactions occurring in the body through an interaction with molecules at specific parts of their structures. Some drugs are able to interact with the enzyme either at its binding site (or sometimes elsewhere on its structure) and can interrupt this action. As a result, the physiological process that is mediated by the enzyme will be prevented. This might include inhibition of the normal breakdown of a neurotransmitter, prolonging its effect (e.g. the inhibition of acetylcholine

*Rapid Medicines Management for Healthcare Professionals*, First Edition. Paul Deslandes, Simon Young and Ben Pitcher.

metabolism by donepezil). Alternatively, it could be the inhibition of the formation of a clotting factor, resulting in impaired blood clotting and an anticoagulant effect (e.g. the factor Xa inhibitor rivaroxaban).

## Transport proteins and channels

The movement of many molecules and ions across cell membranes is facilitated by transport proteins and channels. These membrane-spanning proteins allow water-soluble substances to move across the lipid membranes responsible for maintaining cellular homeostasis. Preventing or in some cases facilitating the movement of these substances with drugs can result in a therapeutic effect. An example is the calcium channel blocker group of drugs, which prevent the movement of calcium ions into (and within) nerve cells and muscle cells, and which are used in the treatment of angina and hypertension.

## Other sites of drug action

In addition to the above, drugs may also mediate their therapeutic effects through other actions within the body. Monoclonal antibody based therapies (such as adalimumab) bind to specific inflammatory proteins to prevent them from exerting their normal physiological effect. Osmotic laxatives (such as lactulose), maintain water in the colon by increasing the osmolarity when they are present in the gastrointestinal tract. Replacement therapies (such as fluids, electrolytes, and oxygen) are sometimes considered a separate group of medicines and could be considered less pharmacologically active in this regard. However, the molecule that is being replaced may have an action at one of the pharmacological sites of action mentioned above (examples include levothyroxine or insulin).