Wider contexts**[]**

Pharmacology can be studied in relation to wider contexts than the physiology of individuals. For example, pharmacoepidemiology concerns the variations of the effects of drugs in or between populations, it is the bridge between clinical pharmacology and epidemiology.[34][35] Pharmacoenvironmentology or environmental pharmacology is the study of the effects of used pharmaceuticals and personal care products (PPCPs) on the environment after their elimination from the body.[] Human health and ecology are intimately related so environmental pharmacology studies the environmental effect of drugs and pharmaceuticals and personal care products in the environment.[]

Drugs may also have ethnocultural importance, so ethnopharmacology studies the ethnic and cultural aspects of pharmacology.[38]

Emerging fields**[]**

Photopharmacology is an emerging approach in medicine in which drugs are activated and deactivated with light. The energy of light is used to change for shape and chemical properties of the drug, resulting in different biological activity.[39] This is done to ultimately achieve control when and where drugs are active in a reversible manner, to prevent side effects and pollution of drugs into the environment.[40][41]

Theory of pharmacology[]

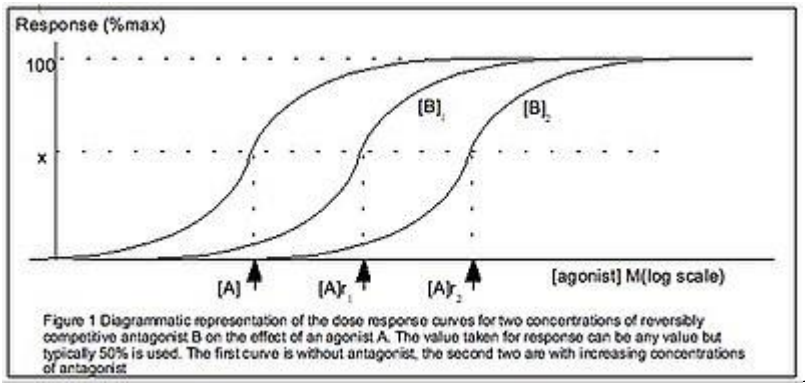


Figure 1 Diagrammatic representation of the dose response curves for two concentrations of reversibly competitive antagonist B on the effect of an agonist A. The value taken for response can be any value but typically 50% is used. The first curve is without antagonist, the second two are with increasing concentrations of antagonist

A trio of dose response curves. Dose response curves are studied extensively in pharmacology.

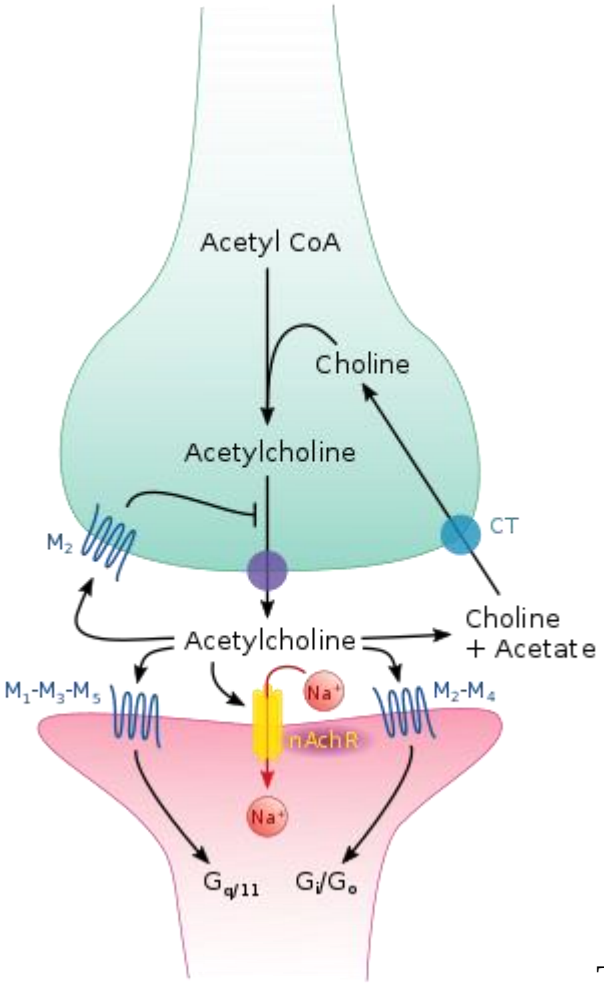
The study of chemicals requires intimate knowledge of the biological system affected. With the knowledge of cell biology and biochemistry increasing, the field of pharmacology has also changed substantially. It has become possible, through molecular analysis of receptors, to design chemicals that act on specific cellular signaling or metabolic pathways by affecting sites directly on cell-surface receptors

(which modulate and mediate cellular signaling pathways controlling cellular function).

Chemicals can have pharmacologically relevant properties and effects. Pharmacokinetics describes the effect of the body on the chemical (e.g. half-life and volume of distribution), and pharmacodynamics describes the chemical's effect on the body (desired or toxic).

Systems, receptors and ligands**[]**

Main articles: Ligand (biochemistry), List of drugs, and Neurotransmitter



The cholinergic synapse. Targets in synapses can be modulated with pharmacological agents. In this case, cholinergics (such as muscarine) and anticholinergics (such as atropine) target receptors; transporter inhibitors (such as hemicholinium) target membrane transport proteins and anticholinesterases (such as sarin) target enzymes.

Pharmacology is typically studied with respect to particular systems, for example endogenous neurotransmitter systems. The major systems studied in pharmacology can be categorised by their ligands and

include acetylcholine, adrenaline, glutamate, GABA, dopamine, histamine, serotonin, cannabinoid and opioid.

Molecular targets in pharmacology include receptors, enzymes and membrane transport proteins. Enzymes can be targeted with enzyme inhibitors. Receptors are typically categorised based on structure and function. Major receptor types studied in pharmacology include G protein coupled receptors, ligand gated ion channels and receptor tyrosine kinases.

Network pharmacology is a subfield of pharmacology that combines principles from pharmacology, systems biology, and network analysis to study the complex interactions between drugs and targets (e.g., receptors or enzymes etc) in biological systems. The topology of a biochemical reaction network determines the shape of drug dose-response curve[42] as well as the type of drug-drug interactions,[43] thus can help designing efficient and safe therapeutic strategies. The topology Network pharmacology utilizes computational tools and network analysis algorithms to identify drug targets, predict drug-drug interactions, elucidate signaling pathways, and explore the polypharmacology of drugs.

Pharmacodynamics[]

Main article: Pharmacodynamics

Pharmacodynamics is defined as how the body reacts to the drugs. Pharmacology models include the Hill equation, Cheng-Prusoff equation and Schild regression. Pharmacodynamics theory often investigates the binding affinity of ligands to their receptors.

Medication is said to have a narrow or wide *therapeutic index*, certain safety factor or *therapeutic window*. This describes the ratio of desired effect to toxic effect. A compound with a narrow therapeutic index (close to one) exerts its desired effect at a dose close to its toxic dose. A compound with a wide therapeutic index (greater than five) exerts its desired effect at a dose substantially below its toxic dose. Those with a narrow margin are more difficult to dose and administer, and may require therapeutic drug monitoring (examples are warfarin, some antiepileptics, aminoglycoside antibiotics). Most anti-cancer drugs have a narrow therapeutic margin: toxic side-effects are almost always encountered at doses used to kill tumors.

The effect of drugs can be described with Loewe additivity which is one of several common reference models.[43]

Pharmacokinetics[]

Main article: Pharmacokinetics

Pharmacokinetics is the study of the bodily absorption, distribution, metabolism, and excretion of drugs.[44]

When describing the pharmacokinetic properties of the chemical that is the active ingredient or active pharmaceutical ingredient (API), pharmacologists are often interested in *L-ADME*:

- Liberation – How is the API disintegrated (for solid oral forms (breaking down into smaller particles), dispersed, or dissolved from the medication?
- Absorption – How is the API absorbed (through the skin, the intestine, the oral mucosa)?
- Distribution – How does the API spread through the organism?
- Metabolism – Is the API converted chemically inside the body, and into which substances. Are these active (as well)? Could they be toxic?
- Excretion – How is the API excreted (through the bile, urine, breath, skin)?

Drug metabolism is assessed in pharmacokinetics and is important in drug research and prescribing.

Administration, drug policy and safety[]

Drug policy**[]**

Main article: Drug policy

In the United States, the Food and Drug Administration (FDA) is responsible for creating guidelines for the approval and use of drugs. The FDA requires that all approved drugs fulfill two requirements:

1. The drug must be found to be effective against the disease for which it is seeking approval (where 'effective' means only that the drug performed better than placebo or competitors in at least two trials).
2. The drug must meet safety criteria by being subject to animal and controlled human testing.

Gaining FDA approval usually takes several years. Testing done on animals must be extensive and must include several species to help in the evaluation of both the effectiveness and toxicity of the drug. The dosage of any drug approved for use is intended to fall within a range in which the drug produces a therapeutic effect or desired outcome.[45]

The safety and effectiveness of prescription drugs in the U.S. are regulated by the federal Prescription Drug Marketing Act of 1987.

The Medicines and Healthcare products Regulatory Agency (MHRA) has a similar role in the UK.

Medicare Part D is a prescription drug plan in the U.S.

The Prescription Drug Marketing Act (PDMA) is an act related to drug policy.

Prescription drugs are drugs regulated by legislation.