



Drug Metabolism Pathways: Biochemical Processes That Determine Medication Fate in the Body

Olivia Bennett*

Department of Pharmacology and Drug Development, University of Cambridge, Cambridge, UK

DESCRIPTION

Drug metabolism pathways describe the biochemical processes through which medicines are chemically modified inside the body. These reactions influence how long a drug remains active, how much reaches its target and how efficiently it is removed. The liver is the primary organ involved in drug metabolism, although the kidneys, intestines, lungs, blood and other tissues also contain enzymes capable of modifying pharmaceutical compounds. Understanding these pathways is important for medication selection, dosage decisions, drug safety and the interpretation of interactions between medicines.

After administration, a drug passes through several stages before reaching its target and eventually being eliminated. Absorption determines how much of the administered substance enters the circulation. Distribution determines how it moves between blood and tissues. Metabolism chemically changes the original compound, while elimination removes the parent drug and its metabolites from the body. These processes collectively influence drug concentration and duration of action. Drug metabolism is commonly divided into Phase I and Phase II reactions. Phase I reactions generally involve oxidation, reduction, or hydrolysis. These reactions may introduce or expose functional chemical groups within a drug molecule. Phase II reactions generally involve conjugation, in which the drug or its Phase I metabolite is joined with another molecule. These reactions often increase water solubility and support elimination through urine or bile.

Cytochrome P450 enzymes are among the most important enzymes involved in Phase I metabolism. They are located mainly in liver cells but can also be found in the intestinal wall and other tissues. Cytochrome P450 2D6, CYP2D6, CYP2C9, CYP2C19 and CYP1A2 contribute to the metabolism of many medicines. Each enzyme has a different range of substrates, although considerable overlap exists between their activities. CYP3A4 is involved in the metabolism of a large number of pharmaceutical compounds. It is present in both the liver and

intestinal tract and can influence the amount of an orally administered medicine that reaches systemic circulation. Medicines or dietary substances that inhibit CYP3A4 may increase the concentration of another drug, whereas substances that increase enzyme activity may lower drug exposure.

CYP2D6 is another important metabolic enzyme. Genetic variation in the CYP2D6 gene produces differences in enzyme activity between individuals. Some people have reduced activity, while others have normal or increased activity. For medicines processed through this pathway, such differences can affect drug concentration and clinical response. Pharmacogenetic information can therefore be relevant for selected medicines. CYP2C19 and CYP2C9 also contribute to the metabolism of many therapeutic agents. Genetic differences in these enzymes can alter metabolic capacity. In addition to genetic factors, age, liver function, diet, smoking, disease conditions and exposure to other substances can affect enzyme activity. Consequently, drug metabolism reflects both inherited characteristics and environmental influences.

Phase II reactions include glucuronidation, sulfation, acetylation, methylation and conjugation with glutathione. Glucuronidation is particularly important and is carried out by UDP-glucuronosyltransferase enzymes. These enzymes attach glucuronic acid to selected drug molecules or metabolites, often producing compounds that are more water-soluble and easier to eliminate. Glutathione conjugation can protect cells from certain reactive metabolites. Glutathione S-transferase enzymes facilitate the attachment of glutathione to electrophilic compounds. The resulting products can subsequently undergo additional reactions before elimination. This pathway is important because some metabolic reactions can produce chemically reactive intermediates that require further processing.

Drug metabolism does not always make a medicine inactive. Some medicines are administered as inactive or less active compounds known as prodrugs. Metabolic conversion can

Correspondence to: Olivia Bennett, Department of Pharmacology and Drug Development, University of Cambridge, Cambridge, UK, E-mail: olivia.bennett@drugmet.uk

Received: 29-Aug-2025, Manuscript No. JPP-25-32621; **Editor assigned:** 01-Sept-2025, PreQC No. JPP-25-32621 (PQ); **Reviewed:** 15-Sept-2025, QC No. JPP-25-32621; **Revised:** 22-Sept-2025, Manuscript No. JPP-25-32621 (R); **Published:** 29-Sept-2025, DOI: 10.35248/2153-0645.25.16.145

Citation: Bennett O (2025). Drug Metabolism Pathways: Biochemical Processes That Determine Medication Fate in the Body. J Pharmacogenom Pharmacoproteomics. 16:145.

Copyright: © 2025 Bennett O. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

transform these substances into pharmacologically active products. The effectiveness of such medicines may therefore depend on the activity of particular metabolic enzymes. Genetic variation or enzyme inhibition can influence the amount of active compound produced. Metabolism can also produce compounds that remain pharmacologically active. In some cases, an active metabolite contributes significantly to the overall therapeutic effect. In other situations, a metabolite may contribute to unwanted reactions. Understanding the metabolic profile of a medicine is therefore important when evaluating its complete pharmacological activity.

Drug interactions can strongly influence metabolic pathways. An enzyme inhibitor can slow the metabolism of another

medicine, potentially increasing its concentration. An enzyme inducer can increase metabolic activity and reduce drug exposure. These interactions may alter treatment effectiveness or increase the possibility of adverse effects. Healthcare professionals therefore consider a patient's complete medication list when selecting and adjusting therapy. The kidneys also contribute to drug elimination, particularly after metabolic transformation has increased the water solubility of a compound. Metabolites can enter the urine through filtration, secretion, or other renal processes. Some compounds are eliminated through bile and may reach the intestine, where they can be excreted in feces or undergo further transformation by intestinal microorganisms.