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PERSPECTIVE

Perspective article: A proposal for rational drug class terminology

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'Belovéd, what are names but air?
Choose thou whatever suits the line'

(When Coleridge wrote those lines published in 1799, he was thinking about a beloved person close to him and not pharmacology. Almost certainly.)

Collective names for drugs were coined for various reasons, some of which we would now recognise as misguided. For many groups of drugs, the molecular mechanism/s of action were initially obscure and so an interpretation of their clinical impact was often adopted. When drugs in such groups undergo a change in use, the previous nomenclature provides a layer of unnecessary confusion. Older nomenclature can lead to preconceptions about drug action, for example, referring to daunorubicin (daumomycin) as an antibiotic, when the clinical usage is for treating cancer. Or the use of particular 'antidepressants' for treating chronic neuropathic pain.

At a linguistic level, using the term 'antibiotic' to describe the drugs used to treat bacterial infection is clearly a misnomer (Seifert & Schirmer, 2021a). At a pharmacological level, the use of the prefix *anti-* as an indication of a drug that interferes with a particular process is also best avoided. The term anticholinergic, for example, has been imprecise since Henry Hallett Dale's identification in the 1910s of atropine-insensitive effects of acetylcholine (Feldberg, 1970). Similarly, anti-adrenergic, anti-oestrogen, antihistamine and so on are all similarly too imprecise and are, therefore, to be discouraged.

The rational terminologies for drug classes we describe in this Perspective (Table 1), which follows on from publications in other resources (Seifert, 2018; Seifert & Schirmer, 2021b), focus on the predominant molecular mechanism of action. We anticipate several benefits for adopting this rational terminology, beyond satisfying a need to be correct and consistent in nomenclature. Literature searches will be simplified and the teaching of pharmacology to healthcare professionals becomes more transparent to allow (for example) greater clarity about the possibility of drug : drug interactions (drug safety). Using a more rational nomenclature should also provide clarity in discussions with the general public as there is a wider drive to informing oneself.

1 | CHALLENGES TO ADOPTING THE NEW NOMENCLATURE

The easiest challenge is in the adoption of the nomenclature in pharmacology teaching and assessments. We are reassured that educators in pharmacology should recognise the value of such changes and rapidly assimilate them into their teaching. Indeed, in Germany, these were incorporated into the national medical curriculum in 2020, with national assessments taking place in 2022 (https://www.impp.de/pruefungen/allgemein/gegenstandskataloge.html). It has been suggested that those in the early stages of their careers are more receptive to change as they have less investment in the status quo. Anecdotally, feedback from students in Germany on the rational drug class terminology, where it was first introduced, has been overwhelmingly positive.

A more difficult hurdle to overcome will be the adoption of the nomenclature in scientific (and clinical) literature. While Naunyn-Schmiedeberg's Archives of Pharmacology (Seifert & Schirmer, 2021b) has led the way, the *British Journal of Pharmacology* and the Nomenclature and Standards Committee of the International Union of Basic and Clinical Pharmacology continue to champion the use of rational, systematic nomenclature for drug targets and their groupings. We anticipate that collectively, pharmacological journals and those of a multidisciplinary nature will also adopt these terminologies.

TABLE 1 Replacing the therapeutic orientation with a description of the predominant molecular target

Drugs to treat	'Old' usage	Preferred usage
Cardiovascular disorders		
Bradycardia	Parasympatholytics, anticholinergics	Muscarinic (M) receptor antagonists
Cardiac arrhythmias	Anti-arrhythmics, chronotropes, inotropes	Voltage-gated sodium channel (Na_v) inhibitors Potassium (K) channel inhibitors Phosphodiesterase (PDE) inhibitors Voltage gated calcium channel (Ca_v) inhibitors β-Adrenoceptor antagonists Adenosine receptor agonists Na^+/K^+-ATPase inhibitors
Coronary artery disease, deep vein thrombosis, myocardial infarction	Anticoagulants, antithrombotics	Antithrombin III activators Thrombin (factor IIa) inhibitors Factor Xa inhibitors Vitamin K modulators
Heart failure (and hypertension)	Diuretics, thiazide diuretics, loop diuretics	SLC12A3/Na-Cl symporter inhibitors SLC12A1/Na-K-Cl symporter inhibitors Carbonic anhydrase inhibitors Mineralocorticoid receptor (MR) antagonists Osmotic diuretic drugs
Hypertension	Antihypertensives	Voltage gated calcium channel (Ca_v) inhibitors Angiotensin-converting enzyme inhibitors β-Adrenoceptor antagonists AT_1 angiotensin receptor antagonists
Hypotension	Pressors, sympathomimetics	Vasopressin receptor (V) agonists
Stroke, peripheral artery disease	Antiplatelets, blood thinners, 'aspirin'	$P2Y_{12}$ receptor antagonists PDE3 inhibitors PAR1 receptor antagonists Glycoprotein αIIbβIII inhibitors SLC29A1/ENT1 inhibitors Thromboxane synthase inhibitors Thromboxane receptor (TP) antagonists
Respiratory disorders		
Asthma, COPD	Anti-asthmatics, bronchodilators, broncholytics	Muscarinic (M) receptor antagonists β_2-adrenoceptor agonists 5-lipoxygenase (5-LOX) inhibitors $CysLT_2$ receptor antagonists Phosphodiesterase (PDE) inhibitors Glucocorticoid receptor (GR) agonists
Endocrine		
Diabetes	Antidiabetics, insulin sensitizers, incretins	K_{ATP} channel inhibitors α-Glucosidase inhibitors Insulin receptor agonists SLC5A2/SGLT2 inhibitors PPARγ agonists DPP-4 inhibitors GLP-1 receptor agonists
Central nervous system disorders		
Anxiety	Anxiolytics, hypnotics, sedatives	$GABA_A$ receptor PAMs
Depression	Antidepressants	5-HT transporter inhibitors (SSRI) NA/5-HT transporter inhibitors (SNRI) Monoamine oxidase inhibitors (MAOI) Melatonin (MT) receptor agonists
Epilepsy	Anti-epileptics, anticonvulsants	Voltage-gated sodium channel (Na_v) inhibitors, voltage-gated calcium channel (Ca_v) inhibitors, $GABA_A$ receptor PAMs
Pain	Analgesics	Opioid receptor agonists
	Local anaesthetics	Voltage-gated sodium channel (Na_v) inhibitors

TABLE 1 (Continued)

Drugs to treat	'Old' usage	Preferred usage
	Non-steroidal anti-inflammatory drugs (NSAIDs)	Cyclooxygenase (COX) inhibitors
Psychosis	Antipsychotics, neuroleptics	Drugs to treat psychosis[b]
Infection and immune		
Allergies/atopy	Antihistamines	Histamine H_1 receptor antagonists
Bacterial infection	Antibiotics	Antibacterials (antibacterial drugs)
Rheumatoid arthritis, chronic inflammation	Disease-modifying anti-rheumatic drugs (DMARDs)	Purine synthesis inhibitors Phosphodiesterase 4 (PDE4) inhibitors TNFα (receptor) inhibitors Interleukin (receptor) inhibitors
Other disorders		
Cancer	Anticancer agents	Microtubule inhibitors, topoisomerase inhibitors, DNA alkylating drugs, and multiple 'untargetted' and 'targetted' therapeutic options
Upper gastrointestinal disorders	Anti-ulcer	Histamine H_2 receptor antagonists
Lower gastrointestinal disorders	Antispasmodics, spasmolytics	Muscarinic (M) receptor antagonists Mebeverine/papaverine[a]
Nausea	Anti-emetics	Histamine H_1 receptor antagonists $5HT_3$ receptor antagonists NK_1 receptor antagonists

[a]We await clarity about the molecular mechanism/s of action of these drugs, which may be targetting phosphodiesterases.
[b]We would wish to simplify this descriptor, since 'D_2 dopamine receptor antagonists with diverse pharmacology' or 'antagonists at multiple amine GPCRs' are both unsatisfactory.

TABLE 2 Replace the chemical class with the intended molecular target description

'Old' usage	Preferred usage
Benzodiazepines Barbiturates	$GABA_A$ receptor positive allosteric modulators (PAMs)
Cardiac glycosides	Na^+/K^+-ATPase inhibitors
Coxibs	Cyclooxygenase 2 (COX-2) inhibitors
Fentanils	μ opioid receptor agonists
Fibrates	PPARα agonists
Gliflozins	SLC5A2/SGLT2 inhibitors
Sartans	AT_1 receptor antagonists
Setrons	$5\text{-}HT_3$ receptor antagonists
Statins	HMG-CoA reductase (HMGCR) inhibitors
Sulfonylureas	K_{ATP} channel inhibitors
Thiazolidinediones (TZDs)	PPARγ agonists
Triptans	$5\text{-}HT_{1B/1D}$ receptor agonists

The most difficult hurdle to overcome is likely to be the usage of the old terminology by clinicians and the lay public. This may turn out to be a generational thing, as those educated using the more rational approach replace their elders.

While we have some clarity about the majority of preferred terminology described in this Perspective, there remain examples of continuing uncertainty. For example, while a major commonality of the drugs used to treat psychosis is the blockade of D_2 dopamine receptors (Table 1), clearly these drugs are complex in their molecular mechanisms (arguably true for many treatments for psychiatric disorders). As such, therefore, we have yet to formulate a more precise nomenclature for this group of drugs. There are also likely to be further examples of drugs in current clinical usage beyond the lists in this Perspective, where a preferred molecular target descriptor is a more appropriate nomenclature (Table 2).

As an exception, in the field of drug discovery, we would tolerate the use of the chemical class descriptor as a comparator to identify chemical and pharmacological similarities and differences with established classes.

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AUTHOR CONTRIBUTIONS

Both authors contributed equally to developing the concept and writing of the paper.

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