IUPHAR/BPS Guide to PHARMACOLOGY

Database Report

November 2023

www.guidetopharmacology.org

enquiries@guidetopharmacology.org

Contents

Introduction

This database report provides an overview of recent progress and the current status of the IUPHAR/BPS Guide to PHARMACOLOGY (GtoPdb) since our last NC-IUPHAR meeting held in April 2023. Previous reports are online for Apr 2023, Nov 2022, Apr 2022, Nov 2021 and April 2021. We have reduced redundancy between the reports by purging sections without significant changes. Thus, if you remember any aspect that is not here, it may well be in a previous report (and by all means enquire).

Zenodo repository of reports:

- April 2023 doi: 10.5281/zenodo.7915909
- November 2022 doi: 10.5281/zenodo.7458274
- April 2022 doi: 10.5281/zenodo.7786340
- November 2021 doi: 10.5281/zenodo.7786355

Key Updates / Notifications

- 1 Database release (2023.2)
    - 217 new ligands added (34 approved drugs)
    - 16 new targets added
    - 35 human targets with new quantitative interactions (total 1662)
    - 146 ligands with new quantitative interactions (total 8960)
    - 265 new ligand-target interactions

- ~40,000 Sessions per month (~52,000 sessions)

GtoPdb Website Analytics

GtoPdb Website Access Statistics

Monthly statistics	**Oct 2022 - Sep 2023** (*last report figures*)
Engaged Sessions	52,014 (52,425)
Users	40,733 (36,960)
Page views	297,514 (146,694)
Pages / Session	4.64 (2.80)
Avg. Session Duration	00:03:48 (00:02:29)
Views per User	7.31

The above table summarises the access statistics for the Guide to Pharmacology over the last year, comparing against our previous reporting period (Apr 2022 - Mar 2023). Data is generated using Google Analytics GA4.

This second table, shows the breakdown of these access stats by country. Around 56% of all engaged sessions come from the USA, China, UK and India. Engaged sessions are sessions lasting longer than 10 seconds, or containing 2 or more screen/page views.

	Country	Total users	Sessions	↓ Engaged sessions	Engaged sessions per user	Views	Views per session
	Totals	**488,799**	**770,034**	**624,168**	**1.28**	**3,570,169**	**4.64**
1	United States	143,015	202,691	169,187	1.18	732,496	3.61
2	China	60,390	89,346	67,074	1.11	399,430	4.47
3	United Kingdom	38,745	77,774	64,321	1.66	592,291	7.62
4	India	41,943	60,359	49,918	1.19	204,350	3.39
5	Germany	13,457	23,036	19,068	1.42	122,601	5.32
6	Japan	11,970	20,867	17,365	1.45	111,939	5.36
7	Australia	11,166	21,005	16,977	1.52	107,631	5.12
8	Canada	11,285	19,367	16,067	1.43	100,008	5.16
9	South Korea	11,473	18,213	14,991	1.31	79,350	4.36
10	France	7,019	11,925	9,700	1.39	68,261	5.72
11	Italy	6,516	11,143	9,376	1.44	60,179	5.4
12	Russia	8,161	10,903	9,317	1.14	47,870	4.39
13	Mexico	5,086	10,600	8,944	1.76	79,874	7.54
14	Spain	5,609	10,089	8,305	1.48	63,417	6.29
15	Netherlands	5,665	9,015	7,583	1.34	45,286	5.02
16	Brazil	4,685	7,977	6,757	1.44	46,418	5.82
17	Philippines	5,644	6,958	6,024	1.07	21,871	3.14
18	Denmark	3,195	6,228	4,997	1.57	31,897	5.12

Download Statistics

Google Analytics moved from UA to GA4. This has changed how downloads are recorded. There is a period in the middle of 2023 where we don't have details of downloads from the website.

Google Analytics: Comparison of Downloads (Universal Analytics)

Event Category: Downloads

	Count
Jul - Dec 2022	2,145
Jan - Jun 2023	**2,080**

This corresponds to files downloaded from our main downloads page: http://www.guidetopharmacology.org/download.jsp

This indicates the file download is around 4,000 files per year, which is around the same level in our last report.

Due to issues with setting up and collecting data using GA4 we only have partial file download data from GA4 for 2023. As the table below shows, monthly file downloads are around the expected level but we don't have full data from before August 2023.

Month	09	08	10	05	04	Totals
Year	2023	2023	2023	2023	2023	
Event name	Event count	Event count	Event count	Event count	Event count	↑ Event count
Totals	**560** 42.3% of total	**343** 25.9% of total	**173** 13.1% of total	**45** 3.4% of total	**35** 2.6% of total	**1,325** 100.0% of total
1 file_download	560	343	173	45	35	1,325

GtoPdb Content

These database statistics were compiled on 12th October 2023 from the 2023.2 All database statistics can be found at http://www.guidetopharmacology.org/about.jsp#content.

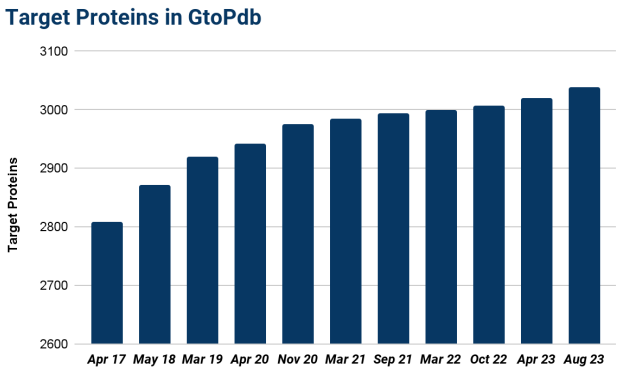
Targets	**Number of (Human) UniProt IDs**
7TM receptors	399
Nuclear hormone receptors	48
Catalytic receptors	253
Ligand-gated ion channels	81
Voltage-gated ion channels	144
Other ion channels	53

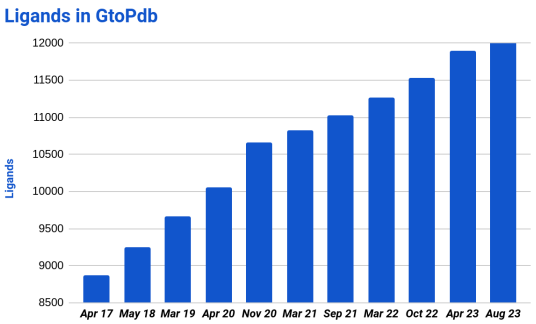
Enzymes	1277
Transporters	555
Other protein targets	229
Human targets with ligand interactions	1947
Human targets with quantitative ligand interactions	1695
Human targets with approved drug interactions	732
Human Primary Targets with approved drug interactions	347
Total number of targets	**3039**

Ligands	**Number of Ligands**
Synthetic organics	8551
Metabolites	509*
Endogenous peptides	813
Other peptides including synthetic peptides	1494
Natural products	403
Antibodies	354
Inorganics	39
Approved drugs	1919
Withdrawn drugs	109
Drugs with INNs	3312
Labelled ligands	645
Unique PubChem CIDs	9852
Ligands with target interactions	10138
Ligands with quantitative interactions (approved drugs)	8960 (1108)
Ligands with clinical use summaries (approved drugs)	3495 (1911)
Total number of ligands (PubChem SIDs)	**12164**
Number of binding constants curated from the literature	**20,141**

GtoPdb Entity Growth

Growth rates over the span of the previous Wellcome Trust grant are documented in earlier reports and our 2016, 2018, 2020 and 2022 NAR papers. Updates come via subcommittee contributions to the Concise Guide, and the continued tagging of pre-existing targets and ligands with comments and references to GtoImmuPdb and GtoMPdb. Note that, while we highlight newly-liganded targets in release notes, the growth of new targets is slow but ligand expansion continues.





	May 18	Mar 19	Apr 20	Nov 20	Mar 21	Sep 21	Mar 22	Oct 22	Apr 23	Aug 23
Target protein IDs	**2872**	**2920**	**2943**	**2976**	**2985**	**2995**	**3000**	**3007**	**3021**	**3039**
Ligands total	**9251**	**9662**	**10053**	**10659**	**10821**	**11025**	**11271**	**11532**	**11893**	**12164**
Approved drugs	1364	1421	1471	1614	1643	1689	1734	1787	1865	1919
PubChem CIDs	7109	7407	7483	7994	8102	8262	8462	8633	9307	9852

GtoPdb Updates

Targets

New human protein targets:

Target ID	Name	Potential application	Ligand(s)?
3230	DNA polymerase theta	ONCOLOGY	inhibitors
3231	DNA polymerase beta	ONCOLOGY	inhibitor
3232	BCL3 transcription coactivator	ONCOLOGY	inhibitor
3233	F-box protein 3	INFLAMMATION	inhibitor
3234	Cbl proto-oncogene B	ONCOLOGY	inhibitor

3235	S-phase kinase associated protein 2	ONCOLOGY	inhibitor
3236	ketohexokinase	METABOLIC DISEASE	Ph 2 inhibitor
3237	axin 2	ONCOLOGY	inhibitor
3238	phospholipid scramblase 1	ANTIVIRAL (CoV)	none
3239	glutathione peroxidase 4	ONCOLOGY	inhibitors
3240-3243	TEA domain transcription factors 1-4	ONCOLOGY	inhibitor
3244	DDB1 and CUL4 associated factor 1 (DCAF1)	PROTAC DEV	inhibitors
3245	ATP citrate lyase	METABOLIC DISEASES & ONCOLOGY	inhibitors, incl approved drug bempedoic acid
3246	CD55 molecule (Cromer blood group)	CHAPLE DISEASE	none
3247	stabilin 1 (CLEVER-1)	IMMUNO-ONCOLOGY	mAb bexmarilimab

Ligands

Curation of new ligands is generally guided by the target family subcommittees as part of routine update processes. Where targets don't have a formal GtoPdb subcommittee, curators are able to independently add ligands when pharmacological relevance is demonstrated.

Caveat: new ligands will only be added to GtoPdb when the curators can confirm name-to-structure associations, find citable evidence that confirms MMOA and a source of quantitative interaction data.

Additional ligand sources include the medicinal chemistry literature, INN lists from the WHO, DrugHunter (https://drughunter.com/), first disclosures from scientific meetings (such as AACR and ACS), BJP/BJCP author requests, patents.

- 17 new kinase inhibitors were added, with structures arising from the Aug 2023 proposed INN list
- 6 new ligands with potential anti-CoV activity were added (Mpro inhibitors)
- 30/41 of the drugs that have been approved by the FDA in 2023 are curated in the GtoPdb. We have not included a set that don't meet our inclusion criteria.
- 7 drug approvals from outside of the US and EU were identified and curated. 5 of these are not approved by the FDA, 2 were approved elsewhere ahead of FDA.

Summary of ligands added to GtoPdb in 2023.1 release (compared to 2022.1)

	New Ligands	Updated Ligands	Total Ligands (2023.1)	Total Ligands (2022.1)
Approved Drugs	34	10	1919	1875
WHO Essential Medicines	3	0	301	298
Ligands with Quantitative Interaction Data	144	2	8960	8814
Anibacterials	30	6	471	435
All Ligands	217	-	12164	11947

We also track the comment fields in GtoPdb to see which comments have been applied to new ligands, but also any updates to comments for existing ligands. Nearly all new ligands will have a general comment added.

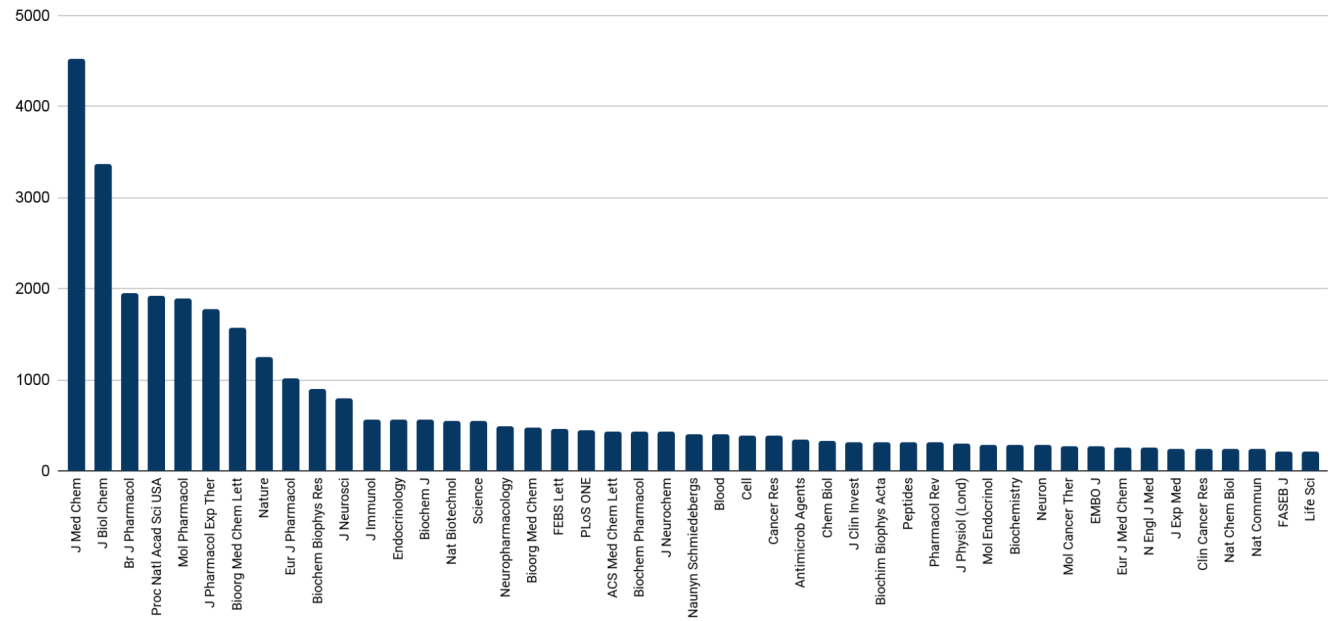
Comment Type	New Ligands	Updated Ligands
General	216	82
Clinical Use	106	52
Bioactivity	92	4
MOA	14	0

Analysis of journals contributing to curated data

The following table and graph show the count of unique articles from journals curated in the GtoPdb. The table is restricted to those journals with over 500 unique curated articles. The graph expands this to all journals with over 200 unique curated articles.

Title	Count
J Med Chem	4524
J Biol Chem	3363
Br J Pharmacol	1950
Proc Natl Acad Sci USA	1920
Mol Pharmacol	1892
J Pharmacol Exp Ther	1771
Bioorg Med Chem Lett	1576
Nature	1247
Eur J Pharmacol	1020
Biochem Biophys Res Commun	895

J Neurosci	793
J Immunol	570
Endocrinology	560
Biochem J	557
Nat Biotechnol	556
Science	554



Antibiotic DB and Global Antibiotic Research and Development Partnership

We have collaborated with Antibiotic DB (ADB; www.antibioticdb.com) since 2019, with the aim of extending the coverage of antibacterial compounds in GtoPdb and providing comprehensive chemistry and pharmacology for select antibacterials curated within ADB. This collaboration is supported by the Global Antibiotic Research and Development Partnership (GARDP; https://gardp.org/), with funding in place until March 2025. This includes continued financial support for a curator (with an increase from 0.2FTE to 0.3FTE) and additional funding for a software developer (0.5FTE), who will work on developing a 'Guide to ANTIMICROBIAL PHARMACOLOGY' portal to GtoPdb and the new ADB database and website (please see the section on GtoPdb Web-Application Developments for further details of this work).

Currently we have **471 ligands** tagged in GtoPdb as 'antibacterial' and **458** of these have links to compounds at ADB. The antibacterials in the GtoPdb include approved drugs, WHO essential Medicines-listed medicines, drugs in clinical development, and a number of investigational and experimental compounds. The focus of recent work has been the curation of antibacterials included in the GARDP REVIVE Encyclopaedia (https://revive.gardp.org/resources/encyclopaedia/), most of which are approved or previously approved drugs. Of the **353** antibacterials listed, **285** are now entries in the GtoPdb.

For further information about our work with ADB please refer to previous Database Reports. This collaboration has also been described in more detail in our 2022 NAR update:

Harding SD, Armstrong JF, Faccenda E, Southan C, Alexander SPH, Davenport AP, Pawson AJ, Spedding M, Davies JA; NC-IUPHAR. The IUPHAR/BPS Guide to PHARMACOLOGY in 2022: curating pharmacology for COVID-19, malaria and antibacterials. *Nucleic Acids Research*, Volume 50, Issue D1, 7 January 2022, Pages D1282–D1294, https://doi.org/10.1093/nar/gkab1010. PMID: 34718737.

GtoPdb Web-Application Developments

AntibioticDB Collaboration

We are pleased to report that Dr. Liangcui Chu joined the team in September as the software developer for the ADB collaboration.

A significant amount of development time has been spent on work related to our collaboration with AntibioticDB in building the new AntibioticDB website which is being hosted and maintained at the University of Edinburgh. The three main aspects we are currently working on are

- Setting up a PostgresQL database table to store AntibioticDB data
- Building tools to curate AntibtioicDB data
- Building a new website to access the new database and represents the data in a very similar fashion to the existing AntibioticDB website (https://antibioticdb.com/)

We are also planning to develop a new portal at the Guide to Pharmacology, similar to those created for the Guide to Malaria Pharmacology and Guide to Immunopharmacology. This will aim to provide optimised access to antibacterial and more broadly antimicrobial pharmacology data in the database.

Connectivity

Links to other resources

GtoPdb has built many collaborative connections with other resources, many of which are reciprocal. The table below shows the number of ligands and targets with out-links to each of the named resources. The table is not exhaustive, but shows those specialist resources we link with and resources that have reciprocal links back into GtoPdb.

Given we submit our ligand data to PubChem, all ligands with structural data linked to PubChem have out-links. Our recent and ongoing work with AntibioticDB has built links between antibacterials in GtoPdb (455) and AntibioticDB (https://antibioticdb.com/). Links from antibodies in GtoPdb are made to the IMGT/mAb-DB (https://www.imgt.org/mAb-DB/) database. We also link out to Wikipedia pages that describe ligands - often there are reciprocal links from these Wikipedia pages back to GtoPdb via the main ‘chemical infoboxes’.

For our targets, we use UniProtKB identifiers as our primary protein identifier. We use HGNC IDs to provide the primary human gene identifier for our targets. We also provide links to NCBI and Ensembl Gene resources. Specialist resources include GPCRdb (https://gpcrdb.org/), who we have a longstanding collaboration with, linking with GPCR targets. For transporter targets, we have links with Resolute and SLC tables at Bioparadigms.

We ensure that the cross-links are regularly refreshed through formal and informal contacts with database providers.

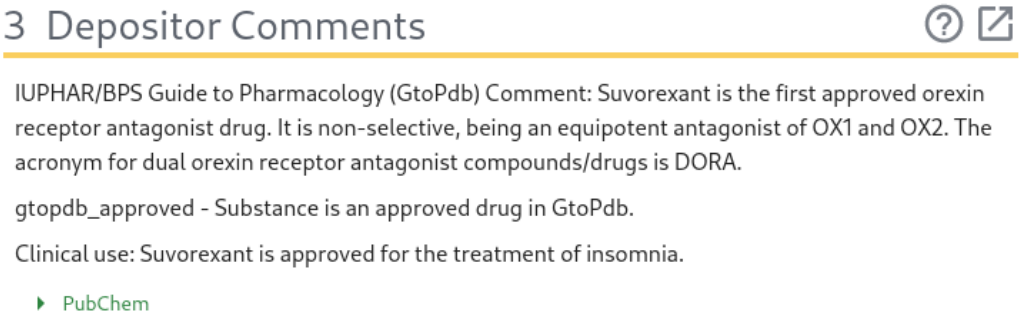
Site	Ligand Links	Site	Target Links
PubChem	10082	GPCRdb	372
ChEMBL	6506	ChEMBL	2245
Reactome	323	Resolute (SLC)	421
AntibioticDB	458	BioParadigms (SLC)	387
IMGT/mAb-DB	338	HGNC	3117
DrugCentral	1687	NCBI (Entrez) Gene	3047
Wikipedia	3024	Ensembl Gene	3060
GPCRdb	4249	UniProt	3120

Pubchem Connectivity

All GtoPdb ligands are submitted to PubChem after each database release, this gives them a PubChem Substance ID.

PubChem Substances are community-provided compounds, and many entries may exist for the same molecule. Each may contain different information about the molecule, depending on the information provided by the submitter. PubChem extracts the unique chemical structures from Substance records (standardization) and stores them as PubChem Compounds. This means that substance records from different data sources about the same molecule are aggregated in a common Compound record in PubChem.

Our PubChem connectivity is enhanced by the addition of curatorial (depositor) comments that we provide when submitting compounds. These depositor comments can be viewed on a substance page at PubChem (see example for suvorexant below). We include ligand general comments, clinical use comments and flagged whether the compound is an approved drug and whether it is tagged as relevant to immunopharmacology, antimalarial pharmacology or antibacterial.



Depositor comments section of PubChem SID 135650615.

We recently posted a blog on how users can exploit these tags when using PubChem. This was reproduced with kind permission from Dr. Chris Southan's blog post: Exploiting the Guide to Pharmacology substance (SID) tags in PubChem

PubChem Statistics for GtoPdb, GtoImmuPdb and GtoMPdb

The stats for the 2023.2 release (with 2023.1 in brackets) are as follows (N.B. the links below can be slow but if they do time out try purging your browser cache).

1. Substances (SID) that we submit to PubChem (refreshing previous submissions) are up to 12173 (11957).
2. Those that have defined chemical structures are merged into 10044 (9838) Compound Identifiers, CIDs (i.e. small molecules and peptides below ~ 70 residues)
3. From our 9498 CIDs 8178 have vendor matches
4. The select "IUPHAR/BPS Guide to PHARMACOLOGY"[SourceName] AND gtopdb_approved [Comment] now retrieves 1918 SIDs (1813) which link to 1698 approved drug CIDs
5. Of our SIDs, 1410 (1384) are tagged in GtoImmuPdb and 361 (356) of these are approved drugs
6. Of our CIDs 983 are tagged in GtoImmuPdb
7. Of our SIDs, 136 are tagged in GtoMPdb and 25 of these are approved drugs
8. Of our CIDs 134 are tagged in GtoMPdb
9. We have now included an **antibacterial tag in our PubChem upload.** Of our SIDs, 469 are tagged as antibacterial and 210 of these are approved drugs
10. Of our CIDs 468 are tag as antibacterial
11. We have 2284 (2331) structures that ChEMBL does not have, 7237 (7076) not in DrugBank.
12. 82 (359) structures where GtoPdb is unique as the source. In most cases this is because we were first to extract the paper or patent and push the ligand structures into PubChem where they get linked to the PubMed entries (see Link out section below). There may be some cases where our stereo configuration is unique (InChIKey) but related to other entries (InChKey inner layer). Inspection of " Related Compounds" and "Same Connectivity" will indicate this.

13. We continue to curate clinical monoclonal antibodies with the PubChem Substance select "IUPHAR/BPS Guide to PHARMACOLOGY"[SourceName] gtopdb_antibody" returning 354 SIDs. Adding "gtopdb_approved" gives 139.

A useful guide/summary of GtoPbd's PubChem substance tagging is given in Dr. Chris Southan's blog post on Exploiting the Guide to Pharmacology substance (SID) tags in PubChem.

The ability to combine selects and filters of our own PubChem entries, find related linked sets (e.g. pivoting from Substances to Compounds) and compare these to other sources in PubChem becomes very informative and powerful. Users are also reminded that, via the InChIKeys or SMILES strings, any of our ligand downloads (including combinations or parts of) can be cast against PubChem using their Identifier Exchange Service to allow detailed exploration of the extensive PubChem links. Users needing guidance for PubChem interrogations are welcome to contact us.

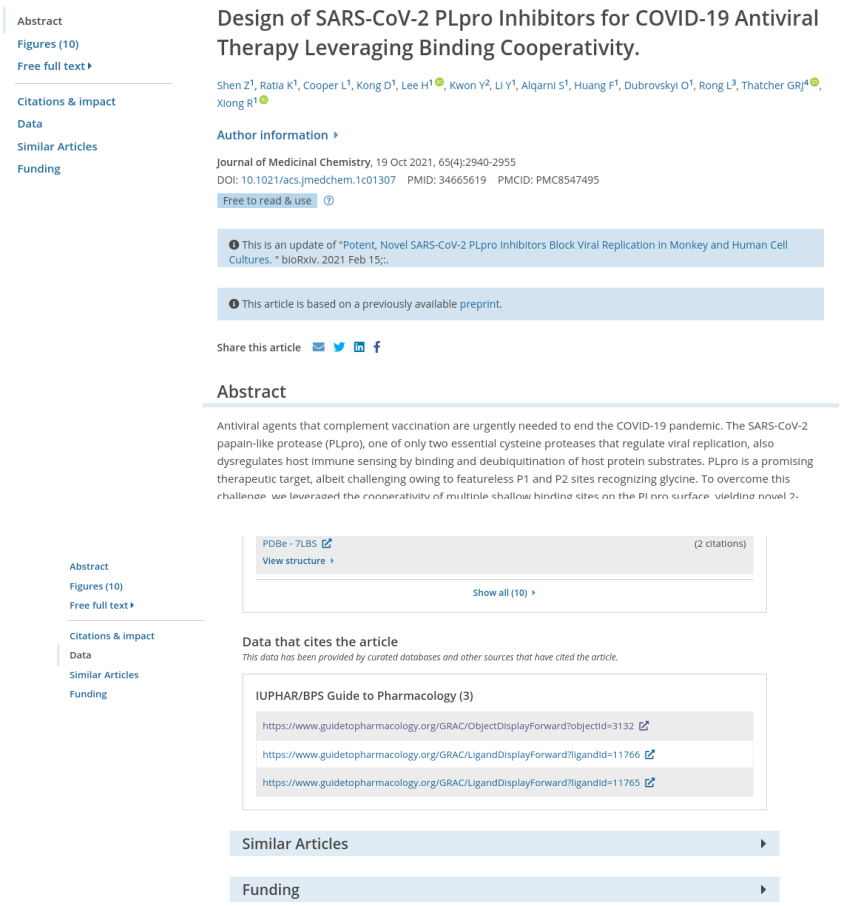
NCBI LinkOuts

GtoPdb maintains sets of links in the NCBI LinkOut service, to the Protein, Nucleotide, Gene and PubMed databases. Our links are updated frequently. Below is the count of all NCBI database records that contain 'LinkOuts' to GtoPdb. The PubMed count covers all references in the databases including reviews and additional reading for target families. Note that the LinkOut pointers link users back to the database. For various technical reasons associated with NCBI mapping stringencies the three sets of entity links have an element of over-counting with redundancy. However the PubMed links are clean because they are assigned via our own curation.

Protein	5955
Nucleotide	5902
Gene	8604
PubMed	32,470 (https://pubmed.ncbi.nlm.nih.gov/?term=loprovguidpharm[SB])

Europe PMC

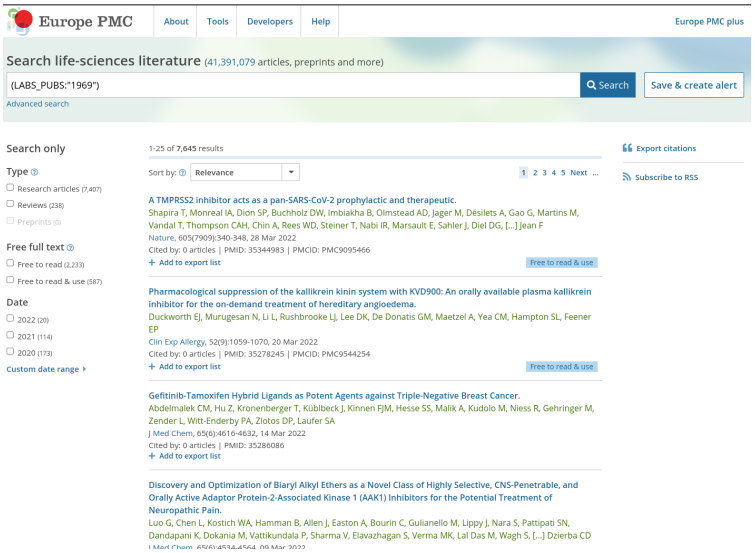
GtoPdb maintains records in the Europe PMC External Links Service. Unlike the larger set of NCBI Outlinks, these publication links are restricted to papers from which GtoPdb interaction data have been curated. These link targets and/or ligands mentioned in the article back to GtoPdb detailed pages.



The above screengrabs show an example of the links from (Shen et al. 2021). Under the 'Data' tab on the left-hand side the data cited in the article can be found. This shows 3 links back to GtoPdb ligands and targets.

As of 6th November 2023 there were 8,198 articles in Europe PMC with links to GtoPdb targets and/or ligands. The EPMC interface query is (LABS_PUBS:"1969")

Full URL: https://europepmc.org/search?query=%28LABS_PUBS%3A%221969%22%29 (screenshot below)



Bibliometrics and Scholarly Portals

NAR and CGTP

We are delighted that our latest submission to the Nucleic Acids Research Database Issue has been accepted and published online.

> Harding SD, Armstrong JF, Faccenda E, Southan C, Alexander SPH, Davenport AP, Spedding M, Davies JA. (2023) **The IUPHAR/BPS Guide to PHARMACOLOGY in 2024**. *Nucl. Acids Res.* 2023 Oct 28:gkad944. Online ahead of print. doi: 10.1093/nar/gkad944. PMID: 37897341

The 6th Edition (2023/24) of the Concise Guide to Pharmacology is due for publication shortly.

We note that our **2020 NAR Database Issue** article has picked up 99 PubMed citations.

We continue to get high citation rates in our previous NAR Database Issues and Concise Guide articles because BJP and BJCP select these as reference citations for the GtoPdb outlinks. Top of the list is our NAR 2018 entry (PMC5753190) with 1,281 citations (according to EPMC) or 1,315 (according to PubMed) and 1,623 by Google Scholar. This thus overtakes our 2016 paper (PMC4702778) with 924 (EMPC) or 930 (PubMed) citations or 1,095 by Google Scholar, and the 2014 paper (PMC3965070) that reached 714 (EPMC) / 736 (PubMed).

The "Concise Guide" citations are currently led by 2017/18 Enzymes (PMC5650666) at 563 followed by 2015/16: Enzymes (PMC4718211) at 513 and 2013/14: G protein-coupled receptors (PMC3892287) at 474.

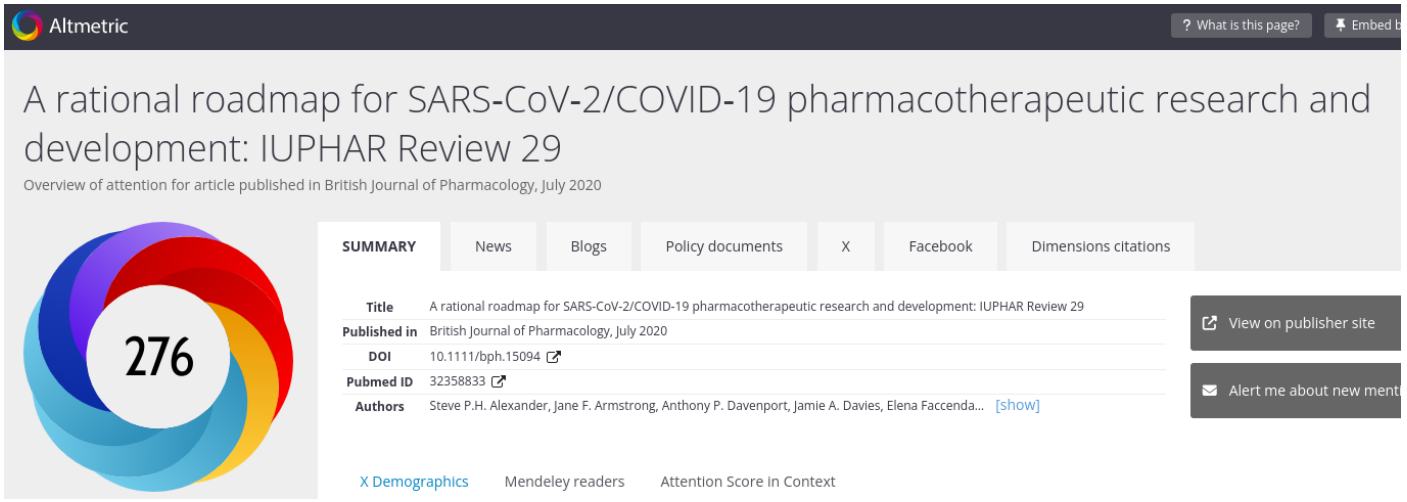
From the most recent edition of the Concise Guide, 2021/22 the G protein-coupled receptors has 105 citations and the Ion Channels has 65 citations.

SARS-CoV-2 Review

Our BJP SARS-Cov-2 review has acquired 50 citations (according to CrossRef).

Alexander SPH et al. A rational roadmap for SARS-CoV-2/COVID-19 pharmacotherapeutic research and development: IUPHAR Review 29. Br J Pharmacol. 2020 Nov;177(21):4942-4966.

The Altmetric rankings for all our OA papers are indexed in ScienceOpen. Top of the list by some margin at 276 is our BJP SARS-Cov-2 review.



Other

- As outlined in previous reports we track various metrics for the GtoPdb team and NC-IUPHAR affiliated papers in PubMed, PubMed Central , European PubMed Central (EPMC) Kudos entries and Altmetrics.

- Research output by members of the GtoPdb Curation team can be seen via ORCID IDs for which we have JLS 0000-0002-5275-6446 , EF 0000-0001-9855-7103 , AJP 0000-0003-2280-845X, CS 0000-0001-9580-0446, SDH 0000-0002-9262-8318 and JFA 0000-0002-0524-0260.

- The overall citation performance has resulted in team members JFA, SDH, JLS, EF, AJP, CS and JAD, along with IUPHAR co-authors, SPHA, MS, and APD being listed in the Clarivate 2022 rankings of Highly Cited Researchers.

- GtoPdb team members have 196 cumulative co-authored publications

Below are the (live) April 2022 bibliometric updates compared to the November 2020 metrics. These are given with EPMC links which have the advantage over PubMed of directly generating a citation ranking for any set (but with lower citation rates than PubMed, Google Scholar or WOS).

- The team is on their 9th NAR Database Issue from 2009 to 2024

- IUPHAR reviews in BJP: 39.

- IUPHAR Pharmacological Reviews: 110

- The cumulative BJP “Concise Guide” set now takes us to 40 papers

EBI UniProtKB/Swiss-Prot cross-references

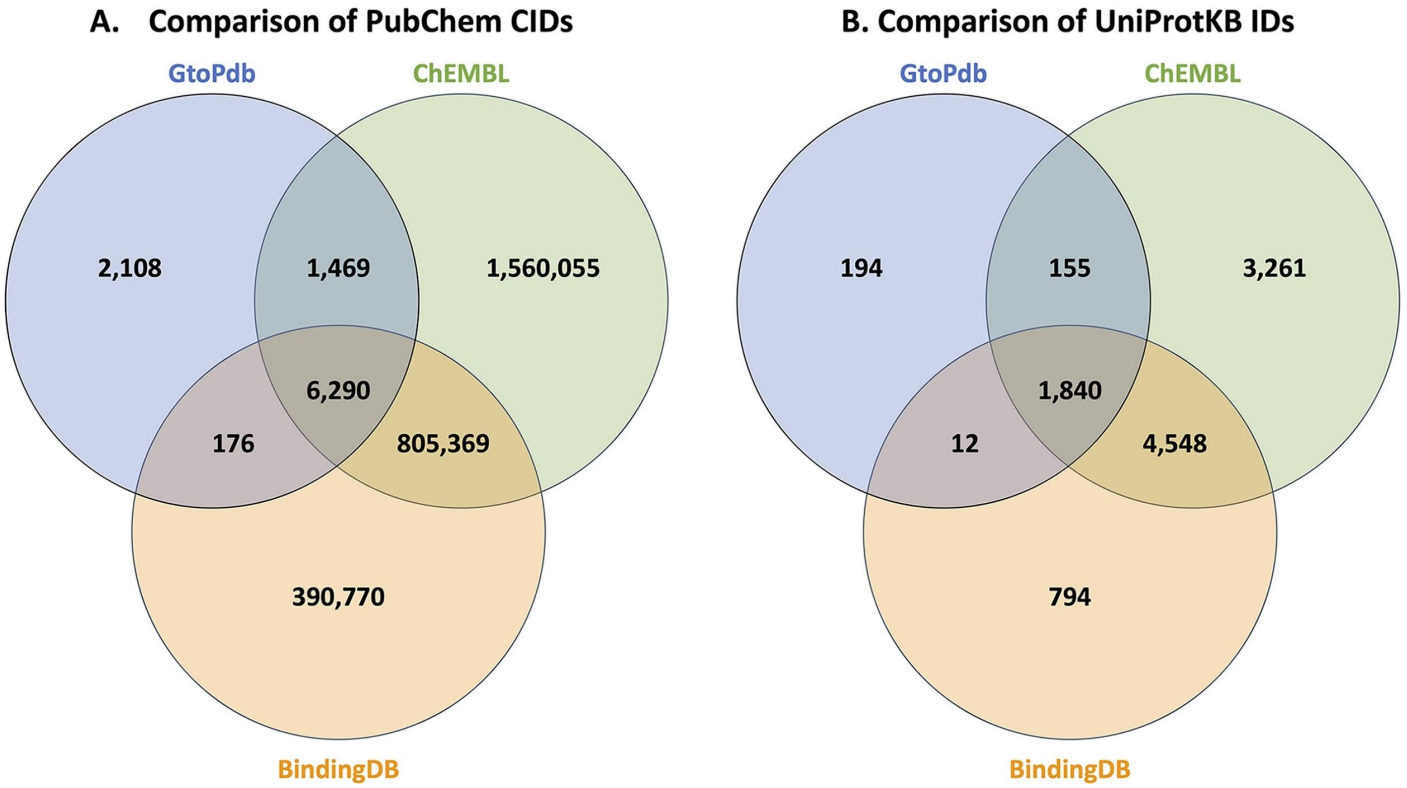
Below are the metrics for UniProt 2023_02 chemistry sources. The context for these has been given in previous reports. They provide valuable protein < > chemistry mappings including our own targets where we have curated quantitative ligand interactions of generally < 1uM. Note that SwissLipids is the odd-man-out where the curated chemical interactions are for metabolites rather than activity modulators but nonetheless useful.

Cross-referenced databases 6 results

Download View: Cards ○ Table ◉ Customize columns Share ▾

ID	Name	Abbreviation	Category	Statistics
DB-0019	Drug and drug target database	DrugBank	Chemistry databases	5,192 UniProtKB entries 4,742 reviewed UniProtKB entries 450 unreviewed UniProtKB entries
DB-0127	BindingDB database of measured binding affinities	BindingDB	Chemistry databases	7,236 UniProtKB entries 6,413 reviewed UniProtKB entries 823 unreviewed UniProtKB entries
DB-0174	ChEMBL database of bioactive drug-like small molecules	ChEMBL	Chemistry databases	9,755 UniProtKB entries 8,623 reviewed UniProtKB entries 1,132 unreviewed UniProtKB entries
DB-0182	IUPHAR/BPS Guide to PHARMACOLOGY	GuidetoPHARMACOLOGY	Chemistry databases	2,159 UniProtKB entries 2,137 reviewed UniProtKB entries 22 unreviewed UniProtKB entries
DB-0197	SwissLipids knowledge resource for lipid biology	SwissLipids	Chemistry databases	1,398 UniProtKB entries 1,394 reviewed UniProtKB entries 4 unreviewed UniProtKB entries
DB-0239	DrugCentral	DrugCentral	Chemistry databases	2,722 UniProtKB entries 2,564 reviewed UniProtKB entries 158 unreviewed UniProtKB entries

Even though these sources have different ways of curating, it is informative to compare and contrast. Below is a Venn diagram prepared for our recently accepted NAR issue showing the comparison of PubChem CIDs and UniProtKB between GtoPdb, ChEMBL and BindingDB.



Venn diagrams showing the comparison of PubChem CIDs (A) and UniProtKB identifiers (B) between GtoPdb, ChEMBL and BindingDB. CID counts are taken using the advanced PubChem Compound search (https://www.ncbi.nlm.nih.gov/pccompound), specifying source name in the query (i.e. 'IUPHAR/BPS Guide to PHARMACOLOGY'[SourceName] NOT 'ChEMBL'[SourceName]). UniProtKB counts are taken from the UniProtKB advanced search, filtering on Cross-Reference > Chemistry Database (i.e. https://www.uniprot.org/uniprotkb?query=%28database%3Aguidetopharmacology%29+NOT+%28database%3Achembl%29). The update frequency of these cross-references may be variable depending on the sources.

Around 23% of GtoPdb compounds do not overlap with ChEMBL. ChEMBL extracts all assay data, including ADMET determinations, from a paper whereas GtoPdb usually extracts just the lead compound but will also curate reported secondary target activity. In the comparison with BindingDB, 36% of GtoPdb compounds do not overlap. BindingDB's uniqueness is mainly their patent curation; it also has an arrangement with ChEMBL from which it subsumes just the individual protein target-mapped data. GtoPdb target overlap with both ChEMBL and BindingDB is extensive, GtoPdb has 206 not in ChEMBL and 349 not in BindingDB

HGNC

We continued to use HGNC gene identifiers and names for targets in GtoPdb. In total this covers 3,000 human targets. We also use HGNC nomenclature for updating protein names and gene names as part of our regular database update process.

GPCRdb

There are 943 links from 372 GPCR protein targets in GtoPdb to GPCRdb (https://gpcrdb.org/). This gives users specific pointers to GPCRdb's detailed features, curation of mutations, sequence display toolbox and residue numbering system. There are also now links from GPCRdb and GtoPdb ligand pages following work done by GPCRdb to pick up endogenous ligand data from GtoPdb.

IUPHAR Pharmacology Education project (PEP)

The IUPHAR Pharmacology Education Project continues to be developed “as a learning resource to support education and training in pharmacological sciences” and celebrated its 7th birthday on 1st April 2023.

Financial support ended on 31.10.2023. The University of Edinburgh will continue to host the website, so that it’s still available for users.

Succession Planning

Under the stewardship of Clare Guilding (PEP Deputy Director; Newcastle University, Vice-Chair of IUPHAR’s Education Section & contributor to BPS Education and Training Committee), John Szarek and Simon Maxwell (PEP co-Directors) PEP has been integrated into the IUPHAR-ed section’s jurisdiction. We hold quarterly combined PEP/IUPHAR-ed meetings. These meetings rotate around reports from PEP, IUPHAR-ed and the Core Concepts working group.

Google Analytics data charts for PEP site usage since 1st April 2016

Google Analytics shows that user sessions continue to average >20K/month. Accumulated page views total >1.8 million.

Global Access

The website has been revised to handle the new Google Analytics 4 (GA4). This required technical input from the University of Edinburgh Drupal team who developed and now maintain the site. To date, data collection is comparable between the current Universal Analytics (UA) and the new GA4 system.

Social Media

PEP has >2000 followers (+300 since last report) of our twitter handle, @PharmacologyEd. IUPHAR-Ed & PEP have established a combined social media team, to try to increase exposure of both resources on social media.

General overview of database team activities

GtoPdb Team Interactions

For more details of previous and continuing interactions please see previous reports. Only significant changes since April 23 are reported below.

ELIXIR

Engagement continues with this important Europe-wide bioinformatics infrastructure initiative. Our involvement with ELIXIR-UK brings closer ties with other key UK bioinformatics resources and facilitates collaboration on the use of standard ontologies and identifiers. This is valuable as we continue seeking to ensure GtoPdb is a FAIR-compliant (Findable, Accessible, Interoperable, Reusable) resource.

As reported before, we have an entry in the ELIXIR bio-tools directory as one of the official UK ELIXIR Node Services and part of the Excelerate initiative.

Public Engagement and Promotion

BPS/BHF Drug Targets in Cardiovascular Disease Webinar

A free-webinar was held on 18th April 2023, hosted by the British Society of Pharmacology and the British Heart Foundation on 'Drug Targets for Cardiovascular Disease: Developing a portal into the Guide to Pharmacology for Cardiovascular clinical and basic researchers.

The aim was to build on the work of the GtoPdb and bring together established leaders in the cardiovascular field to discuss the latest updates in drug development within their area, and the impact that nomenclature and access to tool compounds can have on this.

Presentations were made by Prof. Steve Alexander, Prof. Jamie Davies & Prof. Anthony Davenport

WCP 2023

The 19th World Congress of Basic & Clinical Pharmacology 2023 was held in Glasgow on 2-7 July 2023

Prof. Jamie Davies chaired the Drug discovery and development for Malaria symposium, which included a presentation on 'The IUPHAR/MMV Guide to Malaria Pharmacology database' given by Dr. Jane Armstrong.

Dr. Simon Harding presented poster

- The IUPHAR/BPS Guide to PHARMACOLOGY: open, accessible and expert-curated pharmacology

Dr. Chris Southan two poster presentations

- Will the correct drug please stand up? Advantages of stringent curation and PubChem tagging for approved medicines in the Guide to Pharmacology
- Challenges of curating patent data to populate the Guide to Malaria Pharmacology (GtoMPdb)

Dr. Jane Armstrong presented a poster on our collaboration with ADB.

- AntibioticDB and GtoPdb - the interconnected open access platforms to advance antibiotic research

Publications

Listed here are our most recent/upcoming publications.

The next edition (6th) of the Concise Guide to Pharmacology (2022/23) was submitted in September 2023 with online publication expected later in 2023.

In October 2023 our latest database update paper was accepted and published online in the annual Nucleic Acids Research Database Issue.

Harding SD, Armstrong JF, Faccenda E, Southan C, Alexander SPH, Davenport AP, Spedding M, Davies JA. (2023) **The IUPHAR/BPS Guide to PHARMACOLOGY in 2024**. *Nucl. Acids Res.* 2023 Oct 28:gkad944. Online ahead of print. doi: 10.1093/nar/gkad944. PMID: 37897341

An IUPHAR review 'Advances in Malaria Pharmacology and the online Guide to MALARIA PHARMACOLOGY: IUPHAR Review 38' was published:

Armstrong, J. F., Campo, B., Alexander, S. P. H., Arendse, L. B., Cheng, X., Davenport, A. P., Faccenda, E., Fidock, D. A., Godinez-Macias, K. P., Harding, S. D., Kato, N., Lee, M. C. S., Luth, M. R., Mazitschek, R., Mittal, N., Niles, J. C., Okombo, J., Ottilie, S., Pasaje, C. F. A., … Davies, J. A. (2023). Advances in malaria pharmacology and the online guide to MALARIA PHARMACOLOGY: IUPHAR review 38. *British Journal of Pharmacology*, 180(15), 1899–1929. PMID: 37197802. https://doi.org/10.1111/bph.16144

Outreach and Social Media

We use mainstream social media outlets for five primary purposes 1) outreach to potential new users and/or followers 2) informing on new features or releases 3) enhancing awareness of our publications and presentations 4) fostering contacts with our direct collaborators and other followers (including many other databases) 5) establishing reciprocity with key followers and collaborators.

Twitter

@GuidetoPHARM has, as of 6th November 2023, 5,336 followers (increased from 5,080). This platform remains useful as an alerting system for our blog posts, key papers, including from BJP, other pharmacology journals, immunology, biochemistry and medicinal chemistry, new PDB structures, etc.

Most of our Hot Topics are now first picked up from Twitter. We also engage in a discrete re-tweeting for reciprocal outreach. These include @BritPharmSoc (who are active in promoting the Concise Guide) @BrJPharmacol, @PharmRevJournal, @PRandP_Journal @IUPHAR, @PharmacologyEd @immunopaedia @cdsouthan and @mqzspa (NC-IUPHAR chair).

(NB readers of this document are most welcome to follow @GuidetoPHARM and Steve Alexander (@mqzspa) and re-tweet posts of interest).

LinkedIn

The Curation Team continues to encourage Subcommittee Chairs and collaborators to increase their reciprocal connectivity as individual LinkedIN users. This expands our collective inter-network reach for posting updates, new papers etc. (N.B. interested readers of this report are encouraged to make connection requests from GtoPdb and IUPHAR scientists they know). Our own LinkedIN group page now has 457 followers, up from 404 in April 2023.

Guide to Pharmacology Blog

Our Edinburgh blog (http://blog.guidetopharmacology.org/) has received over 1,100 visitors between Nov 2022 and Mar 2023 - an average of 222 visitors per month. Over the same period there have been 1,540 views of our blog, which gives an average views per visitor of 1.38.

The blog is our primary news feed and includes database release updates, new features, technical items or articles. Our regular posts with expert commentaries on hot topics relevant to pharmacology are particularly popular, always ranking in the top 5 posts for any given month.

Team member Chris Southan maintains his own (http://cdsouthan.blogspot.com/) where relevant posts include cross-pointers to GtoPdb.

Hot Topics

An established feature, our Hot Topics in Pharmacology track and highlight new significant papers in pharmacology and drug discovery. These are communicated to us from Subcommittee members or picked up from Social Media. For a selection we commission concise commentaries from our expert contacts.

Since April 2023 we have added 34 new hot topic articles.

Slides

We continue to provide a set of generic slides which can be used by anyone presenting or teaching on GtoPdb and a generic poster which can be printed out in various sizes and taken to meetings or handed out as flyers.

Engaging with Us

As is implicit from the Social Media section above, it is crucial to extend our external presence and impact. Thus, the more readers of this document who “connect” with us, (via whichever of the channels above they use for their own professional profile) the more our outreach extends. This also has mutual advantages. In particular re-tweets and LinkedIN likes are useful for extending the alerting network for new releases,

publications, meeting slide sets and blog posts. Note also that each time you either save one of our publications to your own Mendeley account or mention it in a tweet, blog or PubMed commons comment (but make sure you specify a DOI or PubMed link for the auto-indexing) the Altmetrics score.