

# NC-IUPHAR

---

Annual Report

2013/14



International Union of Basic  
and Clinical Pharmacology

## Background

NC-IUPHAR was initiated in 1987 at the Xth International Congress of Pharmacology. In 1989, the Executive Committee of IUPHAR named Paul Vanhoutte (Hong Kong) as chairman of a revised and enlarged committee. This committee energetically expanded its activities and the number of subcommittees (to 33), eventually producing the first official compendium on the occasion of the XIIIth International Congress of Pharmacology at Munich in 1998. Robert Ruffolo (USA) was Chairman of NC-IUPHAR from 1998-2002. Michael Spedding (France) became Chairman in 2002 and was elected again in 2006 and 2010.

NC-IUPHAR and its partners are developing a knowledge environment that will enable students and scientists in academia and industry, working in areas related to pharmacology and drug/target research, to exploit the full potential of the considerable amount of information on drug action available in the published scientific literature. This knowledge environment will be a valuable tool for basic and clinical scientists seeking new approaches for drug discovery research, and the diagnosis and treatment of disease, and a valuable teaching resource for students of pharmacology and translational medicine.

NC-IUPHAR has the objectives of:

1. Issuing guidelines for the nomenclature and classification of all the (human) biological targets, including all the targets of current and future prescription medicines;
2. Facilitating the interface between the discovery of new sequences from the Human Genome Project and the designation of the derived entities as functional biological targets and potential drug targets;
3. Designating polymorphisms and variants which are functionally important;
4. Developing an authoritative and freely available, global online resource, the IUPHAR database (<http://www.iuphar-db.org>), which is now accessible via the Guide to PHARMACOLOGY portal (<http://www.guidetopharmacology.org>), with a remit to:
  - provide access to data on all known biological targets;
  - enable students and scientists in academia and industry, working in areas related to pharmacology and drug/target research, to exploit the full potential of the considerable amount of information on drug action available in the published literature;
  - provide an entry point into the pharmacological literature for basic and clinical scientists from other disciplines;
  - provide an integrated educational resource with access to high quality training in the principles of basic and clinical pharmacology and techniques;
  - foster innovative drug discovery.

## Chairman's Statement

2013/14 was another year of remarkable progress for NC-IUPHAR in building our long-term foundations, in line with our strategic objectives.

The immense recent growth of drug target knowledge, including their crystal structures, has been a major support to drug discovery. This includes use of both the IUPHAR classifications and the database. We are approaching the point of defining of nearly all potentially druggable sites encoded by the human genome. However, drug discovery success has not grown at the same rate as our knowledge of drug targets. This is partly due to the exponentially-increasing number of drug-related variables as well as a rapidly increasing knowledge of receptor polymorphisms, which may be crucial in disease states, and also contribute to controversy. The highlighting of these variables *via* groups of experts has been shown to be a first step towards controlling them. In the Guide to PHARMACOLOGY, such identification and highlighting is the result of expert-driven analysis using our (~90) subcommittees. The original IUPHAR database has now been subsumed into the Guide to PHARMACOLOGY as a necessary step because of our commitment to cover all data-supported potential drug targets.

A collaboration with the British Pharmacological Society (BPS) has also produced 'The Concise Guide to PHARMACOLOGY', the successor to the BPS Guide to Receptors and Channels (GRAC). This will be a biennial snapshot of the concise target family summaries in the database, published as a series of PDFs as desktop reference

guides. This has been a major effort of the database team in 2013/14. They have also made significant improvements and enhancements to the web interface and database. There are now a total of 2538 proteins presently in the database, 6245 ligands, 663 approved drugs, 554 radioactive ligands, 41244 binding constants, 374 targets mapped to approved drugs, ~450 kinases with pharmacology.

Thanks to the attendees, the twice yearly NC-IUPHAR meetings (now in Edinburgh and Paris) have been scientifically exciting, administratively effective - and kept to time! The Grant-holders' meetings every two months have also kept the Wellcome grant on track. The management structure, with input from IUPHAR exec, BPS, and input from ASPET, ASCEPT and the Japanese Pharmacological Society, is functioning well.

The database team now consists of five full-time staff with a part-time administrator, thanks to the agreement between IUPHAR, the BPS, the Wellcome Trust and the University of Edinburgh. This has boosted our capacity as evidenced by the expanded number of subcommittees they are now the nexus of. As the latest recruit, Chris Southan brings a new dimension to our chemistry and bioinformatics. The database team is efficient, highly motivated and a great credit to Tony Harmar, who has built up this team over the decade and a half that we have been working together. Tony is not only the driver of the database team but also a great friend, and we all feel for him in his current illness – this is the only real black cloud in 2013/14 and we wish him, Jillian and their boys the best of health possible in the coming year. It is also important to thank Jamie Davies and Gareth Leng of the University of Edinburgh for their engagement to cover Tony's physical (but neither computing, nor motivational!) absences over the past year. We are especially thankful to Jamie who has agreed to replace Tony as the Principal Investigator for the Wellcome Grant.

Good health and luck for 2014.



**Michael Spedding**  
Chairman

## Future directions for NC-IUPHAR

Major efforts continue to define the main variables in drug/receptor interactions including the parameters that can lead to variation in receptor function and pharmacology (*i.e.* biased signalling, splice variation, hetero-oligomerisation, allosteric modulation, post-translational modification, linkage to multiple signalling cascades). These areas are of great interest because they may considerably expand the repertoire of potential targets for drug development, and are under evaluation by working groups, which will lead to a number of reports about issues which are of crucial importance for pharmacology.

Several exciting projects around target validation have been initiated in the past two years, and these are at various stages of advancement. These including the characterisation of the enzymes involved in epigenetics (*e.g.* histone-modifying enzymes), as well as kinases, transporters, non-coding RNAs (initiative with HGNC and miRBase) and antibodies (initiative with IMGT/mAb-DB and the Antibody Society). Subcommittees have been formed to address these areas (see Appendix II) and articles have been commissioned for publication in *British Journal of Pharmacology*. The epigenetics review has been submitted to BJP. The kinase section of the database is now established as announced in the November 2013 newsletter.

However, future progress is essentially dependent on funding for our long-term objectives. We have consulted with many pharma companies and, it is evident that, while they do not have as much funding as in the last decade, we can play critical roles in capturing the pharmacology of the new research areas, setting up precompetitive expert academic/industrial committees to ensure that the main difficulties and variables in a given approach can be overcome, with *validated* data. Pharmacological training is also essential, at a time when the top ten pharma lost

89000 jobs over the last 3 years.

Another important new direction is supporting the new IUPHAR Immunopharmacology Section in defining the immunological/inflammatory targets in disease states, with their main pharmacology. We are applying for a specific funding of an action in Neuropharmacology/neuroimmunology, this is partly as a result of a collaboration with the European College of Neuropsychopharmacology (ECNP) and members of the Nomenclature Task Force for drugs in psychiatry. There is a long way to go but, as a first strategic step, we are collating the drugs in development for Alzheimer's and several examples (in conjunction with ECNP) in psychiatry, data trawling, and linking with expert subcommittees. Thus we would not only be able to regroup targets by type but also by therapeutic indication. This would be of great use to patient groups.

For the 2014 World Congress of Pharmacology in Cape Town, we will have 6 symposia with NC-IUPHAR connections (and 6 members will present plenary lectures). We are also preparing a section on drug targets for Malaria.

Working with the University of Edinburgh Drupal Website Service, and with funding from ASPET, we hope, with Simon Maxwell, to contribute to an education portal that will be closely linked with the IUPHAR/BPS Guide to PHARMACOLOGY. It will provide access to high quality training in the principles and techniques of basic and clinical pharmacology.

## Organisation

### Core committee

The core committee of NC-IUPHAR is listed in Appendix I. The biannual core NC-IUPHAR meetings are themed and we have established an alliance with the Japanese Pharmacology Society who pay the travel for two members\*, but who are invited according to the meeting themes.

### Corresponding Members

In order to broaden the expertise of the core committee, the number of corresponding members (see Appendix I) has been further increased, to include Roland Staal (Lundbeck). Corresponding members attend selected meetings of NC-IUPHAR and include representatives of the major pharma companies.

### Evolving Pharmacology Group

Anthony Davenport leads a group (see Appendix I) which monitors the 'de-orphanisation' of GPCRs. Particularly important and timely breakthroughs are included in the Hot Topics section of the database along with email alerts.

### Clinical Translational Pharmacology Group

In order to provide advice on the translational aspects of receptor pharmacology, a subgroup (see Appendix I) of clinical pharmacologists (core member, Sir Colin Dollery) discuss how best to respond to the wishes of our clinical colleagues and to translate activity at drug target sites to clinical efficacy.

### Subcommittees

Chairpersons (see Appendix II) propose a list of experts, ratified by NC-IUPHAR, to ensure adequate representation of the field. The chairperson of each subcommittee plays a critical role co-ordinating the actions of the subcommittee, organising meetings, finalising documents and the website pages. However, we encourage postdocs to join the subcommittee, as chairs simply do not have enough time to fill in the various template fields - postdocs can therefore get publication credits, and several NC-IUPHAR publications have become citation classics. The h-index of IUPHAR is >60. The subcommittees meet to establish consensus on classification, and to ensure that the NC-IUPHAR guidelines are complied with. We now have more than 90 subcommittees (see Appendix II).

# Publications and Outreach

## Recent publications

NC-IUPHAR benefits from a privileged relationship with ASPET and BPS, with core nomenclature articles appearing in *Pharmacological Reviews*, while in a new series of general 'state-of-the-field' review articles are published (alongside database updates) in the *British Journal of Pharmacology*.

Four NC-IUPHAR nomenclature articles (see Appendix III) have appeared in *Pharmacological Reviews* (Editor, Eliot Ohlstein) so far during the 2012/13 period, reflecting the activity of NC-IUPHAR. In addition, four NC-IUPHAR commissioned reviews for the *British Journal of Pharmacology* (Editor-in-Chief, Ian McGrath) have recently been accepted (see Appendix III).

## Newsletter

The biannual NC-IUPHAR newsletter had a major makeover and was distributed in the first week of November 2013, through a mailing list (using MailChimp - Email Marketing and Email List Manager software) comprising all IUPHAR member societies, NC-IUPHAR subcommittees and collaborators, pharmacology departments worldwide, and database users who have signed-up to receive news alerts; and was made available for download from the Guide to PHARMACOLOGY homepages. The newsletter was also advertised on social media and the RSS feed.

## Representation of NC-IUPHAR at conferences and meetings

The activities of NC-IUPHAR have been promoted by NC-IUPHAR representatives at the following conferences and meetings during the past year:

- Joint FEBS/Biochemical Society Focused Meeting; Exploring kinomes: pseudokinases and beyond, Cambridge, March 2013;
- The 6th International Biocuration Conference (International Society for Biocuration), Cambridge, April 2013;
- Semantic Web Application and Tools 4 Life Science, Edinburgh 2013;
- BPS Pharmacology 2013 meeting, London, December 2013.

### Upcoming:

- Edinburgh Neuroscience Day, Edinburgh, March 2014;
- The 7th International Biocuration Conference (International Society for Biocuration), Toronto, April 2014;
- The Barcelona GPCR Spring Conference 2014, GPCRDB Satellite Meeting, Barcelona, April 2014;
- World congress of Pharmacology 2014, Cape Town, South Africa, July 2014;
- BPS Pharmacology 2014 meeting, London, December 2014.

## Wikipedia pages

The Wikipedia page for the Guide to PHARMACOLOGY has been updated.

## Social media

We use social media sites to further the outreach of the IUPHAR/BPS Guide to PHARMACOLOGY, and to keep existing users updated.

- **Facebook:** These pages are updated with regular features, database news and links to papers on topics relevant to the database content. Regular features include 'Drug of the week' featuring a profile on one of our ligands, 'Website tip of the week', highlighting specific content or features of the sites and 'Word Cloud of the week' displaying an eye-catching graphic created from key words from a particular target family page. Facebook users are able to 'Like' the databases and the individual items posted by the curators.
- **Twitter:** Updates to our feeds include a 'at-a-glance' version of the regular features on our Facebook pages, 're-tweets' of items posted by our ~360 followers and Twitter users we follow, and tweets about key papers 'Following' various other databases, publications, suppliers and individuals working in the fields of pharmacology and bioinformatics is a useful marketing tool for the databases (so please follow us).
- **LinkedIn:** The Curation Team and Committee Chairs have increased their reciprocal connectivity over 2013

and have thereby significantly extended the collective inter-network outreach for posting major updates.

- **Blogging:** The new 'guidetopharmacology blog' (<http://blog.guidetopharmacology.org/>) allows the database team to share feature developments, technical updates, articles or events at a greater level of detail and cross-linking than shorter postings typical of the other three networks (guest posts are welcome).

## The Guide to PHARMACOLOGY web portal, now incorporating the IUPHAR Database

The Guide to PHARMACOLOGY (<http://www.guidetopharmacology.org>) is a new open access resource providing pharmacological, chemical, genetic, functional and pathophysiological data on the targets of approved and experimental drugs. Created under the auspices of the IUPHAR and the BPS, the portal provides concise, peer-reviewed overviews of the key properties of a wide range of established and potential drug targets (G protein-coupled receptors, nuclear hormone receptors, voltage- and ligand-gated ion channels, enzymes, catalytic receptors and transporters) and their rodent orthologues, with in-depth information for a subset of important targets. The resource is the result of curation and integration of data from the IUPHAR Database (<http://www.iuphar-db.org/>) and the published 5<sup>th</sup> Edition of the BPS 'Guide to Receptors and Channels' (GRAC) compendium. The data are derived from a global network of expert contributors, and the information is extensively linked to relevant databases, including ChEMBL, DrugBank, Ensembl, PubChem, UniProt and PubMed. Each of the ~6000 small molecule and peptide ligands is annotated with manually curated 2D chemical structures or amino acid sequences, nomenclature and database links. Future expansion of the resource will complete the coverage of all the targets of currently approved drugs and future candidate targets, alongside educational resources to guide scientists and students in pharmacological principles and techniques. The Edinburgh portal and database is run by one full-time database developer, four full-time curators and one part-time project administrator, with joint funding from IUPHAR and BPS, and a three year grant from The Wellcome Trust (initiated in November 2012). Consequent to Professor Tony Harmar's recent retirement, Professor Jamie Davies is now the new Principal Investigator for the Wellcome grant.

### Current and future work

Our long-term aims are to provide:

- an authoritative synopsis of the complete landscape of current and research drug targets, providing quantitative pharmacological information on all of the (human) targets of current prescription medicines and other likely targets of future small molecule drugs;
- an accurate source of information on the basic science underlying drug action, and rigorous curation of the structures and nomenclature of the chemical substances in the resource, shared and refined in collaboration with other databases, including ChEMBL, ChemSpider, DrugBank and PubChem with whom we have strong ties;
- guidance to researchers in selecting appropriate compounds for in vitro and in vivo experiments, including commercially available pharmacological tools for each target;
- information on clinically used drugs in the resource (e.g. approval date, ADME, molecular mechanism of action, summary of clinical use);
- an integrated educational resource for researchers, students and the interested public (seed funding provided by ASPET).

A summary of recent improvements to the Guide to PHARMACOLOGY has been published in *Nucleic Acids Research* (see Pawson, *et al.* 2014 reference in Appendix III).

## Recent web interface and database developments (2013/14)

- 1. Web hosting:** The University of Edinburgh Information Services have moved our databases to a University hosting environment. The new server hosts three separate environments. The development database is available on [dev.guidetopharmacology.org](http://dev.guidetopharmacology.org) and [dev.iuphar-db.org](http://dev.iuphar-db.org). There is also a test environment for testing of updates to the website and database structure before release to the development and public sites.
- 2. New features of the web interface and database:**
  - Approved drugs tab for the ligand lists;
  - New 'on the fly' connections to PubMed for drug names and Google for InChi chemical searches;
  - Updated tutorial and help pages;
  - Updated table of databases we link to, and who link back to us;
  - Update ligand and target search functionality; additional search functionality enables retrieval of implicated ligands and targets by disease name (e.g. a search for Alzheimer's disease returns the following result; <http://tinyurl.com/ns83e5r>);
  - New table of database statistics on the 'About' page (see Appendix IV);
  - Update on the new kinase section of the database:
    - Coverage is now complete for all the human protein kinases and selected lipid kinases, including genomic and structural information for all the kinases;
    - Additional information is provided on the 24 clinically-used kinase inhibitors (including summaries of clinical use and ADME data);
    - Selected bioactivity data for approved kinase inhibitors;
    - Data from published screening assays by DiscoverX, EMD Millipore and Reaction Biology are also included for 71, 158 and 176 kinase inhibitors respectively. DiscoverX data include links to their TREEspot™ visualisation tool;
    - Future plans include an introduction for the database and more detailed curation for selected kinases (including mutants).
- 3. General overview of the content of the database:**
  - Concise target family summary pages are available for GPCRs, voltage-, ligand-gated, and other ion channels, nuclear hormone receptors, catalytic receptors, transporters and enzymes;
  - A new section on 'Other protein targets' has now been added;
  - More detailed views are available for all GPCRs, voltage- and ligand-gated ion channels, and nuclear hormone receptors;
  - We have introduced a new expandable tree navigation scheme for all the targets in the resource.
- 4. Database page updates (2013/14):**  $\alpha$ -adrenoceptors, Adhesion GPCRs, Angiotensin, Apelin, Bombesin, Formylpeptide, Free fatty acid, Galanin, Ghrelin, Leukotriene, Metabotropic glutamate, Neurotensin, P2Y, Prokineticin, Prostanoid, QRFP, Trace amine; Kca, NaV, TRP, CatSper and Two-pore, CNG channels.
- 5. New targets in the database:**
  - **Proteases and hydrolases:** the database now includes pages with genomic and structural information for 175 proteases and 14 hydrolases with activity records in ChEMBL. Detailed ligand activity (Ki or IC50) mapping has been curated for 46 proteases and 14 hydrolases for either approved prodrugs, drugs, clinical candidates or selected research compounds. Future plans include an introduction for the database with inputs from the new subcommittee. Clinical candidates and research compound mappings can be extended for these classes, depending on overall priorities for target expansion;
  - **New epigenetics targets:** Histone-modifying proteins, including bromodomain-containing proteins and DiscoverX BROMOScan screening data are being incorporated into the database, as will data from the upcoming IUPHAR review article;
  - **New concise summary pages are now available for:**
    - Catalytic Receptors:
      - Integrins
    - Transporters:

- SLC52 family of riboflavin transporters;
- Enzymes involved in:
  - Acetylcholine turnover;
  - Catecholamine turnover;
  - Ceramide turnover;
  - GABA turnover;
  - Sphingosine 1-phosphate turnover;
  - Glycerophospholipid turnover) now includes Phosphatidylinositol kinases and Phosphatidylinositol phosphate kinases.
- The new target class of 'Other protein targets' includes:
  - Fatty acid-binding proteins;
  - Sigma receptors.

#### 6. Ligand updates:

- 35 new approved antibodies with IMGT/mAb-DB crosslinks;
- Approved drugs are now annotated with date of approval and molecular mechanism of action supported by in vitro data, typically  $K_i$ ,  $IC_{50}$  or  $K_d$ ;
- Links to clinical trials and PubMed literature for INNs.

#### 7. Hosted lists:

- The website now hosts selected target and drug lists for download with brief descriptions (<http://www.guidetopharmacology.org/lists.jsp>).

#### 8. New external database links and collaborations:

- PubChem - We are working to increase visibility of our data on PubChem and plan to take advantage of its new features such as data views for targets/PubMed papers/patents, APIs for programmatic access, and JavaScript widgets for integration on 3rd party sites We also plan to increase prominence by introducing 'IUPHARXXXX' as a PubChem synonym. As well as bioassay data from Guide to PHARMACOLOGY, we plan to add information which will allow the searching of data by target and action;
- Genecards/Malacards - interactions between our databases, including setting up reciprocal links between our targets and ligands on GeneCards and MalaCards, as well as between diseases on MalaCards;
- Royal Society of Chemistry/ChemSpider - links between the IUPHAR/BPS Guide to PHARMACOLOGY and both RSC and ChemSpider as the RSC's new open innovation e-platform for early stage drug development are being explored;
- GPCRDB crosslinks;
- IMGT/mAb-DB crosslinks.

## Producing 'The Concise Guide to PHARMACOLOGY – 2013/14'

A major effort of the database team in 2013/14 has been the production of 'The Concise Guide to PHARMACOLOGY- 2013/14' (which replaces GRAC), which will be a biennial snapshot of the concise target family summaries in the database, published as a series of PDFs, and intended to be a quick desktop reference guide. Details of the publication process:

- The Editors of the 'Concise Guide' are Steve Alexander, Tony Harmar and John Peters;
- The 2013/14 edition of the 'Concise Guide' was published in December 2013;
- Over 170 expert collaborators contributed to updating the concise target family summaries in the database in preparation for publication.
- It was produced directly from the HTML of the database which was generated on 27<sup>th</sup> September 2013 following an extensive round of updates to the database entries;
- This strategy was a significant departure from previous publications of GRAC, and intended to streamline the publication process in the future and enhance the final product;
- The PDF files are in landscape format, and include embedded hyperlinks from gene names and UniProt IDs direct to HGNC and UniProt entries respectively, from target and ligand names direct to the IUPHAR/BPS Guide to PHARMACOLOGY, and from PubMed IDs direct to PubMed citations;
- A rolling programme of updates to the concise summaries in the database will now also be implemented in preparation for future editions of the 'Concise Guide'.

## Acknowledgements

We are very grateful to our sponsors. We are also immensely grateful for the work done by our colleagues on NC-IUPHAR and all the contributing chairs and subcommittees. It is a privilege to be associated with so much work freely given for the good of science. We repeat that NC-IUPHAR is a global resource and all scientists are welcome to contribute (contact: [curators@guidetopharmacology.org](mailto:curators@guidetopharmacology.org); [enquiries@guidetopharmacology.org](mailto:enquiries@guidetopharmacology.org)).

# Appendix I: NC-IUPHAR membership

## Chair

Michael Spedding, France

## Vice Chairs

Anthony Davenport, UK - Chairman Evolving Pharmacology

Anthony Harmar, UK - Database Chairman

Rick Neubig, USA - GPCRs

Eliot Ohlstein, USA - Editor

## Members

Steve Alexander, UK

Thomas Bonner, USA

William Catterall, USA

Arthur Christopoulos, Australia

Sir Colin Dollery, UK

Doriano Fabbro, Switzerland

Kozo Kaibuchi, Japan\*

Yoshikatsu Kanai, Japan\*

John Peters, UK

Jean-Philippe Pin, France

## Ex Officio

Patrick du Souich, Canada (Clinical) - IUPHAR President

Sam Enna, USA - IUPHAR Secretary-General

Urs Ruegg, Switzerland - IUPHAR Treasurer

Simon Maxwell, UK - Educational Site Project Leader

Jamie Davies, UK - Database Principal Investigator

Joanna Sharman, UK - Database Developer

Adam Pawson, UK - Senior Database Curator

Helen Benson, UK - Database Curator

Elena Faccenda, UK - Database Curator

Christopher Southan, Sweden - Chemical Curator

Veronika Divincova, UK - Project Administrator

Matt Wright, UK - representing HGNC

## Past Chairs (Ex Officio)

Paul Vanhoutte, Hong Kong

Bob Ruffolo, USA

## Corresponding Members

Susan Amara, USA

Michel Bouvier, Canada

Stephen Charlton, UK

Moses Chao, USA

Steven Colletti, USA

Graham Collingridge, UK

Sue Duckles, USA

Richard Eglén, UK

Steven Foord, UK

Debbie Hay, New Zealand

Yu Huang, Hong Kong

Allyn Howlett, USA

Franz Hofmann, Germany

Ad Ijzerman, The Netherlands

Michael Jarvis, USA

Terry Kenakin, USA

Janos Kiss, Hungary

Chris Langmead, Australia

Vincent Laudet, France

Alistair Mathie, UK

Ian McGrath, UK

Graeme Milligan, UK

Stefan Offermanns, Germany

Richard Olsen, USA

Helgi Schiöth, Sweden

Graeme Semple, USA

David Searls, USA

Roland Staal, USA

Bart Staels, France

Mary Vore, USA

## Clinical Translational Pharmacology Group (core member Sir Colin Dollery)

Ed Bullmore, UK

Robert Dow, UK

Garrett Fitzgerald, USA

Alex Phipps, UK

Patrick du Souich, Canada

David Webb, UK

Don Birkett, Australia

# Appendix II: NC-IUPHAR Subcommittees (listing of chairs)

## G protein-coupled receptors Subcommittees

5-Hydroxytryptamine: Nick Barnes, John Neumaier	Acetylcholine (muscarinic): Arthur Christopoulos	Adenosine: Adriaan Izjerma
alpha <sub>1</sub> -adrenoceptors: Dianne Perez	alpha <sub>2</sub> -adrenoceptors: Lutz Hein	Angiotensin: Sadashiva Karnik
Apelin: Anthony Davenport	beta-adrenoceptors: Terry Hébert	Bile acid: Anthony Davenport
Bombesin: Robert Jensen	Bradykinin: VACANT	Calcitonin: Debbie Hay, David Poyner
Calcium-sensing: Ed Brown, Hans Bräuner-Osborne	Cannabinoid: Roger Pertwee, Allyn Howlett	Chemokine: Philip Murphy
Cholecystokinin: Laurence Miller	Complement peptide: Peter Monk	Corticotropin-releasing factor: Richard Hauger, Frank Dautzenberg
Dopamine: Raul Gainetdinov	Endothelin: Anthony Davenport	Estrogen (G protein coupled): Richard Neubig
Formylpeptide family: Richard Ye	Free fatty acid: Graeme Milligan	Frizzled: Gunnar Schulte
GABA <sub>B</sub> : Bernhard Bettler	Galanin: Andrew Gundlach	Ghrelin: Birgitte Holst
Glucagon receptor family: Laurence Miller	Glycoprotein hormone: VACANT	Gonadotrophin-releasing hormone: Adriaan Izjerma
Histamine: Paul Chazot, Rob Leurs	Hydroxycarboxylic acid: Stefan Offermanns	Kisspeptin: Anthony Davenport
Leukotriene: Magnus Bäck	Lysophospholipid (LPA): Jerold Chung	Lysophospholipid (S1P): Sarah Spiegel
Melanin-concentrating hormone: Jean-Louis Nahon	Melanocortin: Tung Fong, Helgi Schiöth	Melatonin: Ralf Jockers
Metabotropic glutamate: Jean-Philippe Pin	Motilin: Anthony Davenport	Neuromedin U: Gary Willars
Neuropeptide FF/neuropeptide AF: Jean-Marie Zajac	Neuropeptide S: Girolamo Calò	Neuropeptide W/neuropeptide B: Anthony Davenport
Neuropeptide Y: Dan Larhammar	Neurotensin: Jean Mazella	Opioid: Larry Toll
Orexin: Christopher Winrow	P2Y: Geoffrey Burnstock	Parathyroid hormone: Ted Usdin
Peptide P518: Jerome Leprince	Platelet-activating factor: VACANT	Prokineticin: Philippe Rondard
Prolactin-releasing peptide: Helgi Schiöth	Prostanoid: Robert Jones	Protease-activated: VACANT
Relaxin family peptide: Roger Summers	Relaxin-like: Nick Barker	Somatostatin: Stephan Schulz
Tachykinin: Susan Leeman, Steven Douglas	Trace amine: Janet Maguire	Thyrotropin-releasing hormone: Marvin Gershengorn
Urotensin: Hubert Vaudry	Vasopressin and oxytocin: Bernard Mouillac	VIP and PACAP: Anthony Harmar

## Ligand-gated ion channels Subcommittees

*John Peters (Liaison for all LGIC subcommittees)*

5-HT<sub>3</sub>: John Peters  
 GABA<sub>A</sub>: Richard Olsen  
 Glycine: Joseph Lynch  
 Ionotropic glutamate: Graham Collingridge  
 Nicotinic acetylcholine: Neil Millar  
 P2X: Charles Kennedy  
 ZAC: Timothy Hales

## 'Concise Guide to PHARMACOLOGY' Editors

Stephen Alexander, Anthony Harmar, John Peters

## Voltage-gated ion channels Subcommittees

*William Catterall (Liaison for all VGIC subcommittees)*

Calcium-activated potassium: George Gutman  
 CatSper and Two-Pore: David Chapman  
 Cyclic nucleotide-regulated: Martin Biel  
 Inwardly rectifying potassium: Yoshihiro Kubo  
 Transient Receptor Potential: David Clapham  
 Two-P potassium: Steven Goldstein  
 Voltage-gated calcium: William Catterall  
 Voltage-gated potassium: George Gutman  
 Voltage-gated sodium: William Catterall

## Nuclear hormone receptors Subcommittees

*John Cidlowski and Thomas Burris (Liaisons for all NHR subcommittees)*

NHR subcommittees are being reformed

## Antibodies Subcommittee

Alex Phipps

## Drug Target and Chemistry Curation Subcommittee

Christopher Southan

## Epigenetics Subcommittee

Rabinder Prinjha

## Kinases Subcommittee

Doriano Fabbro

## Non-coding RNAs Subcommittee

Matt Wright

## Pattern Recognition Receptors Subcommittee

Clare Bryant

## Proteases Subcommittee

Anthony Turner

## Transporters Subcommittee

Stephen Alexander

## Appendix III: Publications

### NC-IUPHAR publications in *Pharmacological Reviews* (2013/14)

Klos A, Wende E, Wareham KJ, Monk PN. (2013) International Union of Pharmacology. LXXXVII. Complement Peptide C5a, C4a, and C3a Receptors. *Pharmacol Rev.* 65: 500-543.

Davenport AP, Alexander SPH, Sharman JL, Pawson AJ, Benson HE, Monaghan AE, Liew WC, Mpamhanga CP, Bonner TI, Neubig RR, Pin JP, Spedding M, and Harmar AJ. (2013) International Union of Basic and Clinical Pharmacology. XXX. G-protein coupled receptor list: recommendations for new pairings with cognate ligands. *Pharmacol Rev.* 17;65(3):967-86.

Bachelier F, Ben-Baruch A, Burkhardt AM, Combadiere C, Farber JM, Graham GJ, Horuk R, Sparre-Ulrich AH, Locati M, Luster AD, Mantovani A, Matsushima K, Murphy PM, Nibbs R, Nomiyama H, Power CA, Proudfoot AE, Rosenkilde MM, Rot A, Sozzani S, Thelen M, Yoshie O, Zlotnik A. (2014) International Union of Pharmacology. LXXXIX. Update on the extended family of chemokine receptors and introducing a new nomenclature for atypical chemokine receptors. *Pharmacol Rev.* 2013 Nov 11;66(1):1-79. doi: 10.1124/pr.113.007724. Print 2014 Jan.

### NC-IUPHAR reviews in the *British Journal of Pharmacology* (2013/14)

Kenakin T. (2013) New concepts in pharmacological efficacy at 7<sup>TM</sup> receptors: IUPHAR Review 2. *Br J Pharmacol.* 168: 554-75.

Dijksterhuis JP, Petersen J and Schulte G (2013) WNT/Frizzled signaling: receptor-ligand selectivity with focus on FZD-G protein signaling and its physiological relevance. *Br J Pharmacol.* 2013 Aug 30. doi: 10.1111/bph.12364. [Epub ahead of print].

Bonner TI (2013) Should pharmacologists care about alternative splicing? :IUPHAR Review. *Br J Pharmacol.* 2014 Jan 15. doi: 10.1111/bph.12526. [Epub ahead of print].

Schulz S, Lehmann A, Kliewer A and Nagel F (2013) Fine-tuning Somatostatin Receptor Signaling by Agonist-Selective Phosphorylation and Dephosphorylation. *Br J Pharmacol.* 2014 Dec 13. doi: 10.1111/bph.12551. [Epub ahead of print].

Dollery CT. (2014) Lost in Translation (LiT): IUPHAR Review. *Br J Pharmacol.* 2014 Nov 26. doi: 10.1111/bph.12580. [Epub ahead of print].

### NC-IUPHAR publications in other journals (2013/14)

Alexander SPH, Benson HE, Faccenda E, Pawson AJ, Sharman JL, McGrath JC, Catterall WA, Spedding M, Peters JA and Harmar AJ, CGTP Collaborators. (2013) The Concise Guide to PHARMACOLOGY 2013/14. *Br J Pharmacol.* 170: 1449–1867.

Sharman JL, Benson HE, Pawson AJ, Lukito V, Mpamhanga CP, Bombail V, Davenport AP, Peters JA, Spedding M, Harmar AJ, and NC-IUPHAR. (2013) IUPHAR-DB: updated database content and new features. *Nucl. Acids Res.* 41 (Database Issue): D1083-8.

Pawson AJ, Sharman JL, Benson HE, Faccenda E, Alexander SP, Buneman OP, Davenport AP, McGrath JC, Peters JA, Southan C, Spedding M, Yu W, Harmar AJ; NC-IUPHAR (2014) The IUPHAR/BPS Guide to PHARMACOLOGY: an expert-driven knowledgebase of drug targets and their ligands. *Nucleic Acids Res.* 2014 Jan 1;42(1):D1098-106.

Pawson AJ, Sharman JL, Benson HE, Faccenda E, Spedding M, Harmar AJ (2013). The Guide to PHARMACOLOGY portal – a one-stop pharmacology shop. *Biochemist* 35: 36–39.

Davenport AP, Harmar AJ (2013) Evolving pharmacology of orphan GPCRs: IUPHAR Commentary. *Br J Pharmacol.* 2013 Oct;170(4):693-5.

### Additional Curation Team publications that include the Wellcome grant acknowledgment

Southan C, Hancock JM (2013) A tale of two drug targets: the evolutionary history of BACE1 and BACE2. *Front Genet.* 2013 Dec 17;4:293.

Southan C, Sitzmann M, Muresan S.(2013) Comparing the chemical structure and protein content of ChEMBL, DrugBank, Human Metabolome Database and the Therapeutic Target Database. *Molecular Informatics* 32, issue 11-12, Dec 2013, 881–897.

## Appendix IV: Database Statistics

Target class	Number of targets
7TM receptors	400
G protein-coupled receptors including orphans	394
Orphan G protein-coupled receptors	130
Other 7TM proteins	6
Nuclear hormone receptors	48
Catalytic receptors	223
Ligand-gated ion channels	84
Voltage-gated ion channels	142
Other ion channels	49
Enzymes	1043
Transporters	505
Other protein targets	44
Total number of targets	2538
Chemical class	Number of ligands
Synthetic organics	3639
Metabolites	555
Endogenous peptides	703
Other peptides including synthetic peptides	1108
Natural products	166
Antibodies	41
Inorganics	33
Approved drugs	663
Withdrawn drugs	23
Drugs with INNs	990
Radioactive ligands	554
Total number of ligands	6245
Number of synonyms	52030
Number of binding constants	41244
Number of references	22291