

Cannabinoid receptors (version 2019.4) in the IUPHAR/BPS Guide to Pharmacology Database

Mary Abood¹, Stephen P.H. Alexander², Francis Barth³, Tom I. Bonner⁴, Heather Bradshaw⁵, Guy Cabraf⁶, Pierre Casellas⁷, Ben F. Cravatt⁸, William A. Devane⁶, Vincenzo Di Marzo⁹, Maurice R. Elphick¹⁰, Christian C. Felder¹¹, Peter Greasley¹², Miles Herkenham⁴, Allyn C. Howlett¹³, George Kunos¹⁴, Ken Mackie¹⁵, Raphael Mechoulam¹⁶, Roger G. Pertwee¹⁷ and Ruth A. Ross¹⁸

1. Temple University, USA
2. University of Nottingham, UK
3. Sanofi Synthelabo Recherche, France
4. National Institute of Mental Health, USA
5. Indiana University, USA
6. Medical College of Virginia, USA
7. Université de Montpellier, France
8. Scripps Research Institute, USA
9. CNR Institute of Biomolecular Chemistry, Italy
10. Queen Mary University of London, UK
11. Lilly Research Laboratories, USA
12. AstraZeneca R&D Mölndal, Sweden
13. North Carolina Central University, USA
14. National Institutes of Health, USA
15. University of Washington, USA
16. Hebrew University, Israel
17. University of Aberdeen, UK
18. University of Toronto, Canada

Abstract

Cannabinoid receptors (**nomenclature as agreed by the NC-IUPHAR Subcommittee on Cannabinoid Receptors [107]**) are activated by endogenous ligands that include N-arachidonylethanolamine (**anandamide**), **N-homo- γ -linolenylethanolamine**, **N-docosatetra-7,10,13,16-enylethanolamine** and **2-arachidonoylglycerol**. Potency determinations of endogenous agonists at these receptors are complicated by the possibility of differential susceptibility of endogenous ligands to enzymatic conversion [4].

There are currently three licenced cannabinoid medicines each of which contains a compound that can activate CB₁ and CB₂ receptors [104]. Two of these medicines were developed to suppress nausea and vomiting produced by chemotherapy. These are **nabilone** (Cesamet®), a synthetic CB₁/CB₂ receptor agonist, and synthetic **Δ^9 -tetrahydrocannabinol** (Marinol®; dronabinol), which can also be used as an appetite stimulant. The third medicine, Sativex®, contains mainly **Δ^9 -tetrahydrocannabinol** and **cannabidiol**, both extracted from cannabis, and is used to treat multiple sclerosis and cancer pain.

Contents

This is a citation summary for Cannabinoid receptors in the [Guide to Pharmacology](#) database (GtoPdb). It exists purely as an adjunct to the database to facilitate the recognition of citations to and from the database by citation analyzers. Readers will almost certainly want to visit the relevant sections of the database which are given here under database links.

[GtoPdb](#) is an expert-driven guide to pharmacological targets and the substances that act on them. GtoPdb is a reference work which is most usefully represented as an on-line database. As in any publication this work should be appropriately cited, and the papers it cites should also be recognized. This document provides a citation for the relevant parts of the database, and also provides a reference list for the research cited by those parts.

Please note that the database version for the citations given in GtoPdb are to the most recent preceding version in which the family or its subfamilies and targets were substantially changed. The links below are to the current version. If you need to consult the cited version, rather than the most recent version, please contact the GtoPdb curators.

Database links

Cannabinoid receptors

<http://www.guidetopharmacology.org/GRAC/FamilyDisplayForward?familyId=13>

Introduction to Cannabinoid receptors

<http://www.guidetopharmacology.org/GRAC/FamilyIntroductionForward?familyId=13>

Receptors

CB₁ receptor

<http://www.guidetopharmacology.org/GRAC/ObjectDisplayForward?objectId=56>

CB₂ receptor

<http://www.guidetopharmacology.org/GRAC/ObjectDisplayForward?objectId=57>

References

1. Abadji V, Lin S, Taha G, Griffin G, Stevenson LA, Pertwee RG and Makriyannis A. (1994) (R)-methanandamide: a chiral novel anandamide possessing higher potency and metabolic stability. *J. Med. Chem.* **37**: 1889-93 [PMID:8021930]
2. Abood ME and Martin BR. (1992) Neurobiology of marijuana abuse. *Trends Pharmacol. Sci.* **13**: 201-6 [PMID:1604713]
3. Adam L, Salois D, Rihakova L, Lapointe S, St-Onge S, Labrecque J and Payza K. (2007) Positive allosteric modulators of CB1 receptors. *In 17th Annual Symposium of the Cannabinoids, St-Sauveur, Canada* International Cannabinoid Research Society: 86
4. Alexander SP and Kendall DA. (2007) The complications of promiscuity: endocannabinoid action and metabolism. *Br. J. Pharmacol.* **152**: 602-23 [PMID:17876303]
5. Baek JH, Zheng Y, Darlington CL and Smith PF. (2008) Cannabinoid CB2 receptor expression in the rat brainstem cochlear and vestibular nuclei. *Acta Otolaryngol.* **128**: 961-7 [PMID:19086305]
6. Banister SD, Stuart J, Kevin RC, Edington A, Longworth M, Wilkinson SM, Beinat C, Buchanan AS, Hibbs DE and Glass M *et al.* (2015) Effects of bioisosteric fluorine in synthetic cannabinoid designer drugs JWH-018, AM-2201, UR-144, XLR-11, PB-22, 5F-PB-22, APICA, and STS-135. *ACS Chem Neurosci* **6**: 1445-58 [PMID:25921407]
7. Bauer M, Chicca A, Tamborrini M, Eisen D, Lerner R, Lutz B, Poetz O, Pluschke G and Gertsch J. (2012) Identification and quantification of a new family of peptide endocannabinoids (Pepcans) showing negative allosteric modulation at CB1 receptors. *J. Biol. Chem.* **287**: 36944-67 [PMID:22952224]
8. Bayewitch M, Avidor-Reiss T, Levy R, Barg J, Mechoulam R and Vogel Z. (1995) The peripheral

- cannabinoid receptor: adenylate cyclase inhibition and G protein coupling. *FEBS Lett.* **375**: 143-7 [PMID:7498464]
9. Bayewitch M, Rhee MH, Avidor-Reiss T, Breuer A, Mechoulam R and Vogel Z. (1996) (-)-Delta9-tetrahydrocannabinol antagonizes the peripheral cannabinoid receptor-mediated inhibition of adenylyl cyclase. *J. Biol. Chem.* **271**: 9902-5 [PMID:8626625]
 10. Beltramo M, Bernardini N, Bertorelli R, Campanella M, Nicolussi E, Fredduzzi S and Reggiani A. (2006) CB2 receptor-mediated antihyperalgesia: possible direct involvement of neural mechanisms. *Eur. J. Neurosci.* **23**: 1530-8 [PMID:16553616]
 11. Ben-Shabat S, Fride E, Sheskin T, Tamiri T, Rhee MH, Vogel Z, Bisogno T, De Petrocellis L, Di Marzo V and Mechoulam R. (1998) An entourage effect: inactive endogenous fatty acid glycerol esters enhance 2-arachidonoyl-glycerol cannabinoid activity. *Eur. J. Pharmacol.* **353**: 23-31 [PMID:9721036]
 12. Blaazer AR, Lange JH, van der Neut MA, Mulder A, den Boon FS, Werkman TR, Kruse CG and Wadman WJ. (2011) Novel indole and azaindole (pyrrolopyridine) cannabinoid (CB) receptor agonists: design, synthesis, structure-activity relationships, physicochemical properties and biological activity. *Eur J Med Chem* **46**: 5086-98 [PMID:21885167]
 13. Bouaboula M, Bourrié B, Rinaldi-Carmona M, Shire D, Le Fur G and Casellas P. (1995) Stimulation of cannabinoid receptor CB1 induces krox-24 expression in human astrocytoma cells. *J. Biol. Chem.* **270**: 13973-80 [PMID:7775459]
 14. Bouaboula M, Poinot-Chazel C, Bourrié B, Canat X, Calandra B, Rinaldi-Carmona M, Le Fur G and Casellas P. (1995) Activation of mitogen-activated protein kinases by stimulation of the central cannabinoid receptor CB1. *Biochem. J.* **312 (Pt 2)**: 637-41 [PMID:8526880]
 15. Bouaboula M, Poinot-Chazel C, Marchand J, Canat X, Bourrié B, Rinaldi-Carmona M, Calandra B, Le Fur G and Casellas P. (1996) Signaling pathway associated with stimulation of CB2 peripheral cannabinoid receptor. Involvement of both mitogen-activated protein kinase and induction of Krox-24 expression. *Eur. J. Biochem.* **237**: 704-11 [PMID:8647116]
 16. Bowles NP, Karatsoreos IN, Li X, Vemuri VK, Wood JA, Li Z, Tamashiro KL, Schwartz GJ, Makriyannis AM and Kunos G *et al.*. (2015) A peripheral endocannabinoid mechanism contributes to glucocorticoid-mediated metabolic syndrome. *Proc. Natl. Acad. Sci. U.S.A.* **112**: 285-90 [PMID:25535367]
 17. Breivogel CS, Sim LJ and Childers SR. (1997) Regional differences in cannabinoid receptor/G-protein coupling in rat brain. *J. Pharmacol. Exp. Ther.* **282**: 1632-42 [PMID:9316881]
 18. Brown SM, Wager-Miller J and Mackie K. (2002) Cloning and molecular characterization of the rat CB₂ cannabinoid receptor. *Biochim. Biophys. Acta* **1576**: 255-264 [PMID:12084572]
 19. Buckley NE, McCoy KL, Mezey E, Bonner T, Zimmer A, Felder CC, Glass M and Zimmer A. (2000) Immunomodulation by cannabinoids is absent in mice deficient for the cannabinoid CB(2) receptor. *Eur. J. Pharmacol.* **396**: 141-9 [PMID:10822068]
 20. Cabral GA and Staab A. (2005) Effects on the immune system. *Handb Exp Pharmacol* 385-423 [PMID:16596782]
 21. Calandra B, Portier M, Kernéis A, Delpech M, Carillon C, Le Fur G, Ferrara P and Shire D. (1999) Dual intracellular signaling pathways mediated by the human cannabinoid CB1 receptor. *Eur. J. Pharmacol.* **374**: 445-55 [PMID:10422789]
 22. Carlisle SJ, Marciano-Cabral F, Staab A, Ludwick C and Cabral GA. (2002) Differential expression of the CB2 cannabinoid receptor by rodent macrophages and macrophage-like cells in relation to cell activation. *Int. Immunopharmacol.* **2**: 69-82 [PMID:11789671]
 23. Chakrabarti A, Onaivi ES and Chaudhuri G. (1995) Cloning and sequencing of a cDNA encoding the mouse brain-type cannabinoid receptor protein. *DNA Seq.* **5**: 385-8 [PMID:8777318]
 24. Childers SR and Deadwyler SA. (1996) Role of cyclic AMP in the actions of cannabinoid receptors. *Biochem. Pharmacol.* **52**: 819-27 [PMID:8781498]
 25. Chin CN, Lucas-Lenard J, Abadji V and Kendall DA. (1998) Ligand binding and modulation of cyclic AMP levels depend on the chemical nature of residue 192 of the human cannabinoid receptor 1. *J. Neurochem.* **70**: 366-73 [PMID:9422383]

26. Chin CN, Murphy JW, Huffman JW and Kendall DA. (1999) The third transmembrane helix of the cannabinoid receptor plays a role in the selectivity of aminoalkylindoles for CB₂, peripheral cannabinoid receptor. *J. Pharmacol. Exp. Ther.* **291**: 837-44 [PMID:10525107]
27. Das SK, Paria BC, Chakraborty I and Dey SK. (1995) Cannabinoid ligand-receptor signaling in the mouse uterus. *Proc. Natl. Acad. Sci. U.S.A.* **92**: 4332-6 [PMID:7753807]
28. Del Rio C, Cantarero I, Palomares B, Gómez-Cañas M, Fernández-Ruiz J, Pavicic C, García-Martín A, Luz Bellido M, Ortega-Castro R and Pérez-Sánchez C *et al.*. (2018) VCE-004.3, a cannabidiol aminoquinone derivative, prevents bleomycin-induced skin fibrosis and inflammation through PPAR γ - and CB₂ receptor-dependent pathways. *Br. J. Pharmacol.* **175**: 3813-3831 [PMID:30033591]
29. Devane WA, Breuer A, Sheskin T, Järbe TU, Eisen MS and Mechoulam R. (1992) A novel probe for the cannabinoid receptor. *J. Med. Chem.* **35**: 2065-9 [PMID:1317925]
30. Devane WA, Hanus L, Breuer A, Pertwee RG, Stevenson LA, Griffin G, Gibson D, Mandelbaum A, Etinger A and Mechoulam R. (1992) Isolation and structure of a brain constituent that binds to the cannabinoid receptor. *Science* **258**: 1946-1949 [PMID:1470919]
31. Di Marzo V, Bisogno T, De Petrocellis L, Brandi I, Jefferson RG, Winckler RL, Davis JB, Dasse O, Mahadevan A, Razdan RK and Martin BR. (2001) Highly selective CB₁ cannabinoid receptor ligands and novel CB₁/VR1 vanilloid receptor "hybrid" ligands. *Biochem. Biophys. Res. Commun.* **281**: 444-451 [PMID:11181068]
32. Di Marzo V, De Petrocellis L and Bisogno T. (2005) The biosynthesis, fate and pharmacological properties of endocannabinoids. *Handb Exp Pharmacol* 147-85 [PMID:16596774]
33. Edery H, Grunfeld Y, Ben-Zvi Z and Mechoulam R. (1971) Structural requirements for cannabinoid activity. *Ann. N.Y. Acad. Sci.* **191**: 40-53
34. Facci L, Dal Toso R, Romanello S, Buriani A, Skaper SD and Leon A. (1995) Mast cells express a peripheral cannabinoid receptor with differential sensitivity to anandamide and palmitoylethanolamide. *Proc. Natl. Acad. Sci. U.S.A.* **92**: 3376-80 [PMID:7724569]
35. Felder CC, Joyce KE, Briley EM, Glass M, Mackie KP, Fahey KJ, Cullinan GJ, Hunden DC, Johnson DW and Chaney MO *et al.*. (1998) LY320135, a novel cannabinoid CB₁ receptor antagonist, unmasks coupling of the CB₁ receptor to stimulation of cAMP accumulation. *J. Pharmacol. Exp. Ther.* **284**: 291-7 [PMID:9435190]
36. Felder CC, Joyce KE, Briley EM, Mansouri J, Mackie K, Blond O, Lai Y, Ma AL and Mitchell RL. (1995) Comparison of the pharmacology and signal transduction of the human cannabinoid CB₁ and CB₂ receptors. *Mol. Pharmacol.* **48**: 443-50 [PMID:7565624]
37. Felder CC, Veluz JS, Williams HL, Briley EM and Matsuda LA. (1992) Cannabinoid agonists stimulate both receptor- and non-receptor-mediated signal transduction pathways in cells transfected with and expressing cannabinoid receptor clones. *Mol. Pharmacol.* **42**: 838-45 [PMID:1331766]
38. Foloppe N, Benwell K, Brooks TD, Kennett G, Knight AR, Misra A and Monck NJ. (2009) Discovery and functional evaluation of diverse novel human CB₁(1) receptor ligands. *Bioorg. Med. Chem. Lett.* **19**: 4183-90 [PMID:19520572]
39. Fong TM, Guan XM, Marsh DJ, Shen CP, Stribling DS, Rosko KM, Lao J, Yu H, Feng Y and Xiao JQ *et al.*. (2007) Antiobesity efficacy of a novel cannabinoid-1 receptor inverse agonist, N-[(1S,2S)-3-(4-chlorophenyl)-2-(3-cyanophenyl)-1-methylpropyl]-2-methyl-2-[[5-(trifluoromethyl)pyridin-2-yl]oxy]propanamide (MK-0364), in rodents. *J. Pharmacol. Exp. Ther.* **321**: 1013-22 [PMID:17327489]
40. Galiègue S, Mary S, Marchand J, Dussossoy D, Carrière D, Carayon P, Bouaboula M, Shire D, Le Fur G and Casellas P. (1995) Expression of central and peripheral cannabinoid receptors in human immune tissues and leukocyte subpopulations. *Eur. J. Biochem.* **232**: 54-61 [PMID:7556170]
41. Gaoni Y and Mechoulam R. (1964) Isolation, structure and partial synthesis of an active constituent of hashish. *J. Am. Chem. Soc.* **86**: 1646-1647
42. Gareau Y, Dufresne C, Gallant M, Rochette C, Sawyer N, Slipetz DM, Tremblay N, Weech PK, Metters KM and Labelle M. (1996) Structure activity relationships of tetrahydrocannabinol analogues on human cannabinoid receptors. *Bioorg. Med. Chem. Lett.* **6**: 189-194

43. Gately SJ, Lan R, Pyatt B, Gifford AN, Volkow ND and Makriyannis A. (1997) Binding of the non-classical cannabinoid CP 55,940, and the diarylpyrazole AM251 to rodent brain cannabinoid receptors. *Life Sci.* **61**: PL 191-7 [PMID:9335234]
44. Gebremedhin D, Lange AR, Campbell WB, Hillard CJ and Harder DR. (1999) Cannabinoid CB1 receptor of cat cerebral arterial muscle functions to inhibit L-type Ca²⁺ channel current. *Am. J. Physiol.* **276**: H2085-93 [PMID:10362691]
45. Glass M and Felder CC. (1997) Concurrent stimulation of cannabinoid CB1 and dopamine D2 receptors augments cAMP accumulation in striatal neurons: evidence for a Gs linkage to the CB1 receptor. *J. Neurosci.* **17**: 5327-33 [PMID:9204917]
46. Gong JP, Onaivi ES, Ishiguro H, Liu QR, Tagliaferro PA, Brusco A and Uhl GR. (2006) Cannabinoid CB2 receptors: immunohistochemical localization in rat brain. *Brain Res.* **1071**: 10-23 [PMID:16472786]
47. Griffin G, Tao Q and Abood ME. (2000) Cloning and pharmacological characterization of the rat CB(2) cannabinoid receptor. *J. Pharmacol. Exp. Ther.* **292**: 886-94 [PMID:10688601]
48. Griffith DA, Hadcock JR, Black SC, Iredale PA, Carpino PA, DaSilva-Jardine P, Day R, DiBrino J, Dow RL and Landis MS *et al.*. (2009) Discovery of 1-[9-(4-chlorophenyl)-8-(2-chlorophenyl)-9H-purin-6-yl]-4-ethylaminopiperidine-4-carboxylic acid amide hydrochloride (CP-945,598), a novel, potent, and selective cannabinoid type 1 receptor antagonist. *J. Med. Chem.* **52**: 234-7 [PMID:19102698]
49. Gérard C, Mollereau C, Vassart G and Parmentier M. (1990) Nucleotide sequence of a human cannabinoid receptor cDNA. *Nucleic Acids Res.* **18**: 7142 [PMID:2263478]
50. Gérard CM, Mollereau C, Vassart G and Parmentier M. (1991) Molecular cloning of a human cannabinoid receptor which is also expressed in testis. *Biochem. J.* **279** (Pt 1): 129-34 [PMID:1718258]
51. Han S, Thatte J, Buzard DJ and Jones RM. (2013) Therapeutic utility of cannabinoid receptor type 2 (CB₂) selective agonists. *J. Med. Chem.* **56**: 8224-56 [PMID:23865723]
52. Han S, Thoresen L, Jung JK, Zhu X, Thatte J, Solomon M, Gaidarov I, Unett DJ, Yoon WH and Barden J *et al.*. (2017) Discovery of APD371: Identification of a Highly Potent and Selective CB₂ Agonist for the Treatment of Chronic Pain. *ACS Med Chem Lett* **8**: 1309-1313 [PMID:29259753]
53. Hanus L, Breuer A, Tchilibon S, Shiloah S, Goldenberg D, Horowitz M, Pertwee RG, Ross RA, Mechoulam R and Fride E. (1999) HU-308: a specific agonist for CB(2), a peripheral cannabinoid receptor. *Proc. Natl. Acad. Sci. U.S.A.* **96**: 14228-33 [PMID:10588688]
54. Henry DJ and Chavkin C. (1995) Activation of inwardly rectifying potassium channels (GIRK1) by co-expressed rat brain cannabinoid receptors in *Xenopus* oocytes. *Neurosci. Lett.* **186**: 91-4 [PMID:7777206]
55. Herkenham M, Lynn AB, Little MD, Johnson MR, Melvin LS, de Costa BR and Rice KC. (1990) Cannabinoid receptor localization in brain. *Proc. Natl. Acad. Sci. U.S.A.* **87**: 1932-6 [PMID:2308954]
56. Hillard CJ, Manna S, Greenberg MJ, DiCamelli R, Ross RA, Stevenson LA, Murphy V, Pertwee RG and Campbell WB. (1999) Synthesis and characterization of potent and selective agonists of the neuronal cannabinoid receptor (CB1). *J. Pharmacol. Exp. Ther.* **289**: 1427-33 [PMID:10336536]
57. Hirst RA, Almond SL and Lambert DG. (1996) Characterisation of the rat cerebella CB1 receptor using SR141716A, a central cannabinoid receptor antagonist. *Neurosci. Lett.* **220**: 101-4 [PMID:8981483]
58. Hoehe MR, Caenazzo L, Martinez MM, Hsieh WT, Modi WS, Gershon ES and Bonner TI. (1991) Genetic and physical mapping of the human cannabinoid receptor gene to chromosome 6q14-q15. *New Biol.* **3**: 880-5 [PMID:1931832]
59. Hollister LE. (1986) Health aspects of cannabis. *Pharmacol. Rev.* **38**: 1-20 [PMID:3520605]
60. Horswill JG, Bali U, Shaaban S, Keily JF, Jeevaratnam P, Babbs AJ, Reynet C and Wong Kai In P. (2007) PSNCBAM-1, a novel allosteric antagonist at cannabinoid CB1 receptors with hypophagic effects in rats. *Br. J. Pharmacol.* **152**: 805-14 [PMID:17592509]
61. Howlett AC, Barth F, Bonner TI, Cabral G, Casellas P, Devane WA, Felder CC, Herkenham M, Mackie K and Martin BR *et al.*. (2002) International Union of Pharmacology. XXVII. Classification of cannabinoid receptors. *Pharmacol. Rev.* **54**: 161-202 [PMID:12037135]
62. Howlett AC, Berglund BA and Melvin LS. (1995) Cannabinoid receptor agonists and antagonists. *Curr. Pharm. Des.* **1**: 343-354

63. Howlett AC, Qualy JM and Khachatrian LL. (1986) Involvement of Gi in the inhibition of adenylate cyclase by cannabimimetic drugs. *Mol. Pharmacol.* **29**: 307-13 [PMID:2869405]
64. Hua T, Vemuri K, Nikas SP, Laprairie RB, Wu Y, Qu L, Pu M, Korde A, Jiang S and Ho JH *et al.* (2017) Crystal structures of agonist-bound human cannabinoid receptor CB₁. *Nature* **547**: 468-471 [PMID:28678776]
65. Hua T, Vemuri K, Pu M, Qu L, Han GW, Wu Y, Zhao S, Shui W, Li S and Korde A *et al.* (2016) Crystal Structure of the Human Cannabinoid Receptor CB₁. *Cell* **167**: 750-762.e14 [PMID:27768894]
66. Huffman JW, Liddle J, Yu S, Aung MM, Abood ME, Wiley JL and Martin BR. (1999) 3-(1',1'-Dimethylbutyl)-1-deoxy-delta⁸-THC and related compounds: synthesis of selective ligands for the CB₂ receptor. *Bioorg. Med. Chem.* **7**: 2905-14 [PMID:10658595]
67. Hung MS, Chang CP, Li TC, Yeh TK, Song JS, Lin Y, Wu CH, Kuo PC, Amancha PK and Wong YG *et al.* (2010) Discovery of 1-(2,4-dichlorophenyl)-4-ethyl-5-(5-(2-(4-(trifluoromethyl)phenyl)ethynyl)thiophen-2-yl)-N-(piperidin-1-yl)-1H-pyrazole-3-carboxamide as a potential peripheral cannabinoid-1 receptor inverse agonist. *ChemMedChem* **5**: 1439-43 [PMID:20652930]
68. Ignatowska-Jankowska BM, Baillie GL, Kinsey S, Crowe M, Ghosh S, Owens RA, Damaj IM, Poklis J, Wiley JL and Zanda M *et al.* (2015) A Cannabinoid CB₁ Receptor-Positive Allosteric Modulator Reduces Neuropathic Pain in the Mouse with No Psychoactive Effects. *Neuropsychopharmacology* **40**: 2948-59 [PMID:26052038]
69. Jackson AR, Hegde VL, Nagarkatti PS and Nagarkatti M. (2014) Characterization of endocannabinoid-mediated induction of myeloid-derived suppressor cells involving mast cells and MCP-1. *J. Leukoc. Biol.* **95**: 609-19 [PMID:24319288]
70. Jansen EM, Haycock DA, Ward SJ and Seybold VS. (1992) Distribution of cannabinoid receptors in rat brain determined with aminoalkylindoles. *Brain Res.* **575**: 93-102 [PMID:1504787]
71. Jarrahan A, Watts VJ and Barker EL. (2004) D₂ dopamine receptors modulate G_{alpha}-subunit coupling of the CB₁ cannabinoid receptor. *J. Pharmacol. Exp. Ther.* **308**: 880-6 [PMID:14634050]
72. Jung M, Calassi R, Rinaldi Carmona M, Chardenot P, Le Fur G, Soubrie P and Oury-Donat F. (1997) Characterization of CB₁ receptors on rat neuronal cell cultures: binding and functional studies using the selective receptor antagonist SR 141716A. *J. Neurochem.* **68**: 402-409 [PMID:8978752]
73. Khanolkar AD, Abadji V, Lin S, Hill WA, Taha G, Abouzid K, Meng Z, Fan P and Makriyannis A. (1996) Head group analogs of arachidonylethanolamide, the endogenous cannabinoid ligand. *J. Med. Chem.* **39**: 4515-9 [PMID:8893848]
74. Kulkarni PM, Kulkarni AR, Korde A, Tichkule RB, Laprairie RB, Denovan-Wright EM, Zhou H, Janero DR, Zvonok N and Makriyannis A *et al.* (2016) Novel Electrophilic and Photoaffinity Covalent Probes for Mapping the Cannabinoid 1 Receptor Allosteric Site(s). *J. Med. Chem.* **59**: 44-60 [PMID:26529344]
75. Kulkarni S, Nikas SP, Sharma R, Jiang S, Paronis CA, Leonard MZ, Zhang B, Honrao C, Mallipeddi S and Raghav JG *et al.* (2016) Novel C-Ring-Hydroxy-Substituted Controlled Deactivation Cannabinergic Analogues. *J. Med. Chem.* **59**: 6903-19 [PMID:27367336]
76. Lan R, Gatley J, Lu Q, Fan P, Fernando SR, Volkow ND, Pertwee R and Makriyannis A. (1999) Design and synthesis of the CB₁ selective cannabinoid antagonist AM281: a potential human SPECT ligand. *AAPS PharmSci* **1**: E4 [PMID:11741201]
77. Lan R, Liu Q, Fan P, Lin S, Fernando SR, McCallion D, Pertwee R and Makriyannis A. (1999) Structure-activity relationships of pyrazole derivatives as cannabinoid receptor antagonists. *J. Med. Chem.* **42**: 769-76 [PMID:10052983]
78. Lange JH, Coolen HK, van Stuivenberg HH, Dijkman JA, Herremans AH, Ronken E, Keizer HG, Tipker K, McCreary AC and Veerman W *et al.* (2004) Synthesis, biological properties, and molecular modeling investigations of novel 3,4-diarylpyrazolines as potent and selective CB₁ cannabinoid receptor antagonists. *J. Med. Chem.* **47**: 627-43 [PMID:14736243]
79. Laprairie RB, Bagher AM, Kelly ME and Denovan-Wright EM. (2015) Cannabidiol is a negative allosteric modulator of the cannabinoid CB₁ receptor. *Br. J. Pharmacol.* **172**: 4790-805 [PMID:26218440]
80. Laprairie RB, Kulkarni AR, Kulkarni PM, Hurst DP, Lynch D, Reggio PH, Janero DR, Pertwee RG,

- Stevenson LA and Kelly ME *et al.*. (2016) Mapping Cannabinoid 1 Receptor Allosteric Site(s): Critical Molecular Determinant and Signaling Profile of GAT100, a Novel, Potent, and Irreversibly Binding Probe. *ACS Chem Neurosci* **7**: 776-98 [PMID:27046127]
81. Lavey BJ, Kozlowski JA, Hipkin RW, Gonsiorek W, Lundell DJ, Piwinski JJ, Narula S and Lunn CA. (2005) Triaryl bis-sulfones as a new class of cannabinoid CB2 receptor inhibitors: identification of a lead and initial SAR studies. *Bioorg. Med. Chem. Lett.* **15**: 783-6 [PMID:15664857]
 82. Ledent C, Valverde O, Cossu G, Petitet F, Aubert JF, Beslot F, Böhme GA, Imperato A, Pedrazzini T and Roques BP *et al.*. (1999) Unresponsiveness to cannabinoids and reduced addictive effects of opiates in CB1 receptor knockout mice. *Science* **283**: 401-4 [PMID:9888857]
 83. Lunn CA, Fine JS, Rojas-Triana A, Jackson JV, Fan X, Kung TT, Gonsiorek W, Schwarz MA, Lavey B and Kozlowski JA *et al.*. (2006) A novel cannabinoid peripheral cannabinoid receptor-selective inverse agonist blocks leukocyte recruitment in vivo. *J. Pharmacol. Exp. Ther.* **316**: 780-8 [PMID:16258021]
 84. Mackie K and Hille B. (1992) Cannabinoids inhibit N-type calcium channels in neuroblastoma-glioma cells. *Proc. Natl. Acad. Sci. U.S.A.* **89**: 3825-9 [PMID:1315042]
 85. Mackie K, Lai Y, Westenbroek R and Mitchell R. (1995) Cannabinoids activate an inwardly rectifying potassium conductance and inhibit Q-type calcium currents in AtT20 cells transfected with rat brain cannabinoid receptor. *J. Neurosci.* **15**: 6552-6561 [PMID:7472417]
 86. Mailleux P, Parmentier M and Vanderhaeghen JJ. (1992) Distribution of cannabinoid receptor messenger RNA in the human brain: an in situ hybridization histochemistry with oligonucleotides. *Neurosci. Lett.* **143**: 200-4 [PMID:1436667]
 87. Makriyannis A and Deng H. (2001) Cannabimimetic indole derivatives Patent number: WO2001028557.
 88. Maneuf YP and Brotchie JM. (1997) Paradoxical action of the cannabinoid WIN 55,212-2 in stimulated and basal cyclic AMP accumulation in rat globus pallidus slices. *Br. J. Pharmacol.* **120**: 1397-8 [PMID:9113356]
 89. Martin BR, Balster RL, Razdan RK, Harris LS and Dewey WL. (1981) Behavioral comparisons of the stereoisomers of tetrahydrocannabinols. *Life Sci.* **29**: 565-74 [PMID:6268916]
 90. Martin BR, Compton DR, Thomas BF, Prescott WR, Little PJ, Razdan RK, Johnson MR, Melvin LS, Mechoulam R and Ward SJ. (1991) Behavioral, biochemical, and molecular modeling evaluations of cannabinoid analogs. *Pharmacol. Biochem. Behav.* **40**: 471-8 [PMID:1666911]
 91. Matsuda LA, Lolait SJ, Brownstein MJ, Young AC and Bonner TI. (1990) Structure of a cannabinoid receptor and functional expression of the cloned cDNA. *Nature* **346**: 561-4 [PMID:2165569]
 92. Mechoulam R, Ben-Shabat S, Hanus L, Ligumsky M, Kaminski NE, Schatz AR, Gopher A, Almog S, Martin BR and Compton DR *et al.*. (1995) Identification of an endogenous 2-monoglyceride, present in canine gut, that binds to cannabinoid receptors. *Biochem. Pharmacol.* **50**: 83-90 [PMID:7605349]
 93. Munro S, Thomas KL and Abu-Shaar M. (1993) Molecular characterization of a peripheral receptor for cannabinoids. *Nature* **365**: 61-5 [PMID:7689702]
 94. Navarro HA, Howard JL, Pollard GT and Carroll FI. (2009) Positive allosteric modulation of the human cannabinoid (CB) receptor by RTI-371, a selective inhibitor of the dopamine transporter. *Br. J. Pharmacol.* **156**: 1178-84 [PMID:19226282]
 95. O'Sullivan SE. (2007) Cannabinoids go nuclear: evidence for activation of peroxisome proliferator-activated receptors. *Br. J. Pharmacol.* **152**: 576-82 [PMID:17704824]
 96. Oka S, Wakui J, Ikeda S, Yanagimoto S, Kishimoto S, Gokoh M, Nasui M and Sugiura T. (2006) Involvement of the cannabinoid CB2 receptor and its endogenous ligand 2-arachidonoylglycerol in oxazolone-induced contact dermatitis in mice. *J. Immunol.* **177**: 8796-805 [PMID:17142782]
 97. Pacheco M, Childers SR, Arnold R, Casiano F and Ward SJ. (1991) Aminoalkylindoles: actions on specific G-protein-linked receptors. *J. Pharmacol. Exp. Ther.* **257**: 170-83 [PMID:1902257]
 98. Pertwee RG. (2000) Cannabinoid receptor ligands: clinical and neuropharmacological considerations, relevant to future drug discovery and development. *Expert Opin Investig Drugs* **9**: 1553-71 [PMID:11060760]
 99. Pertwee RG. (2010) Receptors and channels targeted by synthetic cannabinoid receptor agonists and antagonists. *Curr. Med. Chem.* **17**: 1360-81 [PMID:20166927]

100. Pertwee RG. (2005) Inverse agonism and neutral antagonism at cannabinoid CB1 receptors. *Life Sci.* **76**: 1307-24 [PMID:15670612]
101. Pertwee RG. (2005) Pharmacological actions of cannabinoids. *Handb Exp Pharmacol* 1-51 [PMID:16596770]
102. Pertwee RG. (2008) Ligands that target cannabinoid receptors in the brain: from THC to anandamide and beyond. *Addict Biol* **13**: 147-59 [PMID:18482430]
103. Pertwee RG. (2008) The diverse CB1 and CB2 receptor pharmacology of three plant cannabinoids: delta9-tetrahydrocannabinol, cannabidiol and delta9-tetrahydrocannabivarin. *Br. J. Pharmacol.* **153**: 199-215 [PMID:17828291]
104. Pertwee RG. (2012) Targeting the endocannabinoid system with cannabinoid receptor agonists: pharmacological strategies and therapeutic possibilities. *Philos. Trans. R. Soc. Lond., B, Biol. Sci.* **367**: 3353-63 [PMID:23108552]
105. Pertwee RG. (1997) Pharmacology of cannabinoid CB1 and CB2 receptors. *Pharmacol. Ther.* **74**: 129-80 [PMID:9336020]
106. Pertwee RG. (1999) Pharmacology of cannabinoid receptor ligands. *Curr. Med. Chem.* **6**: 635-64 [PMID:10469884]
107. Pertwee RG, Howlett AC, Abood ME, Alexander SP, Di Marzo V, Elphick MR, Greasley PJ, Hansen HS, Kunos G and Mackie K *et al.*. (2010) International Union of Basic and Clinical Pharmacology. LXXIX. Cannabinoid receptors and their ligands: beyond CB₁ and CB₂. *Pharmacol. Rev.* **62**: 588-631 [PMID:21079038]
108. Pertwee RG and Ross RA. (2002) Cannabinoid receptors and their ligands. *Prostaglandins Leukot. Essent. Fatty Acids* **66**: 101-21 [PMID:12052030]
109. Pertwee RG, Stevenson LA, Elrick DB, Mechoulam R and Corbett AD. (1992) Inhibitory effects of certain enantiomeric cannabinoids in the mouse vas deferens and the myenteric plexus preparation of guinea-pig small intestine. *Br. J. Pharmacol.* **105**: 980-984 [PMID:1324060]
110. Petitet F, Marin L and Doble A. (1996) Biochemical and pharmacological characterization of cannabinoid binding sites using [³H]SR141716A. *Neuroreport* **7**: 789-792 [PMID:8733746]
111. Pettit DA, Harrison MP, Olson JM, Spencer RF and Cabral GA. (1998) Immunohistochemical localization of the neural cannabinoid receptor in rat brain. *J. Neurosci. Res.* **51**: 391-402 [PMID:9486774]
112. Pini A, Mannaioni G, Pellegrini-Giampietro D, Passani MB, Mastroianni R, Bani D and Masini E. (2012) The role of cannabinoids in inflammatory modulation of allergic respiratory disorders, inflammatory pain and ischemic stroke. *Curr Drug Targets* **13**: 984-93 [PMID:22420307]
113. Piscitelli F, Ligresti A, La Regina G, Coluccia A, Morera L, Allarà M, Novellino E, Di Marzo V and Silvestri R. (2012) Indole-2-carboxamides as allosteric modulators of the cannabinoid CB₁ receptor. *J. Med. Chem.* **55**: 5627-31 [PMID:22571451]
114. Price MR, Baillie GL, Thomas A, Stevenson LA, Easson M, Goodwin R, McLean A, McIntosh L, Goodwin G and Walker G *et al.*. (2005) Allosteric modulation of the cannabinoid CB1 receptor. *Mol. Pharmacol.* **68**: 1484-95 [PMID:16113085]
115. Razdan RK. (1986) Structure-activity relationships in cannabinoids. *Pharmacol. Rev.* **38**: 75-149 [PMID:3018800]
116. Rhee M-H, Vogel Z, Barg J, Bayewitch M, Levy R, Hanu L, Breuer A. and Mechoulam R. (1997) Cannabinoid derivatives: binding to cannabinoid receptors and inhibition of adenylyl cyclase *Journal of Medicinal Chemistry* **40**: 3228–3233
117. Rhee MH, Bayewitch M, Avidor-Reiss T, Levy R and Vogel Z. (1998) Cannabinoid receptor activation differentially regulates the various adenylyl cyclase isozymes. *J. Neurochem.* **71**: 1525-34 [PMID:9751186]
118. Rhee MH, Vogel Z, Barg J, Bayewitch M, Levy R, Hanus L, Breuer A and Mechoulam R. (1997) Cannabinol derivatives: binding to cannabinoid receptors and inhibition of adenylyl cyclase. *J. Med. Chem.* **40**: 3228-33 [PMID:9379442]
119. Rinaldi-Carmona M, Barth F, Congy C, Martinez S, Oustric D, Péro A, Poncelet M, Maruani J, Arnone M and Finance O *et al.*. (2004) SR147778 [5-(4-bromophenyl)-1-(2,4-dichlorophenyl)-4-ethyl-N-(1-

- piperidiny]-1H-pyrazole-3-carboxamide], a new potent and selective antagonist of the CB1 cannabinoid receptor: biochemical and pharmacological characterization. *J. Pharmacol. Exp. Ther.* **310**: 905-14 [PMID:15131245]
120. Rinaldi-Carmona M, Barth F, Héaulme M, Shire D, Calandra B, Congy C, Martinez S, Maruani J, Néliat G and Caput D *et al.*. (1994) SR141716A, a potent and selective antagonist of the brain cannabinoid receptor. *FEBS Lett.* **350**: 240-4 [PMID:8070571]
 121. Rinaldi-Carmona M, Barth F, Millan J, Derocq JM, Casellas P, Congy C, Oustric D, Sarran M, Bouaboula M and Calandra B *et al.*. (1998) SR 144528, the first potent and selective antagonist of the CB2 cannabinoid receptor. *J. Pharmacol. Exp. Ther.* **284**: 644-50 [PMID:9454810]
 122. Rinaldi-Carmona M, Pialot F, Congy C, Redon E, Barth F, Bachy A, Breliere JC, Soubrie P and Le Fur G. (1996) Characterization and distribution of binding sites for [³H]-SR 141716A, a selective brain (CB₁) cannabinoid receptor antagonist, in rodent brain. *Life Sci.* **58**: 1239-1247 [PMID:8614277]
 123. Ross RA, Brockie HC, Stevenson LA, Murphy VL, Templeton F, Makriyannis A and Pertwee RG. (1999) Agonist-inverse agonist characterization at CB₁ and CB₂ cannabinoid receptors of L759633, L759656 and AM630. *Br. J. Pharmacol.* **126**: 665-672 [PMID:10188977]
 124. Ross RA, Coutts AA, McFarlane SM, Anavi-Goffer S, Irving AJ, Pertwee RG, MacEwan DJ and Scott RH. (2001) Actions of cannabinoid receptor ligands on rat cultured sensory neurones: implications for antinociception. *Neuropharmacology* **40**: 221-32 [PMID:11114401]
 125. Roth SH. (1978) Stereospecific presynaptic inhibitory effect of delta9-tetrahydrocannabinol on cholinergic transmission in the myenteric plexus of the guinea pig. *Can. J. Physiol. Pharmacol.* **56**: 968-75 [PMID:217512]
 126. Ruiu S, Pinna GA, Marchese G, Mussinu JM, Saba P, Tambaro S, Casti P, Vargiu R and Pani L. (2003) Synthesis and characterization of NESS 0327: a novel putative antagonist of the CB1 cannabinoid receptor. *J. Pharmacol. Exp. Ther.* **306**: 363-70 [PMID:12663689]
 127. Schuler GD, Boguski MS, Stewart EA, Stein LD, Gyapay G, Rice K, White RE, Rodriguez-Tomé P, Aggarwal A and Bajorek E *et al.*. (1996) A gene map of the human genome. *Science* **274**: 540-6 [PMID:8849440]
 128. Selley DE, Stark S and Childers SR. (1996) Cannabinoid receptor stimulation of [³⁵S]GTPγS binding in rat brain membranes. *Life Sci.* **59**: 659-668 [PMID:8761016]
 129. Shao Z, Yin J, Chapman K, Grzemska M, Clark L, Wang J and Rosenbaum DM. (2016) High-resolution crystal structure of the human CB1 cannabinoid receptor. *Nature* **540**: 602-606 [PMID:27851727]
 130. Sharma MK, Murumkar PR, Barmade MA, Giridhar R and Yadav MR. (2015) A comprehensive patents review on cannabinoid 1 receptor antagonists as antiobesity agents. *Expert Opin Ther Pat* **25**: 1093-116 [PMID:26161824]
 131. Sheskin T, Hanus L, Slager J, Vogel Z and Mechoulam R. (1997) Structural requirements for binding of anandamide-type compounds to the brain cannabinoid receptor. *J. Med. Chem.* **40**: 659-67 [PMID:9057852]
 132. Shire D, Calandra B, Delpech M, Dumont X, Kaghad M, Le Fur G, Caput D and Ferrara P. (1996) Structural features of the central cannabinoid CB1 receptor involved in the binding of the specific CB1 antagonist SR 141716A. *J. Biol. Chem.* **271**: 6941-6 [PMID:8636122]
 133. Shire D, Calandra B, Rinaldi-Carmona M, Oustric D, Pessègue B, Bonnin-Cabanne O, Le Fur G, Caput D and Ferrara P. (1996) Molecular cloning, expression and function of the murine CB2 peripheral cannabinoid receptor. *Biochim. Biophys. Acta* **1307**: 132-6 [PMID:8679694]
 134. Shire D, Carillon C, Kaghad M, Calandra B, Rinaldi-Carmona M, Le Fur G, Caput D and Ferrara P. (1995) An amino-terminal variant of the central cannabinoid receptor resulting from alternative splicing. *J. Biol. Chem.* **270**: 3726-31 [PMID:7876112]
 135. Showalter VM, Compton DR, Martin BR and Abood ME. (1996) Evaluation of binding in a transfected cell line expressing a peripheral cannabinoid receptor (CB2): identification of cannabinoid receptor subtype selective ligands. *J. Pharmacol. Exp. Ther.* **278**: 989-99 [PMID:8819477]
 136. Sim LJ, Hampson RE, Deadwyler SA and Childers SR. (1996) Effects of chronic treatment with delta9-

- tetrahydrocannabinol on cannabinoid-stimulated [35S]GTPgammaS autoradiography in rat brain. *J. Neurosci.* **16**: 8057-66 [PMID:8987831]
137. Sim LJ, Selley DE and Childers SR. (1995) In vitro autoradiography of receptor-activated G proteins in rat brain by agonist-stimulated guanylyl 5'-[gamma-[35S]thio]-triphosphate binding. *Proc. Natl. Acad. Sci. U.S.A.* **92**: 7242-6 [PMID:7638174]
 138. Sink KS, McLaughlin PJ, Wood JA, Brown C, Fan P, Vemuri VK, Peng Y, Pang Y, Olszewska T and Olzewska T *et al.*. (2008) The novel cannabinoid CB1 receptor neutral antagonist AM4113 suppresses food intake and food-reinforced behavior but does not induce signs of nausea in rats. *Neuropsychopharmacology* **33**: 946-55 [PMID:17581535]
 139. Skaper SD, Buriani A, Dal Toso R, Petrelli L, Romanello S, Facci L and Leon A. (1996) The ALIAmide palmitoylethanolamide and cannabinoids, but not anandamide, are protective in a delayed postglutamate paradigm of excitotoxic death in cerebellar granule neurons. *Proc. Natl. Acad. Sci. U.S.A.* **93**: 3984-9 [PMID:8633002]
 140. Slipetz DM, O'Neill GP, Favreau L, Dufresne C, Gallant M, Gareau Y, Guay D, Labelle M and Metters KM. (1995) Activation of the human peripheral cannabinoid receptor results in inhibition of adenylyl cyclase. *Mol. Pharmacol.* **48**: 352-61 [PMID:7651369]
 141. Song ZH and Bonner TI. (1996) A lysine residue of the cannabinoid receptor is critical for receptor recognition by several agonists but not WIN55212-2. *Mol. Pharmacol.* **49**: 891-6 [PMID:8622639]
 142. Sugawara K, Zákány N, Hundt T, Emelianov V, Tsuruta D, Schäfer C, Kloeppe JE, Bíró T and Paus R. (2013) Cannabinoid receptor 1 controls human mucosal-type mast cell degranulation and maturation in situ. *J. Allergy Clin. Immunol.* **132**: 182-93 [PMID:23453134]
 143. Sugiura T, Kodaka T, Kondo S, Tonegawa T, Nakane S, Kishimoto S, Yamashita A and Waku K. (1996) 2-Arachidonoylglycerol, a putative endogenous cannabinoid receptor ligand, induces rapid, transient elevation of intracellular free Ca²⁺ in neuroblastoma x glioma hybrid NG108-15 cells. *Biochem. Biophys. Res. Commun.* **229**: 58-64 [PMID:8954083]
 144. Sugiura T, Kondo S, Sukagawa A, Nakane S, Shinoda A, Itoh K, Yamashita A and Waku K. (1995) 2-Arachidonoylglycerol: a possible endogenous cannabinoid receptor ligand in brain. *Biochem. Biophys. Res. Commun.* **215**: 89-97 [PMID:7575630]
 145. Szabo B and Schlicker E. (2005) Effects of cannabinoids on neurotransmission. *Handb Exp Pharmacol* 327-65 [PMID:16596780]
 146. Thomas BF, Gilliam AF, Burch DF, Roche MJ and Seltzman HH. (1998) Comparative receptor binding analyses of cannabinoid agonists and antagonists. *J. Pharmacol. Exp. Ther.* **285**: 285-92 [PMID:9536023]
 147. Thomas BF, Wei X and Martin BR. (1992) Characterization and autoradiographic localization of the cannabinoid binding site in rat brain using [3H]11-OH-delta 9-THC-DMH. *J. Pharmacol. Exp. Ther.* **263**: 1383-90 [PMID:1335065]
 148. Tsou K, Brown S, Sanudo-Pena MC, Mackie K and Walker JM. (1998) Immunohistochemical distribution of cannabinoid CB₁ receptors in the rat central nervous system. *Neuroscience* **83**: 393-411 [PMID:9460749]
 149. Twitchell W, Brown S and Mackie K. (1997) Cannabinoids inhibit N- and P/Q-type calcium channels in cultured rat hippocampal neurons. *J. Neurophysiol.* **78**: 43-50 [PMID:9242259]
 150. Van Sickle MD, Duncan M, Kingsley PJ, Mouihate A, Urbani P, Mackie K, Stella N, Makriyannis A, Piomelli D and Davison JS *et al.*. (2005) Identification and functional characterization of brainstem cannabinoid CB2 receptors. *Science* **310**: 329-32 [PMID:16224028]
 151. Ward SJ, Mastriani D, Casiano F and Arnold R. (1990) Pravadoline: profile in isolated tissue preparations. *J. Pharmacol. Exp. Ther.* **255**: 1230-1239 [PMID:2175798]
 152. Wiley JL and Martin BR. (2003) Cannabinoid pharmacological properties common to other centrally acting drugs. *Eur. J. Pharmacol.* **471**: 185-93 [PMID:12826237]
 153. Wotherspoon G, Fox A, McIntyre P, Colley S, Bevan S and Winter J. (2005) Peripheral nerve injury induces cannabinoid receptor 2 protein expression in rat sensory neurons. *Neuroscience* **135**: 235-45 [PMID:16084654]

154. Yao BB, Mukherjee S, Fan Y, Garrison TR, Daza AV, Grayson GK, Hooker BA, Dart MJ, Sullivan JP and Meyer MD. (2006) In vitro pharmacological characterization of AM1241: a protean agonist at the cannabinoid CB2 receptor? *Br. J. Pharmacol.* **149**: 145-54 [PMID:16894349]
155. Zimmer A, Zimmer AM, Hohmann AG, Herkenham M and Bonner TI. (1999) Increased mortality, hypoactivity, and hypoalgesia in cannabinoid CB1 receptor knockout mice. *Proc. Natl. Acad. Sci. U.S.A.* **96**: 5780-5 [PMID:10318961]
156. Zygmunt PM, Petersson J, Andersson DA, Chuang H, Sørsgård M, Di Marzo V, Julius D and Högestätt ED. (1999) Vanilloid receptors on sensory nerves mediate the vasodilator action of anandamide. *Nature* **400**: 452-7 [PMID:10440374]