

## 1I. Vitamin D receptor-like receptors in GtoPdb v.2025.3

Sylvia Christakos<sup>1</sup>

1. Rutgers University, USA

### Abstract

Vitamin D (VDR), Pregnane X (PXR) and Constitutive Androstane (CAR) receptors (**nomenclature as agreed by the NC-IUPHAR Subcommittee on Nuclear Hormone Receptors [51, 1]**) are members of the NR1I family of nuclear receptors, which form heterodimers with members of the retinoid X receptor family. PXR and CAR are activated by a range of exogenous compounds, with no established endogenous physiological agonists, although high concentrations of bile acids and bile pigments activate PXR and CAR [51].

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#### 1I. Vitamin D receptor-like receptors

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#### Introduction to 1I. Vitamin D receptor-like receptors

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#### Receptors

##### Vitamin D receptor

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##### Pregnane X receptor

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##### Constitutive androstane receptor

<https://www.guidetopharmacology.org/GRAC/ObjectDisplayForward?objectId=607>

### References

1. Alexander SPH, Cidlowski JA, Kelly E, Mathie A, Peters JA, Veale EL, Armstrong JF, Faccenda E, Harding SD and Pawson AJ *et al.*. (2019) THE CONCISE GUIDE TO PHARMACOLOGY 2019/20: Nuclear hormone receptors. *Br J Pharmacol* **176 Suppl 1**: S229-S246 [PMID:31710718]
2. Baes M, Gulick T, Choi HS, Martinoli MG, Simha D and Moore DD. (1994) A new orphan member of the nuclear hormone receptor superfamily that interacts with a subset of retinoic acid response elements. *Mol Cell Biol* **14**: 1544-52 [PMID:8114692]
3. Baker AR, McDonnell DP, Hughes M, Crisp TM, Mangelsdorf DJ, Haussler MR, Pike JW, Shine J

- and O'Malley BW. (1988) Cloning and expression of full-length cDNA encoding human vitamin D receptor. *Proc Natl Acad Sci USA* **85**: 3294-8 [PMID:2835767]
4. Bartolini D, De Franco F, Torquato P, Marinelli R, Cerra B, Ronchetti R, Schon A, Fallarino F, De Luca A and Bellezza G *et al.*. (2020) Garcinoic Acid Is a Natural and Selective Agonist of Pregnane X Receptor. *J Med Chem* **63**: 3701-3712 [PMID:32160459]
  5. Bertilsson G, Heidrich J, Svensson K, Asman M, Jendeberg L, Sydow-Bäckman M, Ohlsson R, Postlind H, Blomquist P and Berkenstam A. (1998) Identification of a human nuclear receptor defines a new signaling pathway for CYP3A induction. *Proc Natl Acad Sci USA* **95**: 12208-13 [PMID:9770465]
  6. Bhalla S, Ozalp C, Fang S, Xiang L and Kemper JK. (2004) Ligand-activated pregnane X receptor interferes with HNF-4 signaling by targeting a common coactivator PGC-1alpha. Functional implications in hepatic cholesterol and glucose metabolism. *J Biol Chem* **279**: 45139-47 [PMID:15322103]
  7. Bishop JE, Collins ED, Okamura WH and Norman AW. (1994) Profile of ligand specificity of the vitamin D binding protein for 1 alpha,25-dihydroxyvitamin D3 and its analogs. *J Bone Miner Res* **9**: 1277-88 [PMID:7976510]
  8. Blumberg B, Sabbagh W, Juguilon H, Bolado J, van Meter CM, Ong ES and Evans RM. (1998) SXR, a novel steroid and xenobiotic-sensing nuclear receptor. *Genes Dev* **12**: 3195-205 [PMID:9784494]
  9. Boehm MF, Fitzgerald P, Zou A, Elgort MG, Bischoff ED, Mere L, Mais DE, Bissonnette RP, Heyman RA, Nadzan AM, Reichman M and Allegretto EA. (1999) Novel nonsteroidal vitamin D mimics exert VDR-modulating activities with less calcium mobilization than 1,25-dihydroxyvitamin D3. *Chem Biol* **6**: 265-75 [PMID:10322128]
  10. Buneman P, Christie G, Davies JA, Dimitrellou R, Harding SD, Pawson AJ, Sharman JL and Wu Y. (2020) Why data citation isn't working, and what to do about it *Database* **2020** [PMID:32367113]
  11. Burmester JK, Maeda N and DeLuca HF. (1988) Isolation and expression of rat 1,25-dihydroxyvitamin D3 receptor cDNA. *Proc Natl Acad Sci USA* **85**: 1005-9 [PMID:2829212]
  12. Cavaillès V, Dauvois S, L'Horset F, Lopez G, Hoare S, Kushner PJ and Parker MG. (1995) Nuclear factor RIP140 modulates transcriptional activation by the estrogen receptor. *EMBO J* **14**: 3741-51 [PMID:7641693]
  13. Chen Y, Kissling G, Negishi M and Goldstein JA. (2005) The nuclear receptors constitutive androstane receptor and pregnane X receptor cross-talk with hepatic nuclear factor 4alpha to synergistically activate the human CYP2C9 promoter. *J Pharmacol Exp Ther* **314**: 1125-33 [PMID:15919766]
  14. Choi HS, Chung M, Tzamelis I, Simha D, Lee YK, Seol W and Moore DD. (1997) Differential transactivation by two isoforms of the orphan nuclear hormone receptor CAR. *J Biol Chem* **272**: 23565-71 [PMID:9295294]
  15. Colston KW, Mackay AG, James SY, Binderup L, Chander S and Coombes RC. (1992) EB1089: a new vitamin D analogue that inhibits the growth of breast cancer cells in vivo and in vitro. *Biochem Pharmacol* **44**: 2273-80 [PMID:1472092]
  16. Dotzlaw H, Leygue E, Watson P and Murphy LC. (1999) The human orphan receptor PXR messenger RNA is expressed in both normal and neoplastic breast tissue. *Clin Cancer Res* **5**: 2103-7 [PMID:10473093]
  17. Dussault I, Yoo HD, Lin M, Wang E, Fan M, Batta AK, Salen G, Erickson SK and Forman BM. (2003) Identification of an endogenous ligand that activates pregnane X receptor-mediated sterol clearance. *Proc Natl Acad Sci USA* **100**: 833-8 [PMID:12569201]
  18. Erben RG, Soegiarto DW, Weber K, Zeitz U, Lieberherr M, Gniadecki R, Möller G, Adamski J and Balling R. (2002) Deletion of deoxyribonucleic acid binding domain of the vitamin D receptor abrogates genomic and nongenomic functions of vitamin D. *Mol Endocrinol* **16**: 1524-37 [PMID:12089348]
  19. Ferguson SS, Chen Y, LeCluyse EL, Negishi M and Goldstein JA. (2005) Human CYP2C8 is transcriptionally regulated by the nuclear receptors constitutive androstane receptor, pregnane X receptor, glucocorticoid receptor, and hepatic nuclear factor 4alpha. *Mol Pharmacol* **68**: 747-57 [PMID:15933212]
  20. Forman BM, Tzamelis I, Choi HS, Chen J, Simha D, Seol W, Evans RM and Moore DD. (1998) Androstane metabolites bind to and deactivate the nuclear receptor CAR-beta. *Nature* **395**: 612-5 [PMID:9783588]
  21. Frank C, Gonzalez MM, Oinonen C, Dunlop TW and Carlberg C. (2003) Characterization of DNA complexes formed by the nuclear receptor constitutive androstane receptor. *J Biol Chem* **278**: 43299-310 [PMID:12896978]
  22. Fraser DJ, Zumsteg A and Meyer UA. (2003) Nuclear receptors constitutive androstane receptor and pregnane X receptor activate a drug-responsive enhancer of the murine 5-aminolevulinic acid synthase gene. *J Biol Chem* **278**: 39392-401 [PMID:12881517]
  23. Fujishima T, Kojima Y, Azumaya I, Kittaka A and Takayama H. (2003) Design and synthesis of

- potent vitamin D receptor antagonists with A-ring modifications: remarkable effects of 2alpha-methyl introduction on antagonistic activity. *Bioorg Med Chem* **11**: 3621-31 [PMID:12901907]
24. Geick A, Eichelbaum M and Burk O. (2001) Nuclear receptor response elements mediate induction of intestinal MDR1 by rifampin. *J Biol Chem* **276**: 14581-7 [PMID:11297522]
  25. Germain P, Staels B, Dacquet C, Spedding M and Laudet V. (2006) Overview of nomenclature of nuclear receptors. *Pharmacol Rev* **58**: 685-704 [PMID:17132848]
  26. Gonzalez MM and Carlberg C. (2002) Cross-repression, a functional consequence of the physical interaction of non-liganded nuclear receptors and POU domain transcription factors. *J Biol Chem* **277**: 18501-9 [PMID:11891224]
  27. Goodwin B, Gauthier KC, Umetani M, Watson MA, Lochansky MI, Collins JL, Leitersdorf E, Mangelsdorf DJ, Kliewer SA and Repa JJ. (2003) Identification of bile acid precursors as endogenous ligands for the nuclear xenobiotic pregnane X receptor. *Proc Natl Acad Sci USA* **100**: 223-8 [PMID:12509506]
  28. Goodwin B, Moore LB, Stoltz CM, McKee DD and Kliewer SA. (2001) Regulation of the human CYP2B6 gene by the nuclear pregnane X receptor. *Mol Pharmacol* **60**: 427-31 [PMID:11502872]
  29. Guo GL, Staudinger J, Ogura K and Klaassen CD. (2002) Induction of rat organic anion transporting polypeptide 2 by pregnenolone-16alpha-carbonitrile is via interaction with pregnane X receptor. *Mol Pharmacol* **61**: 832-9 [PMID:11901222]
  30. Herdick M, Steinmeyer A and Carlberg C. (2000) Carboxylic ester antagonists of 1alpha,25-dihydroxyvitamin D(3) show cell-specific actions. *Chem Biol* **7**: 885-94 [PMID:11094341]
  31. Honkakoski P, Sueyoshi T and Negishi M. (2003) Drug-activated nuclear receptors CAR and PXR. *Ann Med* **35**: 172-82 [PMID:12822739]
  32. Huang W, Zhang J, Washington M, Liu J, Parant JM, Lozano G and Moore DD. (2005) Xenobiotic stress induces hepatomegaly and liver tumors via the nuclear receptor constitutive androstane receptor. *Mol Endocrinol* **19**: 1646-53 [PMID:15831521]
  33. Huang W, Zhang J, Wei P, Schrader WT and Moore DD. (2004) Meclizine is an agonist ligand for mouse constitutive androstane receptor (CAR) and an inverse agonist for human CAR. *Mol Endocrinol* **18**: 2402-8 [PMID:15272053]
  34. Hughes MR, Malloy PJ, Kieback DG, Kesterson RA, Pike JW, Feldman D and O'Malley BW. (1988) Point mutations in the human vitamin D receptor gene associated with hypocalcemic rickets. *Science* **242**: 1702-5 [PMID:2849209]
  35. Ikeda M, Takahashi K, Dan A, Koyama K, Kubota K, Tanaka T and Hayashi M. (2000) Synthesis and biological evaluations of A-ring isomers of 26,26,26,27,27,27-hexafluoro-1,25-dihydroxyvitamin D3. *Bioorg Med Chem* **8**: 2157-66 [PMID:11003160]
  36. Jia Y, Guo GL, Surapureddi S, Sarkar J, Qi C, Guo D, Xia J, Kashireddi P, Yu S, Cho YW, Rao MS, Kemper B, Ge K, Gonzalez FJ and Reddy JK. (2005) Transcription coactivator peroxisome proliferator-activated receptor-binding protein/mediator 1 deficiency abrogates acetaminophen hepatotoxicity. *Proc Natl Acad Sci USA* **102**: 12531-6 [PMID:16109766]
  37. Jones SA, Moore LB, Shenk JL, Wisely GB, Hamilton GA, McKee DD, Tomkinson NC, LeCluyse EL, Lambert MH, Willson TM, Kliewer SA and Moore JT. (2000) The pregnane X receptor: a promiscuous xenobiotic receptor that has diverged during evolution. *Mol Endocrinol* **14**: 27-39 [PMID:10628745]
  38. Kamei Y, Kawada T, Fukuwatari T, Ono T, Kato S and Sugimoto E. (1995) Cloning and sequencing of the gene encoding the mouse vitamin D receptor. *Gene* **152**: 281-2 [PMID:7835717]
  39. Kanno Y, Tanuma N, Takahashi A and Inouye Y. (2013) TO901317, a potent LXR agonist, is an inverse agonist of CAR. *J Toxicol Sci* **38**: 309-15 [PMID:23665929]
  40. Kast HR, Goodwin B, Tarr PT, Jones SA, Anisfeld AM, Stoltz CM, Tontonoz P, Kliewer S, Willson TM and Edwards PA. (2002) Regulation of multidrug resistance-associated protein 2 (ABCC2) by the nuclear receptors pregnane X receptor, farnesoid X-activated receptor, and constitutive androstane receptor. *J Biol Chem* **277**: 2908-15 [PMID:11706036]
  41. Kliewer SA, Moore JT, Wade L, Staudinger JL, Watson MA, Jones SA, McKee DD, Oliver BB, Willson TM, Zetterström RH, Perlmann T and Lehmann JM. (1998) An orphan nuclear receptor activated by pregnanes defines a novel steroid signaling pathway. *Cell* **92**: 73-82 [PMID:9489701]
  42. Kliewer SA, Umehono K, Mangelsdorf DJ and Evans RM. (1992) Retinoid X receptor interacts with nuclear receptors in retinoic acid, thyroid hormone and vitamin D3 signalling. *Nature* **355**: 446-9 [PMID:1310351]
  43. Kodama S, Koike C, Negishi M and Yamamoto Y. (2004) Nuclear receptors CAR and PXR cross talk with FOXO1 to regulate genes that encode drug-metabolizing and gluconeogenic enzymes. *Mol Cell Biol* **24**: 7931-40 [PMID:15340055]
  44. Lehmann JM, McKee DD, Watson MA, Willson TM, Moore JT and Kliewer SA. (1998) The human orphan nuclear receptor PXR is activated by compounds that regulate CYP3A4 gene expression and cause drug interactions. *J Clin Invest* **102**: 1016-23 [PMID:9727070]
  45. Li YC, Pirro AE, Amling M, Delling G, Baron R, Bronson R and Demay MB. (1997) Targeted

- ablation of the vitamin D receptor: an animal model of vitamin D-dependent rickets type II with alopecia. *Proc Natl Acad Sci USA* **94**: 9831-5 [PMID:9275211]
46. Liang D, Li L, Ai Y, Li Z, Hedrich WD, Sakamuru S, Lynch C, Yu W, Watts-Ouattara I and Heyward S *et al.*. (2025) Potent and Selective Human Constitutive Androstane Receptor Activator DL5055 Facilitates Cyclophosphamide-Based Chemotherapies. *J Med Chem* **68**: 7044-7061 [PMID:40145447]
  47. Maglich JM, Parks DJ, Moore LB, Collins JL, Goodwin B, Billin AN, Stoltz CA, Kliewer SA, Lambert MH, Willson TM and Moore JT. (2003) Identification of a novel human constitutive androstane receptor (CAR) agonist and its use in the identification of CAR target genes. *J Biol Chem* **278**: 17277-83 [PMID:12611900]
  48. Makishima M, Lu TT, Xie W, Whitfield GK, Domoto H, Evans RM, Haussler MR and Mangelsdorf DJ. (2002) Vitamin D receptor as an intestinal bile acid sensor. *Science* **296**: 1313-6 [PMID:12016314]
  49. Miki Y, Suzuki T, Kitada K, Yabuki N, Shibuya R, Moriya T, Ishida T, Ohuchi N, Blumberg B and Sasano H. (2006) Expression of the steroid and xenobiotic receptor and its possible target gene, organic anion transporting polypeptide-A, in human breast carcinoma. *Cancer Res* **66**: 535-42 [PMID:16397270]
  50. Miyamoto K, Murayama E, Ochi K, Watanabe H and Kubodera N. (1993) Synthetic studies of vitamin D analogues. XIV. Synthesis and calcium regulating activity of vitamin D3 analogues bearing a hydroxyalkoxy group at the 2 beta-position. *Chem Pharm Bull* **41**: 1111-3 [PMID:8396500]
  51. Moore DD, Kato S, Xie W, Mangelsdorf DJ, Schmidt DR, Xiao R and Kliewer SA. (2006) International Union of Pharmacology. LXII. The NR1H and NR1I receptors: constitutive androstane receptor, pregnane X receptor, farnesoid X receptor alpha, farnesoid X receptor beta, liver X receptor alpha, liver X receptor beta, and vitamin D receptor. *Pharmacol Rev* **58**: 742-59 [PMID:17132852]
  52. Moore LB, Goodwin B, Jones SA, Wisely GB, Serabjit-Singh CJ, Willson TM, Collins JL and Kliewer SA. (2000) St. John's wort induces hepatic drug metabolism through activation of the pregnane X receptor. *Proc Natl Acad Sci USA* **97**: 7500-2 [PMID:10852961]
  53. Moore LB, Parks DJ, Jones SA, Bledsoe RK, Consler TG, Stimmel JB, Goodwin B, Liddle C, Blanchard SG, Willson TM, Collins JL and Kliewer SA. (2000) Orphan nuclear receptors constitutive androstane receptor and pregnane X receptor share xenobiotic and steroid ligands. *J Biol Chem* **275**: 15122-7 [PMID:10748001]
  54. Mu Y, Stephenson CR, Kendall C, Saini SP, Toma D, Ren S, Cai H, Strom SC, Day BW, Wipf P and Xie W. (2005) A pregnane X receptor agonist with unique species-dependent stereoselectivity and its implications in drug development. *Mol Pharmacol* **68**: 403-13 [PMID:15872116]
  55. Mu Y, Zhang J, Zhang S, Zhou HH, Toma D, Ren S, Huang L, Yaramus M, Baum A, Venkataramanan R and Xie W. (2006) Traditional Chinese medicines Wu Wei Zi (Schisandra chinensis Baill) and Gan Cao (Glycyrrhiza uralensis Fisch) activate pregnane X receptor and increase warfarin clearance in rats. *J Pharmacol Exp Ther* **316**: 1369-77 [PMID:16267138]
  56. Nishimura M, Naito S and Yokoi T. (2004) Tissue-specific mRNA expression profiles of human nuclear receptor subfamilies. *Drug Metab Pharmacokinet* **19**: 135-49 [PMID:15499180]
  57. Ourlin JC, Lasserre F, Pineau T, Fabre JM, Sa-Cunha A, Maurel P, Vilarem MJ and Pascussi JM. (2003) The small heterodimer partner interacts with the pregnane X receptor and represses its transcriptional activity. *Mol Endocrinol* **17**: 1693-703 [PMID:12805410]
  58. Peleg S, Uskokovic M, Ahene A, Vickery B and Avnur Z. (2002) Cellular and molecular events associated with the bone-protecting activity of the noncalcemic vitamin D analog Ro-26-9228 in osteopenic rats. *Endocrinology* **143**: 1625-36 [PMID:11956143]
  59. Rochel N, Wurtz JM, Mitschler A, Klaholz B and Moras D. (2000) The crystal structure of the nuclear receptor for vitamin D bound to its natural ligand. *Mol Cell* **5**: 173-9 [PMID:10678179]
  60. Saito N, Matsunaga T, Saito H, Anzai M, Takenouchi K, Miura D, Namekawa J, Ishizuka S and Kittaka A. (2006) Further synthetic and biological studies on vitamin D hormone antagonists based on C24-alkylation and C2alpha-functionalization of 25-dehydro-1alpha-hydroxyvitamin D(3)-26,23-lactones. *J Med Chem* **49**: 7063-75 [PMID:17125259]
  61. Sato K, Nishii Y, Woodiel FN and Raisz LG. (1993) Effects of two new vitamin D3 derivatives, 22-oxa-1 alpha-25-dihydroxyvitamin D3 (OCT) and 2 beta-(3-hydroxypropoxy)-1 alpha, 25-dihydroxyvitamin D3 (ED-71), on bone metabolism in organ culture. *Bone* **14**: 47-51 [PMID:8443002]
  62. Schuetz EG, Brimer C and Schuetz JD. (1998) Environmental xenobiotics and the antihormones cyproterone acetate and spironolactone use the nuclear hormone pregnenolone X receptor to activate the CYP3A23 hormone response element. *Mol Pharmacol* **54**: 1113-7 [PMID:9855641]
  63. Shan L, Vincent J, Brunzelle JS, Dussault I, Lin M, Ianculescu I, Sherman MA, Forman BM and Fernandez EJ. (2004) Structure of the murine constitutive androstane receptor complexed to androstenol: a molecular basis for inverse agonism. *Mol Cell* **16**: 907-17 [PMID:15610734]
  64. Shiina Y, Abe E, Miyaura C, Tanaka H, Yamada S, Ohmori M, Nakayama K, Takayama H,

- Matsunaga I, Nishii Y, DeLuca HF and Suda T. (1983) Biological activity of 24,24-difluoro-1 alpha, 25-dihydroxyvitamin D3 and 1 alpha, 25-dihydroxyvitamin D3-26,23-lactone in inducing differentiation of human myeloid leukemia cells. *Arch Biochem Biophys* **220**: 90-4 [PMID:6572492]
65. Shiraki T, Sakai N, Kanaya E and Jingami H. (2003) Activation of orphan nuclear constitutive androstane receptor requires subnuclear targeting by peroxisome proliferator-activated receptor gamma coactivator-1 alpha. A possible link between xenobiotic response and nutritional state. *J Biol Chem* **278**: 11344-50 [PMID:12551939]
  66. Sicinski RR, Prahl JM, Smith CM and DeLuca HF. (1998) New 1alpha,25-dihydroxy-19-norvitamin D3 compounds of high biological activity: synthesis and biological evaluation of 2-hydroxymethyl, 2-methyl, and 2-methylene analogues. *J Med Chem* **41**: 4662-74 [PMID:9804706]
  67. Sonoda J, Xie W, Rosenfeld JM, Barwick JL, Guzelian PS and Evans RM. (2002) Regulation of a xenobiotic sulfonation cascade by nuclear pregnane X receptor (PXR). *Proc Natl Acad Sci USA* **99**: 13801-6 [PMID:12370413]
  68. Staudinger JL, Goodwin B, Jones SA, Hawkins-Brown D, MacKenzie KI, LaTour A, Liu Y, Klaassen CD, Brown KK, Reinhard J, Willson TM, Koller BH and Kliewer SA. (2001) The nuclear receptor PXR is a lithocholic acid sensor that protects against liver toxicity. *Proc Natl Acad Sci USA* **98**: 3369-74 [PMID:11248085]
  69. Sueyoshi T, Kawamoto T, Zelko I, Honkakoski P and Negishi M. (1999) The repressed nuclear receptor CAR responds to phenobarbital in activating the human CYP2B6 gene. *J Biol Chem* **274**: 6043-6 [PMID:10037683]
  70. Sugatani J, Kojima H, Ueda A, Kakizaki S, Yoshinari K, Gong QH, Owens IS, Negishi M and Sueyoshi T. (2001) The phenobarbital response enhancer module in the human bilirubin UDP-glucuronosyltransferase UGT1A1 gene and regulation by the nuclear receptor CAR. *Hepatology* **33**: 1232-8 [PMID:11343253]
  71. Sugatani J, Nishitani S, Yamakawa K, Yoshinari K, Sueyoshi T, Negishi M and Miwa M. (2005) Transcriptional regulation of human UGT1A1 gene expression: activated glucocorticoid receptor enhances constitutive androstane receptor/pregnane X receptor-mediated UDP-glucuronosyltransferase 1A1 regulation with glucocorticoid receptor-interacting protein 1. *Mol Pharmacol* **67**: 845-55 [PMID:15557560]
  72. Synold TW, Dussault I and Forman BM. (2001) The orphan nuclear receptor SXR coordinately regulates drug metabolism and efflux. *Nat Med* **7**: 584-90 [PMID:11329060]
  73. Tabb MM, Sun A, Zhou C, Grün F, Errandi J, Romero K, Pham H, Inoue S, Mallick S, Lin M, Forman BM and Blumberg B. (2003) Vitamin K2 regulation of bone homeostasis is mediated by the steroid and xenobiotic receptor SXR. *J Biol Chem* **278**: 43919-27 [PMID:12920130]
  74. Takeshita A, Taguchi M, Koibuchi N and Ozawa Y. (2002) Putative role of the orphan nuclear receptor SXR (steroid and xenobiotic receptor) in the mechanism of CYP3A4 inhibition by xenobiotics. *J Biol Chem* **277**: 32453-8 [PMID:12072427]
  75. Tzamelis I, Pissios P, Schuetz EG and Moore DD. (2000) The xenobiotic compound 1,4-bis[2-(3,5-dichloropyridyloxy)]benzene is an agonist ligand for the nuclear receptor CAR. *Mol Cell Biol* **20**: 2951-8 [PMID:10757780]
  76. Verlinden L, Verstuyf A, Van Camp M, Marcelis S, Sabbe K, Zhao XY, De Clercq P, Vandewalle M and Bouillon R. (2000) Two novel 14-Epi-analogues of 1,25-dihydroxyvitamin D3 inhibit the growth of human breast cancer cells in vitro and in vivo. *Cancer Res* **60**: 2673-9 [PMID:10825140]
  77. Wang W, Prorise WW, Chen J, Taremi SS, Le HV, Madison V, Cui X, Thomas A, Cheng KC and Lesburg CA. (2008) Construction and characterization of a fully active PXR/SRC-1 tethered protein with increased stability. *Protein Eng Des Sel* **21**: 425-33 [PMID:18456871]
  78. Wei P, Zhang J, Dowhan DH, Han Y and Moore DD. (2002) Specific and overlapping functions of the nuclear hormone receptors CAR and PXR in xenobiotic response. *Pharmacogenomics J* **2**: 117-26 [PMID:12049174]
  79. Wei P, Zhang J, Egan-Hafley M, Liang S and Moore DD. (2000) The nuclear receptor CAR mediates specific xenobiotic induction of drug metabolism. *Nature* **407**: 920-3 [PMID:11057673]
  80. Wentworth JM, Agostini M, Love J, Schwabe JW and Chatterjee VK. (2000) St John's wort, a herbal antidepressant, activates the steroid X receptor. *J Endocrinol* **166**: R11-6 [PMID:10974665]
  81. Weyts FA, Dhawan P, Zhang X, Bishop JE, Uskokovic MR, Ji Y, Studzinski GP, Norman AW and Christakos S. (2004) Novel Gemini analogs of 1alpha,25-dihydroxyvitamin D(3) with enhanced transcriptional activity. *Biochem Pharmacol* **67**: 1327-36 [PMID:15013848]
  82. Wiberg K, Ljunghall S, Binderup L and Ljunggren O. (1995) Studies on two new vitamin D analogs, EB 1089 and KH 1060: effects on bone resorption and osteoclast recruitment in vitro. *Bone* **17**: 391-5 [PMID:8573413]
  83. Wyde ME, Bartolucci E, Ueda A, Zhang H, Yan B, Negishi M and You L. (2003) The environmental pollutant 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene induces rat hepatic cytochrome P450 2B and 3A expression through the constitutive androstane receptor and

- pregnane X receptor. *Mol Pharmacol* **64**: 474-81 [PMID:12869653]
84. Xie W, Barwick JL, Downes M, Blumberg B, Simon CM, Nelson MC, Neuschwander-Tetri BA, Brunt EM, Guzelian PS and Evans RM. (2000) Humanized xenobiotic response in mice expressing nuclear receptor SXR. *Nature* **406**: 435-9 [PMID:10935643]
  85. Xie W, Radominska-Pandya A, Shi Y, Simon CM, Nelson MC, Ong ES, Waxman DJ and Evans RM. (2001) An essential role for nuclear receptors SXR/PXR in detoxification of cholestatic bile acids. *Proc Natl Acad Sci USA* **98**: 3375-80 [PMID:11248086]
  86. Xie W, Yeuh MF, Radominska-Pandya A, Saini SP, Negishi Y, Bottroff BS, Cabrera GY, Tukey RH and Evans RM. (2003) Control of steroid, heme, and carcinogen metabolism by nuclear pregnane X receptor and constitutive androstane receptor. *Proc Natl Acad Sci USA* **100**: 4150-5 [PMID:12644700]
  87. Xu SZ, Zeng F, Boulay G, Grimm C, Harteneck C and Beech DJ. (2005) Block of TRPC5 channels by 2-aminoethoxydiphenyl borate: a differential, extracellular and voltage-dependent effect. *Br J Pharmacol* **145**: 405-14 [PMID:15806115]
  88. Yoshinari K, Sueyoshi T, Moore R and Negishi M. (2001) Nuclear receptor CAR as a regulatory factor for the sexually dimorphic induction of CYB2B1 gene by phenobarbital in rat livers. *Mol Pharmacol* **59**: 278-84 [PMID:11160864]
  89. Yoshizawa T, Handa Y, Uematsu Y, Takeda S, Sekine K, Yoshihara Y, Kawakami T, Arioka K, Sato H, Uchiyama Y, Masushige S, Fukamizu A, Matsumoto T and Kato S. (1997) Mice lacking the vitamin D receptor exhibit impaired bone formation, uterine hypoplasia and growth retardation after weaning. *Nat Genet* **16**: 391-6 [PMID:9241280]
  90. Zeitz U, Weber K, Soegiarto DW, Wolf E, Balling R and Erben RG. (2003) Impaired insulin secretory capacity in mice lacking a functional vitamin D receptor. *FASEB J* **17**: 509-11 [PMID:12551842]
  91. Zhang H, LeCulyse E, Liu L, Hu M, Matoney L, Zhu W and Yan B. (1999) Rat pregnane X receptor: molecular cloning, tissue distribution, and xenobiotic regulation. *Arch Biochem Biophys* **368**: 14-22 [PMID:10415106]
  92. Zhang J, Huang W, Chua SS, Wei P and Moore DD. (2002) Modulation of acetaminophen-induced hepatotoxicity by the xenobiotic receptor CAR. *Science* **298**: 422-4 [PMID:12376703]