

GABA_A receptors in GtoPdb v.2025.3

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Abstract

The GABA_A receptor is a ligand-gated ion channel of the Cys-loop family that includes the nicotinic acetylcholine, 5-HT₃ and strychnine-sensitive glycine receptors. GABA_A receptor-mediated inhibition within the CNS occurs by fast synaptic transmission, sustained tonic inhibition and temporally intermediate events that have been termed 'GABA_A, slow' [45]. GABA_A receptors exist as pentamers of 4TM subunits that form an intrinsic anion selective channel. Sequences of six α , three β , three γ , one δ , three ρ , one ϵ , one π and one θ GABA_A receptor subunits have been reported in mammals [282, 238, 239, 289]. The π -subunit is restricted to reproductive tissue. Alternatively spliced versions of many subunits exist (e.g. $\alpha 4$ - and $\alpha 6$ - (both not functional) $\alpha 5$ -, $\beta 2$ -, $\beta 3$ - and $\gamma 2$), along with RNA editing of the $\alpha 3$ subunit [71]. The three ρ -subunits, ($\rho 1$ -3) function as either homo- or hetero-oligomeric assemblies [366, 50]. Receptors formed from ρ -subunits, because of their distinctive pharmacology that includes insensitivity to bicuculline, benzodiazepines and barbiturates, have sometimes been termed GABA_C receptors [366], **but they are classified as GABA_A receptors by NC-IUPHAR on the basis of structural and functional criteria [16, 238, 239].**

Many GABA_A receptor subtypes contain α -, β - and γ -subunits with the likely stoichiometry 2 α .2 β .1 γ [170, 238]. It is thought that the majority of GABA_A receptors harbour a single type of α - and β -subunit variant. The $\alpha 1\beta 2\gamma 2$ hetero-oligomer constitutes the largest population of GABA_A receptors in the CNS, followed by the $\alpha 2\beta 3\gamma 2$ and $\alpha 3\beta 3\gamma 2$ isoforms. Receptors that incorporate the $\alpha 4$ - $\alpha 5$ - or $\alpha 6$ -subunit, or the $\beta 1$ -, $\gamma 1$ -, $\gamma 3$ -, δ -, ϵ - and θ -subunits, are less numerous, but they may nonetheless serve important functions. For example, extrasynaptically located receptors that contain $\alpha 6$ - and δ -subunits in cerebellar granule cells, or an $\alpha 4$ - and δ -subunit in dentate gyrus granule cells and thalamic neurones, mediate a tonic current that is important for neuronal excitability in response to ambient concentrations of GABA [212, 276, 84, 19, 294]. GABA binding occurs at the β +/ α - subunit interface and the homologous γ +/ α - subunits interface creates the benzodiazepine site. A second site for benzodiazepine binding has recently been postulated to occur at the α +/ β - interface ([258]; reviewed by [288]). The particular α - and γ -subunit isoforms exhibit marked effects on recognition and/or efficacy at the benzodiazepine site. Thus, receptors incorporating either $\alpha 4$ - or $\alpha 6$ -subunits are not recognised by 'classical' benzodiazepines, such as flunitrazepam (but see [363]). The trafficking, cell surface expression, internalisation and function of GABA_A receptors and their subunits are discussed in detail in several recent reviews [52, 141, 191, 323] but one point worthy of note is that receptors incorporating the $\gamma 2$ subunit (except when associated with $\alpha 5$) cluster at the postsynaptic membrane (but may distribute dynamically between synaptic and extrasynaptic locations), whereas those incorporating the δ subunit appear to be exclusively extrasynaptic.

NC-IUPHAR [16, 238, 3, 2] class the GABA_A receptors according to their subunit structure, pharmacology and receptor function. Currently, eleven native GABA_A receptors are classed as conclusively identified (*i.e.*, $\alpha 1\beta 2\gamma 2$, $\alpha 2\beta \gamma 2$, $\alpha 3\beta \gamma 2$, $\alpha 4\beta \gamma 2$, $\alpha 4\beta 2\delta$, $\alpha 4\beta 3\delta$, $\alpha 5\beta \gamma 2$, $\alpha 6\beta \gamma 2$, $\alpha 6\beta 2\delta$, $\alpha 6\beta 3\delta$ and ρ) with further receptor isoforms occurring with high probability, or only tentatively [238, 239]. It is beyond the scope of this Guide to discuss the pharmacology of individual GABA_A receptor isoforms in detail; such information can be gleaned in the reviews [16, 96, 170, 176, 144, 282, 219,

238, 239, 285, 9, 10]. Agents that discriminate between α -subunit isoforms are noted in the table and additional agents that demonstrate selectivity between receptor isoforms, for example *via* β -subunit selectivity, are indicated in the text below. The distinctive agonist and antagonist pharmacology of ρ receptors is summarised in the table and additional aspects are reviewed in [366, 50, 146, 226].

Several high-resolution cryo-electron microscopy structures have been described in which the full-length human $\alpha 1\beta 3\gamma 2L$ GABA_A receptor in lipid nanodiscs is bound to the channel-blocker picrotoxin, the competitive antagonist bicuculline, the agonist GABA (γ -aminobutyric acid), and the classical benzodiazepines [alprazolam](#) and [diazepam](#) [201].

Contents

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Introduction to GABA_A receptors

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GABA_A receptor $\rho 3$ subunit

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