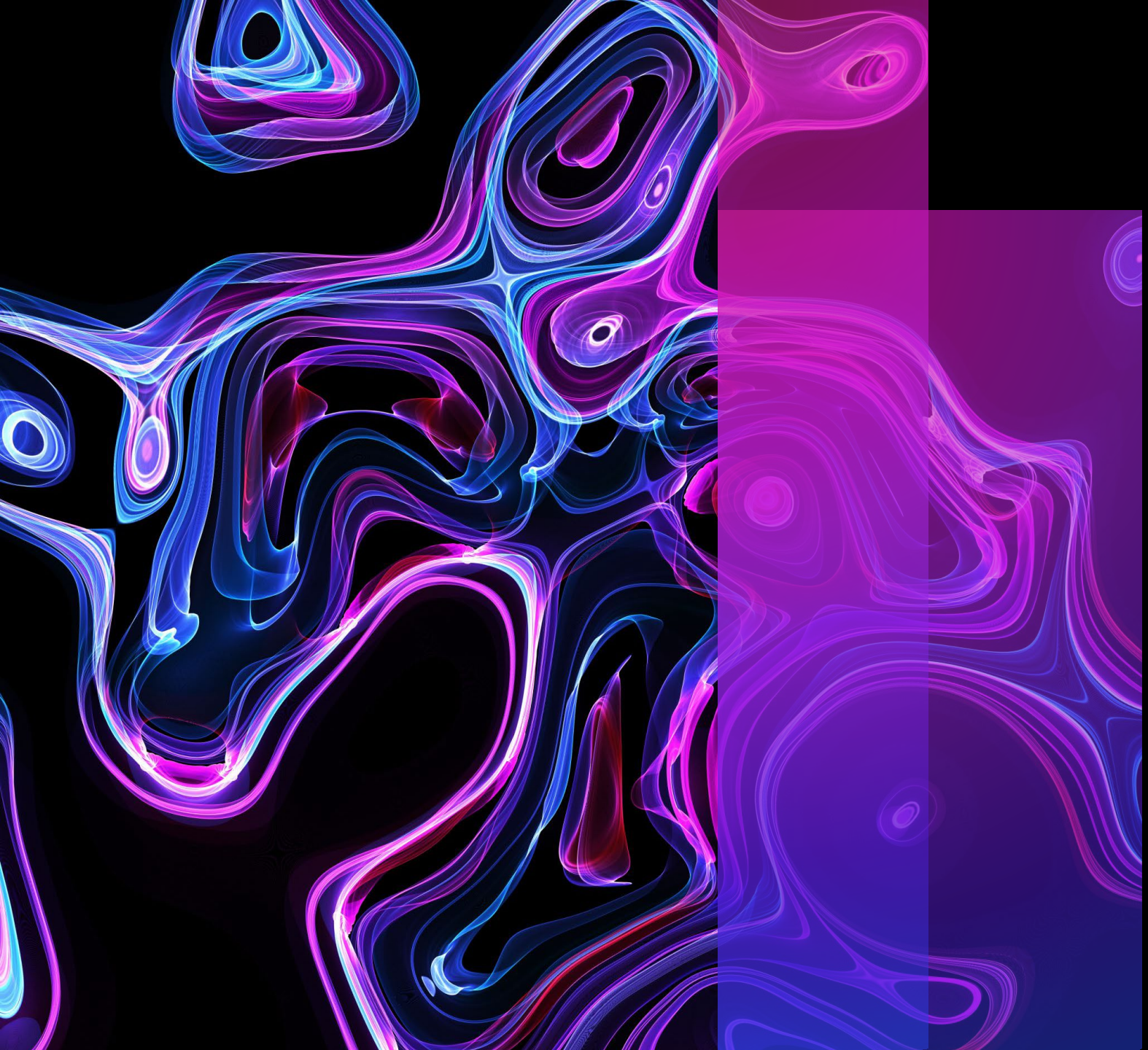


Killing ourselves by Forgetting the Brakes

A deep dive into GABA, Positive Allosteric Modulators, and Natural Equivalents

Scott Sherr MD

Disclosures

- COO, Health Optimization Medicine and Practice
- COO, Troscriptions
- Founder, Integrative HBOT
- Cofounder, OneBase Health
- Dr. Alan Sherr

Top Symptoms of GABA deficiency

- Mental Health:
  - Anxiety, Fear, Depression, short temper, Phobias, impulsiveness / disorganization, addictions, migrains
  - Schizophrenia
  - OCD
- Systemic Symptoms:
  - IBS, Diarrhea, HTN, tinnitus, chronic pain, allergies, frequent urination, flushing/blushing, sweating, salt cravings, muscle tension, muscle wasting (or difficulty gaining muscle)

https://gammaaminobutyricacid.org/gaba-deficiency/

Anxiety

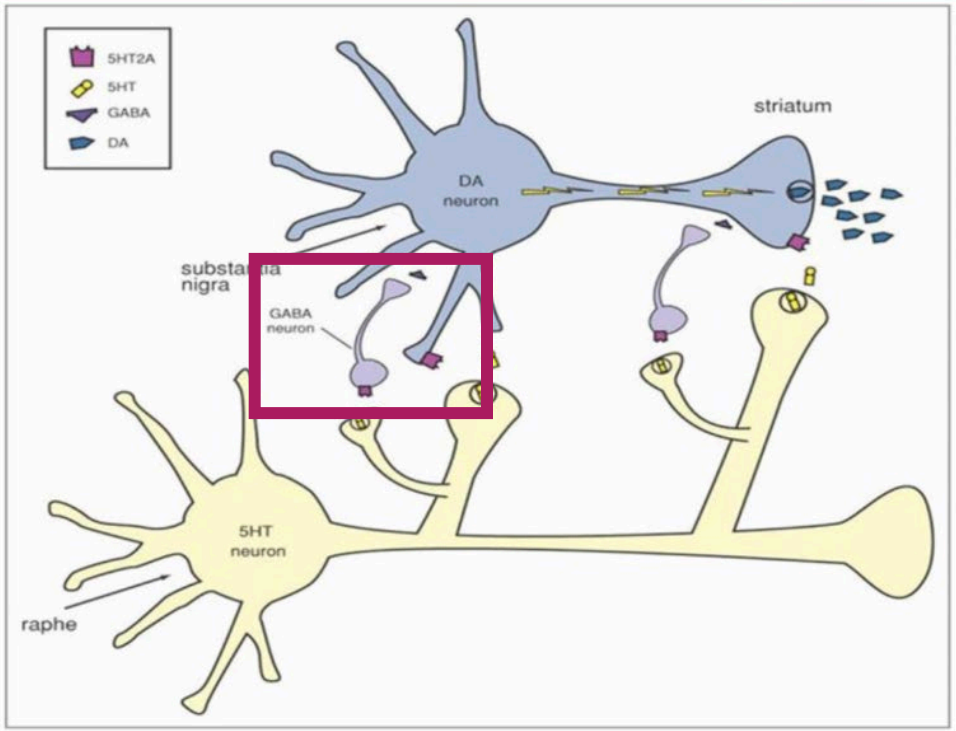
- In 2021, a sample of 1978 American men and women was prevalent in 42% of the population, with women more likely than men to have anxiety symptoms.
- The pandemic increased rates by 25%.
- People are self-medicating with food (→ Obesity), alcohol (→ Liver failure), and illegal drugs (→Overdoses).
- Prescribed medications for anxiety (Xanax, Valium, Ativan, etc) and sleep (Ambien, Lunesta) are highly addictive, very difficult to stop, and are associated with increases in all-cause mortality.

Depression

- Pre-pandemic, between 2015 and 2020, the incidence of depression rose to nearly 10% in American adults and almost 20% in teens and young adults (17%)
- Pandemic increased rates by 25%
- Depression is a primary driver of suicide and suicide attempts
- Often these patients turn to drugs, alcohol, and risky behaviors
- The drugs we use come with black box warnings of suicidality, especially in young people.

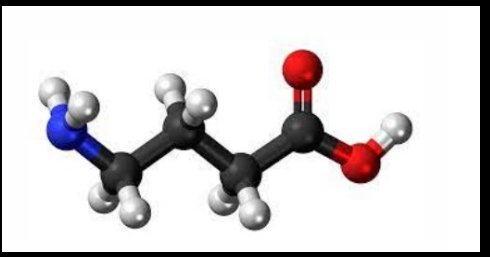
https://www.usnews.com/news/health-news/articles/2022-09-19/depression-affects-almost-1-in-10-americans#:~:text=19%2C%202022-,Sept.,2022%2C%20at%2011%3A55%20a.m.&text=MONDAY%2C%20Sept.,adults%2C%20a%20new%20study%20finds.

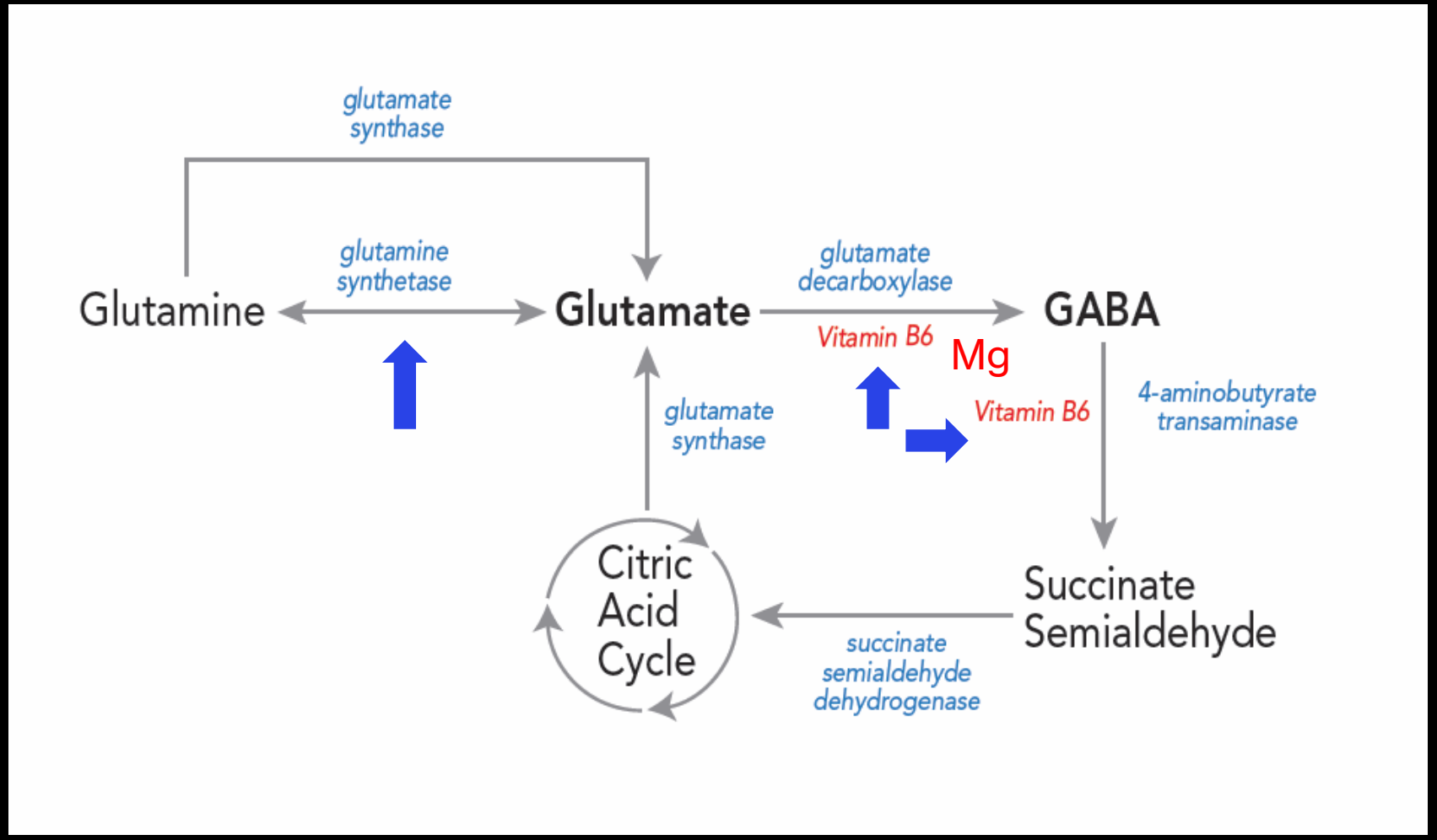
GABA Cells are Inter-neurons



GABA Synthesis

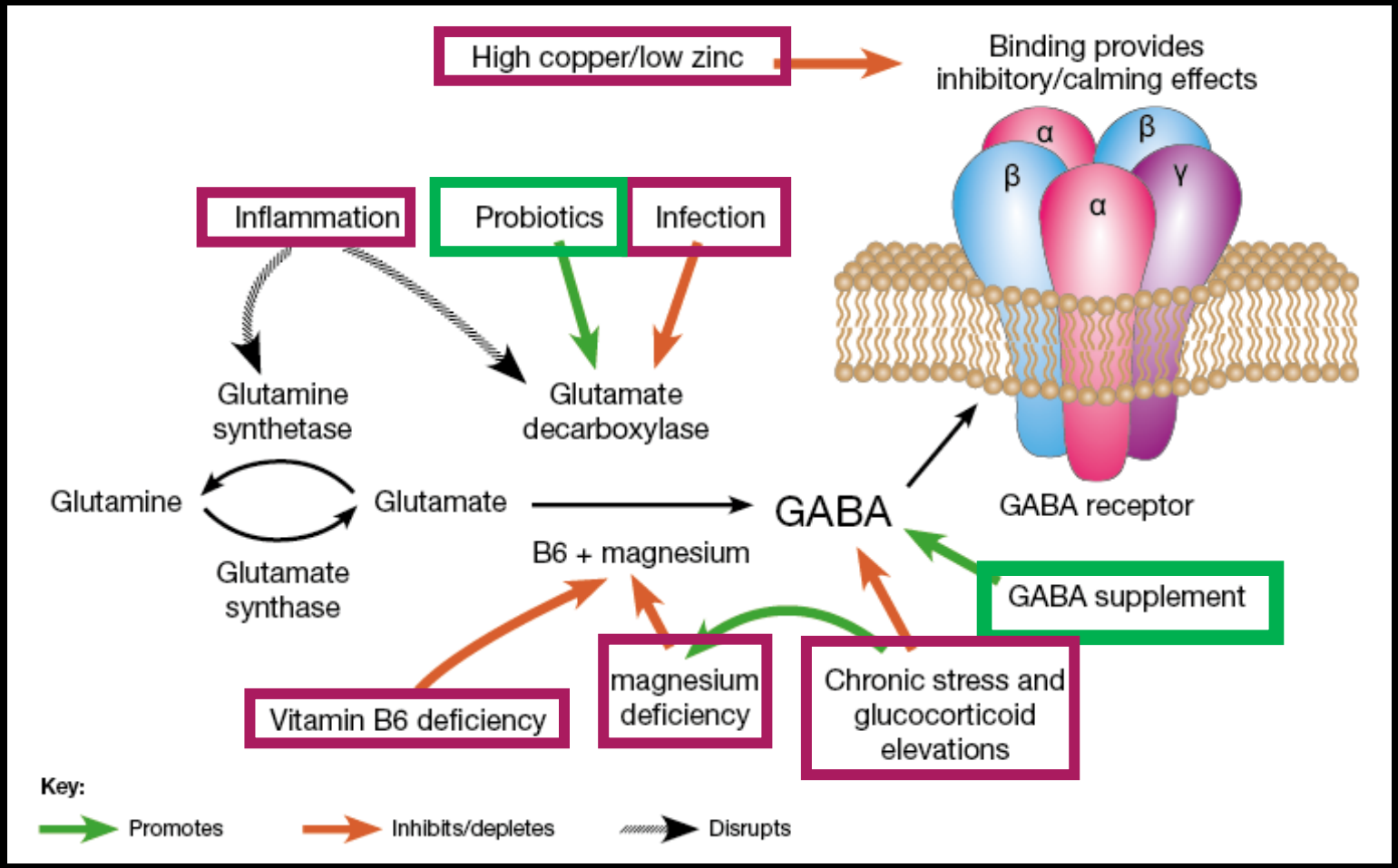
http://neuroendoimmune.files.wordpress.com/2013/07/gaba-glutamate-synthesis.png





https://www.ironmagazine.com/wp-content/uploads/2016/12/What-is-Gaba-720x446.png

Factors Affecting GABA Synthesis



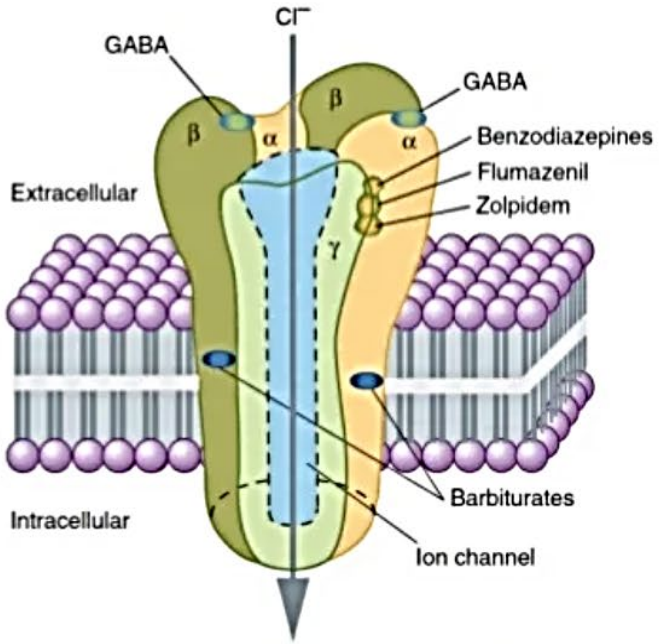
https://openi.nlm.nih.gov/imgs/512/391/4131092/PMC4131092_SCIENTIFICA2014-149187.002.png

GABA Receptors

Gamma aminobutyric acid (**GABA**) is the major inhibitory neurotransmitter

20% 0f CNS transmission

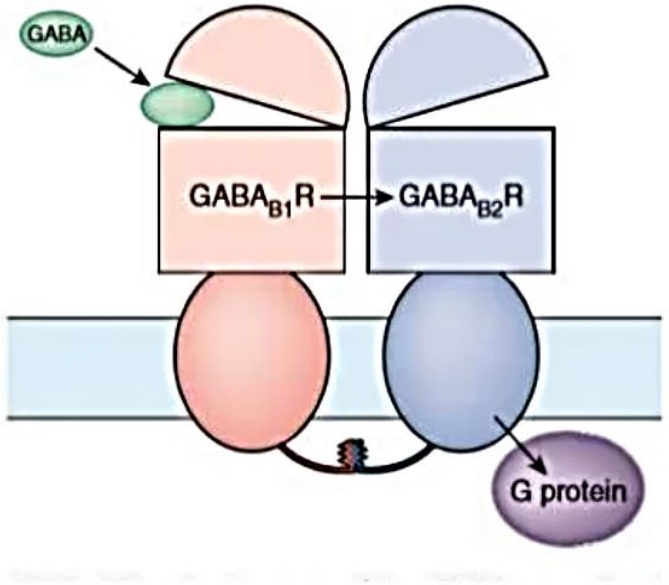
GABA A Receptors



Ionotropic (Cl^- channel)

Pentamer

GABA B Receptors

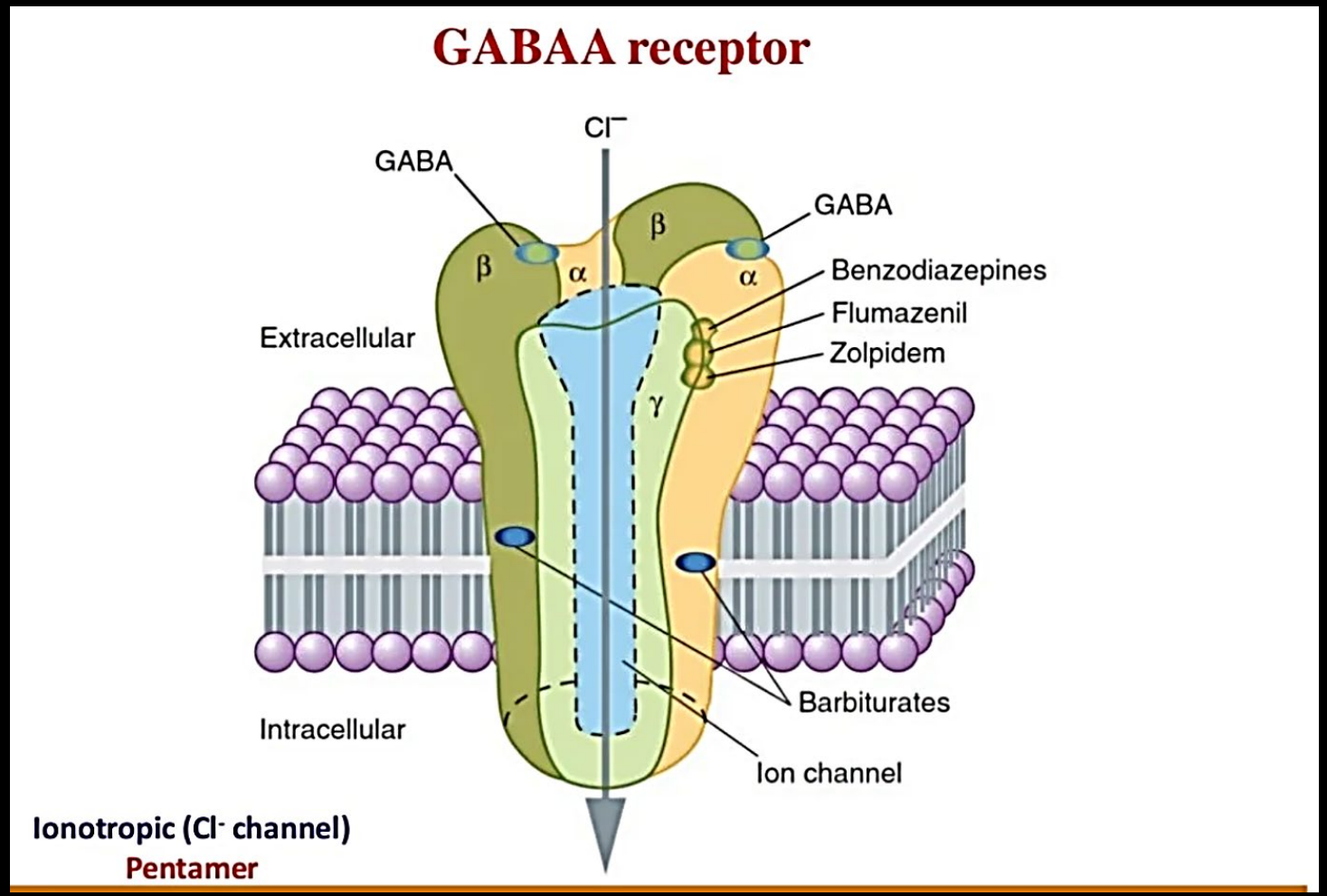


Metabotropic (Gi-prot.)

Dimer

https://openi.nlm.nih.gov/imgs/512/391/4131092/PMC4131092_SCIENTIFICA2014-149187.002.png

GABA A Receptors



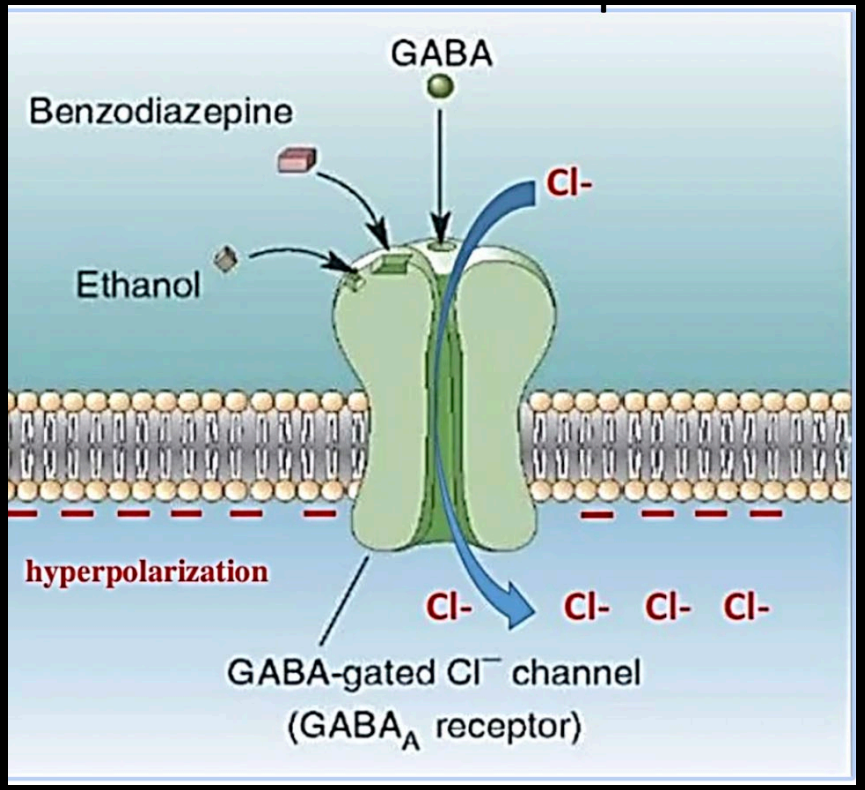
The $GABA_A$ receptors are made up of subunits which form a receptor complex. Humans have 19 receptor subunits and are classified into α (1–6), β (1–3), γ (1–3), δ, ε, π, θ, and ρ (1–3). The function of the receptor is different according to how the pentameric complex is put together. The most common complex that includes around 40% of the $GABA_A$ receptors is the α1β2γ2 combination.

Mechanism of action: GABA A receptor

Mechanism of action

→ Activation of **$GABA_A$** receptor
(Endogenous – **GABA**, Inositol; Exogenous - Drugs)
↓
→ Opening of central pore
↓
→ **↑ influx of Cl- ions** through the pore
↓
→ Hyperpolarization of the neuronal membrane
↓
→ ↓ occurrence of action potential
↓
→ **Inhibition of neurotransmition**
(early part of IPSP)

15



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https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them

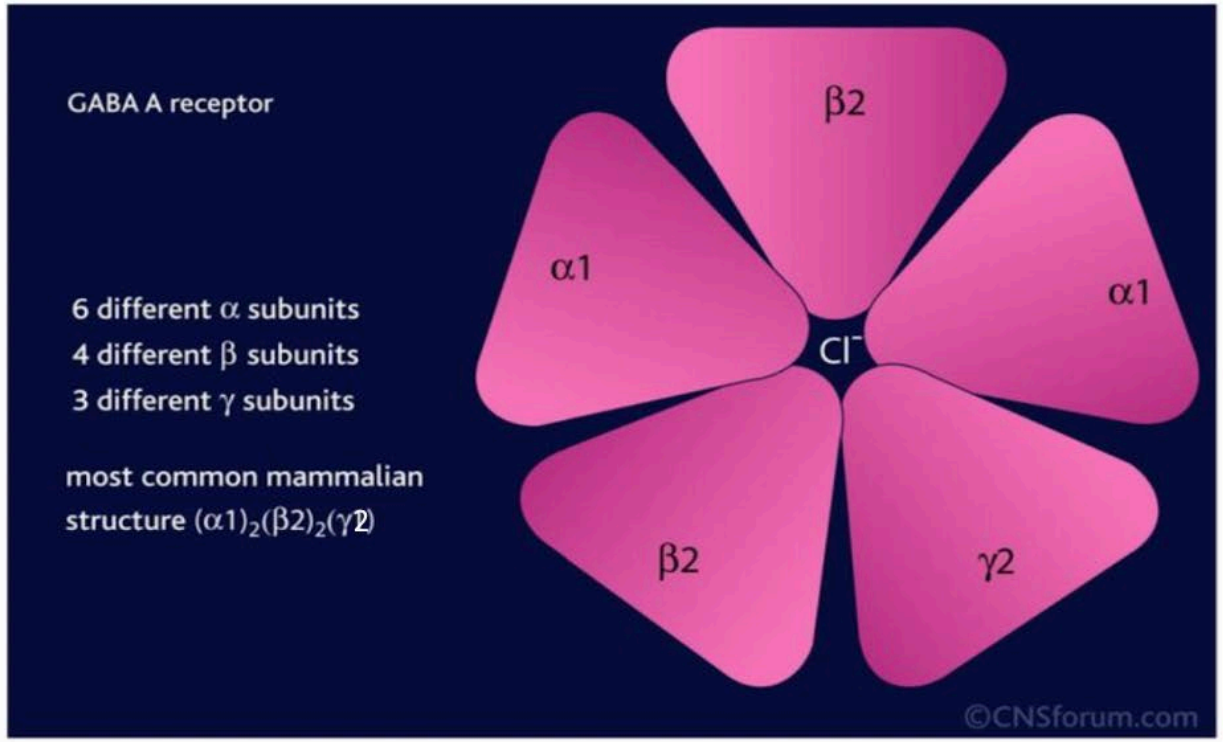
https://image.slidesharecdn.com/benzodiazepines-120115103433-phpapp02/95/benzodiazepines-7-728.jpg?cb=1326625284

Receptor Selectivity

Selectivity for GABA-A Receptor Subunits

GABA A Receptors containing Alpha 1 subunits are involved in SLEEP MODULATION

GABA A Receptors containing alpha 2 or alpha 3 subunits are involved in EXPERIENCES of ANXIETY



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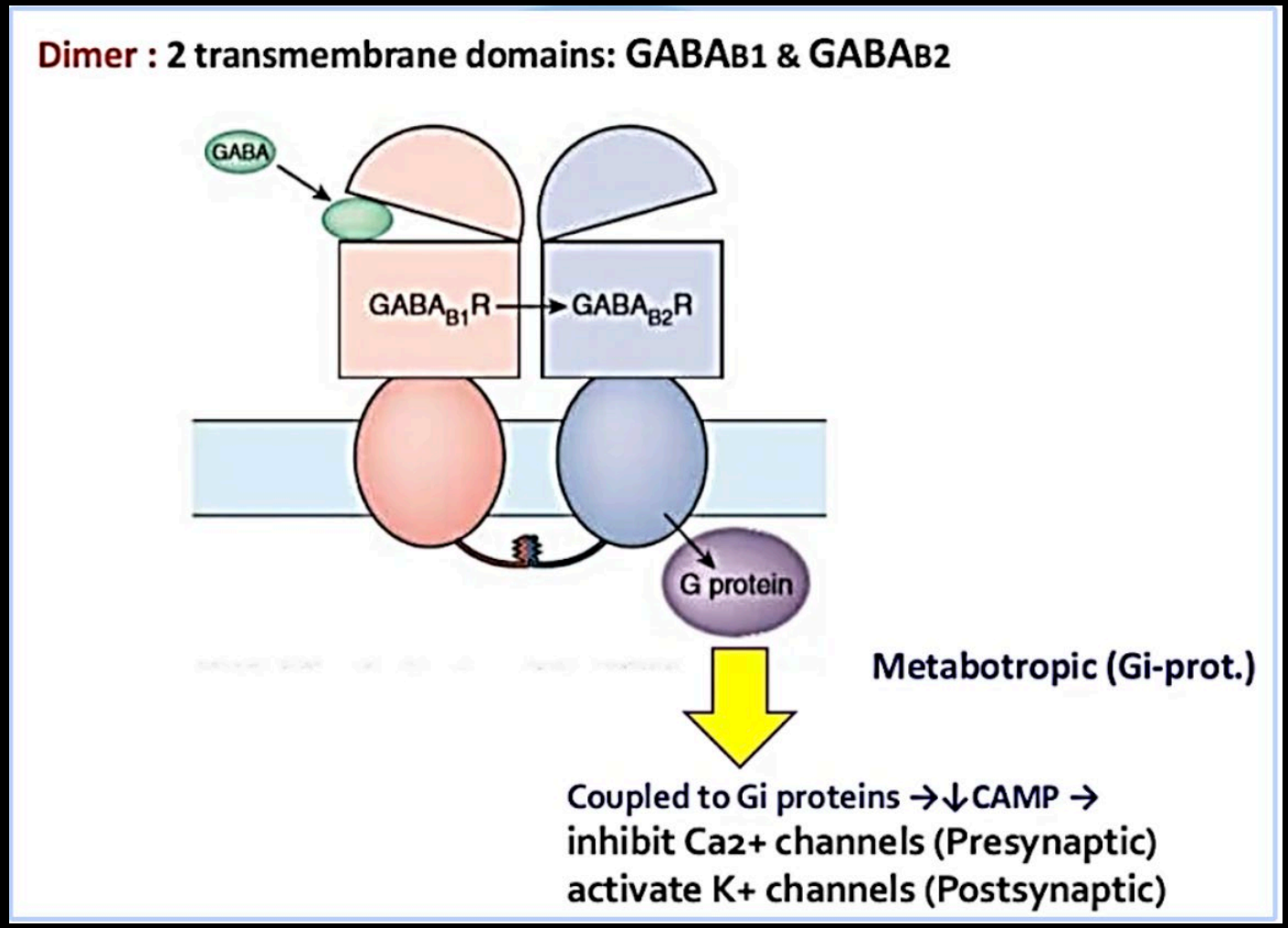
www.mghcme.org

Composition, Distribution, and Major Functions of $GABA_A$ Receptors

SUBUNIT COMPOSITION	LOCATION	FUNCTION
$\alpha1\beta2\gamma2$	Widespread GABA Neurons	Sedation, anticonvulsant activity
$\alpha2\beta3\gamma2$	Forebrain, spinal cord	Anxiety, muscle relaxant
$\alpha2\beta1\gamma1$	Glia	
$\alpha3\beta3\gamma2$	Cortex	Anticonvulsant activity
$\alpha4\beta2\gamma2$	Thalamus	
$\alpha4\beta2/3\gamma2$	Dentate gyrus	
$\alpha4\beta2\delta$	Thalamus	Tonic inhibition
$\alpha4\beta2/3\delta$	Dentate gyrus	
$\alpha5\beta3\gamma2$	Hippocampus CA1	Tonic inhibition
	Sensory Ganglia	
$\alpha6\beta2/3\gamma2$	Cerebellar granule cells	
$\alpha6\beta2/3\delta$	Cerebellar granule cells	Tonic inhibition
$\gamma3$, θ, ε	Little information	

https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them

GABA B receptor



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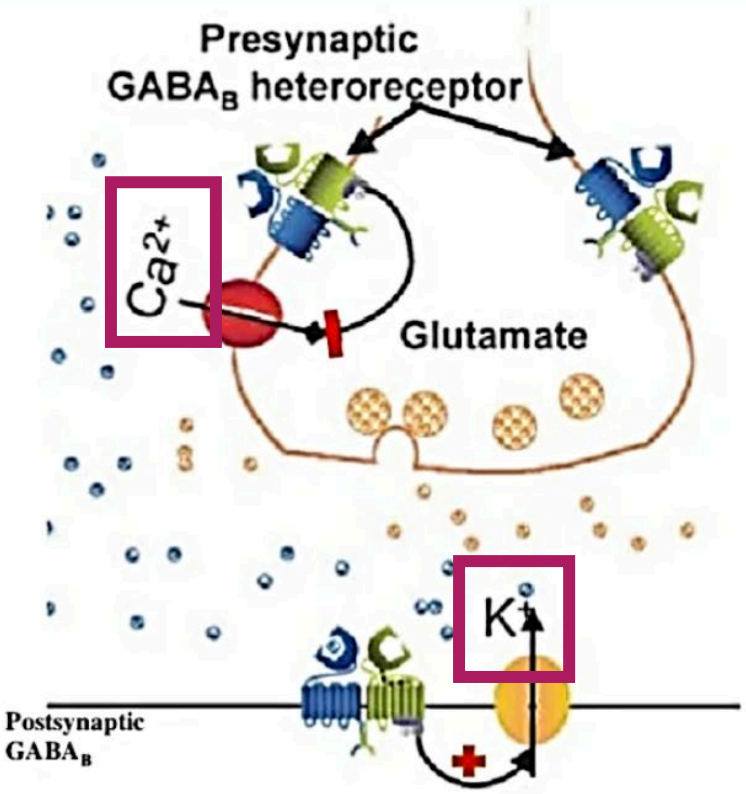
GABA B Receptor Mechanism



Neuronal Inhibition

GABA$_B$ receptors: Metabotropic (G-prot.) > in Spinal cord

Presynaptic ↓ Ca^{2+} influx → ↓ release of the excitatory transmitter glutamate.

Postsynaptic ↑ K+ outflux → hyperpolarization

https://external-content.duckduckgo.com/iu/?u=https%3A%2F%2Fd3i71xaburhd42.cloudfront.net%2F44eb4f10d1836a6101c004a933242dec20b87975%2F3-Figure2-1.png&f=1&nofb=1&ipt=da3f9a0736c3c52adab029a182177b30ce1473d18f37ded43ed31f0acf882452&ipo=images

	GABA A	GABA B
Type	Ionotropic	Metabotropic
Location	Widespread; **Post-synaptic**	Widespread; **Pre-** & **Post-synaptic**
Structure	Pentamer	Dimer
MOA	Post-synaptic inhibition by - **↑ Cl- influx**	Pre-synaptic inhibition by – **↓ Ca2+ entry** Post-synaptic inhibition by – **↑ K+ permeability**
Endogenous agonist	**GABA**	**GABA**

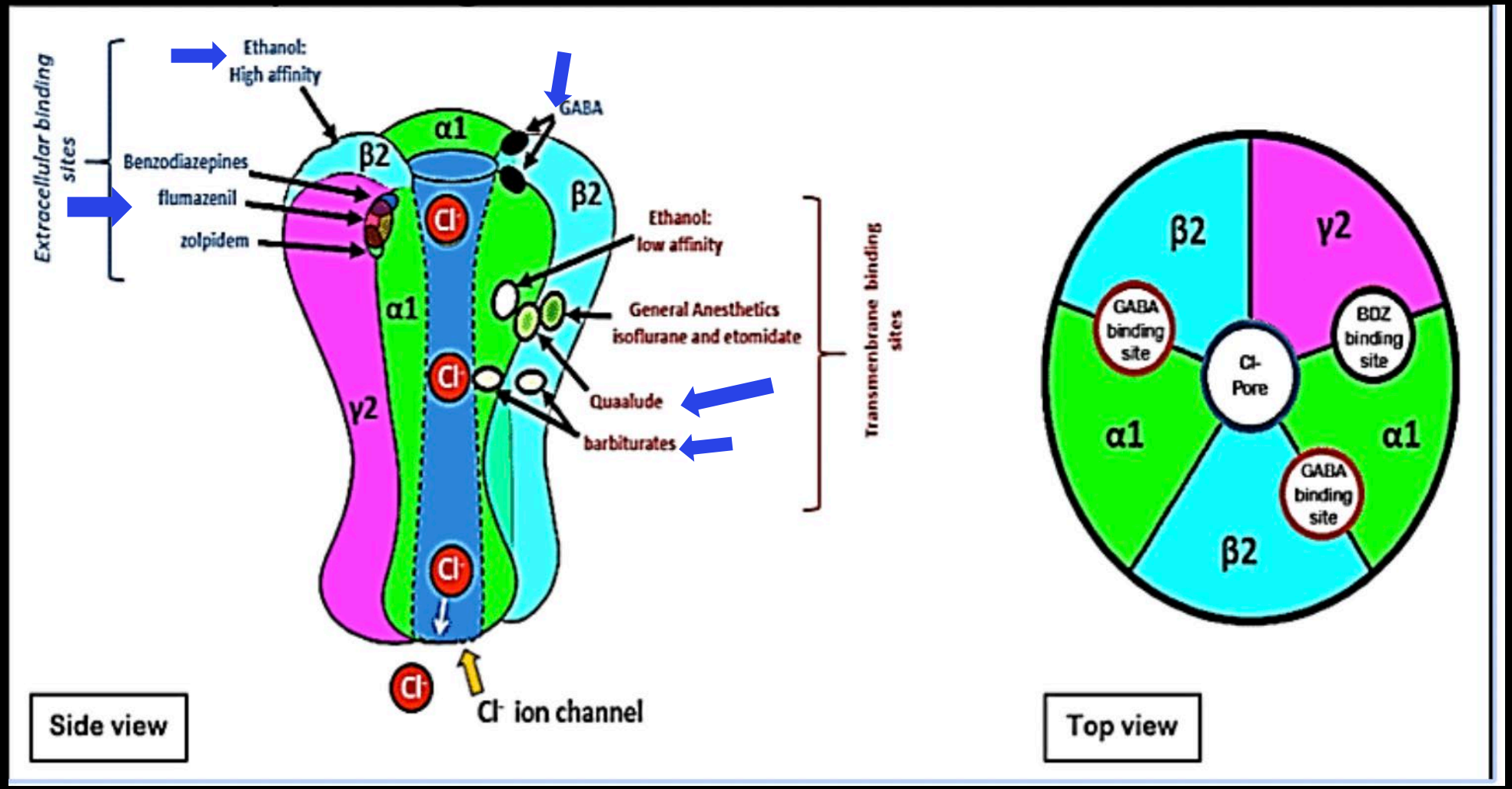
	GABA A	GABA B
Pharmacological effects	✓ Sedation ✓ Hypnosis ✓ Anxiolysis ✓ Anticonvulsant ✓ Amnesia ✓ Muscle relaxation ✓ Euphoria	✓ Central muscle relaxation ✓ Epileptogenesis ✓ Suppression of drug craving ✓ Antinociception ✓ Cognitive impairment ✓ Inhibition of hormone release

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideshare.net%2Fchandiniyrao%2Fgaba-receptors-drugs-acting-on-them&psig=AOvVaw0ylwuGHtJbjVAIu6h10VN3&ust=1679846595654000&source=images&cd=vfe&ved=0CA8QjRxqFwoTCLjwkLK69_0CFQAAAAAdAAAAABAX

Receptor Ligands and Modulators

- Orthosteric Ligands: A chemical that interacts with the same binding sites as the natural endogenous chemicals found in our body. In this case, the natural chemical would be GABA
- Allosteric Ligand (or allosteric modulator): This is a chemical that works by modifying how the receptor behaves when it has been bound to an orthosteric ligand. The allosteric binding sites are distinctly separate from the site of the main neurotransmitter (GABA).
- Positive Allosteric Modulator (PAM): a modulating chemical that binds to an allosteric site and increases the affinity or the efficacy of an agonist for that receptor.

GABA A Receptor Ligands and Modulators

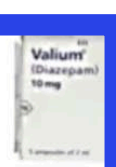


https://www.researchgate.net/publication/343995799/figure/fig1/AS:930642959273984@1598893980172/Structure-of-the-GABAA-receptor-side-and-top-views-and-position-of-the-binding-sites.png

Drugs Acting on the GABA A receptor

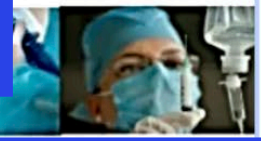
A. Facilitating GABA A Action (Agonist) (+ve Allosteric Modulators)

1. Barbiturates (GABAmimetic)
2. Benzodiazepines (BZDs)
3. Z- Hypnotics (Zolpidem – Eszopiclone).
4. Alcohols, Acamprosate (Partial agonist)
5. IV Anaesthetics: etomidate, propofol & neuroactive steroids
6. Volatile Anaesthetics: isoflurane and enflurane









B. Antagonist at BZD site : Flumazenil (Antidote)

C. Inverse agonists at BZD site : β carbolines

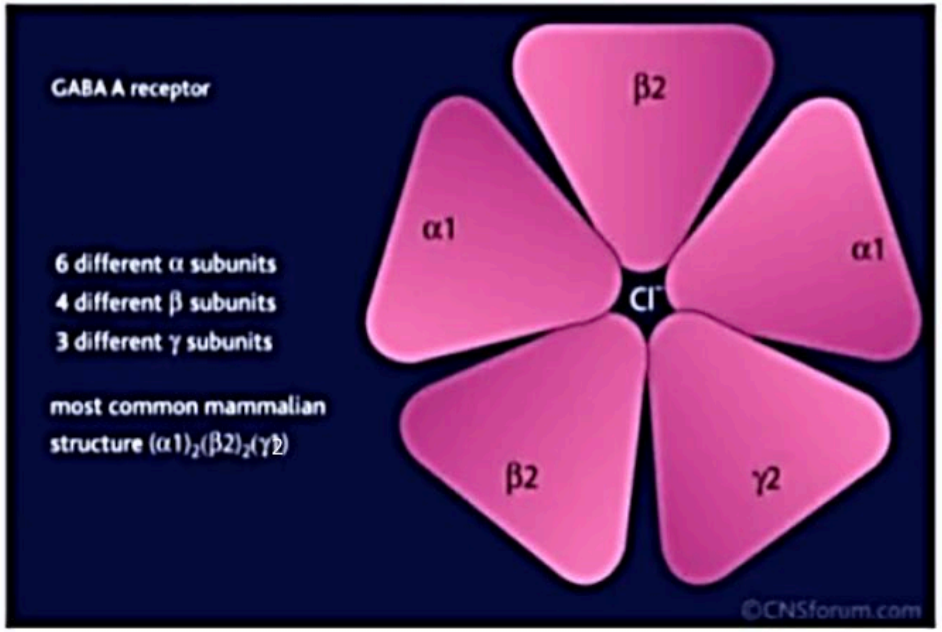
D. GABA A receptor Blocker Bicuculline & Cl^- Channel Blocker Picrotoxin, PTZ Pentylenetetrazole

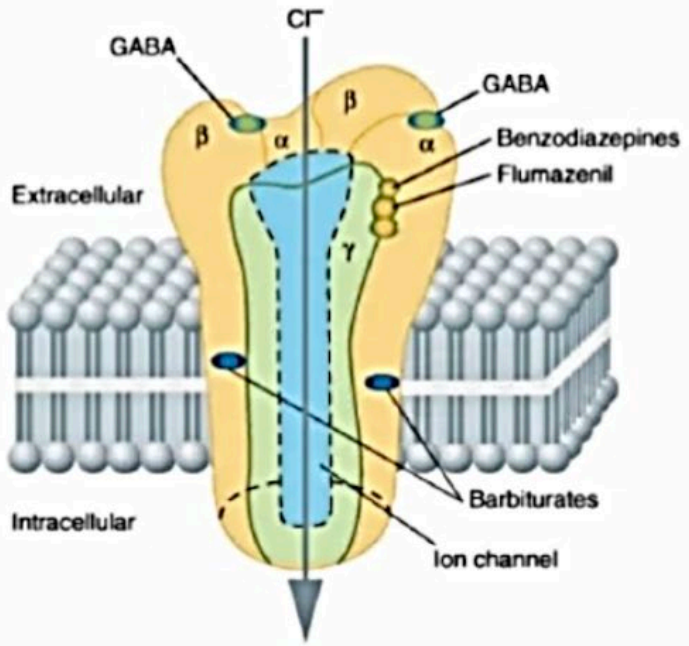
https://image.slidesharecdn.com/gabareceptorsdrugsactngonthem-180105061453/85/gaba-receptors-drugs-acting-on-them-26-320.jpg?cb=1665762549

Benzodiazepines enhance GABA by increasing the frequency of Cl channel-opening.

GABA A receptors containing alpha 1 subunits are involved in sleep.

GABA A receptors containing alpha 2 or alpha 3 subunits are involved in anxiety.





Common BZ receptor subtypes in the CNS are designated as BZ_1 or BZ_2 depending on whether the binding site includes an α_1 or α_2 subunit, respectively.

- **α_1 subunit is associated with sedation/hypnosis. (Z-Hypnotics)**
- **α_2 subunit has greater anxiolytic and muscle relaxation actions**

Drugs acting on the GABA B Receptor

Drugs acting on GABA B receptor		
Agonists	**Positive modulators**	**Antagonists**
Baclofen GHB (ϒ-hydroxy butyrate) Others: Lesogaberan, Phenibut, Isovaline, SKF-97541	BHFF, Fasoracetam, BSPP	**Saclofen, Phaclofen,** 2-OH saclofen, Homotaurine, CGP-35348

https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them slide

Drugs acting on the GABA B Receptor: Baclofen

Baclofen

-Selective $GABA_B$ agonist, muscle relaxant

Uses: Treatment of

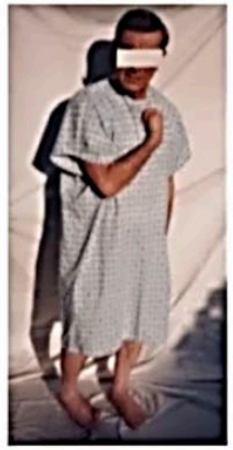
- Spasticity (e.g. UMNL, CP)

-Skeletal muscle rigidity (e.g. PD, EPS)

Side effect:

- Sedation, weakness, ataxia,

-Can aggravate absence seizures (not used in epilepsy) "Epileptogenesis"



	GABA A	GABA B
Type	Ionotropic (Cl- Channel)	Metabotropic (Gi-prot.)
Structure	Pentamer (2α, 2β, 1γ)	Dimer (B1&B2)
Location	Widespread; (mainly) Post-synaptic in CNS	Widespread; Pre- & Post-synaptic In CNS (>spinal cord)
MOA	Post-synaptic inhibition by - ↑ Cl- influx	Pre-synaptic inhibition by – ↓ Ca2+ entry Post-synaptic inhibition by – ↑ K+ permeability
-Endogenous agonist - Drugs acting e.g.	GABA Barbiturates, BZD, z-Hypnotics Anesthetics (IV, Volatile…)	GABA - Baclofen
Pharmacological Actions	▪Sedation, Hypnosis, Anxiolysis ▪Anticonvulsant ▪Amnesia ▪Muscle relaxation ▪Euphoria	▪ Central muscle relaxation ▪ Epileptogenesis ▪ ↓drug craving ▪ Antinociception ▪ Cognitive impairment ▪ ↓hormone release

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideshare.net%2Fsawsanaboulfotouh%2Fgaba-receptors&psig=AOvVaw0yIwuGHtJbjVAIu6h10VN3&ust=1679846595654000&source=images&cd=vfe&ved=0CA8QjRxqFwoTCLjwkLK69_0CFQAAAAAdAAAAABAm

Natural GABA Correction

Lifestyle modification

Diet

Exercise

Meditation

Metabolite Repletion

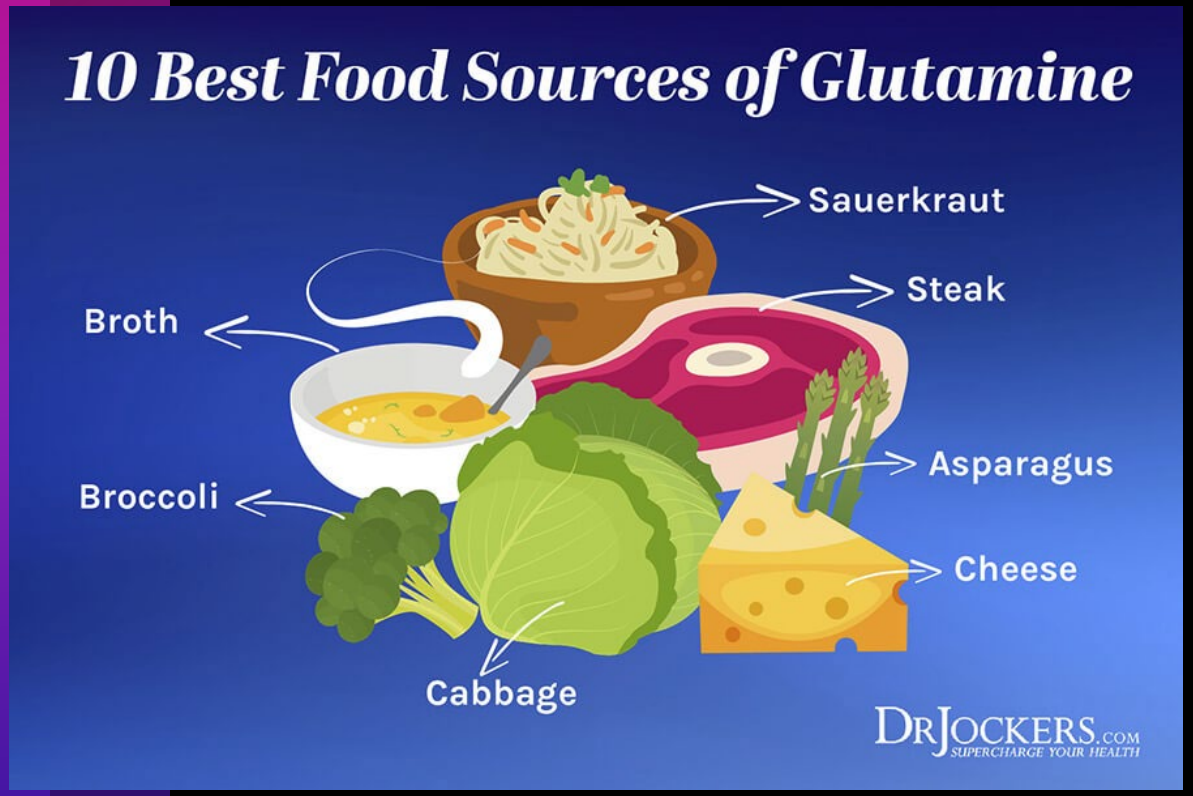
B6, Magnesium, Minerals, AA levels

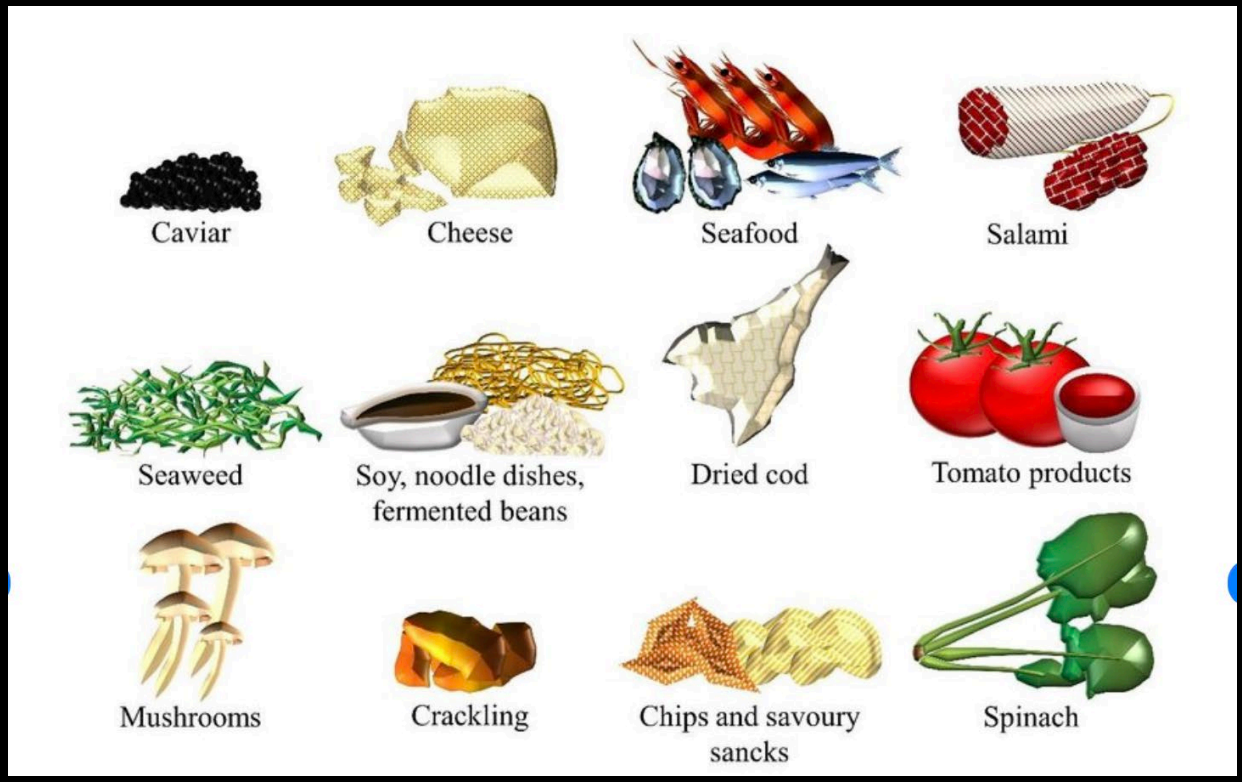
Fix a leaky gut

Supplementation

Does GABA itself get across the BBB?

GABA Correction: Lifestyle Modification





https://drjockers.com/best-food-sources-glutamine/

GABA Correction: Lifestyle Modification

The Journal of Neuroscience, February 24, 2016 • 36(8):2449–2457 • 2449

Cellular/Molecular

Acute Modulation of Cortical Glutamate and GABA Content by Physical Activity

Richard J. Maddock,[1,2] Gretchen A. Casazza,[3] Dione H. Fernandez,[2,3] and Michael I. Maddock[2]

[1]Department of Psychiatry and Behavioral Sciences, [2]Imaging Research Center, and [3]Sports Medicine Program, University of California Davis Medical Center, Sacramento, California 95817

GABA Correction: Lifestyle Modification

The Journal of Alternative and Complementary Medicine > Vol. 13, No. 4 > Original Papers

Yoga Asana Sessions Increase Brain GABA Levels: A Pilot Study

Chris C. Streeter, J. Eric Jensen, Ruth M. Perlmutter, Howard J. Cabral, Hua Tian, Devin B. Terhune, Domenic A. Ciraulo, and Perry F. Renshaw

Published Online: 28 May 2007 | https://doi.org/10.1089/acm.2007.6338

GABA Correction of Metabolites

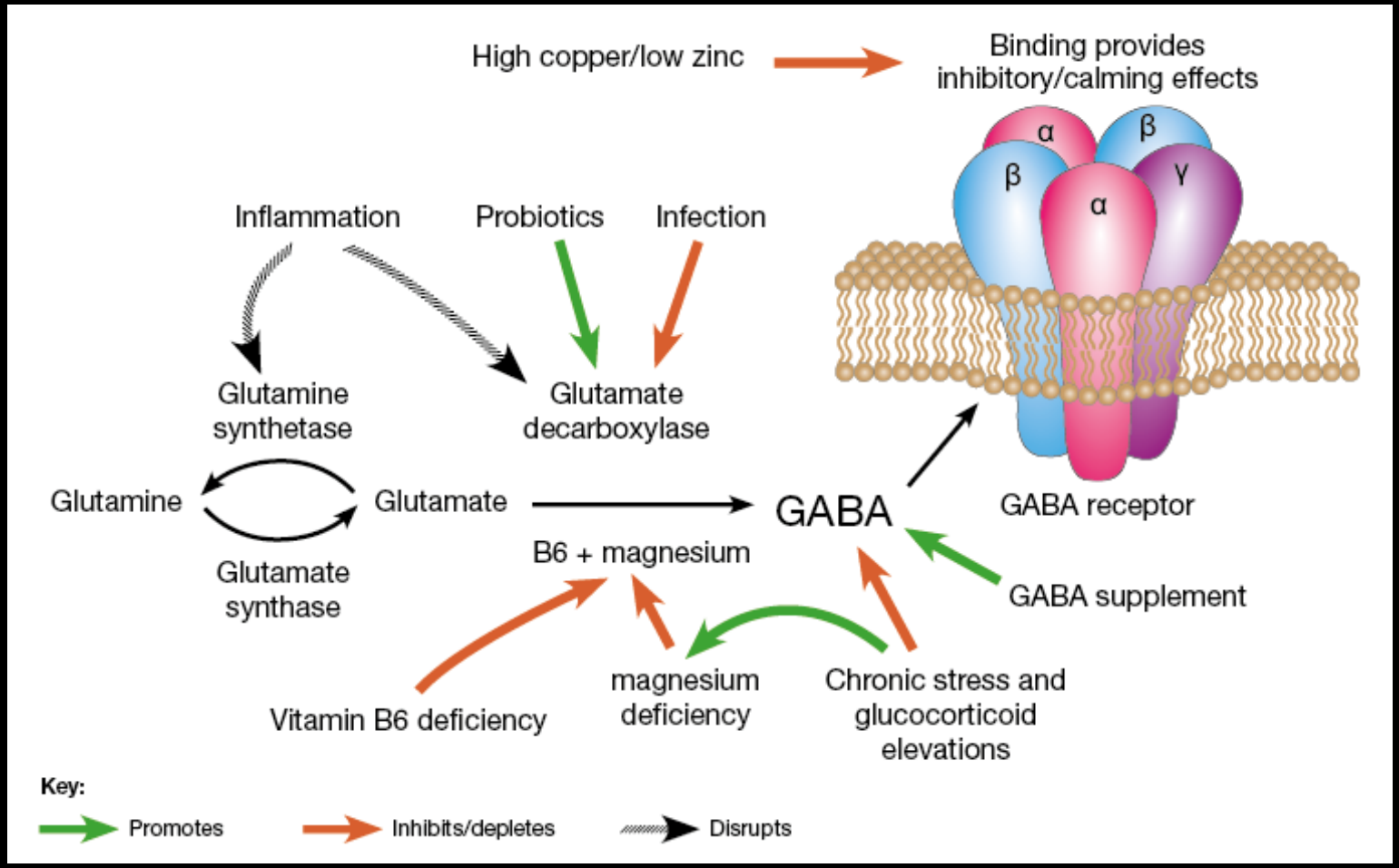
Metabolite Repletion

B6, Magnesium, Minerals, AA levels

Fix a leaky gut

https://www.ironmagazine.com/wp-content/uploads/2016/12/What-is-Gaba-720x446.png

Factors Affecting GABA Synthesis



Neurotransmitter Metabolites

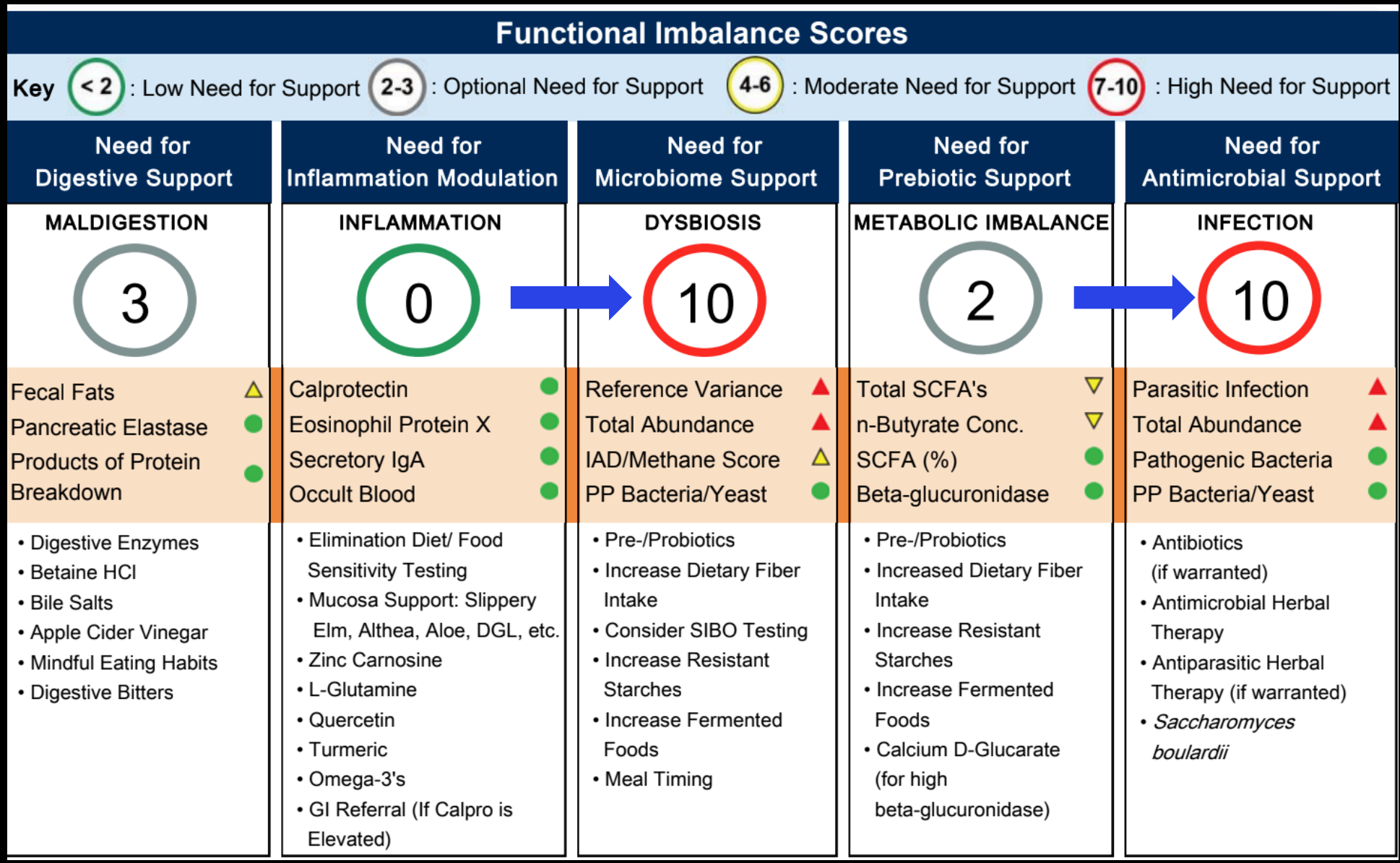
Kynurenine Markers (Vitamin B6)		Reference Range
Kynurenic Acid	3.2	<= 7.1
Quinolinic Acid	6.8	<= 9.1
Kynurenic / Quinolinic Ratio	0.47	>= 0.44
Xanthurenic Acid	0.34	<= 0.96

Nonessential Protein Amino Acids

Amino Acid		Reference Range
Alanine	40	19-45
Asparagine	11.6	3.5-8.3
Aspartic Acid	0.68	<= 0.40
Cyst(e)ine	11.0	5.7-14.1
γ-Aminobutyric Acid	0.04	<= 0.04
Glutamic Acid	10.9	1.7-17.8
Glutamine	66	37-88
Proline	27	16-50
Tyrosine	17.7	6.5-16.5

Nutrient Elements

Element		Reference Range
Copper *(plasma)*	111.2	75.3-192.0 mcg/dL
Magnesium *(RBC)*	37.9	30.1-56.5 mcg/g
Manganese *(whole blood)*	6.8	3.0-16.5 mcg/L
Potassium *(RBC)*	2,243	2,220-3,626 mcg/g
Selenium *(whole blood)*	510	109-330 mcg/L
Zinc *(plasma)*	93.8	64.3-159.4 mcg/dL

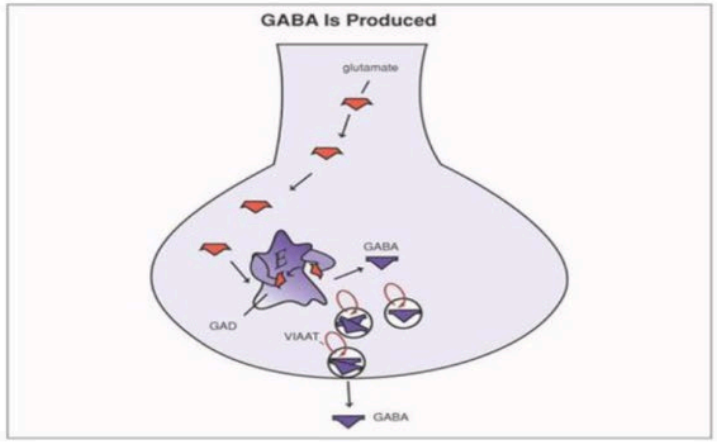

Functional Imbalance Scores
Key
< 2 : Low Need for Support
2-3 : Optional Need for Support
4-6 : Moderate Need for Support
7-10 : High Need for Support
Need for Digestive Support
MALDIGESTION
3
Fecal Fats
Pancreatic Elastase
Products of Protein Breakdown
• Digestive Enzymes
• Betaine HCl
• Bile Salts
• Apple Cider Vinegar
• Mindful Eating Habits
• Digestive Bitters
Need for Inflammation Modulation
INFLAMMATION
0
Calprotectin
Eosinophil Protein X
Secretory IgA
Occult Blood
• Elimination Diet/ Food Sensitivity Testing
• Mucosa Support: Slippery Elm, Althea, Aloe, DGL, etc.
• Zinc Carnosine
• L-Glutamine
• Quercetin
• Turmeric
• Omega-3's
• GI Referral (If Calpro is Elevated)
Need for Microbiome Support
DYSBIOSIS
10
Reference Variance
Total Abundance
IAD/Methane Score
PP Bacteria/Yeast
• Pre-/Probiotics
• Increase Dietary Fiber Intake
• Consider SIBO Testing
• Increase Resistant Starches
• Increase Fermented Foods
• Meal Timing
Need for Prebiotic Support
METABOLIC IMBALANCE
2
Total SCFA's
n-Butyrate Conc.
SCFA (%)
Beta-glucuronidase
• Pre-/Probiotics
• Increased Dietary Fiber Intake
• Increase Resistant Starches
• Increase Fermented Foods
• Calcium D-Glucarate (for high beta-glucuronidase)
Need for Antimicrobial Support
INFECTION
10
Parasitic Infection
Total Abundance
Pathogenic Bacteria
PP Bacteria/Yeast
• Antibiotics (if warranted)
• Antimicrobial Herbal Therapy
• Antiparasitic Herbal Therapy (if warranted)
• Saccharomyces boulardii

How to dim GABA switches (no prescription required)

Do NOT take GABA supplements

Exogenous GABA Does Not Cross the Blood Brain Barrier(BBB)

- GABA is produced in GABA-ergic neurons from the excitatory neurotransmitter Glutamate by the enzyme GAD (glutamic acid decarboxilase)



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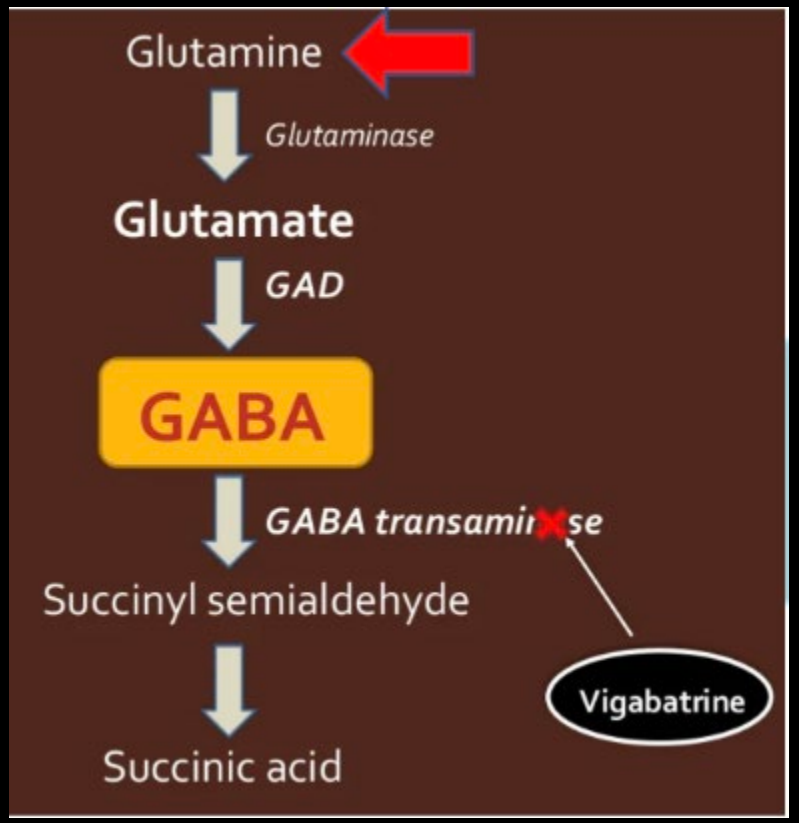
Glutamine & (not) Glutamate Supplementation



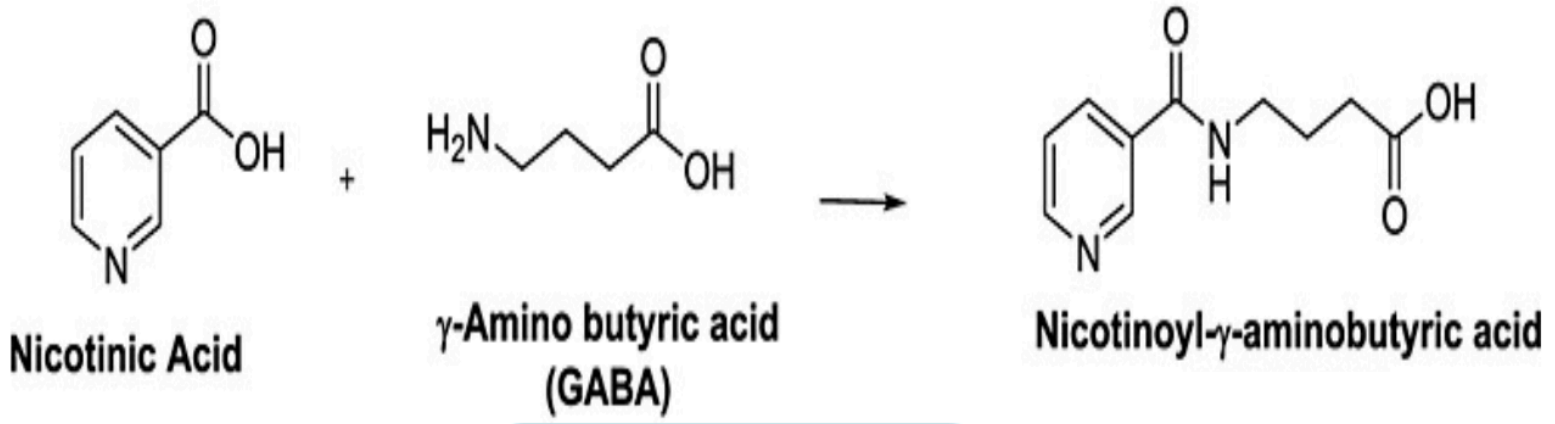
Nonessential Protein Amino Acids

Amino Acid	Reference Range
Alanine	19-45
Asparagine	3.5-7.8
Aspartic Acid	<= 0.40
Cyst(e)ine	5.7-14.1
γ-Aminobutyric Acid	<= 0.04
Glutamic Acid	1.7-17.8
Glutamine	37-88
Proline	16-50
Tyrosine	6.5-16.5

https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them

Orthosteric Ligand: Nicotinoyl GABA

- is a molecule formed by a combination of niacin (Vitamin B3) and γ-aminobutyric acid (GABA)
- permeates the blood–brain barrier and then is hydrolyzed into GABA and niacin (a vasodilator)



Nicotinic Acid

γ-Amino butyric acid (GABA)

Nicotinoyl-γ-aminobutyric acid

Orthosteric Ligand: Agarin

- GABAA receptor Agonist
- Easily crosses the BBB
- High Potency
- Long acting
- Naturally occurring or synthetic
- Low doses safe, effective, low risk of tolerance and withdrawal
- High doses hallucinogenic

https://psychedelicreview.com/compound/muscimol/

GABAA PAM: Valarian Root

Planta Med. 2008 Jan;74(1):19-24. doi: 10.1055/s-2007-993761. Epub 2007 Dec 19.

Modulation of GABAA receptors by valerian extracts is related to the content of valerenic acid

Gabriele Trauner [1], Sophia Khom, Igor Baburin, Birgit Benedek, Steffen Hering, Brigitte Kopp

Affiliations + expand

PMID: 18095218 DOI: 10.1055/s-2007-993761

GABAA PAM: Kavain

PLOS ONE

PLoS One. 2016; 11(6): e0157700.
Published online 2016 Jun 22. doi: 10.1371/journal.pone.0157700

PMCID: PMC4917254
PMID: 27332705

Kavain, the Major Constituent of the Anxiolytic Kava Extract, Potentiates $GABA_A$ Receptors: Functional Characteristics and Molecular Mechanism

Han Chow Chua,[1] Emilie T. H. Christensen,[1,2] Kirsten Hoestgaard-Jensen,[2] Leonny Y. Hartiadi,[1] Iqbal Ramzan,[1] Anders A. Jensen,[2] Nathan L. Absalom,[1] and Mary Chebib[1,*]

Steven Barnes, Editor

PLoS One

GABAA PAM: Honokiol

MINI REVIEW article

Front. Neurol., 11 September 2013
Sec. Neuropharmacology
Volume 4 - 2013 | https://doi.org/10.3389/fneur.2013.00130

Neuro-modulating effects of honokiol: a review

Anna Woodbury[1]*, Shan Ping Yu[1,2], Ling Wei[1] and Paul García[1,2]

[1] Department of Anesthesiology, Emory University, Atlanta, GA, USA
[2] Department of Anesthesiology, Veteran Affairs Medical Center, Atlanta, GA, USA

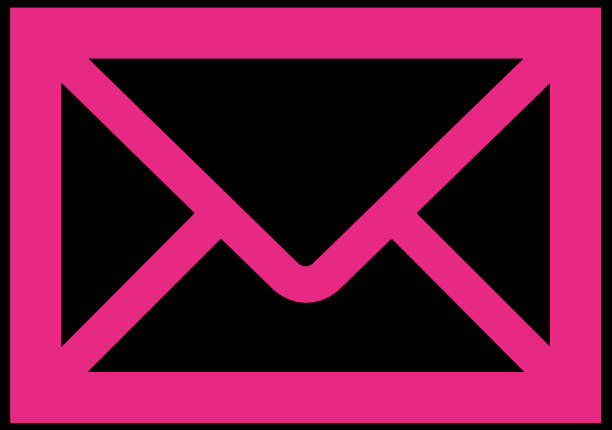
Drugs and Supplements that Decrease GABA Activity

- Stimulants: decrease GABA receptor sensitivity
- Opioids:
  - Mu-opioid receptor agonists like morphine and heroin and inhibit the release of GABA by binding to opioid receptors located on GABAergic neurons
  - Opioids also affect GABAergic neurotransmission in regions of the brain and spinal cord involved in pain perception
- THC inhibits GABA release
- DHEA
- Beta Carbolines
- Anxiety drugs

Detect and Correct GABA Deficiency

- Keep it on your clinical radar
- Implement dietary and lifestyle measure to boost GABA production
- Test for levels of nutrients (magnesium, B6, etc.) to ensure optimized GABA production
- Consider herbal or fungal GABAA Agonists or PAMs to support GABA production / release
- Avoid Benzos and other GABAergic drugs associated w/dependence, withdrawal, and tolerance

Thank you!



scott@snhlife.com

References

- https://www.youtube.com/watch?v=2u9K3t-7f-I
- *https://gammaaminobutyricacid.org/gaba-deficiency*
- *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3135672//*
- https://www.usnews.com/news/health-news/articles/2022-09-19/depression-affects-almost-1-in-10-americans#:~:text=19%2C%202022-,Sept.,2022%2C%20at%2011%3A55%20a.m.&text=MONDAY%2C%20Sept.,adults%2C%20a%20new%20study%20finds.
- http://neuroendoimmune.files.wordpress.com/2013/07/gaba-glutamate-synthesis.png
- https://www.ironmagazine.com/wp-content/uploads/2016/12/What-is-Gaba-720x446.png
- https://openi.nlm.nih.gov/imgs/512/391/4131092/PMC4131092_SCIENTIFICA2014-149187.002.png
- https://openi.nlm.nih.gov/imgs/512/391/4131092/PMC4131092_SCIENTIFICA2014-149187.002.png
- https://i.pinimg.com/originals/33/62/5d/33625d7e443d6a046548606bc06cb21d.jpg
- https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them
- https://image.slidesharecdn.com/benzodiazepines-120115103433-phpapp02/95/benzodiazepines-7-728.jpg?cb=1326625284
- https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them
- https://external-content.duckduckgo.com/iu/?u=https%3A%2F%2Fd3i71xaburhd42.cloudfront.net%2F44eb4f10d1836a6101c004a933242dec20b87975%2F3-Figure2-1.png&f=1&nofb=1&ipt=da3f9a0736c3c52adab029a182177b30ce1473d18f37ded43ed31f0acf882452&ipo=images
- https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideshare.net%2Fchandiniyrao%2Fgaba-receptors-drugs-acting-on-them&psig=AOvVaw0yIwuGHtJbjVAIu6h10VN3&ust=1679846595654000&source=images&cd=vfe&ved=0CA8QjRxqFwoTCLjwkLK69_0CFQAAAAAdAAAAABAQ

References

- https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideshare.net%2Fchandiniyrao%2Fgaba-receptors-drugs-acting-on-them&psig=AOvVaw0ylwuGHtJbjVAIu6h10VN3&ust=1679846595654000&source=images&cd=vfe&ved=0CA8QjRxqFwoTCLjwkLK69_0CFQAAAAAdAAAAABAX
- https://www.researchgate.net/publication/343995799/figure/fig1/AS:930642959273984@1598893980172/Structure-of-the-GABAA-receptor-side-and-top-views-and-position-of-the-binding-sites.png
- https://image.slidesharecdn.com/gabareceptorsdrugsactngonthem-180105061453/85/gaba-receptors-drugs-acting-on-them-26-320.jpg?cb=1665762549
- https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them slide
- https://image.slidesharecdn.com/benzodiazepines-120115103433-phpapp02/95/benzodiazepines-7-728.jpg?cb=1326625284
- https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them slide
- https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.slideshare.net%2Fsawsanaboulfotouh%2Fgaba-receptors&psig=AOvVaw0ylwuGHtJbjVAIu6h10VN3&ust=1679846595654000&source=images&cd=vfe&ved=0CA8QjRxqFwoTCLjwkLK69_0CFQAAAAAdAAAAABAm
- https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-the
- MGHcme.org
- https://www.slideshare.net/chandiniyrao/gaba-receptors-drugs-acting-on-them
- https://drjockers.com/best-food-sources-glutamine/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7914492/
- https://pubmed.ncbi.nlm.nih.gov/18095218/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4917254/
- https://psychedelicreview.com/compound/muscimol/
- https://www.frontiersin.org/articles/10.3389/fneur.2013.00130/full
- https://www.liebertpub.com/doi/10.1089/acm.2007.6338
- https://neurosciencenews.com/exercise-depression-gaba-glutamate-3730/