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Menopause and the Microbiome: Unraveling the Gut's Role in Hormonal and Neurotransmitter Shifts

Carrie Jones, ND, FABNE, MPH, MSCP

Objectives

1. **Understand the Gut-Microbiome Changes in Menopause**: Dive deep into the specific alterations in the gut microbiome during menopause and understand how these changes contribute to systemic inflammation and metabolic disruption.
2. **Examine the Gut-Brain Connection**: Explore how menopausal shifts in the microbiome affect neurotransmitter production, mood regulation, and cognitive function, linking gut health to mental well-being.
3. **Supporting the Microbiome:** Using the interplay between gut health and key hormonal changes in menopause, provide insights into how to best support the microbiome at this time to improve what feels like hormonal chaos and overall health span outcomes.

Definitions

1

Pre-Menopause/Cycling

The years between puberty and perimenopause when menstrual cycles are expected.

2

Perimenopause

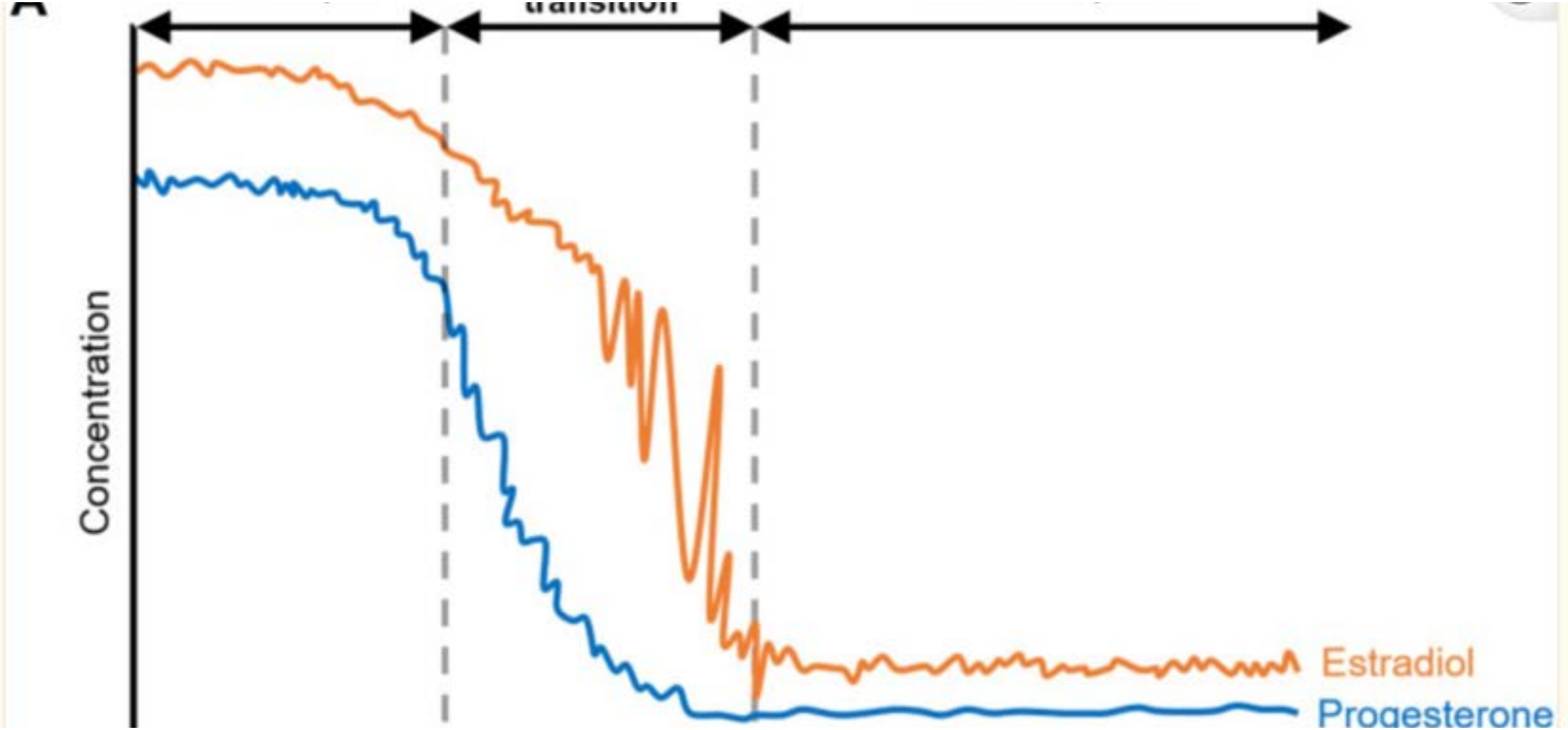
The 6-10 year transitional period before menopause where she goes from regular menstrual periods into more chaos.

3

Post-Menopause

True definition: 12 consecutive months without a menstrual cycle at the appropriate age.
On the 13th cycle free month, she is considered Post-menopausal even if she is still symptomatic.

Peters BA, Santoro N, Kaplan RC, Qi Q. Spotlight on the Gut Microbiome in Menopause: Current Insights. Int J Womens Health. 2022; 14:1059-1072. [PDF]



The Menopause transition is considered an **inflammatory state** largely because of the decline in estrogen levels and the resulting shift in the balance of pro-inflammatory and anti-inflammatory cytokines.

This shift is sometimes called **"inflammopause."**

McCarthy M, Raval AP. The peri-menopause in a woman's life: a systemic inflammatory phase that enables later neurodegenerative disease. *Journal of Neuroinflammation*. 2020;17(1). doi:https://doi.org/10.1186/s12974-020-01998-9

This can manifest greatly in the gastrointestinal tract

The Gut-Hormone Axis and Microbial Diversity

"These studies support a bi-directional relationship of sex hormones with the gut microbiome, in which **higher levels of estrogens and progesterone promote increased microbial diversity** by serving as substrates for a diverse range of species, while at the same time, higher gut microbiome diversity and greater deconjugation activity may promote hormone retention."

Peters B, Santoro N, Kaplan R, Qi Q. Spotlight on the Gut Microbiome in Menopause: Current Insights. *International Journal of Women's Health*. 2022;Volume 14(14):1059-1072. doi:https://doi.org/10.2147/ijwh.s340491

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"It is estimated that microbial cells in the human body exist in approximately a 1:1 ratio with human cells, though the number of **microbial genes outnumbers human genes at a ratio of ≥100:1**, reflecting the vast genetic diversity of the microbiome."

Peters B, Santoro N, Kaplan R, Qi Q. Spotlight on the Gut Microbiome in Menopause: Current Insights. *International Journal of Women's Health*. 2022;Volume 14:1059-1072.
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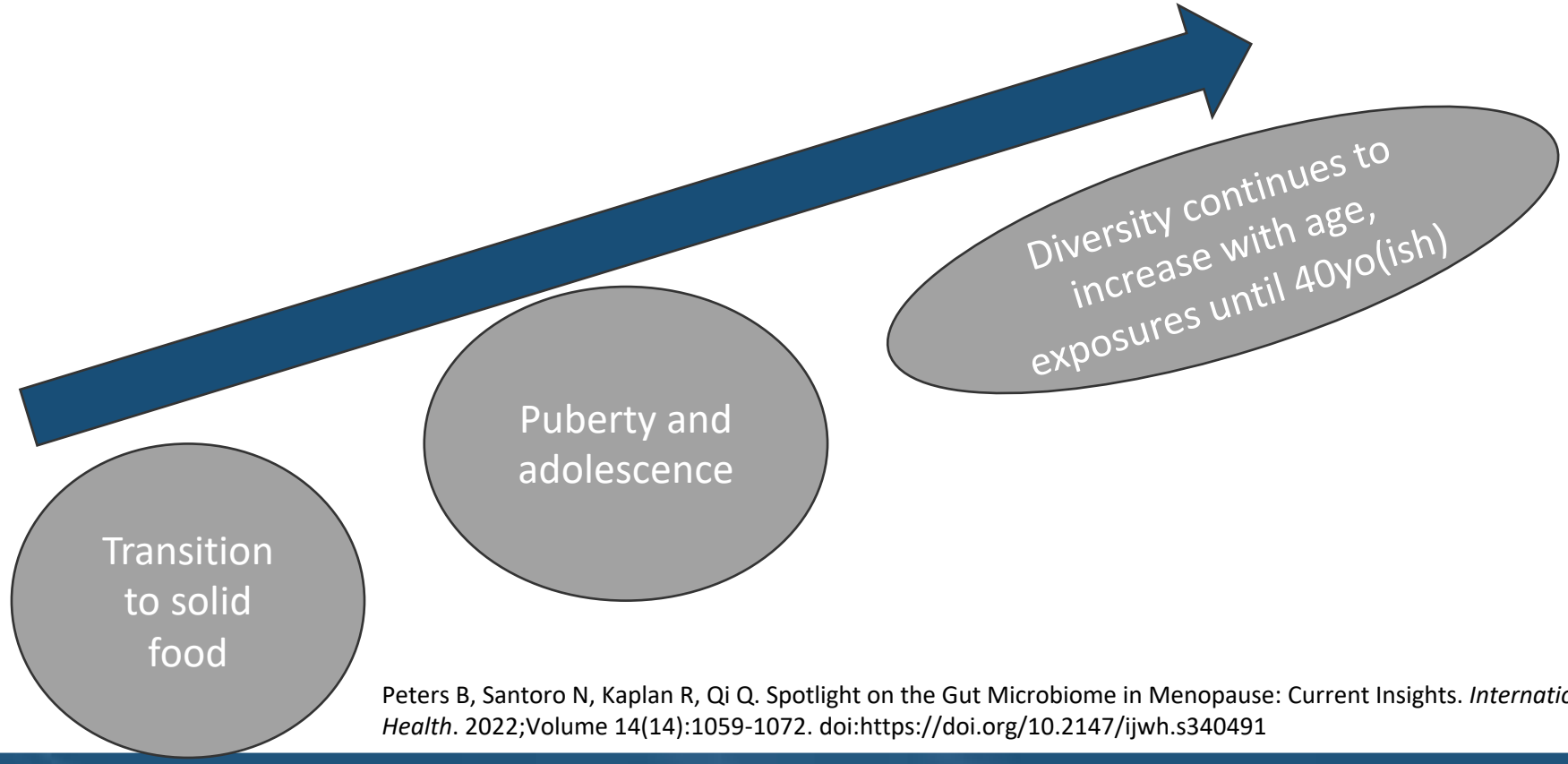
"It is estimated that microbial cells in the human body exist in approximately a 1:1 ratio with huma**bial gene**s**tio of ≥100:1**, reflecting the vast genetic diversity of the microbiome."

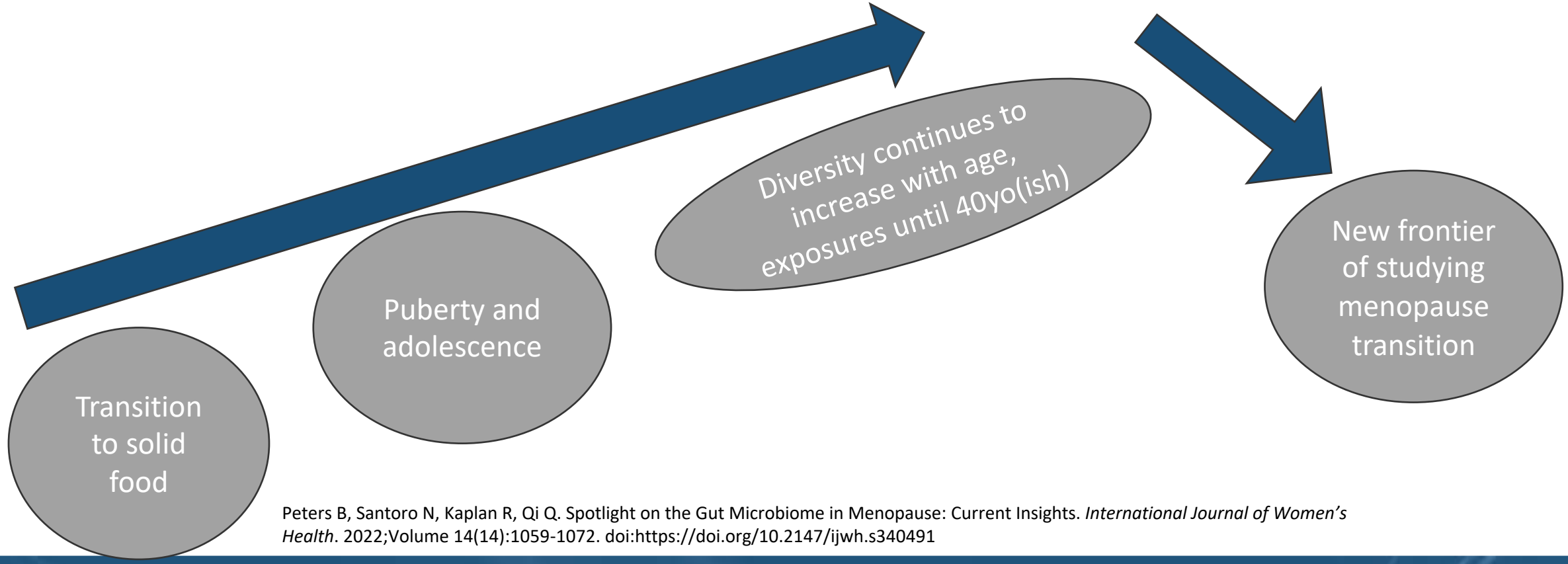
Takeaway: Be nice to your microbiome.
Talk to it. Love on it.
Don't let it take you over.

Key Shifts in the Gut Microbiome



Peters B, Santoro N, Kaplan R, Qi Q. Spotlight on the Gut Microbiome in Menopause: Current Insights. *International Journal of Women's Health*. 2022;Volume 14(14):1059-1072. doi:https://doi.org/10.2147/ijwh.s340491

Key Shifts in the Gut Microbiome



Peters B, Santoro N, Kaplan R, Qi Q. Spotlight on the Gut Microbiome in Menopause: Current Insights. *International Journal of Women's Health*. 2022;Volume 14(14):1059-1072. doi:https://doi.org/10.2147/ijwh.s340491

Estradiol and progesterone help maintain the gut barrier and protect it from gut injury

In Studies:

- Estradiol treatment **protects mucus-producing intestinal epithelial cells** against oxidant injury
- Estradiol and progesterone **maintains and improves epithelial barrier function** in intestinal epithelial cells by **upregulating tight junction proteins**
- In vivo, ovariectomy has been shown to **increase intestinal permeability** in mice
- From pre → post menopause, **plasma intestinal fatty acid binding protein, lipopolysaccharide binding protein, CD14 all increase** (SWAN Study)
- Post menopausal have **less short-chain fatty acid (SCFA) producers** such as *Faecalibacterium* and *Roseburia*
- **Increased microbial translocation (LPS, etc)** increases greatly in menopause

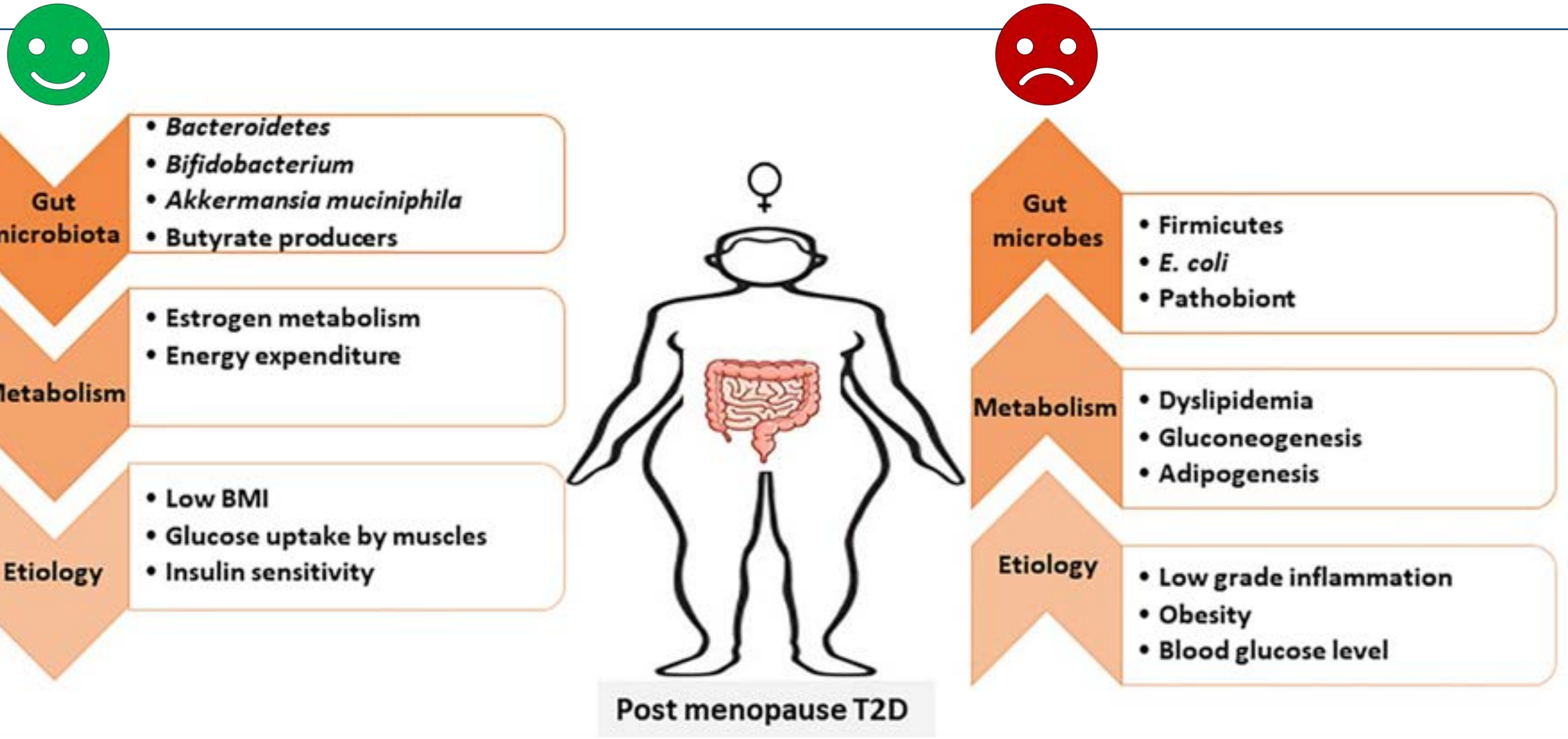
Citations:

- Peters BA, Santoro N, Kaplan RC, Qi Q. Spotlight on the Gut Microbiome in Menopause: Current Insights. Int J Womens Health. 2022; 14:1059-1072. [PDF
- Singh V, Park YJ, Lee GD, Tatsuya Unno, Shin JH. Dietary regulations for microbiota dysbiosis among post-menopausal women with type 2 diabetes. *Critical Reviews in Food Science and Nutrition*. Published online May 30, 2022:1-16. doi:https://doi.org/10.1080/10408398.2022.2076651

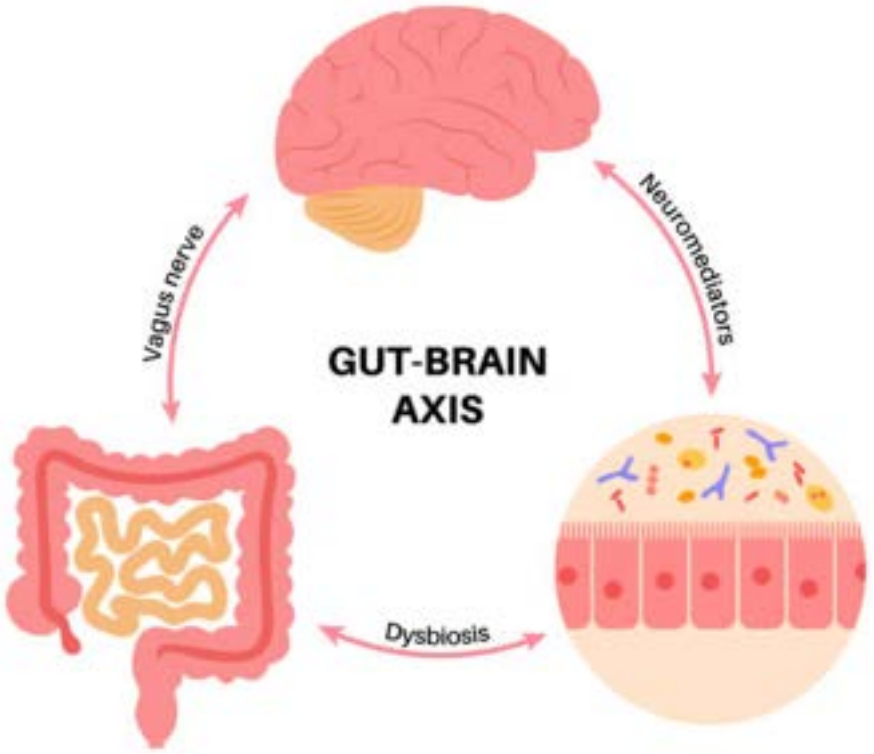
The Gut-Hormone-Metabolic Health Axis

"In addition to sexual dimorphism, estrogen also participates in glucose–lipid homeostasis, and estrogen depletion is associated with **insulin resistance** in the female body…Through various metabolites (SCFAs, secondary bile acid, and serotonin), the **gut microbiota plays a significant role** in regulating glucose homeostasis, oxidative stress, and T2D-associated pro-inflammatory cytokines (IL-1, IL-6)."

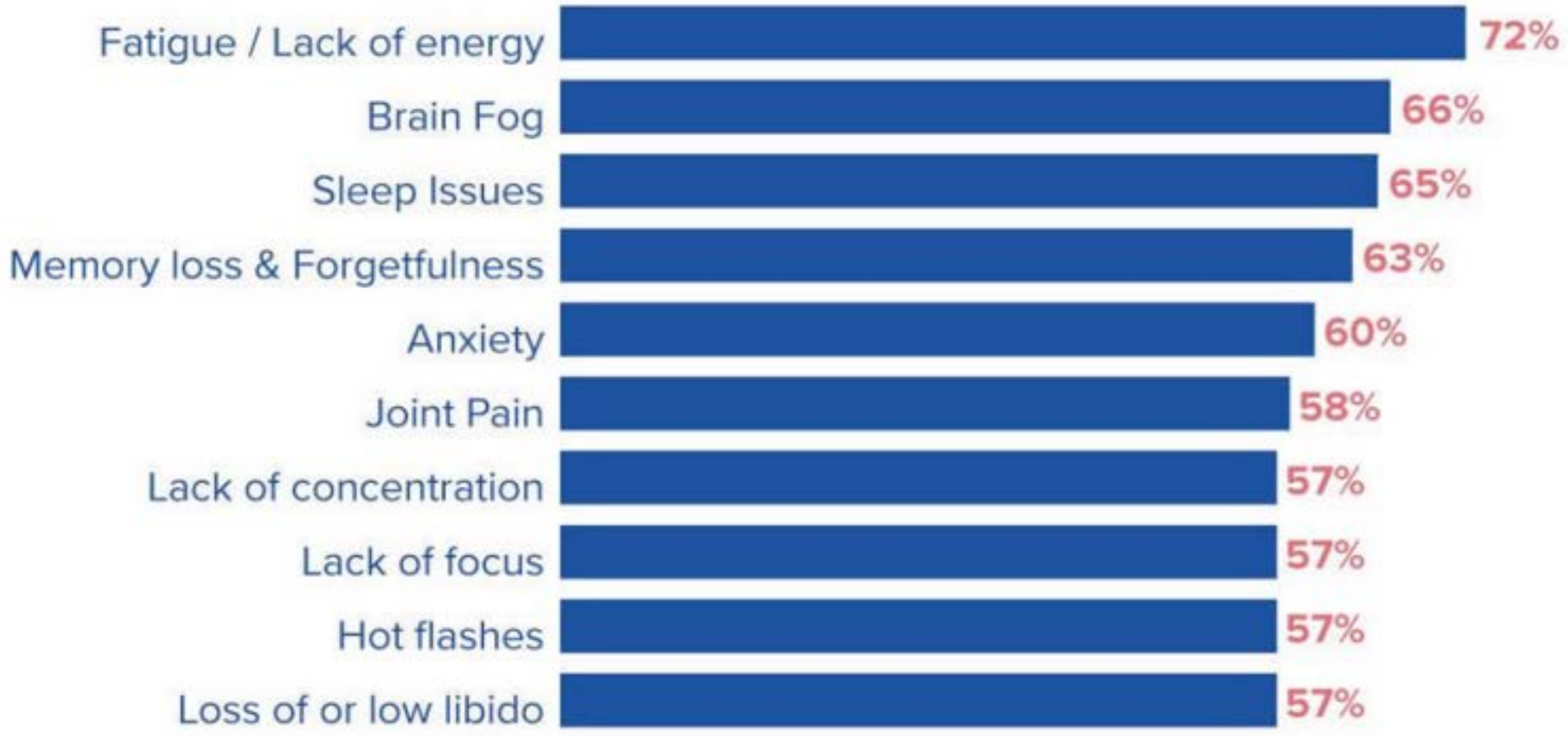
Singh V, Park YJ, Lee GD, Tatsuya Unno, Shin JH. Dietary regulations for microbiota dysbiosis among post-menopausal women with type 2 diabetes. *Critical Reviews in Food Science and Nutrition*. Published online May 30, 2022:1-16. doi:https://doi.org/10.1080/10408398.2022.2076651



Singh V, Park YJ, Lee GD, Tatsuya Unno, Shin JH. Dietary regulations for microbiota dysbiosis among post-menopausal women with type 2 diabetes. *Critical Reviews in Food Science and Nutrition*. Published online May 30, 2022:1-16. doi:https://doi.org/10.1080/10408398.2022.2076651



In 2023, >3,000 perimenopausal and menopausal women were surveyed by Andrea Donsky and her team at Morphus



https://cdn.shopify.com/s/files/1/0572/5129/9508/files/Signs_and_Symptoms_Research_White_Paper_Report_Final.pdf

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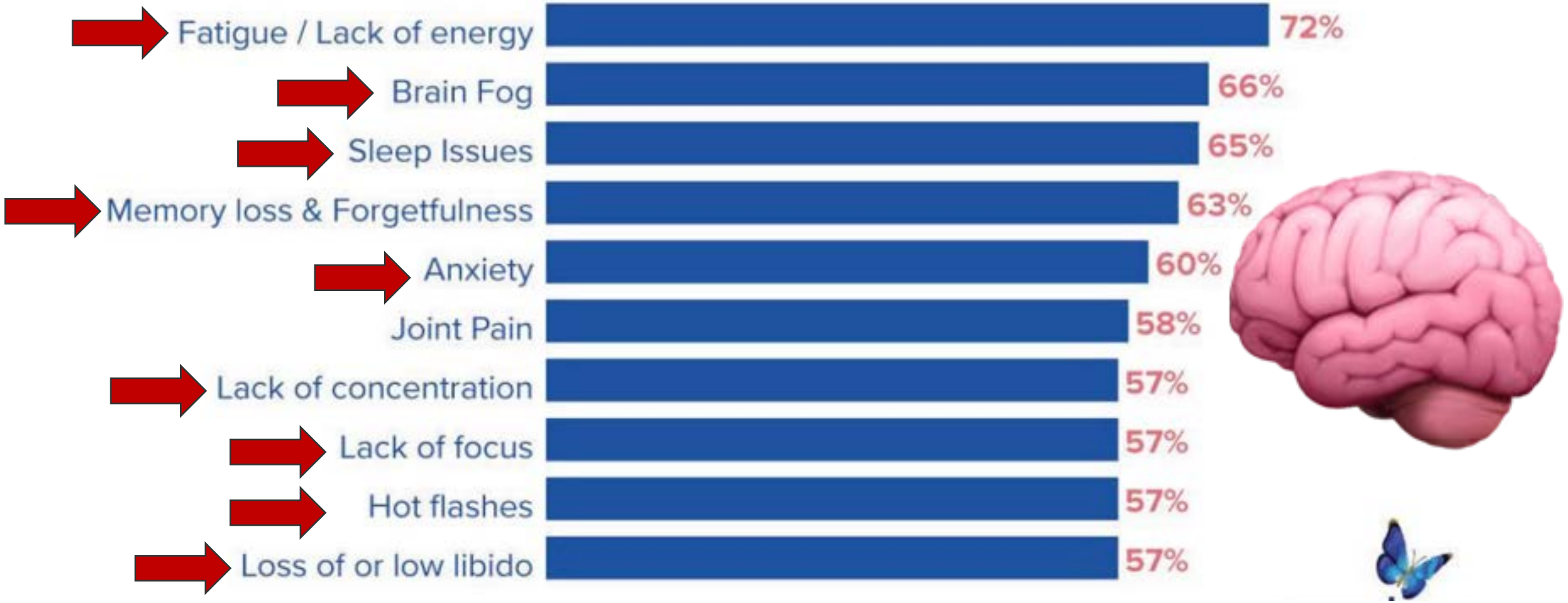

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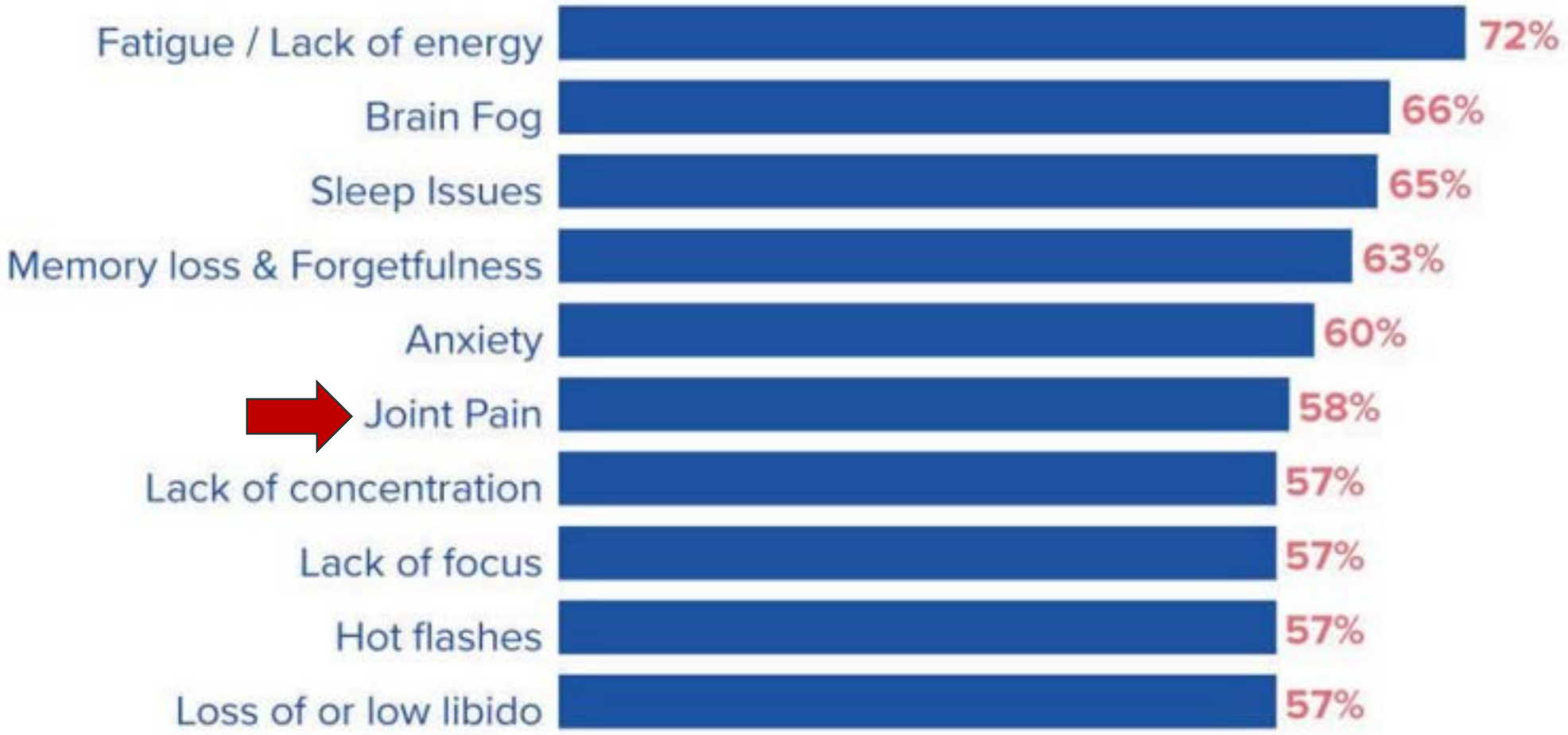
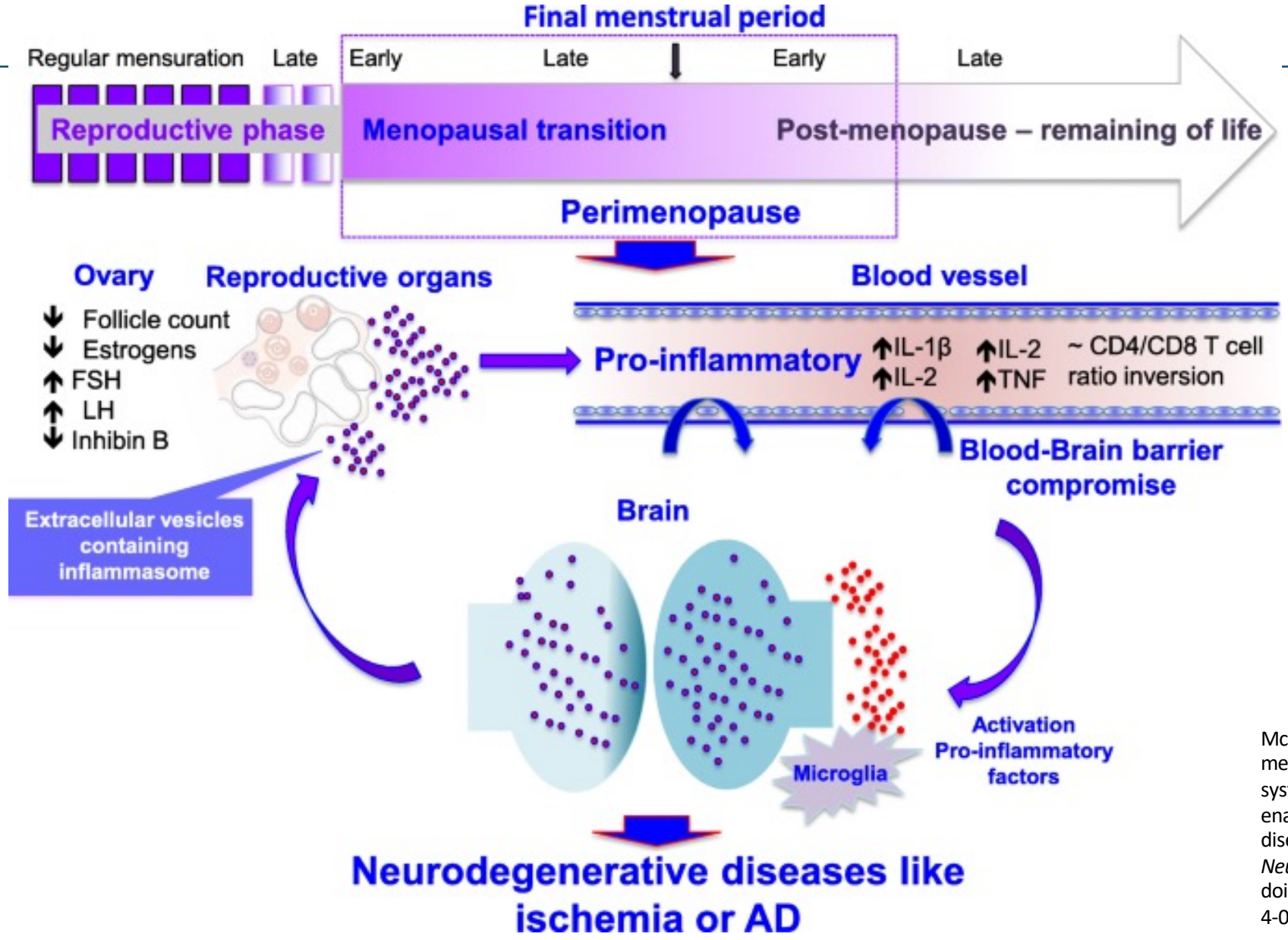
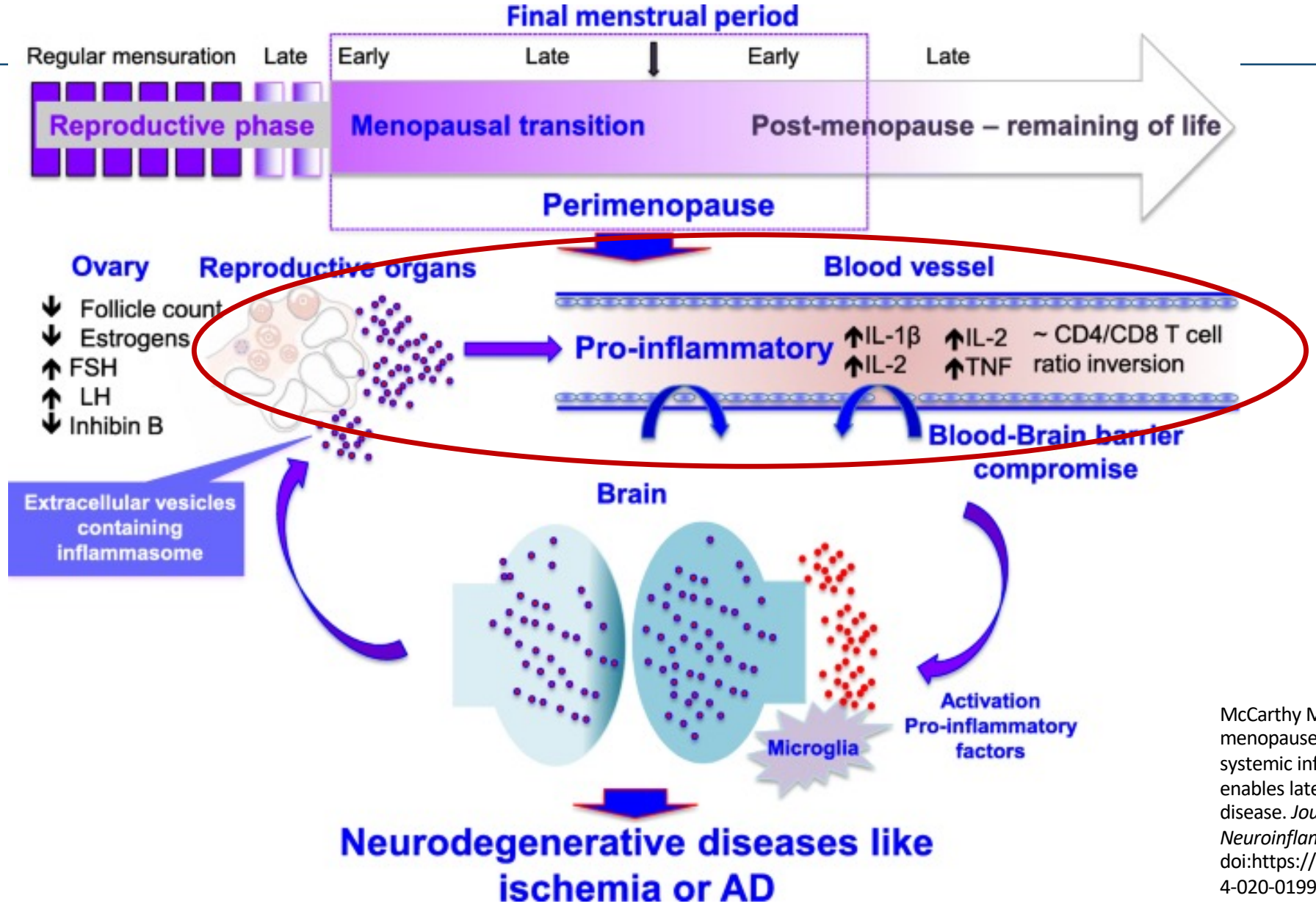
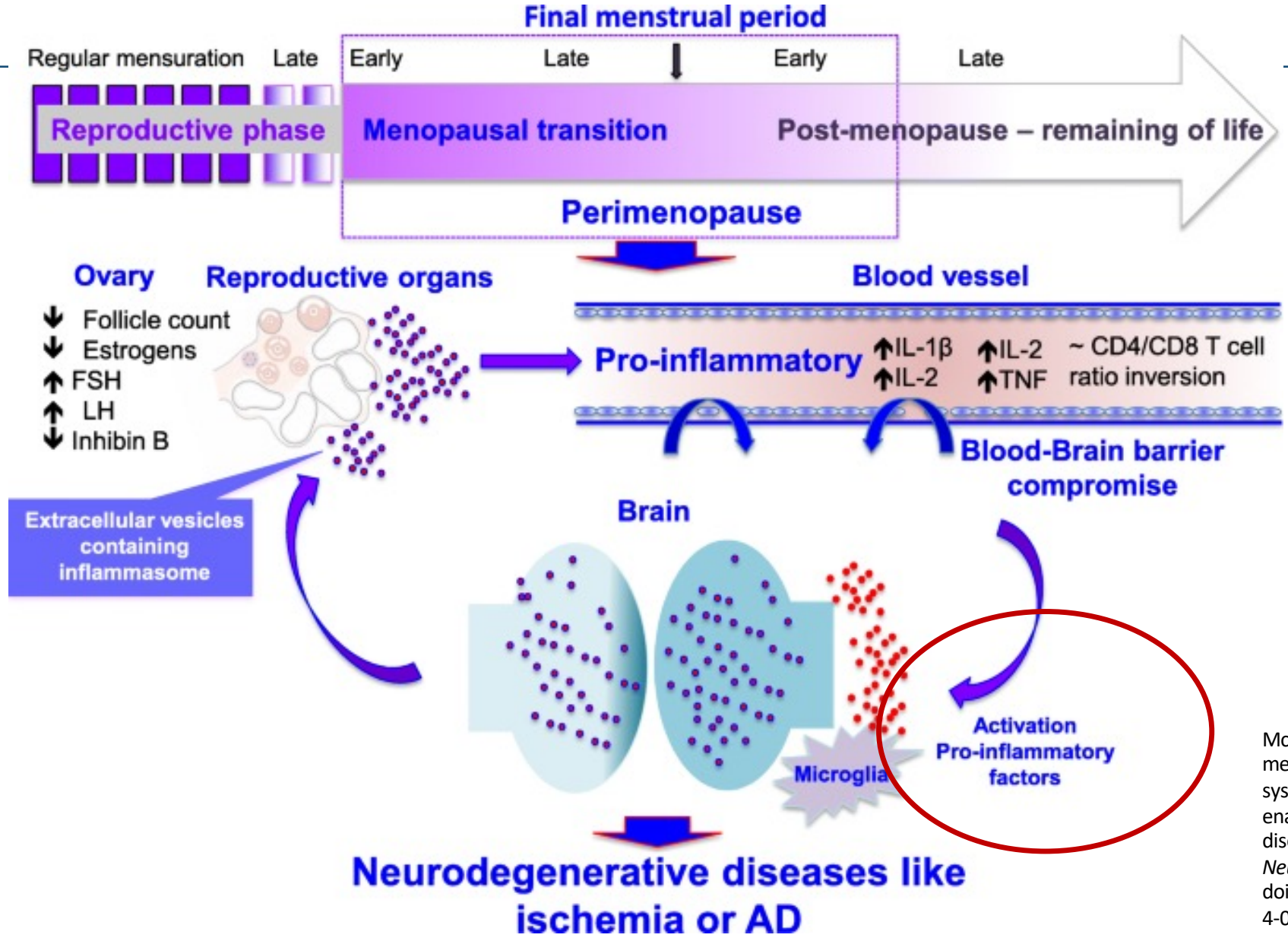




McCarthy M, Raval AP. The peri-menopause in a woman's life: a systemic inflammatory phase that enables later neurodegenerative disease. *Journal of Neuroinflammation*. 2020;17(1). doi:https://doi.org/10.1186/s12974-020-01998-9



McCarthy M, Raval AP. The peri-menopause in a woman's life: a systemic inflammatory phase that enables later neurodegenerative disease. *Journal of Neuroinflammation*. 2020;17(1). doi:https://doi.org/10.1186/s12974-020-01998-9



McCarthy M, Raval AP. The peri-menopause in a woman's life: a systemic inflammatory phase that enables later neurodegenerative disease. *Journal of Neuroinflammation*. 2020;17(1). doi:https://doi.org/10.1186/s12974-020-01998-9

Front Neurosci. 2021; 15: 742065.
Published online 2021 Sep 24. doi: 10.3389/fnins.2021.742065
PMCID: PMC8497816
PMID: 34630027

Microglia in Neuroinflammation and Neurodegeneration: From Understanding to Therapy

Luca Muzio,* Alice Viotti, and Gianvito Martino

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Abstract

Go to:

Microglia are the resident macrophages of the central nervous system (CNS) acting as the first line of defense in the brain by phagocytosing harmful pathogens and cellular debris. Microglia emerge from early erythromyeloid progenitors of the yolk sac and enter the developing brain before the establishment of a fully mature blood–brain barrier. In physiological conditions, during brain development, microglia contribute to CNS homeostasis by supporting cell proliferation of neural precursors. In post-natal life, such cells contribute to preserving the integrity of neuronal circuits by sculpting synapses. After a CNS injury, microglia change their morphology and down-regulate those genes supporting homeostatic functions. However, it is still unclear whether such changes are accompanied by molecular and functional modifications that might contribute to the pathological process. While comprehensive transcriptome analyses at the single-cell level have identified specific gene perturbations occurring in the "pathological" microglia, still the precise protective/detrimental role of microglia in neurological disorders is far from being fully elucidated. In this review, the results so far obtained regarding the role of microglia in neurodegenerative disorders will be discussed. There is solid and sound evidence suggesting that regulating microglia functions during disease pathology might represent a strategy to develop future therapies aimed at counteracting brain degeneration in multiple sclerosis, Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis.

"However, sustained or chronic activation of microglia can lead to irreversible CNS damage. Indeed, persistent inflammation in the brain affects neuronal plasticity, impairs memory, and is generally considered a typical driver of tissue damage in neurodegenerative disorders."

The Study of Women's Health Across the Nation [3] found that being peri-menopausal confers a high risk for recurrence of major depressive disorder (MDD) but not for *de novo* MDD, relative to pre-menopause status. Being peri-menopausal compared to pre-menopausal more than doubled the risk of depression during follow-up.

The Penn Ovarian Aging Study [4] noted a four-fold increase in depression in women with no history of depression during their menopausal transition compared to their pre-menopausal status. Moreover, a diagnosis of MDD was more than twice likely to occur in women with no history of pre-menopausal depression.

The PATH project revealed [5] that being peri-menopausal was associated with a significantly increased risk of depressive symptoms relative to pre-menopause. Furthermore, being peri-menopausal was associated with an increased risk of depression and anxiety in women without history of probable depressive or anxiety disorder.

The Harvard study [6] found that pre-menopausal women with no lifetime history of MDD were nearly twice as likely to develop peri-menopausal depressive symptoms compared to women with no history of depression. The Melbourne women's midlife health project [7] (MWMHP) also found that women in the menopausal transition and early post-menopausal phase were at higher risk of depressive symptoms and low mood than the late post-menopause.

Pimenta et al. [8] showed that psychological symptoms were significantly elevated in peri-menopausal women compared to matched pre-menopausal women. Almeida et al. [9] reported that reproductive status did not affect the prevalence of MDD, but when contrasted with pre-menopause, the peri-menopausal phase was associated with an elevated risk of developing depressive symptoms.

Alblooshi S, Taylor M, Gill N. Does Menopause Elevate the Risk for Developing Depression and anxiety? Results from a Systematic Review. *Australasian Psychiatry*. 2023;31(2):103985622311654. doi:https://doi.org/10.1177/10398562231165439

Table 2.

Risk and protective factors for developing menopausal depression or anxiety

Major risk factors	Minor risk factors	Protective factors
Vasomotor symptoms	Lack of social support	Social support/positive affirmations
History of major depressive disorder	Single or divorced	Menopausal hormone therapy
Neuroticism	Negative perception of aging or menopause	Counselling/psychological therapy
Stressful life events	History of premenstrual syndrome/premenstrual dysmorphic disorder	Healthy lifestyle including exercise
Low financial or educational status		Meditation/mindfulness

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Current Neuropharmacology, 2019, *17*, 459-471

REVIEW ARTICLE

Role of Estradiol in the Expression of Genes Involved in Serotonin Neurotransmission: Implications for Female Depression

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ARTICLE HISTORY

Received: January 09, 2018
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DOI:
10.2174/1570159X16666180628185107

Abstract: ***Background*:** In women, changes in estrogen levels may increase the incidence and/or symptomatology of depression and affect the response to antidepressant treatments. Estrogen therapy in females may provide some mood benefits as a single treatment or might augment clinical response to antidepressants that inhibit serotonin reuptake.

***Objective*:** We analyzed the mechanisms of estradiol action involved in the regulation of gene expression that modulates serotonin neurotransmission implicated in depression.

***Method*:** Publications were identified by a literature search on PubMed.

***Results*:** The participation of estradiol in depression may include regulation of the expression of tryptophan hydroxylase-2, monoamine oxidase A and B, serotonin transporter and serotonin-1A receptor. This effect is mediated by estradiol binding to intracellular estrogen receptor that interacts with estrogen response elements in the promoter sequences of tryptophan hydroxylase-2, serotonin transporter and monoamine oxidase-B. In addition to directly binding deoxyribonucleic acid, estrogen receptor can tether to other transcription factors, including activator protein 1, specificity protein 1, CCAAT/enhancer binding protein β and nuclear factor kappa B to regulate gene promoters that lack estrogen response elements, such as monoamine oxidase-A and serotonin 1A receptor.

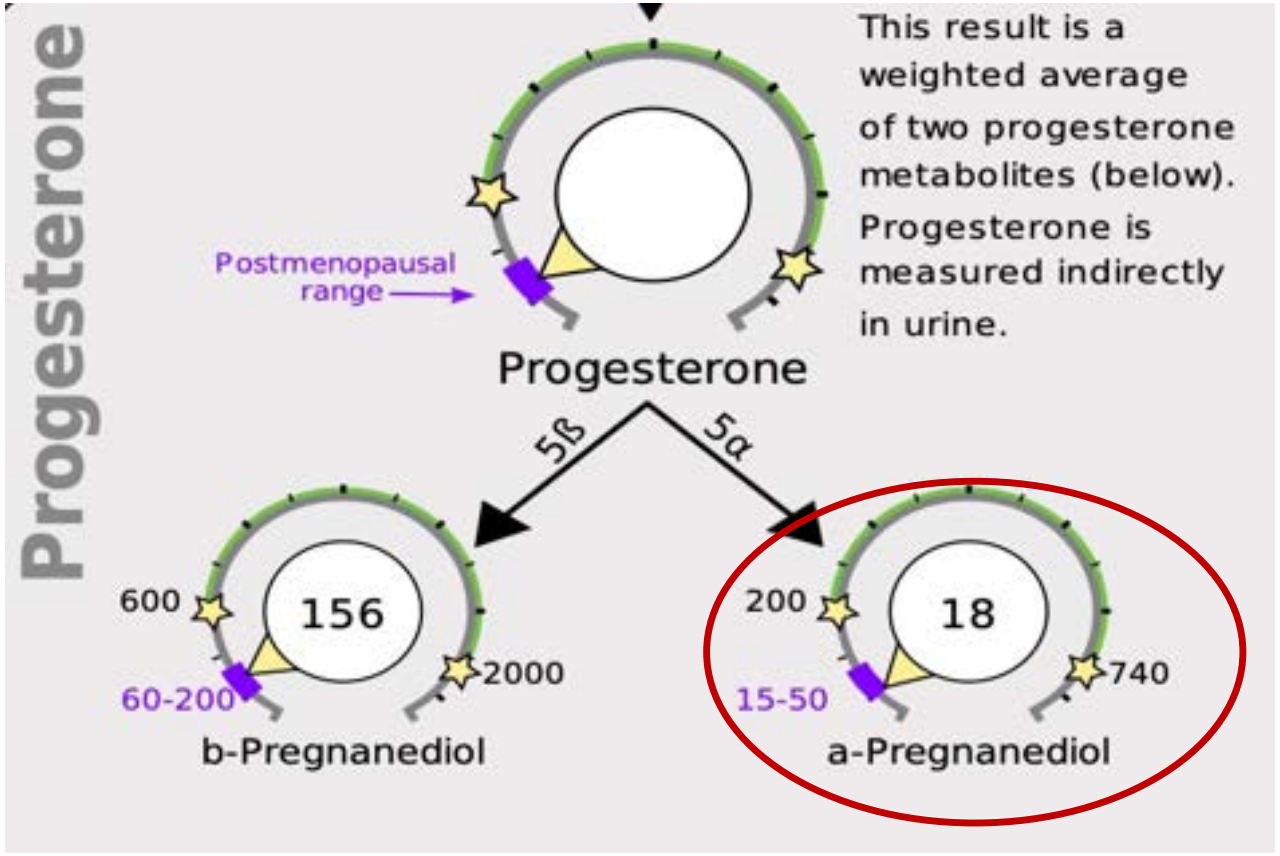
***Conclusion*:** Estradiol increases tryptophan hydroxylase-2 and serotonin transporter expression and decreases the expression of serotonin 1A receptor and monoamine oxidase A and B through the interaction with its intracellular receptors. The understanding of molecular mechanisms of estradiol regulation on the protein expression that modulates serotonin neurotransmission will be helpful for the development of new and more effective treatment for women with depression.

Perimenopause/Post-Menopause and Mood

"The neurosteroid **allopregnanolone**, a downstream metabolite of progesterone, blocks pro-inflammatory neuroimmune signaling through toll-like receptors (TLRs). Allopregnanolone levels drop during the transition to menopause, which **correlates with depressive symptoms."**

Bondy E. Considering the role of estradiol in the psychoneuroimmunology of perimenopausal depression. *Brain, Behavior, & Immunity - Health*. 2024;40:100830. doi:https://doi.org/10.1016/j.bbih.2024.100830

66yo Post-Menopausal Woman not on HRT

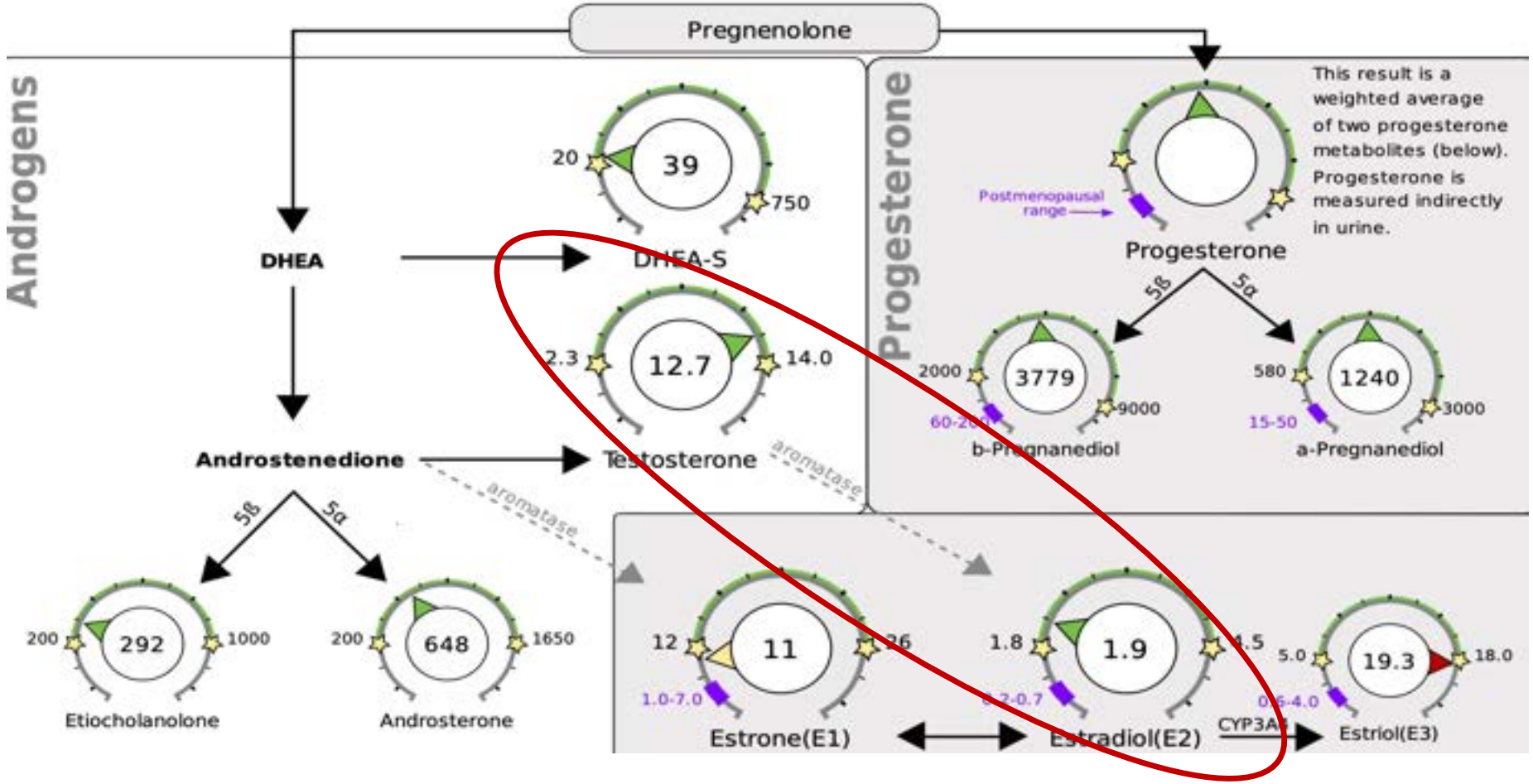


Perimenopause/Post-Menopause and Mood

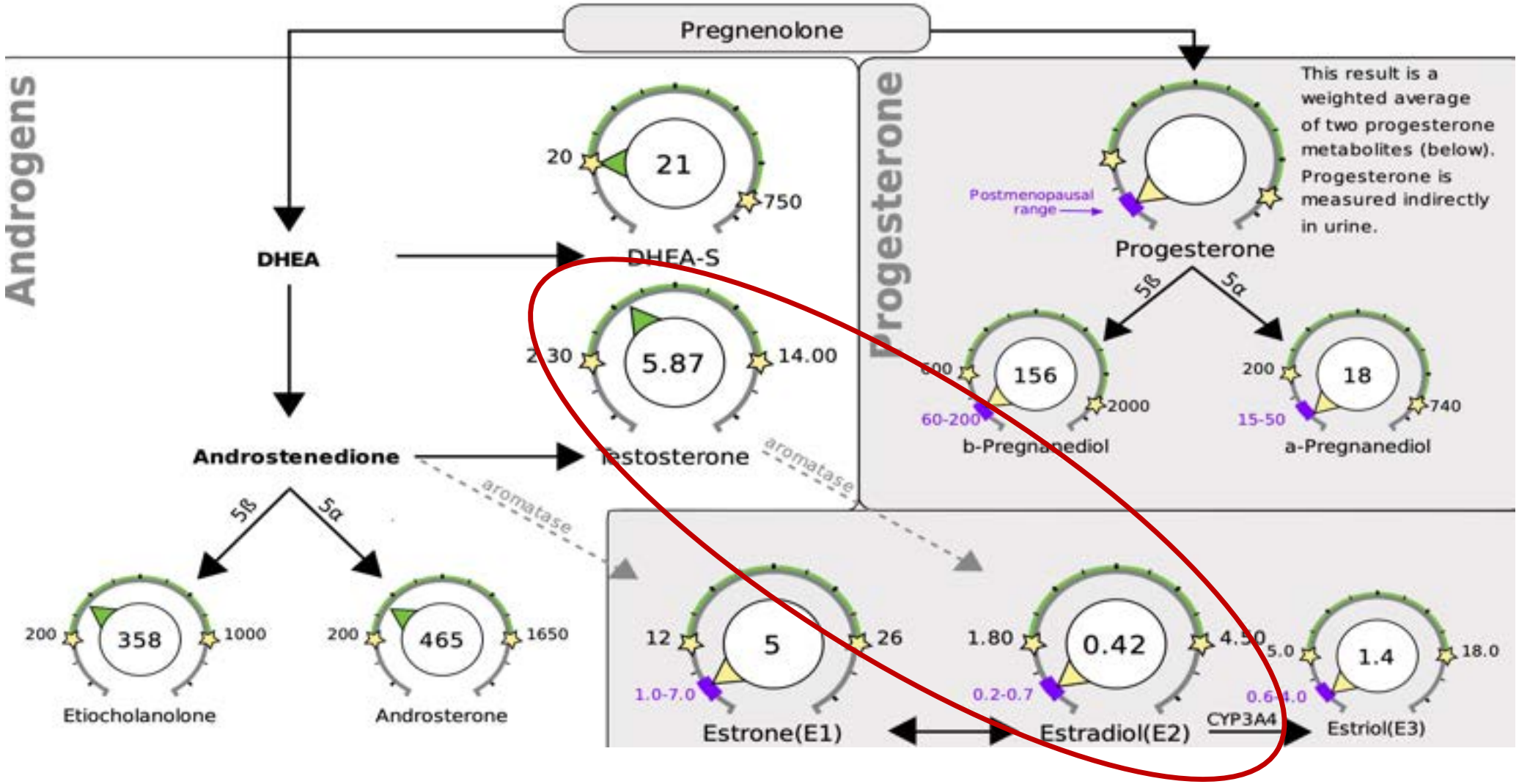
"Rising levels of testosterone, and more specifically the ratio between **testosterone and E2**, during perimenopause has been linked to **increased depressive symptoms**."

Bondy E. Considering the role of estradiol in the psychoneuroimmunology of perimenopausal depression. *Brain, Behavior, & Immunity - Health*. 2024;40:100830. doi:https://doi.org/10.1016/j.bbih.2024.100830

49yo Perimenopausal Woman on 100mg of Oral Progesterone w/ Regular Cycles



66yo Post-Menopausal Woman not on HRT



Retrieved September 28, 2024, from https://news.harvard.edu/gazette/story/2024/03/menopause-depression-risk-has-been-exaggerated/

The Harvard Gazette

Findings | Campus & Community | Health | Science & Tech | Nation & World | Arts & Culture | ≡ Menu

HEALTH

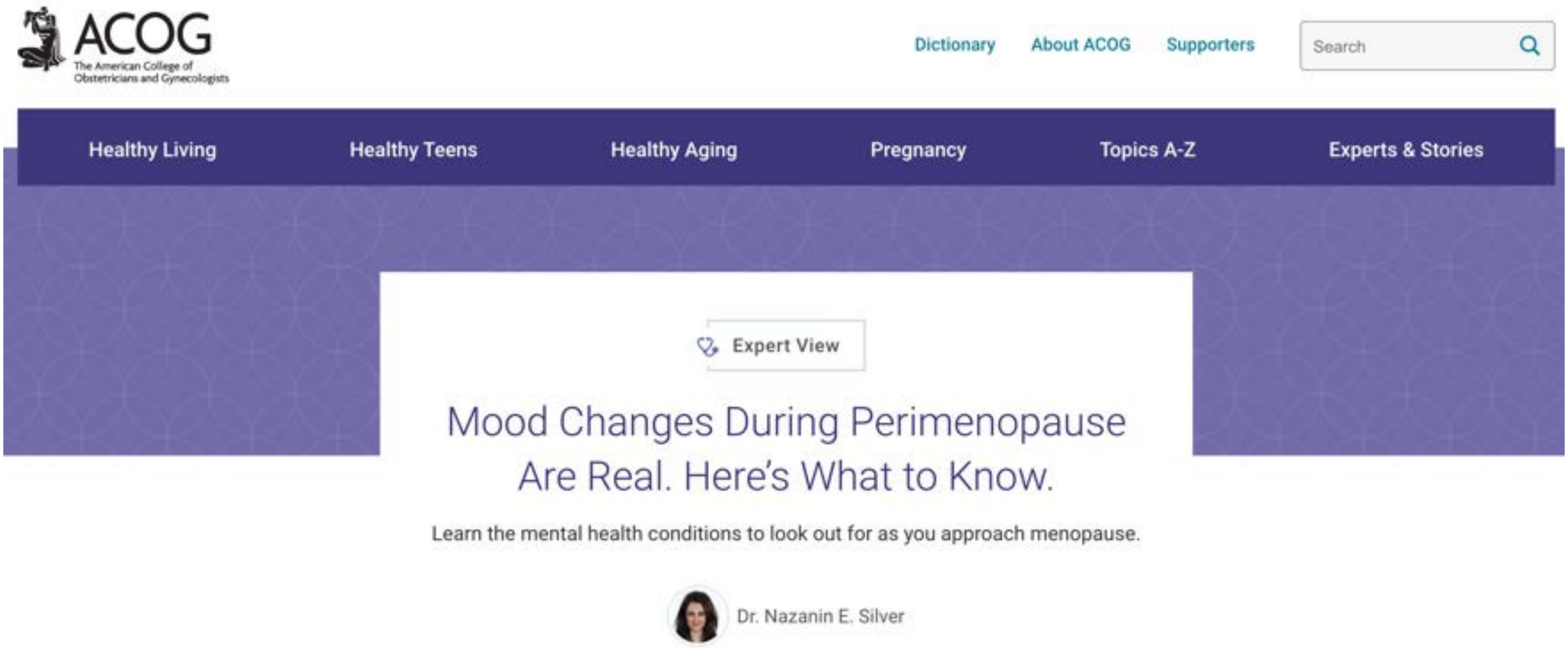
Menopause depression risk has been exaggerated

Some groups are more vulnerable but symptoms far from universal, review finds

| BWH Communications

March 11, 2024 • 4 min read

Retrieved on September 28, 2024, from https://www.acog.org/womens-health/experts-and-stories/the-latest/mood-changes-during-perimenopause-are-real-heres-what-to-know

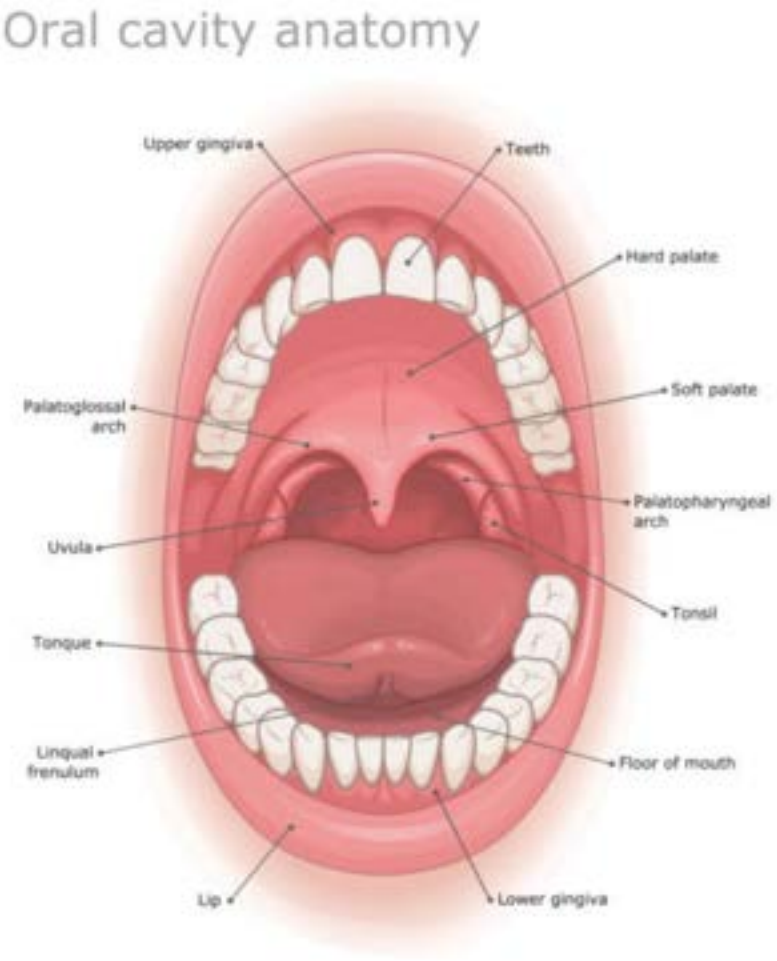


Where Do You Start?

Four Key Areas To Focus:

- Be nice to your whole microbiome
- Gut Dysbiosis/lack of diversity
- Low SCFA
- Inflammation

Start in the Oral Cavity – Top of the GI Tract



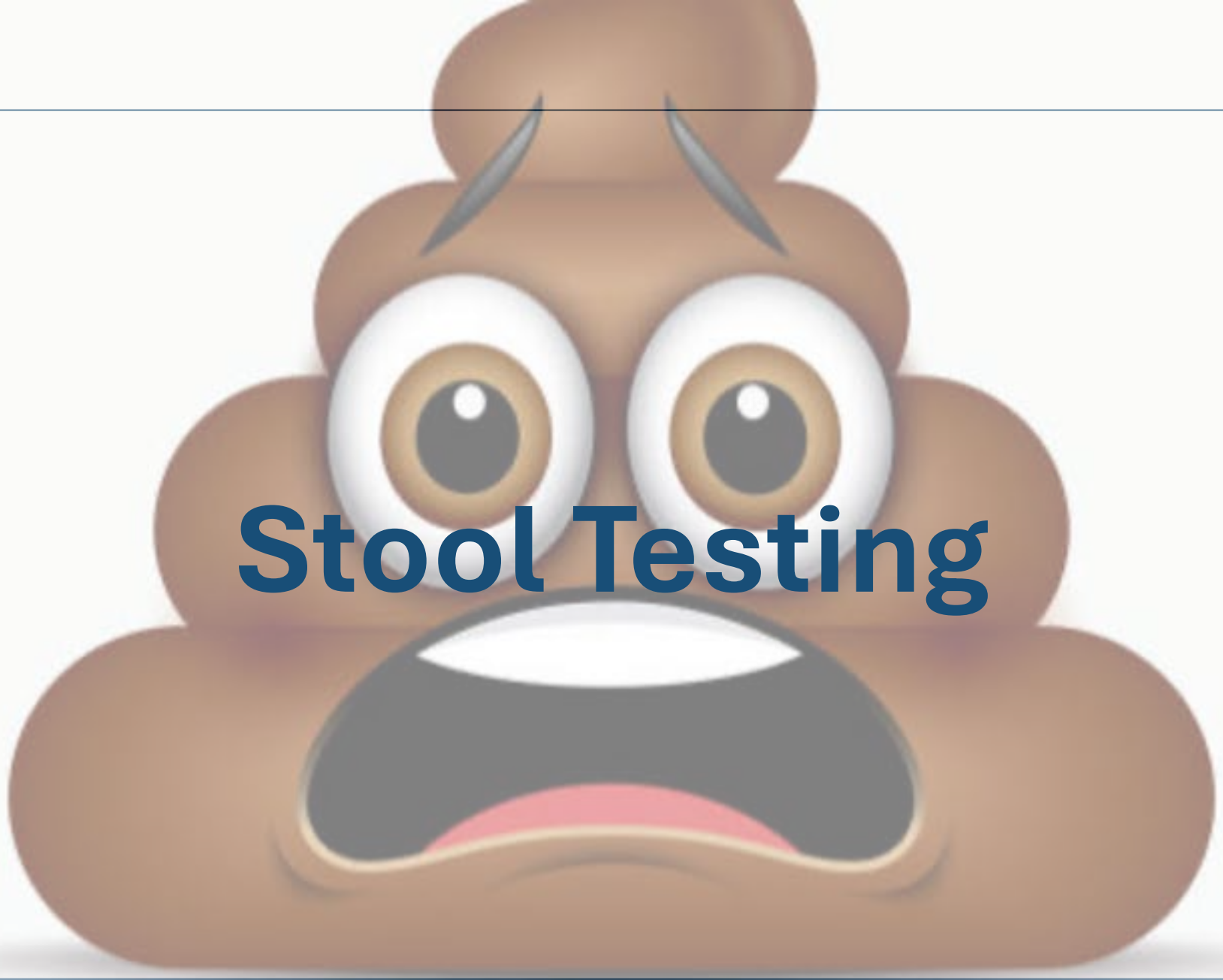
Oral Cavity Support Ideas

- Teeth brushing
- Flossing
- Tongue scraping
- Regular dental visits
- Address inflamed gums and tooth infections
- Be mindful of mouthwash
- Address mouth breathing
- Be mindful of fluoride

Chew your food

You are not a snake

Stool Testing



Eat for Diversity – Don't Get Stuck in a Rut

"A **diverse diet,** and in particular, the **number of different types of plant foods consumed**, has been associated with greater microbial alpha-diversity thought to provide an increased variety of substrates for numerous taxa proliferation"

Leeming ER, Johnson AJ, Spector TD, Le Roy CI. Effect of Diet on the Gut Microbiota: Rethinking Intervention Duration. *Nutrients*. 2019;11(12):2862. doi:https://doi.org/10.3390/nu11122862

Consider Leaving Alcohol Out of the Diversity

Cancer Center

Diet, or what we ingest, has a huge impact on the microbiome. When we drink alcohol, it impacts everything from the oral microbiome all the way through the digestive system. It also involves a lot of other organs along the way.

Here are three things that can happen in the gut microbiome when we drink alcohol.

Alcohol changes the balance of bacteria in the gut microbiome.

First, alcohol can change the composition, or balance, of the gut microbiome. This can cause the gut microbiome to go from a state of homeostasis where everything is happy and calm into a state of dysbiosis where things start to go out of whack.

1.Ph.D CDM. How does alcohol affect the microbiome? MD Anderson Cancer Center. Accessed May 28, 2024. https://www.mdanderson.org/cancerwise/how-does-alcohol-affect-the-microbiome.h00-159696756.html#:~:text=Alcohol%20changes%20the%20balance%20of

Be Mindful of all the Common Antimicrobials

Common food preservative has unexpected effects on the gut microbiome

Analysis of a common preservative used to kill pathogens in food shows that it affects beneficial bacteria as well, threatening the healthy balance of the gut microbiome.

February 2, 2024

Common food preservative has unexpected effects on the gut microbiome | Biological Sciences Division | The University of Chicago. biologicalsciences.uchicago.edu. Published February 2, 2024. Accessed May 28, 2024. https://biologicalsciences.uchicago.edu/news/food-preservatives-gut-microbiome#:~:text=Analysis%20of%20a%20common%20preservative

Prebiotics:

- **Prebiotic:** “a substrate that is selectively used by host microorganisms conferring a health benefit” (Leeming et al, 2019)
- **Prebiotic Examples:** Garlic, Jerusalem artichokes, jicama, dandelion greens, onions, pectin, inulin

What is Jicama?

- Edible tuber in the pea family
- Flavor: slightly sweet and starchy, crunchy
- ½ cup = 40 calories & 5g fiber

Resistant Starches:

- **Resistant starch:** portion of starch that can resist digestion by human pancreatic amylase in the small intestine and thus, reach the colon to be fermented thus modulating the microbiome

RS Examples: Beans, lentils, boiled/cooled rice and potatoes, green banana, guar gum

Citations:Prebiotics/Resistant Starches

- Fuentes-Zaragoza E, Sánchez-Zapata E, Sendra E, et al. Resistant starch as prebiotic: A review. *Starch - Stärke*. 2011;63(7):406-415. doi:https://doi.org/10.1002/star.201000099
- Leeming ER, Johnson AJ, Spector TD, Le Roy CI. Effect of Diet on the Gut Microbiota: Rethinking Intervention Duration. *Nutrients*. 2019;11(12):2862. doi:https://doi.org/10.3390/nu11122862
- Thompson MS, Hui Yan T, Saari N, Sarbini SR. A review: Resistant starch, a promising prebiotic for obesity and weight management. *Food Bioscience*. 2022;50:101965. doi:https://doi.org/10.1016/j.fbio.2022.101965
- Topping DL, Fukushima M, Bird AR. Resistant starch as a prebiotic and synbiotic: state of the art. Proc Nutr Soc. 2003 Feb;62(1):171-6. doi: 10.1079/pns2002224. PMID: 12749342

POSTBIOTICS:

"a preparation of inanimate microorganisms and/or their components that confers a health benefit on the host".

Foods. 2022 Apr; 11(8): 1077. PMCID: PMC9027423
Published online 2022 Apr 8. doi: 10.3390/foods11081077 PMID: 35454664

The Concept of Postbiotics

Gabriel Vinderola,[1,*] Mary Ellen Sanders,[2] and Seppo Salminen[3]

Quang D. Nguyen, Academic Editor and Zsolt Zalán, Academic Editor

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Associated Data

Data Availability Statement

Abstract Go to:

The scientific community has proposed terms such as non-viable probiotics, paraprobiotics, ghostbiotics, heat-inactivated probiotics or, most commonly, postbiotics, to refer to inanimate microorganisms and/or their components that confer health benefits. This article addresses the various characteristics of different definitions of 'postbiotics' that have emerged over past years. In 2021, the International Scientific Association for Probiotics and Prebiotics (ISAPP) defined a postbiotic as "a preparation of inanimate microorganisms and/or their components that confers a health benefit on the host". This definition of postbiotic requires that the whole or components of inactivated microbes be present, with or without metabolic end products. The definition proposed by ISAPP is comprehensive enough to allow the development of postbiotics from different microorganisms, to be applied in different body sites, encouraging innovation in a promising area for any regulatory category and for companion or production animals, and plant or human health. From a technological perspective, probiotic products may contain inanimate microorganisms, which have the potential to impart a health benefit. However, their contribution to health in most cases has not been established, even if at least one probiotic has been shown to confer the same health benefit by live or inanimate cells.

Postbiotic: Akkermansia (dead)

- Akkermansia is part of the microbiome – supports mucin layer
- Akkermansansia plays a role in blood pressure, inflammation (lowers LPS), and metabolic syndrome
- Lower levels are seen in post-menopausal women
  - Research reports it can be estradiol related
- Giving pasteurized (dead) akkermansia is considered a postbiotic
- Pomegranate and grapeseed support akkermansia

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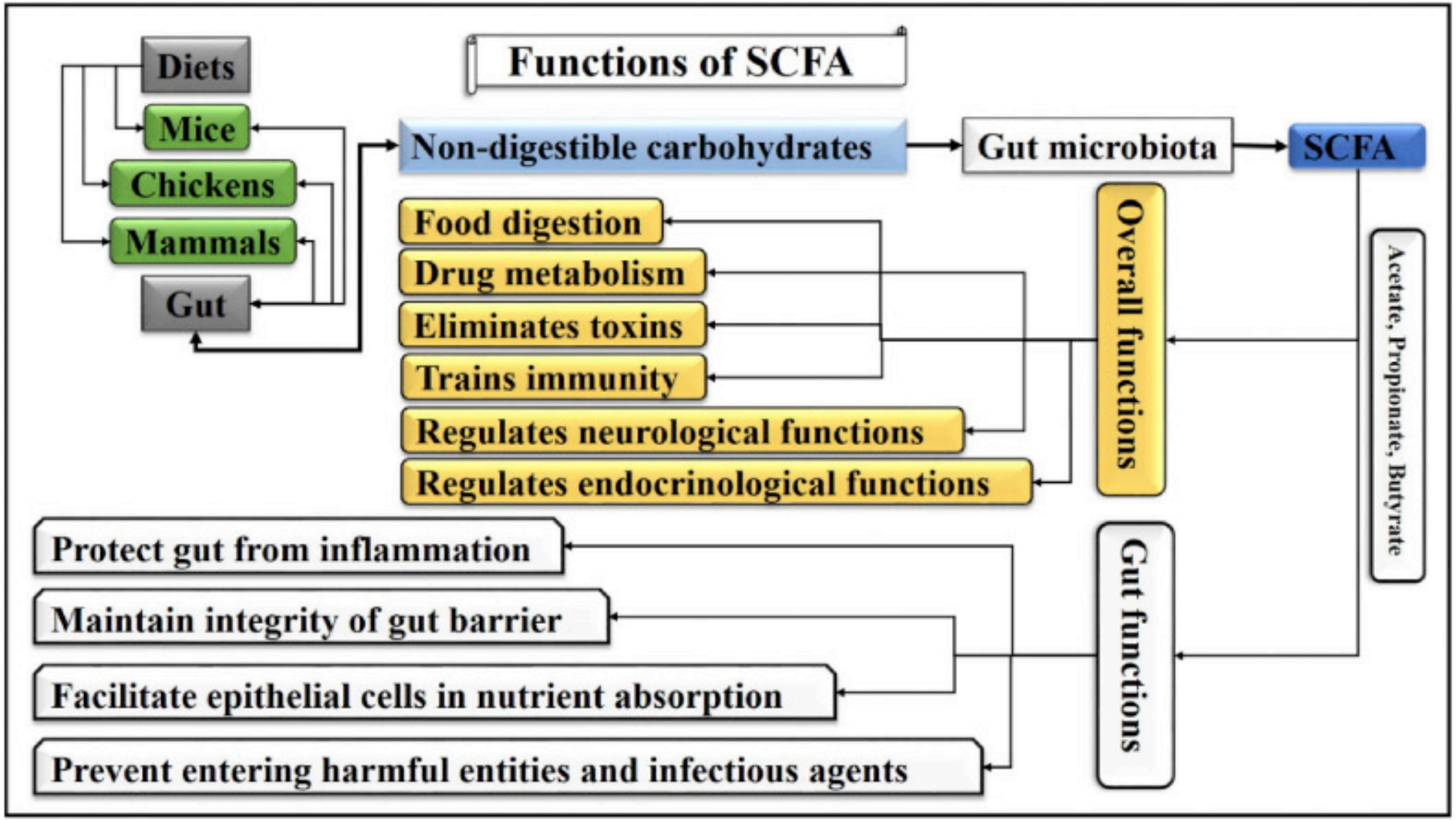
- Anil Sakamuri, Pritam Bardhan, Tummala R, et al. Sex hormones, sex chromosomes, and microbiota: identification of Akkermansia muciniphila as an estrogen-responsive bacterium. *Microbiota and Host*. 2023;1(1). doi:https://doi.org/10.1530/mah-23-0010

Short Chain Fatty Acids (SCFA)

- **Gut microbiota-produced fermentation products of dietary fibers**
- **The big ones:** Formate, acetate, propionate, butyrate, valerate, and caproate
- **Butyrate (Butyric acid)** acts as an energy source for colonocytes
  - Faecalibacterium prausnitzii, Eubacterium hallii and Eubacterium rectale are considered as main butyrate producers
  - Ruminococcus bromii significantly contributes to producing butyrate via fermenting resistant starch
- Akkermansia muciniphila = bacterium for propionate production which helps to degrade the mucin

Akhtar M, Chen Y, Ma Z, et al. Gut microbiota-derived short chain fatty acids are potential mediators in gut inflammation. *Animal Nutrition*. 2022;8:350-360. doi:https://doi.org/10.1016/j.aninu.2021.11.005

Akhtar M, Chen Y, Ma Z, et al. Gut microbiota-derived short chain fatty acids are potential mediators in gut inflammation. *Animal Nutrition*. 2022;8:350-360. doi:https://doi.org/10.1016/j.aninu.2021.11.005



What About HRT?

Menopause: The Journal of The North American Menopause Society
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OPEN

ORIGINAL STUDY

Duodenal microbiome changes in postmenopausal women: effects of hormone therapy and implications for cardiovascular risk

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Abstract

Objective: Hormone therapy (HT) is used to treat menopause-related conditions and symptoms. The small intestine plays key roles in metabolic and endocrine function, but the effects of HT on the small intestinal microbiome are unknown. Here, we characterize duodenal microbiome differences, and the effects of HT, in postmenopausal women.

Methods: Female participants undergoing esophagogastroduodenoscopy who were postmenopausal and taking HT (HT+), postmenopausal but not taking HT (HT−), or of reproductive age and not taking exogenous hormones (RA), were identified and matched for body mass index (±3 kg/m^2). DNAs were isolated from duodenal aspirates obtained during upper endoscopy. V3 and V4 libraries were used for 16S rRNA sequencing. Serum hormone levels were analyzed by Luminex FlexMap.

Results: The core duodenal microbiome was different in HT− participants ($n = 12$) when compared with RA participants ($n = 10$), but more similar in HT+ ($n = 13$) and RA participants. HT− participants had increased Proteobacteria taxa, leading to greater microbial dysbiosis compared with HT+ participants, and had decreased prevalence of Bacteroidetes, which was associated with higher fasting glucose levels, lower duodenal microbial diversity, and lower testosterone levels. HT+ participants had significantly higher estradiol ($P = 0.04$) and progesterone ($P = 0.04$), and lower fasting glucose ($P = 0.03$), than HT− participants, and had increased relative abundance of *Prevotella* ($P = 0.01$), and decreased *Escherichia* ($P = 1.12$E-7), *Klebsiella* ($P = 5.93$E-7), and *Lactobacillus* ($P = 0.02$), all associated with lower cardiovascular disease risks.

Conclusions: These findings support previous studies suggesting that HT may have beneficial effects following menopause, and although preliminary, may also support a beneficial effect of HT on the duodenal microbiome.

Key Words: Duodenal microbiome – Hormone therapy – Menopause.

"In this study, we demonstrate that the core duodenal microbiome at phylum level is **significantly different** in postmenopausal women when compared with women of reproductive age, and that these **differences are lessened** in postmenopausal women taking hormone therapy."

Summary:

- The perimenopausal transition is linked with:
  - Increased leaky gut
  - Less microbial diversity
  - Increased systemic inflammation
  - Increased depression
  - Increased brain changes

- **Focus on the changes in the entire GI tract to reduce inflammation and improve diversity thus reducing many symptoms/risks.**

Thank You!

Carrie Jones, ND, FABNE, MPH, MSCP

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