



NMI SUMMIT 2024

An Energetic View: Mitochondrial Nutrition for Fatigue, the Brain, & Healthy Ageing

Saturday 12th October

Featuring Dr. Joseph Pizzorno, Lorraine Nicolle, Claire Sehinson, Professor Robert Thomas, Dr. Deanna Minich

An event by:  Nutritional Medicine Institute

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An Energetic View: Mitochondrial Nutrition for Fatigue, the Brain, and Healthy Ageing



Dr. Deanna Minich, PhD

Harnessing the Spectrum of Energy for Vitality: The Mitochondrial-Metabolic Muscle Axis

4:15-5:00pm

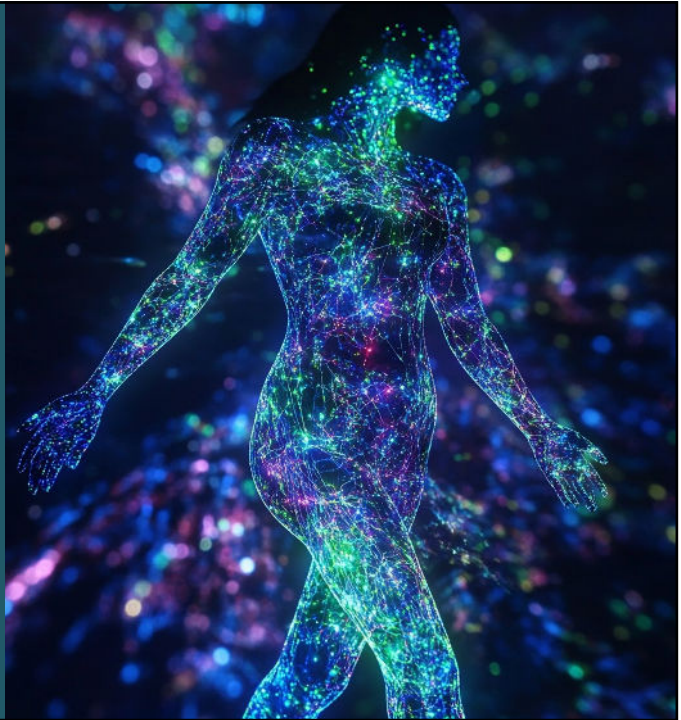
An event by:  Nutritional Medicine Institute

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Harnessing the Spectrum of Energy for Vitality: The Mitochondrial- Metabolic-Muscle Axis

Deanna Minich, MS, PhD, CNS, IFMCP
deannaminich.com

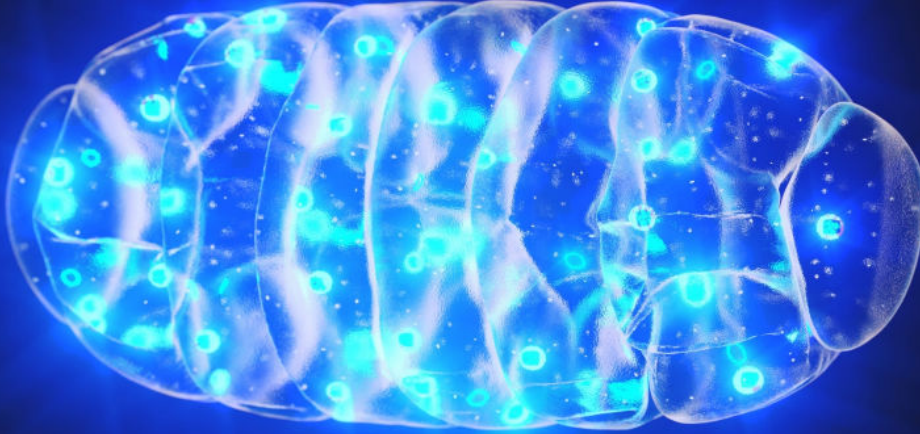


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**Mitochondria as a marker of aging and
vitality at quantum level**

6

Our mitochondria are more than "powerhouses of the cell."
They are the conductors of the **transgenerational vital force**,
the qi carried through the lineage of one's maternal ancestors.

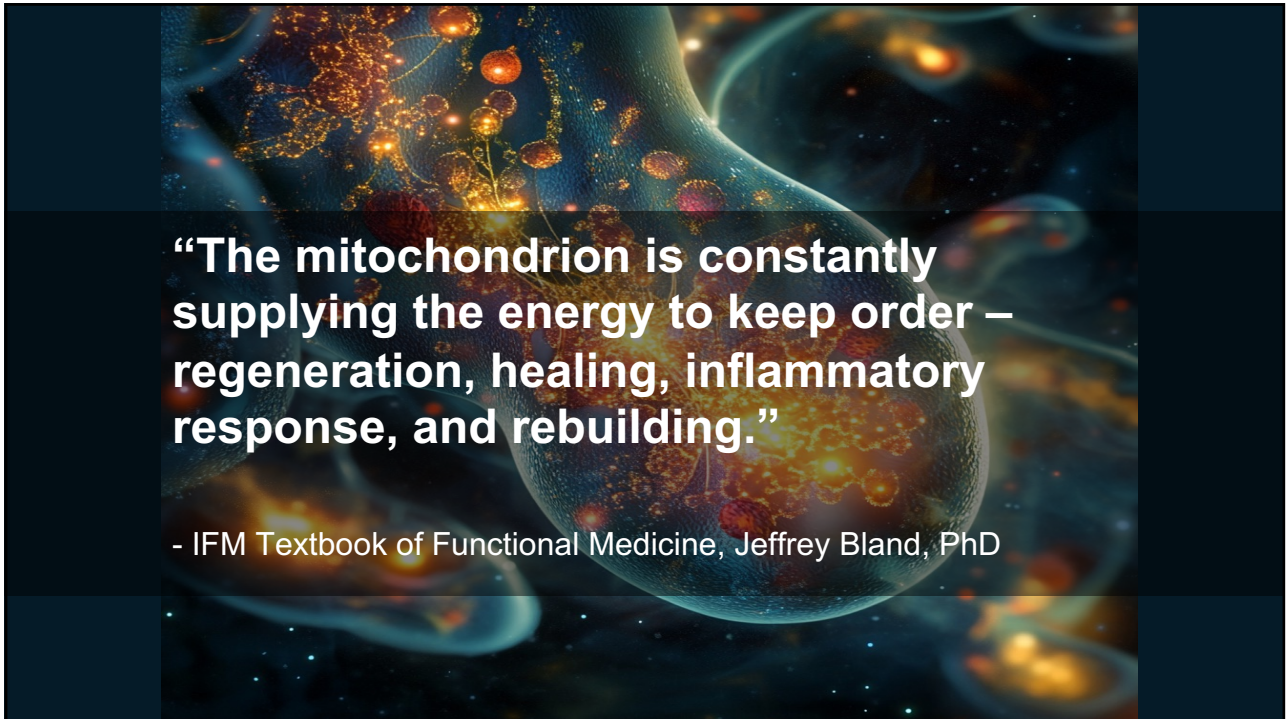


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The mitochondria represent the maternal, the yin, the nourishing and vitalizing force within ~

- Energy
- Function
- Vitality
- Longevity
- Maternal
- Fatigue
- Dysfunction
- Aging
- Balance
- Overwhelm

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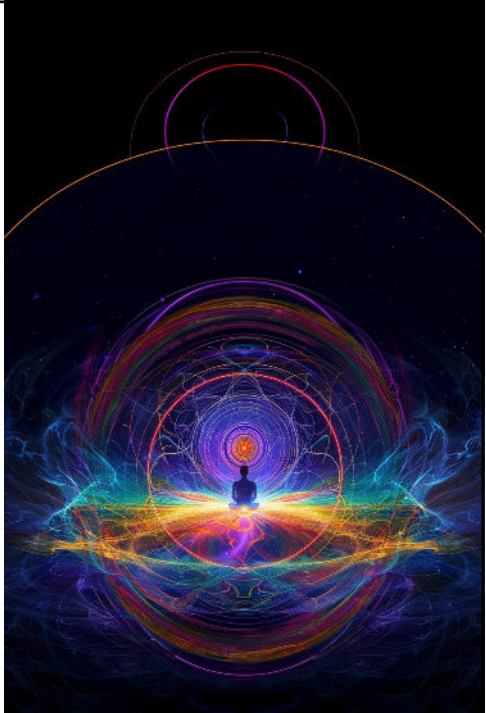


9

The Mitochondria and Quantum Medicine

The mitochondria embody the principles of quantum medicine, in alignment with Einstein’s approach of the human body has a whole, complete system working in harmony with universal principles.

Azeemi ST, Raza SM. A critical analysis of chromotherapy and its scientific evolution. *Evid Based Complement Alternat Med.* 2005;2(4):481-488. doi:10.1093/ecam/neh137



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Quantum Functional Energy Medicine

"Energy transformation in mitochondria produces a special state to condense energy in electrical vibrations."

Gonzalez M., Sutherland E, Olalde J. Quantum Functional Energy Medicine: The Next Frontier of Restorative. *Journal of Restorative Medicine* 2019; 8:10.14200/jrm.2019.0114

Quantum Functional Energy Medicine: The Next Frontier of Restorative Medicine

Michael J. Gonzalez, PhD*
Elizabeth Sutherland, ND[†]
Jose Olalde[‡]

DOI: 10.14200/jrm.2019.0114

If you want to find the secrets of the Universe, think in terms of energy, frequency and vibrations.
Nikola Tesla

ABSTRACT

Living systems may be thought of as complex, nonlinear, dynamic, self-organizing energetic and field phenomena with negative entropy. At the highest level of organization, each life form may possess an innate biologic field, or biofield. This energy field maintains the integrity of the whole organism; regulates its physiologic and biochemical responses; and is integral to development, healing, and regeneration. Energy medicine refers to several systems that work with energy fields of the body to help restore health. Many energy-related therapies challenge the current biomedical paradigm because they cannot be explained by conventional biochemical or physiological mechanisms. Quantum physics is a better paradigm with which to understand these therapies.

Keywords: Functional medicine; Energy Medicine; Resonance; Vibration; Photo-bio-stimulation

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[‡]National University of Natural Medicine, Portland, OR, USA.

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Emergent fields create cellular form, which results in physical functionality.

"From the quantum biology point of view, electromagnetic interactions and photonic communications at intracellular and intercellular levels are indispensable for the emerging evolutions of eukaryotic cells and metazoan species. Microtubules and chromatin fibers are well-known electromagnetic oscillators in eukaryotic cells."

Sun G, Li J, Zhou W, Hoyle RG, Zhao Y. Electromagnetic interactions in regulations of cell behaviors and morphogenesis. *Front Cell Dev Biol.* 2022 Oct 19;10:1014030. doi: 10.3389/fcell.2022.1014030. PMID: 36340041; PMCID: PMC9627210.

The mitochondria are the conduit to color

- All organs, cells, and atoms within the human body have a frequency or vibrational energy.
- Those frequencies align with colors or energy waves.
- Colors create more subtle electric and magnetic impulses that activate biochemical processes.
- The essence of the mitochondria is to harness the complete spectrum of color:
 - “Cytochromes”: Cyto = Cell; Chrome = Color

Azeemi ST, Raza SM. A critical analysis of chromotherapy and its scientific evolution. *Evid Based Complement Alternat Med.* 2005;2(4):481-488. doi:10.1093/ecam/neh137

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Color is the quantum state of matter.

The “Secret” to Healthy Aging and Mitochondria: Is it about color?

Azeemi ST, Raza SM. A critical analysis of chromotherapy and its scientific evolution. *Evid Based Complement Alternat Med.* 2005;2(4):481-488. doi:10.1093/ecam/neh137



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Nutrition is the science of harnessing the spectrum of energy

Food is quantum energy.

Eating is an act of extracting energy from color.

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Eating is an act of in-light-enment.

- Deanna Minich, PhD

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The “Secret” to Healthy Aging and Mitochondria: Is it about fluidity?

Creativity and fluidity:

- Neuronal plasticity
- Heart rate variability
- Metabolic flexibility

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Questionnaire: How Well Are You Aging?
 By Deanna Minich, PhD (www.foodandspirit.com)

Aspects of Yourself	Excellent	Average	Needs Improvement
BRAIN			
I remember names, dates, and faces.			
I beat others at board and card games.			
I focus well on tasks at hand.			
I can concentrate when asked to.			
I am rarely depressed.			
I think positively about situations.			
I sleep 7-8 hours every night.			
My mind is quick, alert and imaginative.			
My intellect is strong and I enjoy facts.			
I am good at doing crossword puzzles, and other mental teasers.			
HEART			
My heart is in good working order.			
My blood cholesterol is normal.			
My level of anxiety is under control.			
My stress level is negligible.			
I am quick to forgive and forget.			
I eat unbreaded fish 3-4 times weekly, or take high-quality fish oil as a supplement.			
My emotions are balanced and even.			
I am rarely breathless, even when walking up a flight of stairs.			
My blood pressure is normal.			
My triglycerides are normal.			
GUT			
I eat a meal and never feel stomach upset.			
I chew my food thoroughly.			
I eat mostly whole, unprocessed foods that are rich in natural colors.			
I have normal bowel movements, about 1-2 per day.			
I eat at least 7 servings (about half a cup) of vegetables and fruit every day.			
My blood glucose tends to be normal.			
I do not suffer from cravings.			
I eat bitter foods, like dark, leafy greens, on a regular basis.			

©Deanna Minich, PhD www.foodandspirit.com Successful Aging Questionnaire

My body is lean, or I do not carry excess weight. I am.			
I rarely experience bloating or discomfort in my gut.			
OTHER			
I am in good health, and I don't take any medications.			
I get at least 30 minutes of moderate activity every day.			
My weight is normal.			
I do not have any evidence of inflammation in my body.			
I am free of any pain.			
My energy levels are optimal.			
I take vitamins and minerals as dietary supplements.			
I exercise regularly and with ease.			
My skin is clear, smooth and hydrated. To the touch it is warm, firm and slightly moist.			
My hair is lustrous and is neither too thin nor too coarse. It grows in the correct places and does not gray or fall prematurely.			
TOTAL SCORES			
EXCELLENT = 3 points			
AVERAGE = 2 points			
NEEDS IMPROVEMENT = 1 point			
KEY			
100 to 95	You are an aging matriarch! You are most likely healthier and more vital than your peers. Your good lifestyle and genes are working for you – wonderful!		
94 to 88	You are aging at an average rate. You may have your good days and not-so-good days, but overall, you are comfortable with your body's functioning. You may realize that you need to improve certain aspects of your lifestyle.		
87 to 40	You have many opportunities to enhance your "successful aging" potential. Inducing toxicive healthy lifestyle habits. Find a healthy professional or health coach to help you on your path!		

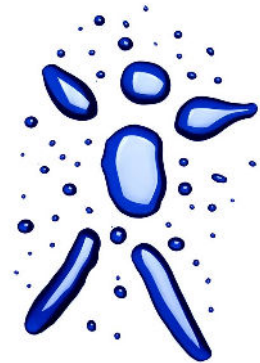
©Deanna Minich, PhD www.foodandspirit.com Successful Aging Questionnaire

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Fluidity to the point of leakiness: Why the epidemic of “leakiness”?

- “Leaky gut”
- “Leaky brain”
- “Leaky membranes”
- “Leaky channels”
- “Leaky mitochondria”
- “Leaky muscle”?

} Leaky life?



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“The reason people eventually die is that the ordering and stabilizing energy systems of the body are exceeded by the natural disordering tendency of the universe.”

- IFM Textbook of Functional Medicine, Jeffrey Bland, PhD



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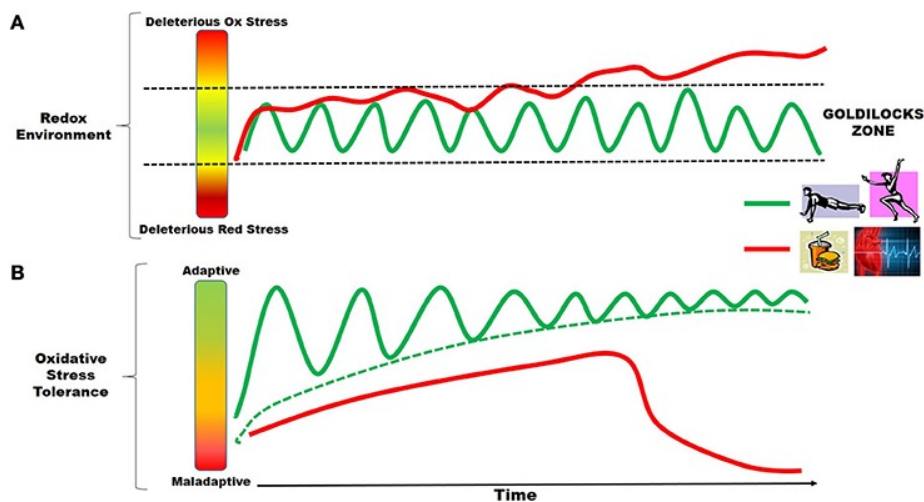
Translating the quantum into health

“The National Academies Keck Futures Initiative; the Future of Human Healthspan, defined healthspan as the time an organism was of good health with health being the **“the ability of a system to maintain or return to homeostasis in response to challenges”**”.

Kathrin Pallauf, Katrin Giller, Patricia Huebbe, and Gerald Rimbach, “Nutrition and Healthy Ageing: Calorie Restriction or Polyphenol-Rich “MediterrAsian” Diet?,” *Oxidative Medicine and Cellular Longevity*, vol. 2013, Article ID 707421, 14 pages, 2013. <https://doi.org/10.1155/2013/707421>.

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The Goldilocks Zone

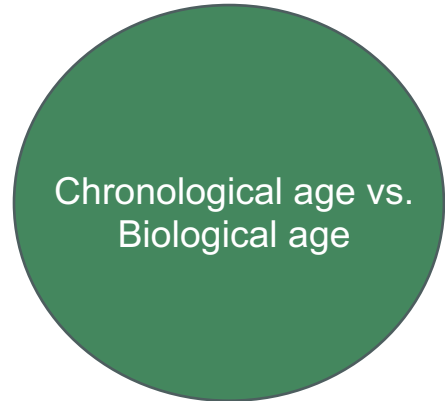


Alleman RJ, Katunga LA, Nelson MAM, Brown DA, Anderson EJ. The “Goldilocks Zone” from a redox perspective—Adaptive vs. deleterious responses to oxidative stress in striated muscle. *Front Physiol.* 2014;5:358. doi:10.3389/fphys.2014.00358. CC BY.

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Select laboratory biomarkers of resilience

- **Inflammaging**
 - High hsCRP
 - Low vitamin D
 - High fasting glucose/insulin
 - Low omega-3 Index
 - Reduced lean body mass
 - High homocysteine (risk factor for chromosome damage, Fenech)
- **Elevated oxidative stress Markers**
 - 8-OHdG
 - Urine lipid peroxides
- **Low levels of vitamins and minerals**
- **Advanced Glycation Endproducts** – High Hgb A1C
- **Elevated autoantibodies**
- **Lowered immune function** (reduced WBCs)

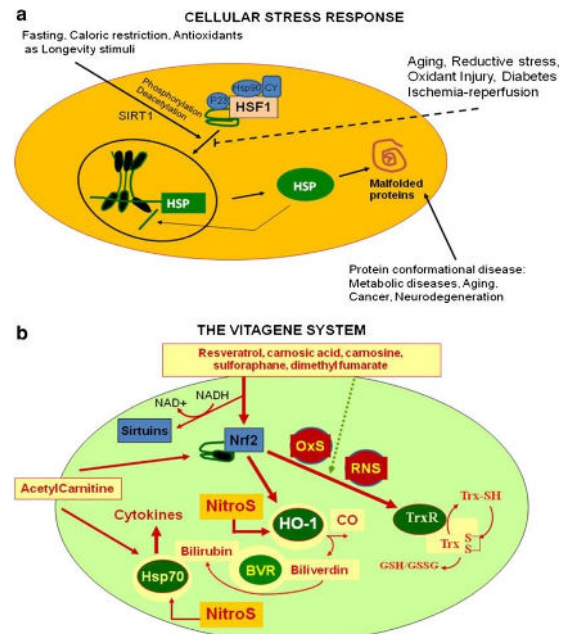


Reference: Based on presenter's clinical experience

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Vitagenes

- Vitagenes encode for proteins, enzymes, and systems to help with stress: heat shock proteins (Hsp) Hsp32, Hsp70, the thioredoxin and the sirtuin protein systems.
- Dietary antioxidants and caloric restriction, have been demonstrated to be neuroprotective through the activation of hormetic pathways, including vitagenes.

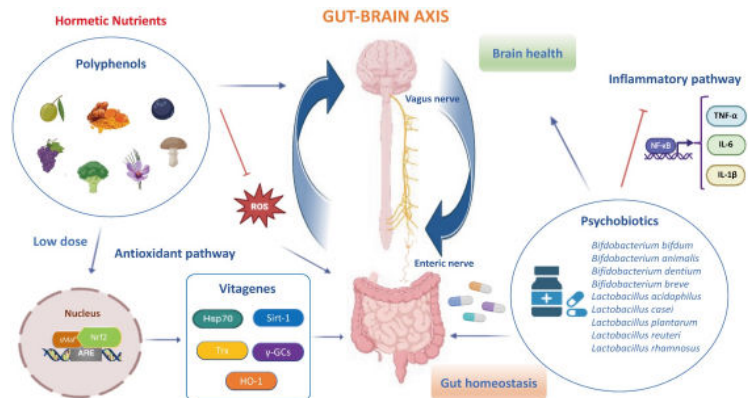


Cornelius C, Perrotta R, Graziano A, Calabrese EJ, Calabrese V. Stress responses, vitagenes and hormesis as critical determinants in aging and longevity: Mitochondria as a "chi". *Immun Ageing*. 2013;10(1):15. Published 2013 Apr 25. doi:10.1186/1742-4933-10-15. CCBY 2.0

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Curcumin and resveratrol induce transcription of vitagenes

- The vitagene heme oxygenase-1 (HO-1) is upregulated via the Nrf2 pathway by curcumin supplementation
- Resveratrol acts on sirtuin-1 (SIRT1)



Scuto M, Rampulla F, Reali GM, Spanò SM, Trovato Salinaro A, Calabrese V. Hormetic Nutrition and Redox Regulation in Gut-Brain Axis Disorders. *Antioxidants*. 2024; 13(4):484. <https://doi.org/10.3390/antiox13040484>. CCBY 4.0

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Resilience in humans and xenohormesis in plants

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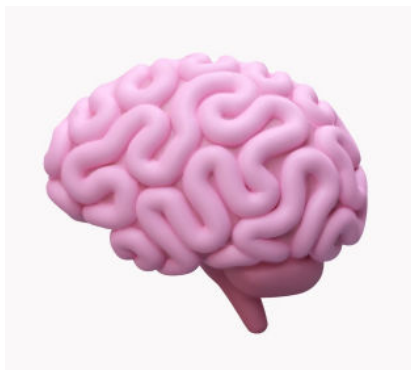
Mitochondrial Mantras

- “What does not kill you makes you stronger.”
- “If you do not use it, you lose it.”

Casanova A, Wevers A, Navarro-Ledesma S, Pruijboom L. Mitochondria: It is all about energy. *Front Physiol.* 2023;14:1114231. Published 2023 Apr 25. doi:10.3389/fphys.2023.1114231

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Resilience = The Ultimate Intelligence



- Resilience does not imply that there is no stress, but that there is an ability to respond in a way that results in adaptation.
- With resilience, there is an acceptance of stress in life as a way to become more neuronally flexible.
- We “bounce back” quicker from stressful events and integrate the learnings.

Bhatnagar S. Rethinking stress resilience. *Trends Neurosci.* 2021 Dec;44(12):936-945. doi: 10.1016/j.tins.2021.09.005. Epub 2021 Oct 25. PMID: 34711401; PMCID: PMC8616827.

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Mitoresilience

Cavezzi A, Colucci R, d'Errico G. Mitoresilience: Hormesis, Psycho-physical Resilience, Mitochondria and Heart Rate Variability as Relevant Interplaying Elements in Longevity Medicine. *Curr Aging Sci.* 2023;16(1):25-32. doi:10.2174/1874609815666220606140754



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Hormesis may extend human lifespan

“...if the normal bounds of human longevity are seen to be approximately as about 100 years, the hormesis concept predicts that it may be possible to extend the human lifespan by 30–60 years at most.”

Cornelius, C., Perrotta, R., Graziano, A. *et al.* Stress responses, vitagenes and hormesis as critical determinants in aging and longevity: Mitochondria as a “chi”. *Immun Ageing* **10**, 15 (2013). <https://doi.org/10.1186/1742-4933-10-15>

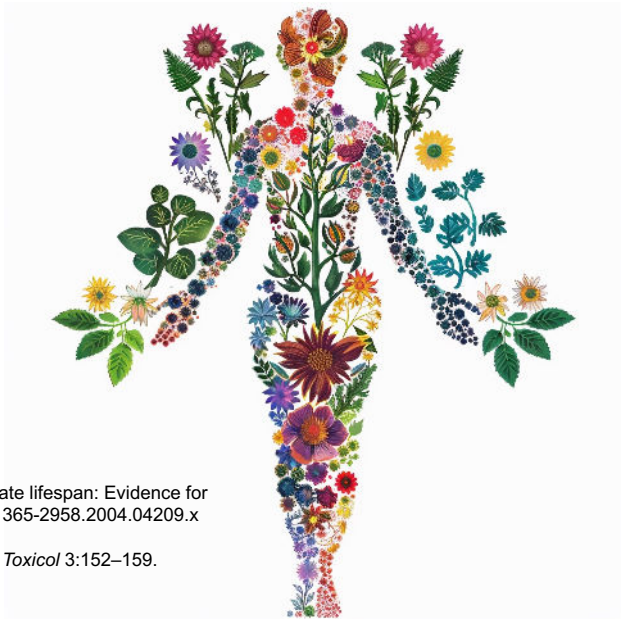
30

Plants keep us in communication with our surroundings to help us adapt

“Xenohormesis”

Lamming DW, Wood JG, Sinclair D (2004) Small molecules that regulate lifespan: Evidence for xenohormesis. *Mol Microbiol* 53:1003–1009. <https://doi.org/10.1111/j.1365-2958.2004.04209.x>

Baur JA, Sinclair DA (2008) What is Xenohormesis? *Am J Pharmacol Toxicol* 3:152–159. <https://doi.org/10.3844/ajptsp.2008.152.159>

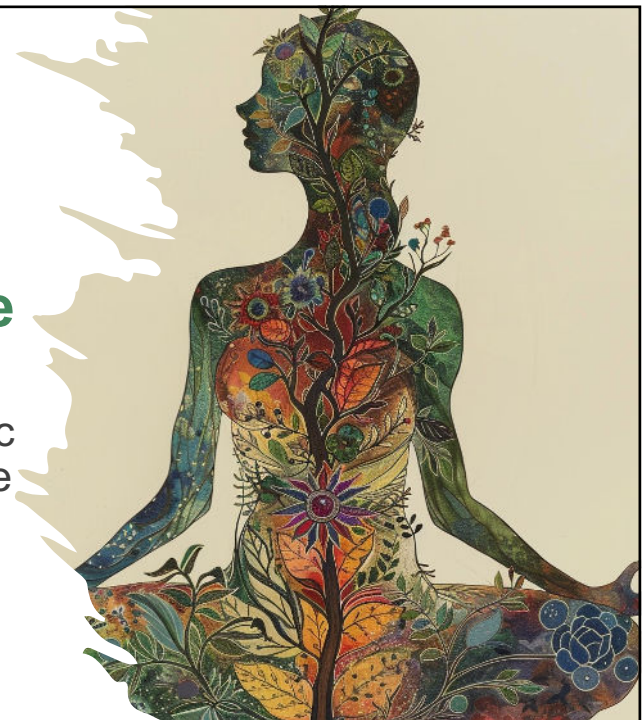


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The Phytoneuroendocrine System:

Aligning plants with the dynamic orchestra of the neuroendocrine system

Minich DM. The Phytoneuroendocrine System: Connecting Plants to Human Systems Biology. *Integr Med* (Encinitas). 2024;23(1):28-31. PMID: 38618161



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Some ways that adaptogenic plants may help with mitochondrial support

- Heat-shock proteins, which help in stress-induced cytoprotection and adaptation
- Glutathione status
- Antioxidant activity
- HPA-axis
- Beta-endorphin
- Nitric oxide
- ATP generation

Panossian A, Wikman G. Effects of Adaptogens on the Central Nervous System and the Molecular Mechanisms Associated with Their Stress-Protective Activity. *Pharmaceuticals (Basel)*. 2010;3(1):188-224. Published 2010 Jan 19. doi:10.3390/ph3010188

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Metabolic flexibility

The mitochondria play an essential role in metabolic flexibility. Metabolic inflexibility is a marker of several metabolic and immune diseases.

Smith RL, Soeters MR, Wüst RCI, Houtkooper RH. Metabolic Flexibility as an Adaptation to Energy Resources and Requirements in Health and Disease. *Endocr Rev*. 2018;39(4):489-517. doi:10.1210/er.2017-00211 PMID: 29697773

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Metabolic inflexibility is a common feature of impaired mitochondrial function

- Metabolic flexibility = ability for a cell (typically muscle) to switch between lipid and carbohydrate oxidation when stimulated by insulin during calorie excess or restriction and with energy demands from exercise.
- Metabolic inflexibility = insulin resistance, metabolic syndrome, type 2 diabetes, cancer
- The state of metabolic inflexibility may precede the development of overt insulin resistance.

Shoemaker ME, Gillen ZM, Fukuda DH, Cramer JT. Metabolic Flexibility and Inflexibility: Pathology Underlying Metabolism Dysfunction. *J Clin Med.* 2023;12(13):4453. Published 2023 Jul 3. doi:10.3390/jcm12134453; PMID: 29697773

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Mitochondria and Metabolic Flexibility

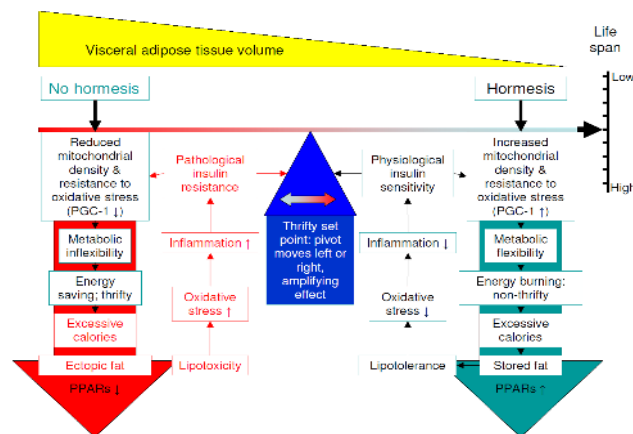



Figure 2
The tipping point and the metabolic syndrome. Without hormesis, and in the presence of excess calories, VAT can build up, which is associated with excessive ectopic fat due to metabolic inflexibility. This is associated with rising oxidative stress and a shift from thrifty to inflammatory insulin resistance; this results in the metabolic syndrome and an accelerated ageing phenotype.

Nunn AV, Bell JD, Guy GW. Lifestyle-induced metabolic inflexibility and accelerated ageing syndrome: insulin resistance, friend or foe? *Nutr Metab (Lond).* 2009 Apr 16;6:16. doi: 10.1186/1743-7075-6-16. CCBY 2.0

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Causes of Metabolic Dysfunction

Beta-cell:

- Glucotoxicity
- Lipotoxicity
- Gluco-lipotoxicity

Oberhauser L, Maechler P. Lipid-Induced Adaptations of the Pancreatic Beta-Cell to Glucotoxic Conditions Sustain Insulin Secretion. *Int J Mol Sci.* 2021;23(1):324. Published 2021 Dec 28. doi:10.3390/ijms23010324

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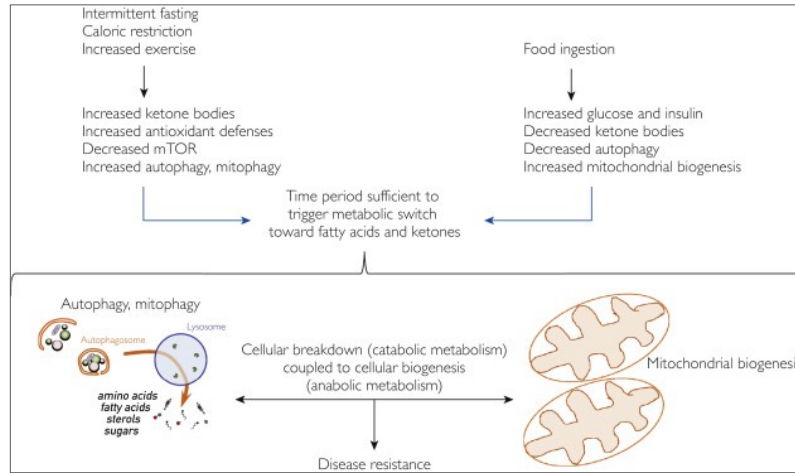
Modalities to enhance metabolic flexibility

- Temperature changes (cold, hot)
- Hibernation in animals
- Increase fat browning and brown-like adipocytes within WAT (“beige” adipocytes) through temperature and phytochemicals
- Circadian alignment
- Maintain health over disease

Smith RL, Soeters MR, Wüst RCI, Houtkooper RH. Metabolic Flexibility as an Adaptation to Energy Resources and Requirements in Health and Disease. *Endocr Rev.* 2018;39(4):489-517. doi:10.1210/er.2017-00211 PMID: 29697773

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Cellular mechanisms leading to increased metabolic flexibility



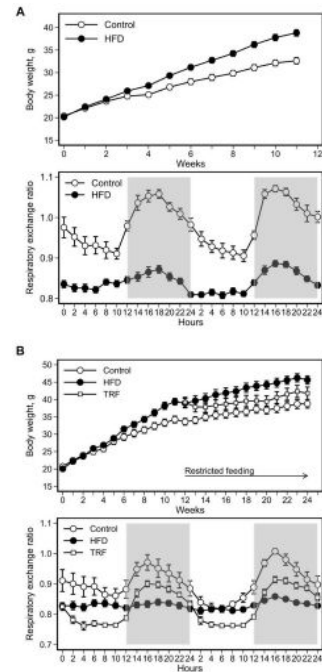
Palmer BF, Clegg DJ. Metabolic Flexibility and Its Impact on Health Outcomes. *Mayo Clin Proc.* 2022 Apr;97(4):761-776. doi: 10.1016/j.mayocp.2022.01.012. Epub 2022 Mar 11. CCBY

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Time-restricted feeding restores metabolic flexibility in adult mice with excess adiposity

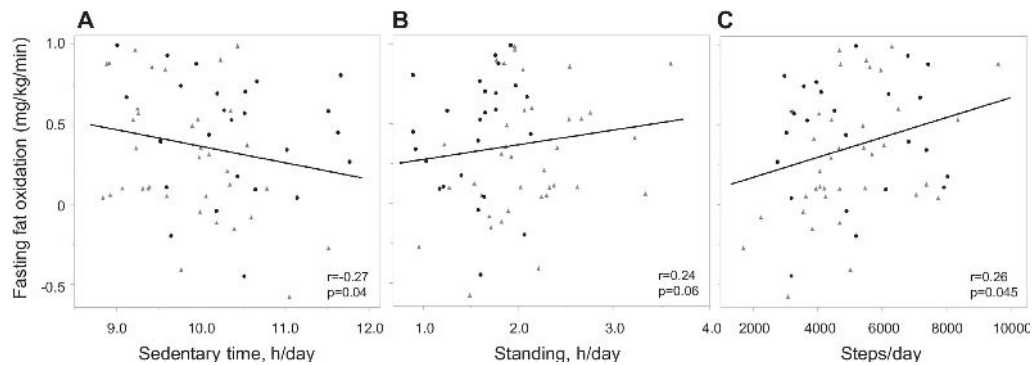
- Mice fed a high-fat diet (HFD), assigned to *ad libitum* HFD or time-restricted feeding (TRF) for 12 weeks
- TRF restored respiratory exchange ratio, insulin sensitivity, lipid metabolism, circadian rhythm

Yan L, Rust BM and Palmer DG (2024) Time-restricted feeding restores metabolic flexibility in adult mice with excess adiposity. *Front. Nutr.* 11:1340735. doi: 10.3389/fnut.2024.1340735. CCBY



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Metabolic flexibility changes with physical activity



Garthwaite T, Sjöros T, Laine S, et al. Sedentary time associates detrimentally and physical activity beneficially with metabolic flexibility in adults with metabolic syndrome. *Am J Physiol Endocrinol Metab.* 2024;326(4):E503-E514. doi:10.1152/ajpendo.00338.2023. CCBY 4.0

41

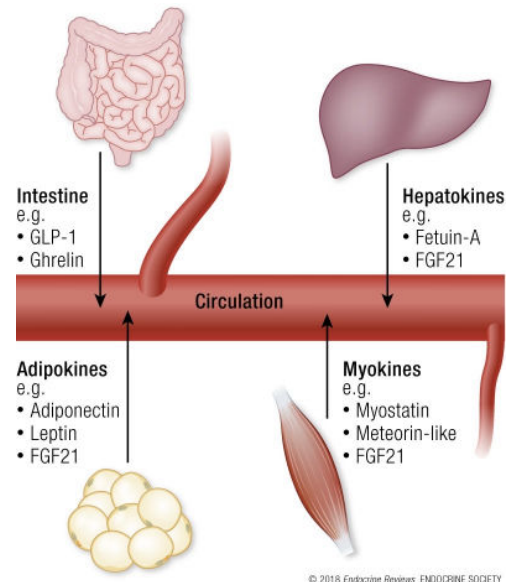
The role of muscle and adipose tissue in the mitochondria

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The evolution and expansion of the endocrine system

- Adipose tissue: Adipokines
- Muscle: Myokines
- Liver: Hepatokines

Smith RL, Soeters MR, Wüst RCI, Houtkooper RH. Metabolic Flexibility as an Adaptation to Energy Resources and Requirements in Health and Disease. *Endocr Rev.* 2018;39(4):489-517. doi:10.1210/er.2017-00211. CCBY



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“Muscle plasticity”

- Metabolically-active, endocrine tissue made of more than 500 skeletal muscles making up 40-50% of body weight.
- They secrete myokines.
- “Muscle plasticity”: ability of the muscle to switch to different muscle fibers

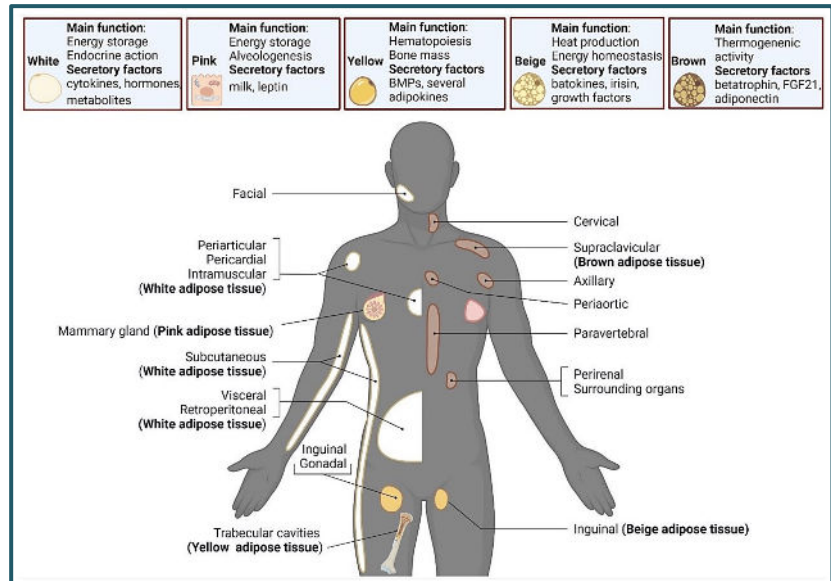
Hoppeler H, Baum O, Lurman G, Mueller M. Molecular mechanisms of muscle plasticity with exercise. *Compr Physiol.* 2011;1(3):1383-1412. doi:10.1002/cphy.c100042

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Colors of adipose tissue

de Sousa Neto IV, Durigan JLO, da Silva ASR, de Cássia Marqueti R. Adipose Tissue Extracellular Matrix Remodeling in Response to Dietary Patterns and Exercise: Molecular Landscape, Mechanistic Insights, and Therapeutic Approaches. *Biology* (Basel). 2022 May 17;11(5):765. doi: 10.3390/biology11050765. PMID: 35625493; PMCID: PMC9138682.

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Lifestyle therapies for mitochondria – muscle – metabolic fitness

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Lifestyle therapies for mitochondria – muscle – metabolic fitness

Mitochondrial “poisons”

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Artificial light at night (ALAN): An overlooked endocrine and mitochondrial disruptor

PMID: 29545373; doi:10.1080/07420528.2023.2236708

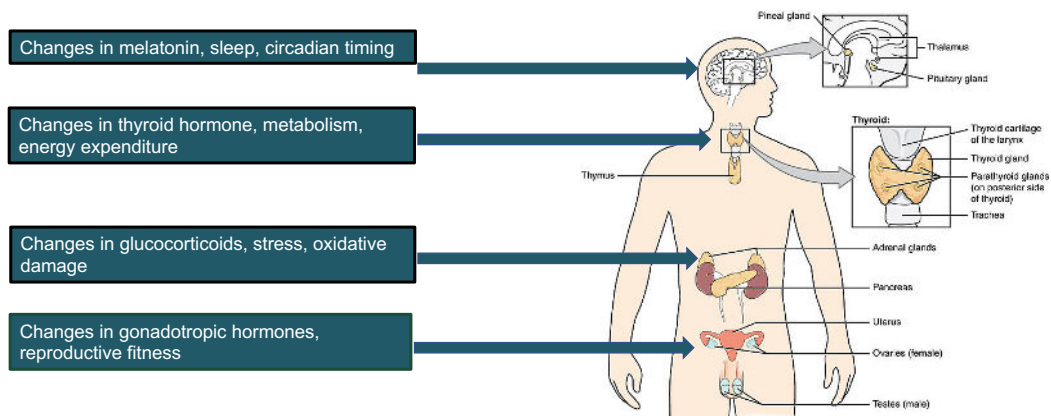


Image Credit: Illustration from Anatomy & Physiology, OpenStax College, Connexions Web site. <http://cnx.org/content/col11496/1.6/>, Jun 19, 2013. CC BY 3.0. <https://creativecommons.org/licenses/by/3.0/> https://commons.wikimedia.org/wiki/File:1801_The_Endocrine_System.jpg#/media/File:1801_The_Endocrine_System.jpg

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Lifestyle therapies for mitochondria – muscle – metabolic fitness

Role of gut microbiome, phytochemicals, mitophagy

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Gut-muscle axis: The microbiome

- Associations have been observed between those with low muscle mass or sarcopenia and changes in their gut microbiome.
- Those with chronic liver disease who had lower muscle mass possessed a lower *Firmicutes/ Bacteroidetes* ratio and a higher abundance of gram-negative bacteria (corresponding to higher LPS) than those with normal muscle mass (**PMID:** 35256716).
- In frail older people, *Lactobacilli*, *F. prausnitzii*, and *Bacteroides / Prevotella* ratio declined sharply and *Enterobacteriaceae* increased (**PMID:** 16204576)
- Consider the Functional Medicine 5R program

Chew W, Lim YP, Lim WS, et al. Gut-muscle crosstalk. A perspective on influence of microbes on muscle function. *Front Med (Lausanne)*. 2023;9:1065365. Published 2023 Jan 9. doi:10.3389/fmed.2022.1065365

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Gut-muscle axis: SCFAs

- The microbiome can impact muscle through microorganisms that produce SCFAs.
- SCFAs not metabolized by colon or liver could be used by myocytes as part of macronutrient metabolism.
- Glucose uptake by myotubes can be increased by a certain ratio of SCFAs.
- Butyrate can promote mitochondrial biogenesis.
- Higher SCFAs in older age correlated with greater muscle strength.

Chew W, Lim YP, Lim WS, et al. Gut-muscle crosstalk. A perspective on influence of microbes on muscle function. *Front Med (Lausanne)*. 2023;9:1065365. Published 2023 Jan 9. doi:10.3389/fmed.2022.1065365

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An animal study showed that the gut microbiome may play a role in motivation to exercise.

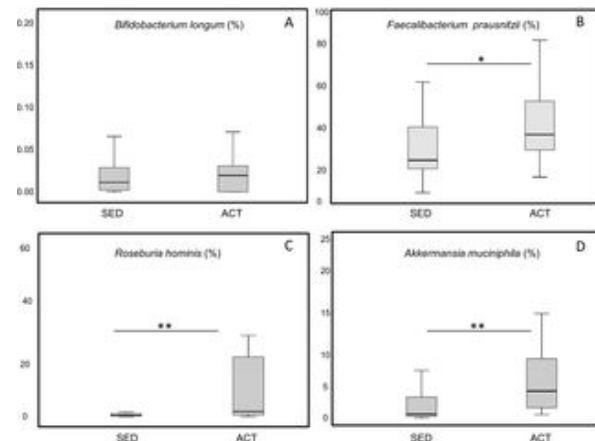
Dohnalová L, Lundgren P, Carty JRE, et al. A microbiome-dependent gut-brain pathway regulates motivation for exercise. *Nature*. 2022;612(7941):739-747. doi:10.1038/s41586-022-05525-z

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Exercise can modulate intestinal microbiome composition

As shown in active and sedentary women, healthy bacteria, including *Faecalibacterium prausnitzii*, *Roseburia hominis*, and *Akkermansia muciniphila*, were increased with low-dose, continuous physical activity.

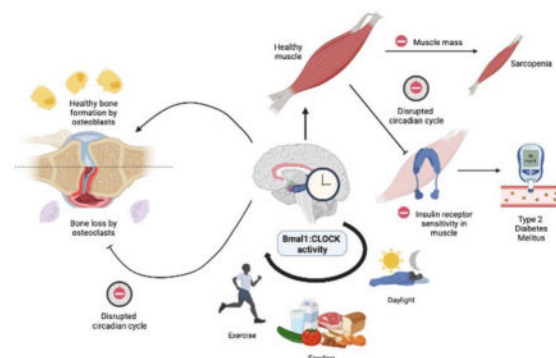


Bressa C, Bailén-Andrino M, Pérez-Santiago J, et al. Differences in gut microbiota profile between women with active lifestyle and sedentary women. *PLoS One*. 2017;12(2):e0171352. Published 2017 Feb 10. doi:10.1371/journal.pone.0171352. CCBY 4.0.

53

The circadian rhythm & muscle

- The “master clock” influences peripheral clocks such as the musculoskeletal system (approx. 1600 circadian genes).
- *Bmal1* is a clock protein impacted by sleep quality, exercise, and diet. If disrupted or changed in expression, it can have direct effects on muscle atrophy or loss.
- Muscle strength is reduced by constant and long-term light exposure in mice. PMID: 27426518



Juliana N, Azmi L, Effendy NM, et al. Effect of Circadian Rhythm Disturbance on the Human Musculoskeletal System and the Importance of Nutritional Strategies. *Nutrients*. 2023;15(3):734. Published 2023 Feb 1. doi:10.3390/nu15030734. CCBY 4.0.

54

Does the muscle “taste”?

- TAS1R2 is a gene that contributes to the activity of sweet taste receptors on the tongue and in muscles.
- In a study with mice, muscle-specific deletion of this gene resulted in:
 - An increase in lean mass independent of total body mass
 - An association with an increase in muscle strength and running endurance compared to controls
 - Lower oxygen consumption during moderate-intensity exercise and improved mitochondrial function.
- In older obese humans, those with reduced function of the TAS1R2 gene had improved responses to exercise training, increased skeletal mass, improved mitochondrial capacity, and improved aerobic performance after a 6-month trial of weight loss through diet and exercise.
- TAS1R2 as a future target for muscle fitness.

Serrano J, Boyd J, Mason C, et al. The TAS1R2 sweet taste receptor regulates skeletal muscle mass and fitness. Preprint. *Res Sq.* 2023;rs.3.rs-2475555. Published 2023 Feb 9. doi:10.21203/rs.3.rs-2475555/v1

55

Whole grain phytoactives and anti-fatigue effects

Enhancing muscle tissue formation and metabolic function by improving mitochondrial function and altering muscle enzymes to change fatigue effects.

- Anti-inflammatory potential
- Promote mitochondrial biogenesis
- Help with insulin signaling
- Increase cellular resilience

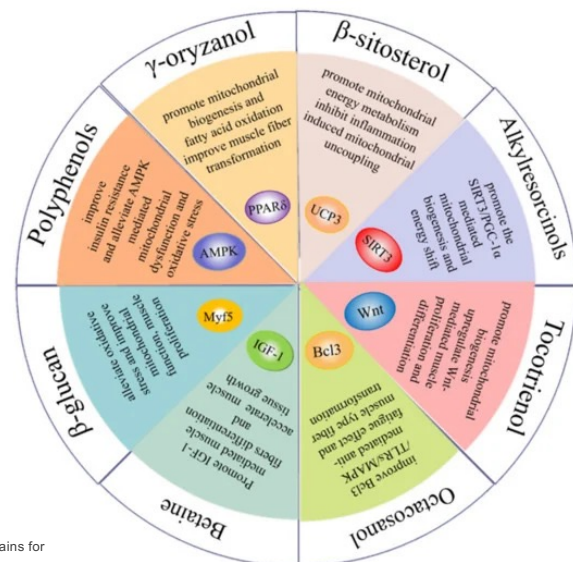


Image Credit: Li Q, Yang H, Song S, Liu J, Wang Z, Wang J. Bioactive Components in Whole Grains for the Regulation of Skeletal Muscle Function. *Foods.* 2022 Sep 7;11(18):2752. doi: 10.3390/foods11182752. PMID: 36140879; PMCID: PMC9498156. <https://creativecommons.org/licenses/by/4.0/>

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Functional phytonutrients for muscle

- **Carotenoids** (lutein, beta-carotene)
 - Antioxidant, anti-inflammatory effects
- **Phenolic acids** (oats, quinoa)
 - Ferulic acid to reduce insulin resistance and enhance glucose uptake
 - *p*-coumaric acid to help with lipid regulation in muscle
- **Resveratrol**
 - Supports redox/mitochondrial health
- **Flavonoids**
 - Quercetin to support antioxidant, anti-inflammatory activity and to help with myofiber function, anti-fatigue effects
 - Catechins to increase muscle mass and strength

Li Q, Yang H, Song S, Liu J, Wang Z, Wang J. Bioactive Components in Whole Grains for the Regulation of Skeletal Muscle Function. *Foods*. 2022 Sep 7;11(18):2752. doi: 10.3390/foods11182752. PMID: 36140879; PMCID: PMC9498156.

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Resveratrol combined with exercise to improve mitochondrial density and muscle fatigue

- Older men (n=12) and women (n=18) 65-80 years old on an exercise protocol for 12 weeks.
- They took either placebo or 500 mg resveratrol per day.

Alway SE, McCrory JL, Kearcher K, et al. Resveratrol Enhances Exercise-Induced Cellular and Functional Adaptations of Skeletal Muscle in Older Men and Women. *J Gerontol A Biol Sci Med Sci*. 2017;72(12):1595-1606. doi:10.1093/gerona/glx089

58

Stimulating mitophagy through the gut

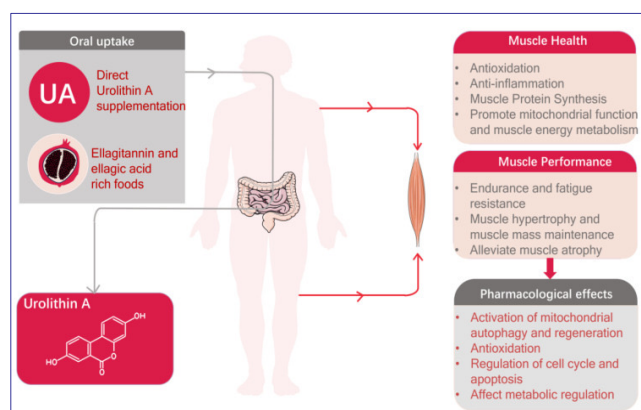
- **Nicotinamide** is a metabolite of commensal bacteria.
- It can convert to NAD⁺ inside the cell and positively affect mitochondrial quality by inducing fission and mitophagy.
 - Nicotinamide riboside and nicotinamide mononucleotide have had similar results.
- **Urolithin A** is derived from gut microbiota metabolizing ellagic acid (walnuts, pomegranate) that can also induce mitophagy and improve muscle and nerve function.

Borbolis F, Mytilinaiou E, Palikaras K. The Crosstalk between Microbiome and Mitochondrial Homeostasis in Neurodegeneration. *Cells*. 2023;12(3):429. Published 2023 Jan 28. doi:10.3390/cells12030429

59

Mitophagy and muscle health through urolithin A

- Urolithin A is a natural metabolite derived from dietary ellagitannins present pomegranates (especially peel and seeds) and certain other fruits and nuts such as strawberries, walnut kernels, and peanuts.
- These ellagitannins must be metabolized by *Proteobacteria*, *Clostridium*, *Bifidobacterium*, *Eubacterium*, and *Enterococcus faecium* to get urolithin A.



Zhao H, Song G, Zhu H, et al. Pharmacological Effects of Urolithin A and Its Role in Muscle Health and Performance: Current Knowledge and Prospects. *Nutrients*. 2023;15(20):4441. Published 2023 Oct 19. doi:10.3390/nu15204441. CCBY 4.0

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Tips to improve the muscle-mitochondria axis:

- Add whole grains such as oats, quinoa, and buckwheat in the diet (or other polyphenol-rich plant foods if whole grains are not able to be eaten);
- Support the gut microbiome with a variety of plant foods, especially those rich in prebiotic fibers, and fermented products;
- Eat colorful fruits and vegetables to reduce inflammation; and
- Align with your circadian rhythm with regular sleeping routines.

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Lifestyle therapies for mitochondria – muscle – metabolic fitness

Biophotons: food, assessment, and therapies

62

“Cells can influence each other without using a molecular signal for the purpose: this means that not all cellular processes are necessarily based on a molecule-receptor recognition. The non-molecular signals are most probably **photons.**”

Fels D. Cellular communication through light [published correction appears in PLoS One. 2009;4(7). doi:10.1371/annotation/8d99ccc5-cc76-44f4-b468-d63e42e0b9e1]. *PLoS One.* ;4(4):e5086. doi:10.1371/journal.pone.0005086



63

“Moreover, the changes in O₂-consumption were dependent on the origin of mitochondria (cancer vs. non-cancer) as well as the presence of "ambient" light.”

Mould RR, Kalampouka I, Thomas EL, Guy GW, Nunn AVW, Bell JD. Non-chemical signalling between mitochondria. *Front Physiol.* 2023;14:1268075. Published 2023 Sep 22. doi:10.3389/fphys.2023.1268075

frontiers | Frontiers in Physiology

TYPE Original Research
PUBLISHED 22 September 2023
DOI 10.3389/fphys.2023.1268075

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Non-chemical signalling between mitochondria

Rhys R. Mould^{1*}, Ifigeneia Kalampouka¹, E. Louise Thomas¹,
Geoffrey W. Guy², Alistair V. W. Nunn^{1,2} and Jimmy D. Bell¹

¹Research Centre for Optimal Health, School of Life Sciences, University of Westminster, London, United Kingdom, ²The Guy Foundation, Dorset, United Kingdom

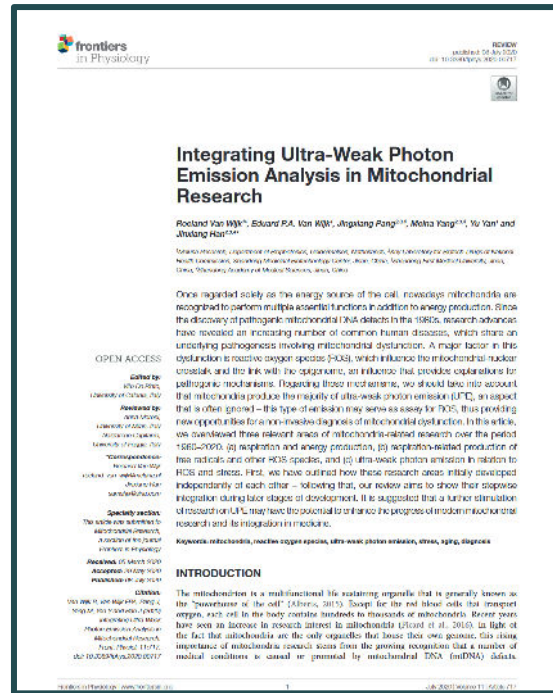
A wide variety of studies have reported some form of non-chemical or non-
aqueous communication between physically isolated organisms, eliciting changes
in cellular proliferation, morphology, and/or metabolism. The sources and
mechanisms of such signalling pathways are still unknown, but have been
postulated to involve vibration, volatile transmission, or light through the
phenomenon of ultraweak photon emission. Here, we report non-chemical
communication between isolated mitochondria from MCF7 (cancer) and
MCF10A (non-cancer) cell lines. We found that mitochondria in one cuvette,
stressed by an electron transport chain inhibitor, antimycin, alters the
respiration of mitochondria in an adjacent, but chemically and physically
separate cuvette, significantly decreasing the rate of oxygen consumption
compared to a control ($p = <0.0001$ in MCF7 and MCF10A mitochondria).
Moreover, the changes in O₂-consumption were dependent on the origin of
mitochondria (cancer vs. non-cancer) as well as the presence of "ambient" light.
Our results support the existence of non-chemical signalling between isolated
mitochondria. The experimental design suggests that the non-chemical
communication is light-based, although further work is needed to fully
elucidate its nature.

KEYWORDS
biophoton, ultraweak luminescence, bystander effect, non-chemical signalling, radicals,
metabolic alteration, emission, ultraweak photon emission

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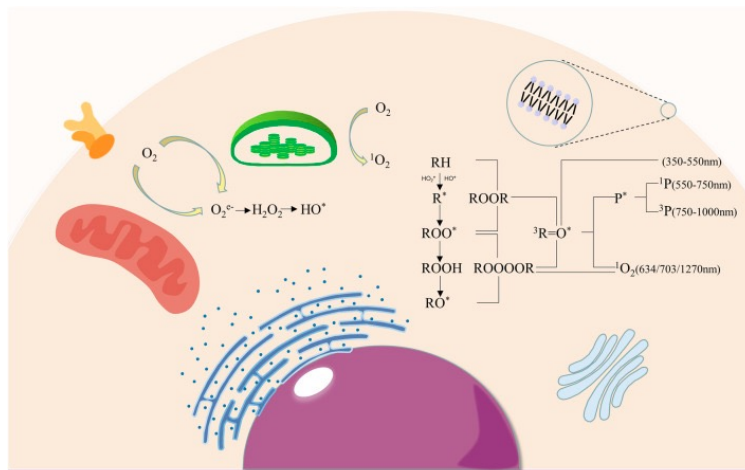
Light as diagnostic, light as therapeutic

Van Wijk R, Van Wijk EPA, Pang J, Yang M, Yan Y, Han J. Integrating Ultra-Weak Photon Emission Analysis in Mitochondrial Research. *Front Physiol.* 2020;11:717. Published 2020 Jul 8. doi:10.3389/fphys.2020.00717



65

Intracellular ROS translating into photon emission at different spectral wavelengths



Du J, Deng T, Cao B, Wang Z, Yang M, Han J. The application and trend of ultra-weak photon emission in biology and medicine. *Front Chem.* 2023;11:1140128. Published 2023 Feb 17. doi:10.3389/fchem.2023.1140128. CCBY

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Ultra-weak biophotons can be emitted by living organisms (“bioluminescence”)

- Ultra-weak biophoton emission (UWBE) is the energy released as light through the changes in metabolism related to free radicals.
- Dr. Fritz Popp’s early work demonstrated body light emission according to the following:
 - Biological rhythms (14 days, 1 month, 3 months, 9 months)
 - Physiological functions
 - Disease and broken symmetry between R and L sides
 - Left-right symmetry

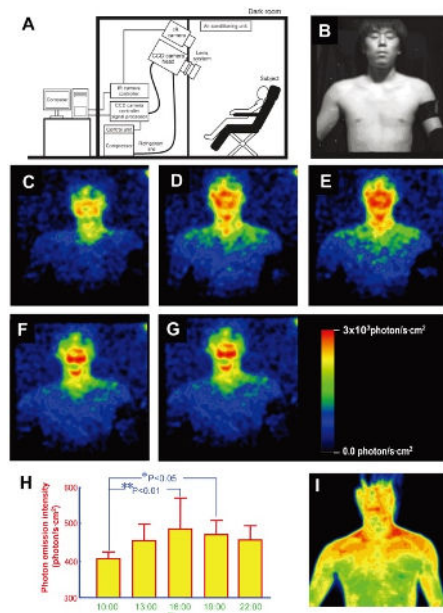
Cohen S, Popp FA. Low-level luminescence of the human skin. *Skin Res Technol.* 1997;3(3):177-180. doi:10.1111/j.1600-0846.1997.tb00184.x PMID: 27333495; Cohen S, Popp FA. Biophoton emission of human body. *Indian J Exp Biol.* 2003;41(5):440-445. PMID: 15244265

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Biophoton emissions

- Photon emission higher from the face than from the body
- Area around the mouth and cheeks higher than the lateral area and orbits
- Time-dependent changes on face and upper body suggesting a diurnal rhythm of photon emission:
 - Weak in the AM
 - Increased in PM
 - Peak in late PM

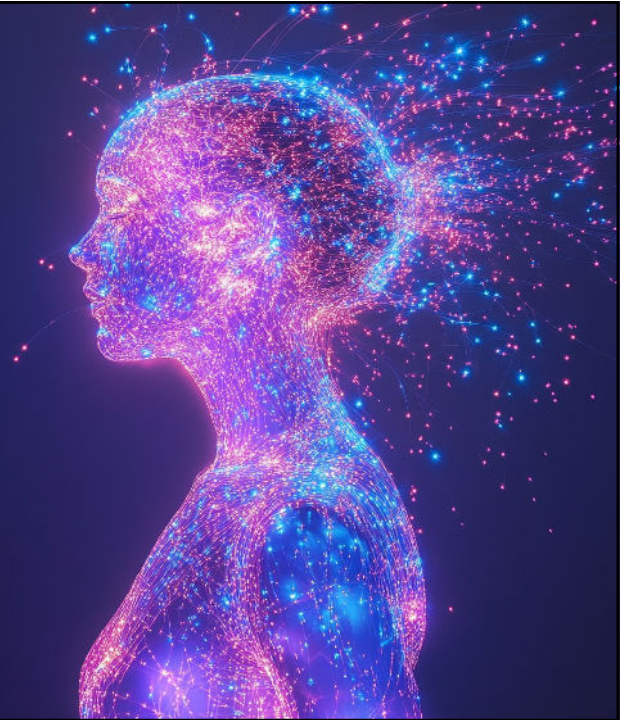
Kobayashi M, Kikuchi D, Okamura H. Imaging of ultraweak spontaneous photon emission from human body displaying diurnal rhythm. *PLoS One.* 2009;4(7):e6256. Published 2009 Jul 16. doi:10.1371/journal.pone.0006256. CCBY



68

“By the regulation of cellular respiratory chain producing reactive oxygen species, which in turns react with molecules including proteins, lipids and fluorophores, whose excited states emit biophotons, the human body glitters to the rhythm of the circadian clock.”

Kobayashi M, Kikuchi D, Okamura H. Imaging of ultraweak spontaneous photon emission from human body displaying diurnal rhythm. *PLoS One*. 2009;4(7):e6256. Published 2009 Jul 16. doi:10.1371/journal.pone.0006256



69

More on light emission (UPE)

- Summer leads to greater UPE than in winter
- Emission is less during light hours of day
- Greater UPE with greater number of tumor cells
- Meditation (transcendental and OM) tends to lower UPE
- A diet rich in antioxidants lowers UPE

Ultra-weak photon emission from biological samples: definition, mechanisms, properties, detection and applications. *Cifra M, Pospíšil P. J Photochem Photobiol B*. 2014 Oct 5; 139():2-10.

70

Clinical application of biophotonic emission to track disease states

Redox Biology
Journal homepage: www.elsevier.com/locate/redox

Research paper
Detecting presence of cardiovascular disease through mitochondria respiration as depicted through biophotonic emission
Nancy R. Rizzo^a, Nicole C. Hank^{a,*}, Jian Zhang^a

ARTICLE INFO
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ABSTRACT
Anoxic, increased production of reactive oxygen species (ROS), in mitochondria, play an important role in the cardiovascular system. Furthermore, oxidative metabolism of mitochondria comprised of biophotonic emission, are linked to ROS and oxidative stress. In this review we investigated the association between the ability of ClearView™ human infrared diagnosis to detect through the absence of cardiovascular disease of cardiovascular disease (CVD) with the former was 85.32%. The OR is 0.0001 corresponding to the 95% CI: 0.0000-0.0001. While biologic were dependent of other in the CVD by using the ClearView™.

Cardiovascular diseases (CVD), including hypertension, coronary artery disease (CAD), cardiomyopathy, heart failure, and stroke are the greatest cause of mortality with over 17.5 million people dying annually [1] costing \$803 billion in direct and indirect economic expenditures each year [2]. Cardiovascular disease is a common complex disorder, which can be caused by a single gene or multifactorial conditions resulting from interactions between environmental (modifiable) and inherited (non-modifiable) risk factors [3]. While significant progress in understanding the development of CVD has been discovered, the mechanisms of individual CVD susceptibility are still not clearly understood. A considerable number of studies suggest that altered levels of oxidative stress within the cardiovascular environment are critical while others suggest CVD is a multifactorial disorder that involves several genetic determinants, including mitochondrial dysfunction [5]. Mitochondrial dysfunction has been associated with a wide range of cardiovascular disorders such as cardiomyopathy and hypertension [6]. In this regard, studies are beginning to illustrate that mitochondria not only appear susceptible to damage mediated by increased oxidative stress but also play a significant role in the regulation of cardiovascular cell function [4]. Furthermore, oxidative metabolism of the mitochondria via biophotonic emission, is linked to increased production of reactive oxygen species (ROS) and overall oxidative stress. This has led to accumulating evidence that a connection among cardiovascular disease development and cardiovascular disease risk factors is due to increased mitochondrial damage and dysfunction [4] which can be measured through biophotonic emission. In this manuscript, we will in-

“In this review we investigated the association between the ability of ClearView™ system (ClearView) to indicate the presence or absence of cardiovascular disease through mitochondria respiration as depicted through biophotonic emission.”

Rizzo NR, Hank NC, Zhang J. Detecting presence of cardiovascular disease through mitochondria respiration as depicted through biophotonic emission. *Redox Biol.* 2016;8:11-17. doi:10.1016/j.redox.2015.11.014

Meditation reduces UPE

Van Wijk EP, Ackerman J, Van Wijk R. Effect of meditation on ultraweak photon emission from hands and forehead. *Forsch Komplementarmed Klass Naturheilkd.* 2005;12(2):107-112. doi:10.1159/000084028

Van Wijk EP, Koch H, Bosman S, Van Wijk R. Anatomic characterization of human ultra-weak photon emission in practitioners of transcendental meditation(TM) and control subjects. *J Altern Complement Med.* 2006;12(1):31-38. doi:10.1089/acm.2006.12.31

Van Wijk EP, Lüdtkke R, Van Wijk R. Differential effects of relaxation techniques on ultraweak photon emission. *J Altern Complement Med.* 2008;14(3):241-250. doi:10.1089/acm.2007.7185



Biophotons in relationship to food

- Affected by:
 - Polyphenol content
 - Ripeness of produce
 - Processing and heating
 - Duration of cooking
 - Irradiation of non-ripe fruit
- Biophotons in food decline as it ages/matures/ripens; correlated with increased mitochondrial content and reactive oxygen species production

Karlo J, Prasad R, Singh SP. Biophotonics in food technology: Quo vadis? *J Agric Food Res.* 2023;11:100482. doi:10.1016/j.jafr.2022.100482

73

**Lifestyle therapies for
mitochondria – muscle – metabolic fitness**

**Adaptogenic plants for mitochondrial
resilience**

74

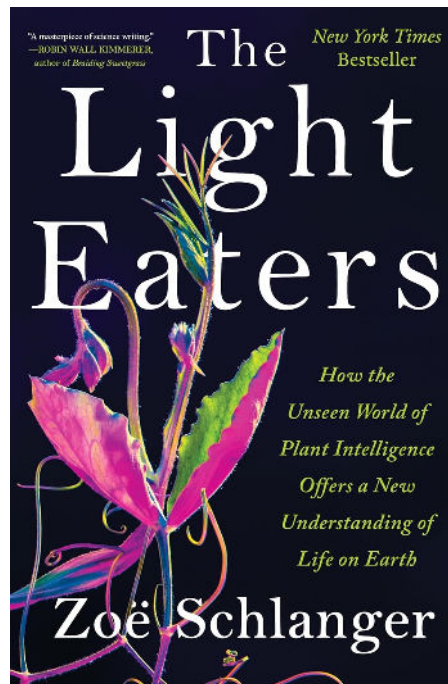


Eat stressed plants.

Howitz KT, Sinclair DA. Xenohormesis: sensing the chemical cues of other species. *Cell*. 2008 May 2;133(3):387-91.

75

“Smarty Plants”



76

Adaptogens & biophotonic emission

- Randomized, double-blind, placebo-controlled study with 30 subjects assigned to three groups:
 - Group 1 (n=10) = Placebo
 - Group 2 (n=10) = Rhodiola rosea
 - Group 3 (n=10) = Three adaptogens combined
- UPE measurements on hands before and after a week of taking the supplements
- Rhodiola group had a significant decrease in UPE compared with placebo group and decrease in fatigue.

Schutgens FW, Neogi P, van Wijk EP, van Wijk R, Wikman G, Wiegant FA. The influence of adaptogens on ultraweak biophoton emission: a pilot-experiment. *Phytother Res.* 2009;23(8):1103-1108. doi:10.1002/ptr.2753

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Maca for the mitochondria

nutrients

Not All Maca Is Created Equal: A Review of Colors, Nutrition, Phytochemicals, and Clinical Uses

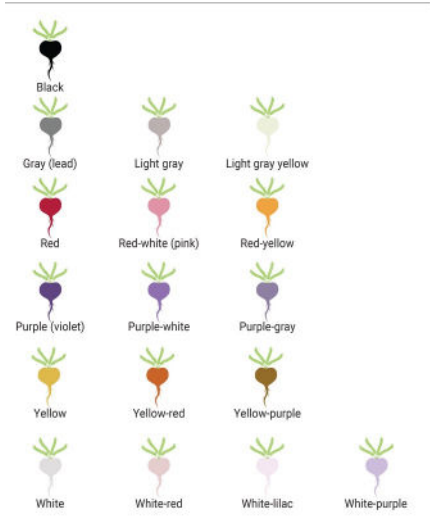
Thomas M. Mielicki ^{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100}, Xiao Bao ^{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100}, James Fraser ^{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100}, Wendy Warner ^{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100} and Henry O. McInnes ^{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100}

Abstract: Maca (*Lepidium meyenii*) is part of the Brassicaceae family and grows at high altitudes in the Peruvian Andes mountain range (3000–5000 m). Historically, it has been used as a natural energy tonic and for its medicinal properties, primarily in enhancing energy and vitality. Scientific research has validated these traditional uses and other clinical applications by elucidating maca's composition of alkaloids, saponins, and phytochemical content. However, research over the last twenty years has identified up to seventeen different colors (phenotypes) of maca. The color is dependent on growing location, cultivation, and post-harvest processing methods and has a significant effect on the nutrient content, phytochemical profile, and clinical application. Yet, research differentiating the colors of maca and clinical application remains limited. In this review, research on the nutrient, phytochemical, and various colors of maca, including black, red, purple, green, yellow, white, and pink, are discussed, along with their potential health benefits. The gaps, deficiencies, and conflicts in the studies will be detailed, along with quality, safety, and efficacy criteria, highlighting the need for future research to specify if these colors of the maca need to be distinguished.

Keywords: adaptogens; glucosinolates; hormones; *Lepidium meyenii*; *Lepidium peruvianum*; maca; saponins; phytochemicals; reproductive health

1. Introduction

Maca refers to two distinct species known as *Lepidium meyenii* and *Lepidium peruvianum* [1], which are classified as the wild and cultivated forms of the plant, respectively. Maca is an annual dicotyledonous root vegetable and one of 200 known *Lepidium* species of plants [2]. It belongs to the same botanical Brassicaceae family as the turnip, cabbage,



Orhan C, Gencoglu H, Tuzcu M, et al. Maca could improve endurance capacity possibly by increasing mitochondrial biogenesis pathways and antioxidant response in exercised rats. *J Food Biochem.* 2022;46(7):e14159. doi:10.1111/jfbc.14159

Zhu H, Xu W, Wang N, et al. Anti-fatigue effect of *Lepidium meyenii* Walp. (Maca) on preventing mitochondrial-mediated muscle damage and oxidative stress in vivo and vitro. *Food Funct.* 2021;12(7):3132-3141. doi:10.1039/d1fo00383f

Gugnani KS, Vu N, Rondón-Ortiz AN, Böhlke M, Maher TJ, Pino-Figueroa AJ. Neuroprotective activity of macamides on manganese-induced mitochondrial disruption in U-87 MG glioblastoma cells. *Toxicol Appl Pharmacol.* 2018;340:67-76. doi:10.1016/j.taap.2017.12.014

Lee E, Park M, Kim B, Kang S. Effect of Black Maca Supplementation on Inflammatory Markers and Physical Fitness in Male Elite Athletes. *Nutrients.* 2023;15(7):1618. Published 2023 Mar 27. doi:10.3390/nu15071618

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Ashwagandha

- Mice fed a high-fat diet containing 0.25% or 0.5% ashwagandha extract for 10 weeks
 - 0.5% supplementation suppressed body weight, serum lipids, lipid accumulation
 - Both increased oxygen consumption and browning of fat

Lee DH, Ahn J, Jang YJ, Seo HD, Ha TY, Kim MJ, Huh YH, Jung CH. *Withania somnifera* Extract Enhances Energy Expenditure via Improving Mitochondrial Function in Adipose Tissue and Skeletal Muscle. *Nutrients*. 2020 Feb 7;12(2):431. doi: 10.3390/nu12020431.

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Ginseng

- Mice fed 400 or 600 mg/kg red ginseng extracts per day for 28 days (PMID: **36618917**)
 - Improved skeletal muscle mitochondrial function via ATP level restoration, mitochondrial membrane potential, and mitochondrial biogenesis.
- Cell, fly, and mouse models treated with ginseng (PMID: **36312736**)
 - Enhanced mitochondrial respiration, ATP production, tricarboxylic acid metabolism, SIRT1 activation, energy metabolism

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Panax ginseng, TCM, and UPE

- Spleen-Qi deficiency assessed through urinary metabonomics biomarkers and UPE intensity.
- Panax ginseng is known to replenish Qi and tonify spleen in TCM.
- Urinary metabonomics was assessed before and after ginseng treatment in subjects with Spleen-Qi deficiency.
- Ultraweak photon emission (UPE) measured at the dazhui point.
- Panax ginseng treatment helped to reduce oxidative stress and UPE intensity.

Wang N, Huang X, Li T, et al. Application of RRLC-QTOF-MS-based metabonomics and UPE for investigating Spleen-Qi deficiency syndrome with Panax ginseng treatment. *J Ethnopharmacol.* 2020;256:112822. doi:10.1016/j.jep.2020.112822

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Astragalus

- Study on over-exercised mice exhibiting oxidative stress, imbalance between fusion-fission, activation of mitophagy, and reduced expression of PGC-1 α
 - Astragalus (100 mg/kg/day) given once per day for 28 days
 - Amelioration of mitochondrial dysfunction via the the Sirt1 pathway.

Huang YF, Lu L, Zhu DJ, Wang M, Yin Y, Chen DX, Wei LB. Effects of Astragalus Polysaccharides on Dysfunction of Mitochondrial Dynamics Induced by Oxidative Stress. *Oxid Med Cell Longev.* 2016;2016:9573291. doi: 10.1155/2016/9573291. Epub 2016 Jan 11. PMID: 26881048; PMCID: PMC4737051.

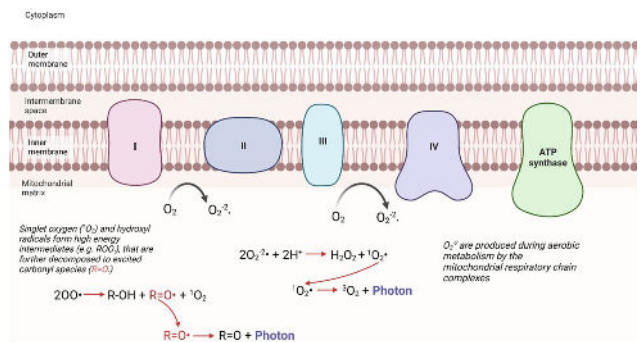
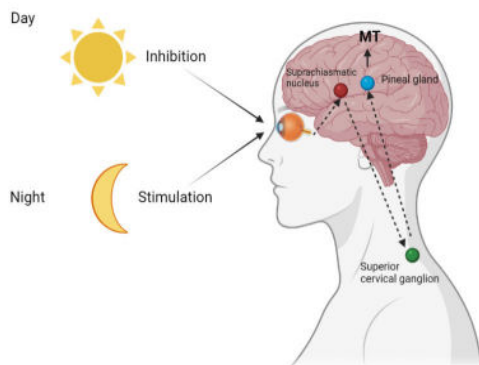
82

Lifestyle therapies for mitochondria – muscle – metabolic fitness

Leveraging rhythms of nature, especially circadian rhythm

83

We are photonic beings, sensing light externally and producing photons internally.



Kvetnoy I, Ivanov D, Mironova E, Evsyukova I, Nasyrov R, Kvetnaia T, Polyakova V. Melatonin as the Cornerstone of Neuroimmunoendocrinology. *Int J Mol Sci.* 2022 Feb 6;23(3):1835. doi: 10.3390/ijms23031835. PMID: 35163757; PMCID: PMC8836571. CC-BY 4.0

Mould RR, Mackenzie AM, Kalampouka I, Nunn AVW, Thomas EL, Bell JD, Botchway SW. Ultra weak photon emission: a brief review. *Front Physiol.* 2024 Feb 14;15:1348915. doi: 10.3389/fphys.2024.1348915. PMID: 38420619; PMCID: PMC10899412. CC-BY

84

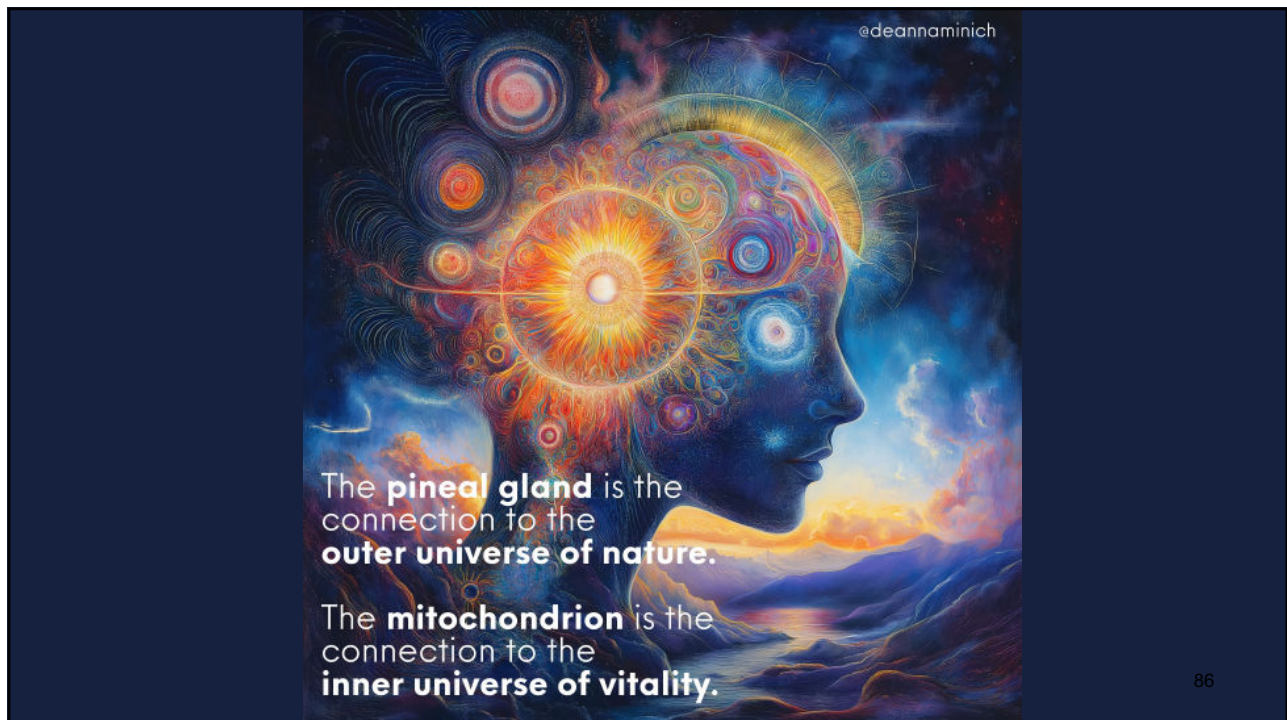
The pineal gland and the mitochondria work together

- Light, dark, colors, and the electromagnetic field are the universal connectors within human health.
- Through melatonin, these factors connect the endocrine orchestra through the eyes to the pineal gland to every cell of the body, allowing harmonization with the oneness of nature. This is our master microregulator of biochemical processes like metabolism.
- From this master signal, the mitochondria receives the message to maintain the balance of light, dark, color, and subtle vibrational fields within the cell through its redox balance, electrochemical gradient, and color-harnessing enzymes known as cytochromes.

Azeemi ST, Raza SM. A critical analysis of chromotherapy and its scientific evolution. *Evid Based Complement Alternat Med*. 2005;2(4):481-488. doi:10.1093/ecam/neh137

85

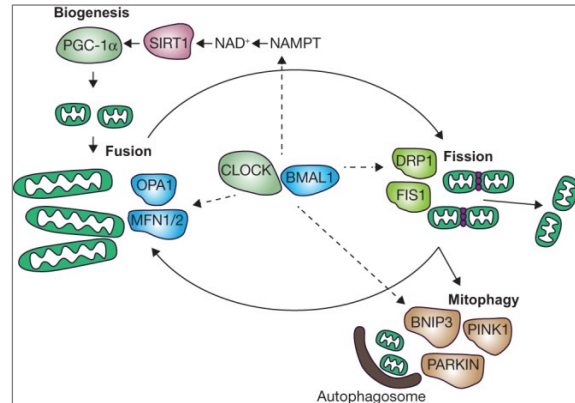
85



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Circadian rhythms in mitochondrial respiration

- Mitochondria processes are dependent on diurnal changes (PMID: 29378772)
 - Fission and fusion
 - Respiration
 - ROS production/cell signaling
 - Nutrient uptake in rate-limiting steps
- Altered clocks coupled with mitochondrial dysfunction can lead to altered ATP production and reduced mitochondrial biogenesis (PMID: 38721230)



de Goede P, Wefers J, Brombacher EC, Schrauwen P, Kalsbeek A. Circadian rhythms in mitochondrial respiration. *J Mol Endocrinol.* 2018;60(3):R115-R130. doi:10.1530/JME-17-0196. CCBY 4.0

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The circadian system and the mitochondria influence each other

“Key aspects such as oxidative phosphorylation, mitochondrial biogenesis, and mitochondrial morphology are regulated by the circadian clock. Functional changes in mitochondria can retrogradely affect the circadian rhythm. Furthermore, there are also transcriptional circadian clock-independent rhythms within mitochondria.”

Kim J, Sun W. Circadian coordination: understanding interplay between circadian clock and mitochondria. *Anim Cells Syst (Seoul).* 2024;28(1):228-236. Published 2024 May 7. doi:10.1080/19768354.2024.2347503

88

Sleep deprivation and oxidative damage as seen in animal models

- Exposure to constant light increased ROS production and altered mitochondrial capacity, decreasing respiration at OXPHOS and ETS (PMID: 25365455).
- Pterostilbene can reduce sleep restriction-induced exercise intolerance associated with circadian misalignment and mitochondrial dysfunction through AMPK/SIRT1/PGC-1 α pathway (PMID: 32277569).

89

Sleep quality and mitochondrial DNA copy number in 238 healthy middle-aged adults

- mtDNA copy number is an indicator of mitochondrial function.
- Poor sleep quality and reduced sleep latency are associated with lower mtDNA copy number.
- Poor sleep may impact aging processes through mitochondrial dysfunction.

Han S, Kim DK, Jun SE, Kim N. Association of sleep quality and mitochondrial DNA copy number in healthy middle-aged adults. *Sleep Med.* 2024;113:19-24. doi:10.1016/j.sleep.2023.11.011

90

Circadian disruption may alter sleep and glymphatic fluid flux

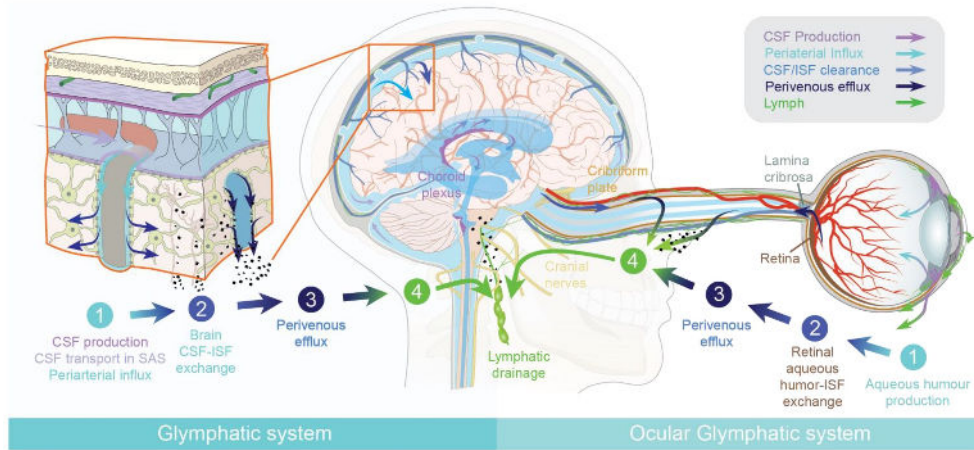
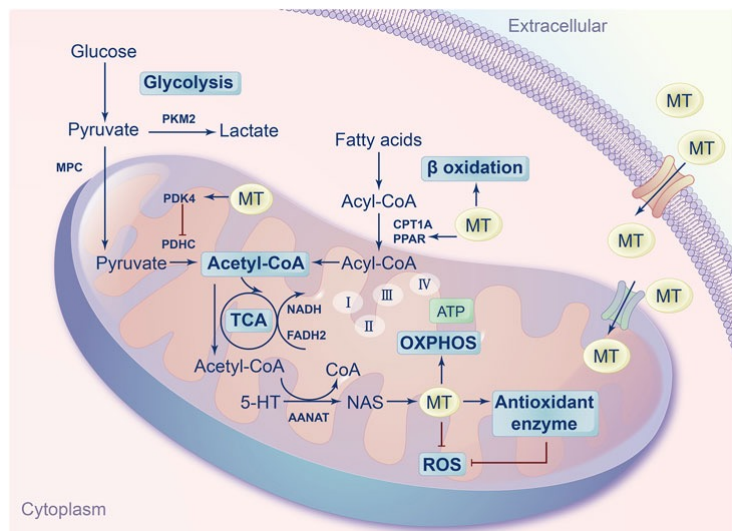


Image Credit: Mogensen, F.L.-H.; Delle, C.; Nedergaard, M. The Glymphatic System (En)during Inflammation. Int. J. Mol. Sci. 2021, 22, 7491. <https://doi.org/10.3390/ijms22147491>. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license. CC BY 4.0.

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Melatonin is a mitochondrial regulator

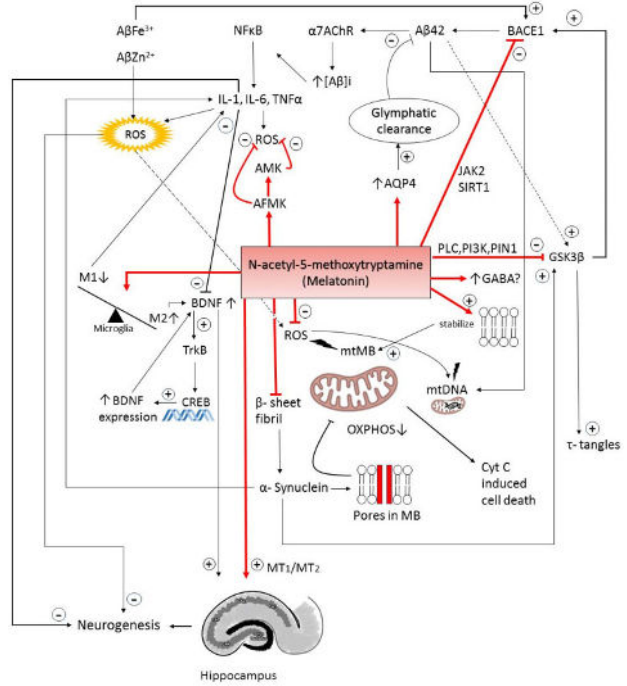
Lei X, Xu Z, Huang L, Huang Y, Tu S, Xu L and Liu D (2024) The potential influence of melatonin on mitochondrial quality control: a review. *Front. Pharmacol.* 14:1332567. doi: 10.3389/fphar.2023.1332567. CCBY



92

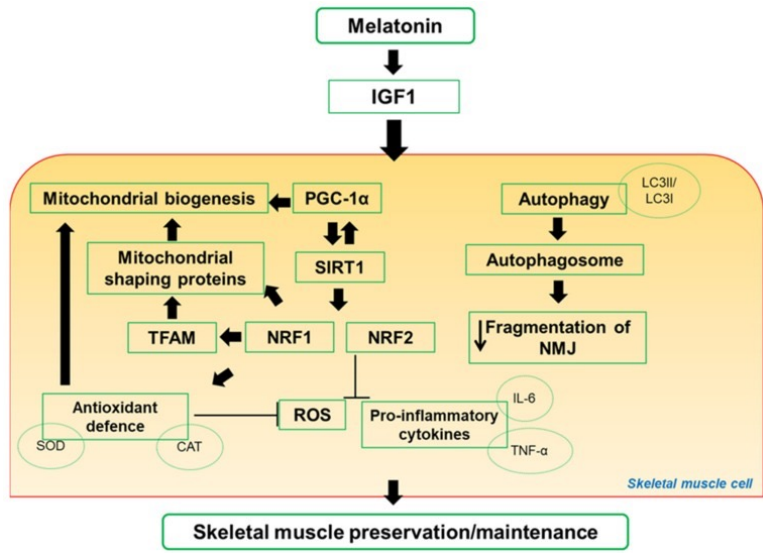
Melatonin is a potent neuroprotective agent through its free radical scavenging activities

Bocheva G, Bakalov D, Iliev P, Tzafrajiiska-Hadjiolova R. The Vital Role of Melatonin and Its Metabolites in the Neuroprotection and Retardation of Brain Aging. *Int J Mol Sci.* 2024;25(10):5122. Published 2024 May 8. doi:10.3390/ijms25105122. CCBY 4.0



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Melatonin for Muscle Health



Stacchiotti A, Favero G, Rodella LF. Impact of Melatonin on Skeletal Muscle and Exercise. *Cells.* 2020 Jan 24;9(2):288. doi: 10.3390/cells9020288. PMID: 319916594
 PMID: PMC7072499. <http://creativecommons.org/licenses/by/4.0/>

94

Chronobiotic effects of plants: Polyphenols as circadian connectors

Polyphenols may be an essential dietary component to keep the circadian system “fit” throughout the year.

- Animal studies have shown that certain polyphenols can:
 - Regulate circadian clock genes
 - Modulate levels of melatonin

Arola-Arnal A, Cruz-Carrión Á, Torres-Fuentes C, Ávila-Román J, Aragonès G, Mulero M, Bravo FI, Muguerza B, Arola L, Suárez M. Chrononutrition and Polyphenols: Roles and Diseases. *Nutrients*. 2019 Oct 30;11(11):2602. doi: 10.3390/nu11112602. PMID: 31671606; PMCID: PMC6893786.

95

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Summary

Clinical Application: Nutrition & Lifestyle
Approaches to Reduce Oxidative Stress

96

Earth Element: Healing for the Mitochondria Using Terrain Therapies

- Grounding (1)
- Intermittent fasting (2)
- Caloric restriction (2)
- Time-based food intake (2)
- Fermented foods (3)
- Phytochemicals (4)
- Massage therapy (5)

1. PMID: 36528336; 2. PMID: 32856431; 3. PMID: 28078251; 4. PMID: 34414181; 5. PMID: 22301554

97

Fire Element: Healing for the Mitochondria Using Thermal Therapies

- Infrared sauna
- Heat exposure
- Cold exposure

Casanova A, Wevers A, Navarro-Ledesma S and Pruijboom L (2023) Mitochondria: It is all about energy. *Front. Physiol.* 14:1114231. doi: 10.3389/fphys.2023.1114231; PMID: 33602887

98

Air Element: Healing for the Mitochondria Using Oxygenation Therapies

- Physical activity (1)
- Hyperbaric oxygen therapy (2)
- Intermittent hypoxia (1)
- Intermittent exercise (1)
- Pranayama breathing and yoga asanas (3)
- Music, especially Chinese five-element music or classical music (4)

1. PMID: 37179826; 2. PMID: 34944468; 3. PMID: 35341229; 4. PMID: 38999952

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Music and the Mitochondria

- Human embryonic kidney cells subjected to 45 minutes of Chinese five-element music, heavy metal, classical or no music.
- **Five-element music** had most benefits:
 - Increases in ATP by 17%
 - Increases in glutathione by 21% (8% in classical music)
 - Increased cell growth rates by 14% (same for classical music)
 - Reduced ROS by 13%
- Heavy metal music resulted in 16% increase in ROS and 11% reduction in cell viability.

Feng Q, Wang L, Chen Y, et al. Effects of different music on HEK293T cell growth and mitochondrial functions. *Explore (NY)*. 2022;18(6):670-675. doi:10.1016/j.explore.2022.01.002

100

100

Water Element: Healing for the Mitochondria Using Hydration Therapies

- Balanced deep-sea water (1)
- Cold showers (2)
- Hydration (3)

1. PMID: 27631616; 2. PMID: 26068191; 3. PMID: 27376070

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Consciousness Element: Healing for the Mitochondria Using Mind-Based Therapies

- Meditation (1)
- Quality sleep (2)
- Melatonin (3)

1. PMID: 35757176; 2. PMID: 37979503; 3. PMID: 38273825

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**Photon Element:
Healing for the Mitochondria
Using Light Therapies**

- Circadian interventions (1)
- Photobiomodulation (2)

1. PMID: 32117978; 2. PMID: 35785362

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“If we are not willing to spend the energy toward creating what we want, we get to spend the same amount of energy coping with what we get.”

- Anonymous




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An Energetic View: Mitochondrial Nutrition for Fatigue, the Brain, and Healthy Ageing

Thank you

An event by:  Nutritional Medicine Institute

Platinum sponsors:  

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