Supplements in Functional Medicine

MICRONUTRIENTS, MACRONUTRIENTS, ORGANIC ACID TESTS

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"Be curious, not judgmental.
The more we ask, the more we learn—and truth, like light, reveals itself to those who seek it with an open heart."

— Walt Whitman

OBJECTIVES

Identify Appropriate Uses of Supplements in Functional Medicine

Understand Supplement Regulation and Safety Standards

Communicate Effectively About Supplement Use

Manage and Monitor Supplement Regimens

Assess Patient Needs for Supplements

Conflicts of Interest: Owner of Brain Treatment Center-Michigan

Ingoude Company

🌱 My Mission in Life

I am here to teach, to pioneer, and to advocate. To give voice to what is often unseen: the subtle deficiencies, the silent suffering, the overlooked brilliance of every human system.

INTRODUCTION TO THE HISTORY OF SUPPLEMENTS

1. The Book of Tobit **2nd Century BC**: “the angel Raphael instructs Tobias to keep the fish's heart, liver, and gall bladder for medicinal purposes, specifically to burn the heart and liver to ward off demons and use the gall to heal blindness
2. “How can a man die who has sage in his garden?” Dioscorides, a Greek, wrote his Materia Medica in **65 AD**
3. Hajar R. The Air of History (Part II) Medicine in the **Middle Ages.** Heart Views. 2012 Oct;13(4):158-62. doi: 10.4103/1995-705X.105744. PMID: 23437419; PMCID: PMC3573364
4. https://www.nobelprize.org/prizes/themes/the-nobel-prize-and-the-discovery-of-vitamins/. The Nobel Prize and the discovery of vitamins. **1929**
5. Veeresham C. **Natural products derived from plants as a source of drugs.** J Adv Pharm Technol Res. **2012 Oct;3**(4):200-1. doi: 10.4103/2231-4040.104709. PMID: 23378939; PMCID: PMC3560124.

Does your cupboard look like this???.

https://www.istockphoto.com/photos/supplements-shelf

TIMELINE: HISTORY OF VITAMIN C

Ascorbate

1747

JAMES LIND DISCOVERS CITRUS PREVENTS SCURVY DURING NAVAL EXPERIMENT

1912

CASIMIR FUNK COINS THE TERM "VITAMIN"

1928–1932

ALBERT SZENT-GYÖRGYI ISOLATES VITAMIN C (ASCORBIC ACID)

1937

SZENT-GYÖRGYI WINS NOBEL PRIZE FOR VITAMIN C DISCOVERY

1930S

REICHSTEIN PROCESS DEVELOPED FOR INDUSTRIAL SYNTHESIS OF VITAMIN C

1940S

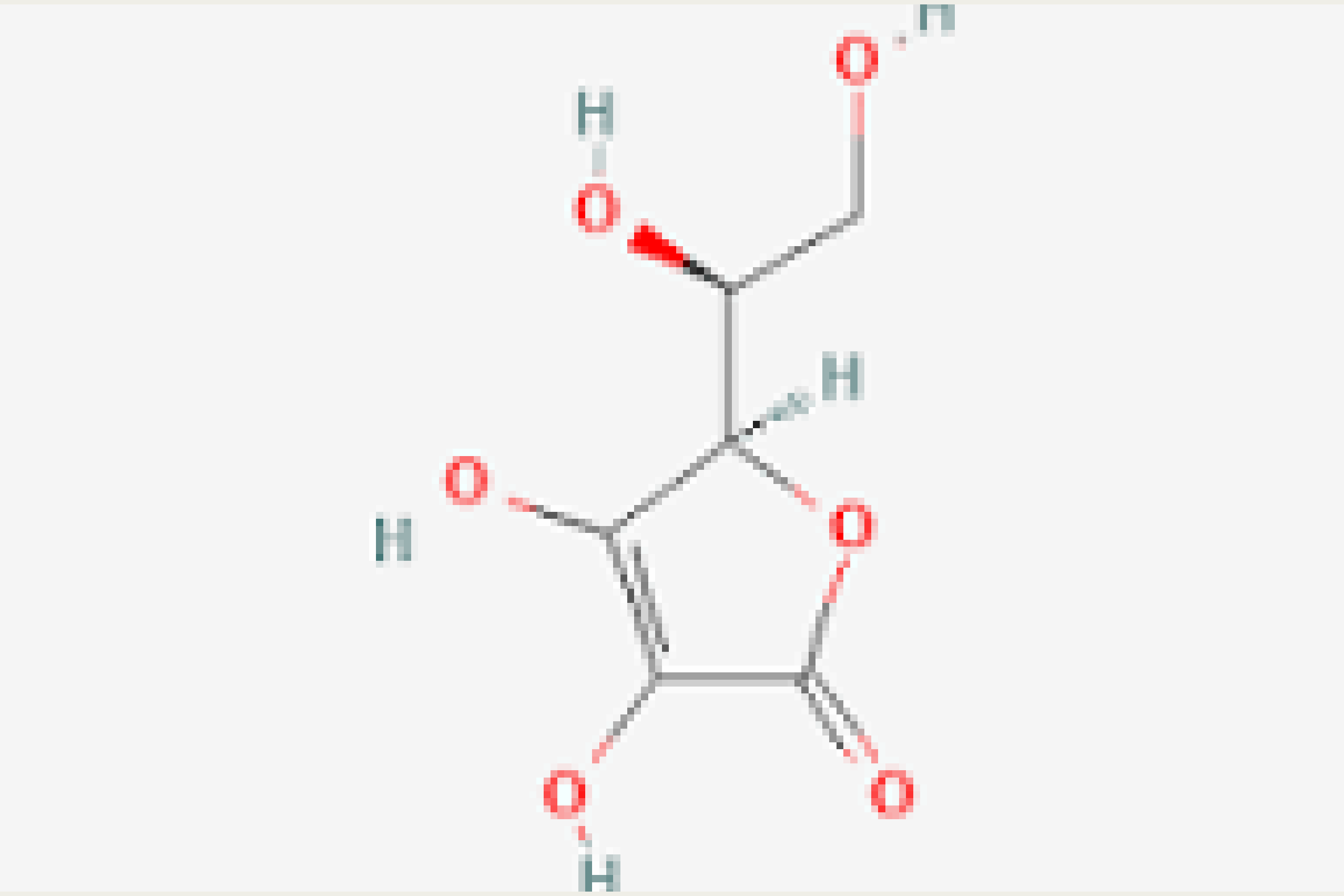
WWII-ERA MASS PRODUCTION OF VITAMIN C FOR SOLDIERS BEGINS

1970S

LINUS PAULING PROMOTES HIGH-DOSE VITAMIN C FOR IMMUNITY AND CANCER PREVENTION

ROLES AND BENEFITS OF VITAMIN C:

- Vitamin C is crucial for the biosynthesis of collagen, L-carnitine, and certain neurotransmitters.
- It is also involved in protein metabolism and, as an antioxidant, helps prevent damage to essential molecules in the body, enhancing immune function.
- Symptoms of Vitamin C Insufficiency and Deficiency Timeline:
- Early symptoms of Vitamin C insufficiency include fatigue, malaise, and inflammation of the gums.
- increased risk of cancer, cardiovascular disease, and age-related macular degeneration.
- https://lpi.oregonstate.edu/mic/vitamins/vitamin-C



VITAMIN C

- Over time, prolonged deficiency can lead to scurvy, characterized by anemia, debility, exhaustion, spontaneous bleeding, pain in the limbs and joints, and swollen gums leading to tooth loss.
- Severe deficiency can develop within 1-3 months of inadequate intake.
- Dietary Sources and Necessity for Oral Intake:
- Humans do not have the ability to synthesize Vitamin C and must obtain it through their diet, with rich sources including citrus fruits, tomatoes, potatoes, strawberries, green and red bell peppers, kiwifruit, broccoli, Brussels sprouts, and cantaloupe.

VITAMIN C

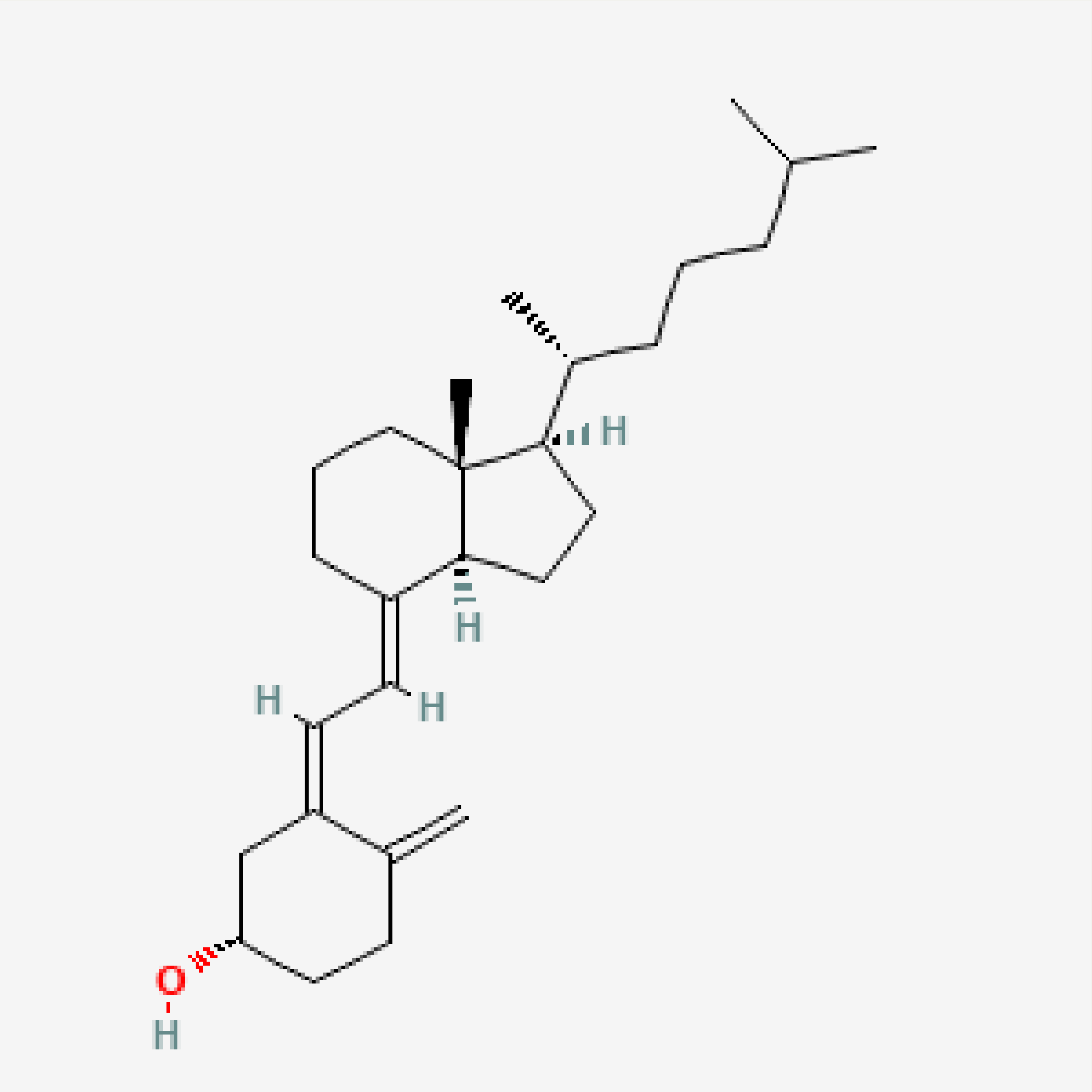
- Daily oral intake is essential to maintain adequate body levels because Vitamin C is water-soluble and the body does not store it in large amounts.
- Genetic Factors and Environmental Contributors:
- Genetic variants in the SLC23A1 gene, which encodes a sodium-dependent Vitamin C transporter, can affect the transport and availability of Vitamin C in the body.
- Environmental factors contributing to deficiency include inadequate dietary intake, smoking, and certain chronic diseases which increase the body's need for Vitamin C.

VITAMIN C

- The recommended daily allowance (RDA) for Vitamin C varies: 90 mg/day for men and 75 mg/day for women, with higher amounts recommended for smokers and during pregnancy.
- Diseases associated with Vitamin C deficiency include scurvy, potential increased risk of cancer, cardiovascular disease, and age-related macular degeneration.
- Numerous studies investigate the relationship between Vitamin C deficiency and chronic pain as well as dental issues, particularly its role in maintaining the health of the periodontal ligament and preventing gingivitis.

VITAMIN D

- Vitamin D is not technically a vitamin because the body can synthesize it, primarily through skin exposure to sunlight, unlike other vitamins that must be obtained from food.
- It's more accurately described as a prohormone or hormone because it can affect cells throughout the body after being modified by the liver and kidneys.
- https://pubchem.ncbi.nlm.nih.gov/compound/Cholecalciferol



VITAMIN D

- **Bone Health**: Vitamin D is vital for calcium absorption in the gut, which is essential for maintaining healthy bones and teeth. Without sufficient vitamin D, bones can become thin, brittle, or misshapen, leading to conditions like rickets in children and osteomalacia in adults.
- **Muscle Function**: Adequate vitamin D levels contribute to muscle strength and function, reducing the risk of falls and fractures, particularly in older adults.
- **Immune Support:** Vitamin D plays a role in modulating the immune system, potentially reducing the risk of infections and certain autoimmune diseases.

VITAMIN D

- **Mental Health**: Low levels of vitamin D have been associated with an increased risk of depression and other mood disorders.
- **Sunlight as a Source:** The body synthesizes vitamin D when the skin is exposed to ultraviolet B (UVB) rays from the sun. Factors such as geographic location, time of day, season, skin pigmentation, age, and sunscreen use can affect this process.
- **Dietary Sources:** While few foods naturally contain vitamin D, sources include fatty fish (like salmon and mackerel), fish liver oils, and egg yolks. Fortified foods such as milk, orange juice, and cereals also provide vitamin D.

During exposure to sunlight, the UV B photons enter the skin and photolyze 7-dehydrocholesterol to previtamin D3 which in turn is isomerized by the body's temperature to vitamin D3.

HOLICK MF. SUNLIGHT, ULTRAVIOLET RADIATION, VITAMIN D AND SKIN CANCER: HOW MUCH SUNLIGHT DO WE NEED?. ADV EXP MED BIOL. 2014;810:1-16.

VITAMIN D

- Populations at Risk: Individuals with limited sun exposure, darker skin (which reduces the skin's ability to produce vitamin D from sunlight), older adults, people with absorption disorders, and those who are obese are at higher risk for vitamin D deficiency.
- Vitamin D Forms: The two main forms of vitamin D are D_2 (ergocalciferol) and D_3 (cholecalciferol). Vitamin D_3, the form produced by the skin and found in animal-based foods, is generally considered more effective at raising blood levels of vitamin D.

VITAMIN D

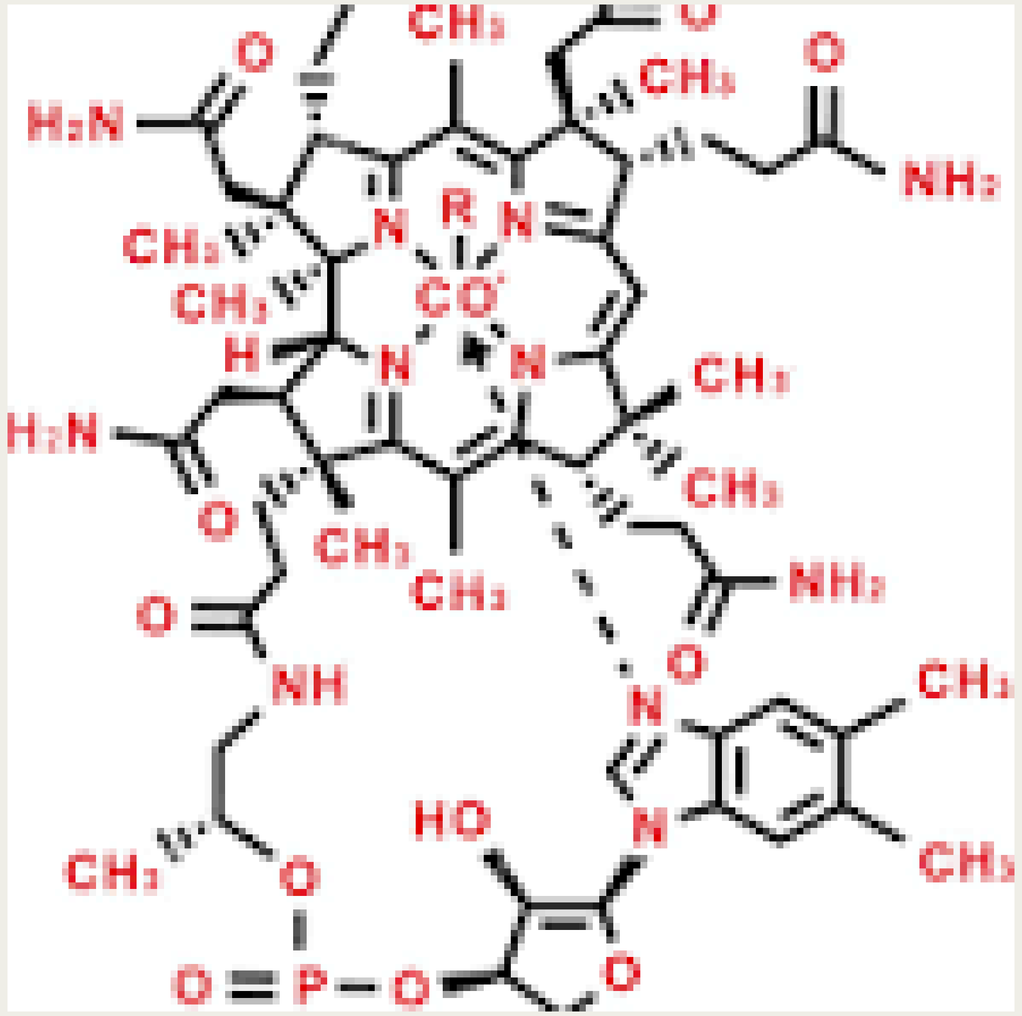
- Recommended Intake: The Recommended Dietary Allowance (RDA) for vitamin D varies by age, sex, and life stage. For adults **aged 19-70 years,** the RDA is **600 International Units (IU)** per day, and for those **over 70 years, it's 800 IU per day.**
- Upper Intake Levels: **The tolerable upper intake level for vitamin D is set at 4,000 IU per day** for adults. Consistently exceeding this amount may increase the risk of adverse health effects. Office of Dietary Supplements (ODS)
- Risks of Excessive Vitamin D: Too much vitamin D can lead to hypercalcemia (high calcium levels), which may cause nausea, vomiting, weakness, and kidney problems. It's important to consult a healthcare provider before taking high-dose supplements.

🌞 VITAMIN D INSIGHTS

- **Genetic risk factors**: Variants in genes like GC (vitamin D binding protein), CYP2R1 (25-hydroxylase), and VDR (vitamin D receptor) may reduce the body's ability to produce, transport, or respond to vitamin D.
- **No sun exposure?** It is possible to maintain adequate vitamin D through diet and supplementation alone, but careful monitoring is needed.
- **Sunscreen and vitamin D:** Sunscreen with SPF 30+ can reduce the skin's vitamin D synthesis by 95–98%. Limited, safe sun exposure is still valuable.
- **Testing:** The most accurate test is serum 25-hydroxyvitamin D [25(OH)D]. Optimal levels are generally considered to be 40–60 ng/mL.
- **https://ods.od.nih.gov/Research/VitaminD.aspx**

VITAMIN B12

- **Definition**: Vitamin B12 is a water-soluble vitamin essential for red blood cell formation, neurological function, DNA synthesis, and energy metabolism.
- **Forms**: Includes cyanocobalamin (synthetic), methylcobalamin (active), adenosylcobalamin (active), and hydroxocobalamin (natural precursor).https://go.drugbank.com/drugs/DB00200
- **Sources**: Found naturally in animal products (meat, fish, eggs, dairy); absent in plant foods unless fortified (e.g., nutritional yeast, cereals).



SYNTHESIS OF VITAMIN B12 IN THE BODY

- Not Synthesized by Humans: Humans cannot produce B12; it's synthesized exclusively by certain bacteria and archaea in specific environments.
- Microbial Production:
  - Bacteria (e.g., Propionibacterium freudenreichii, Lactobacillus reuteri) in soil, water, or animal guts (e.g., ruminants) produce B12.
  - Involves complex pathway (~30 enzymatic steps) creating a corrin ring with cobalt (hence "cobalamin").
- Human Reliance: B12 enters the food chain via animals consuming microbe-rich feed or water, or through fortified foods/supplements using bacterial cultures\/

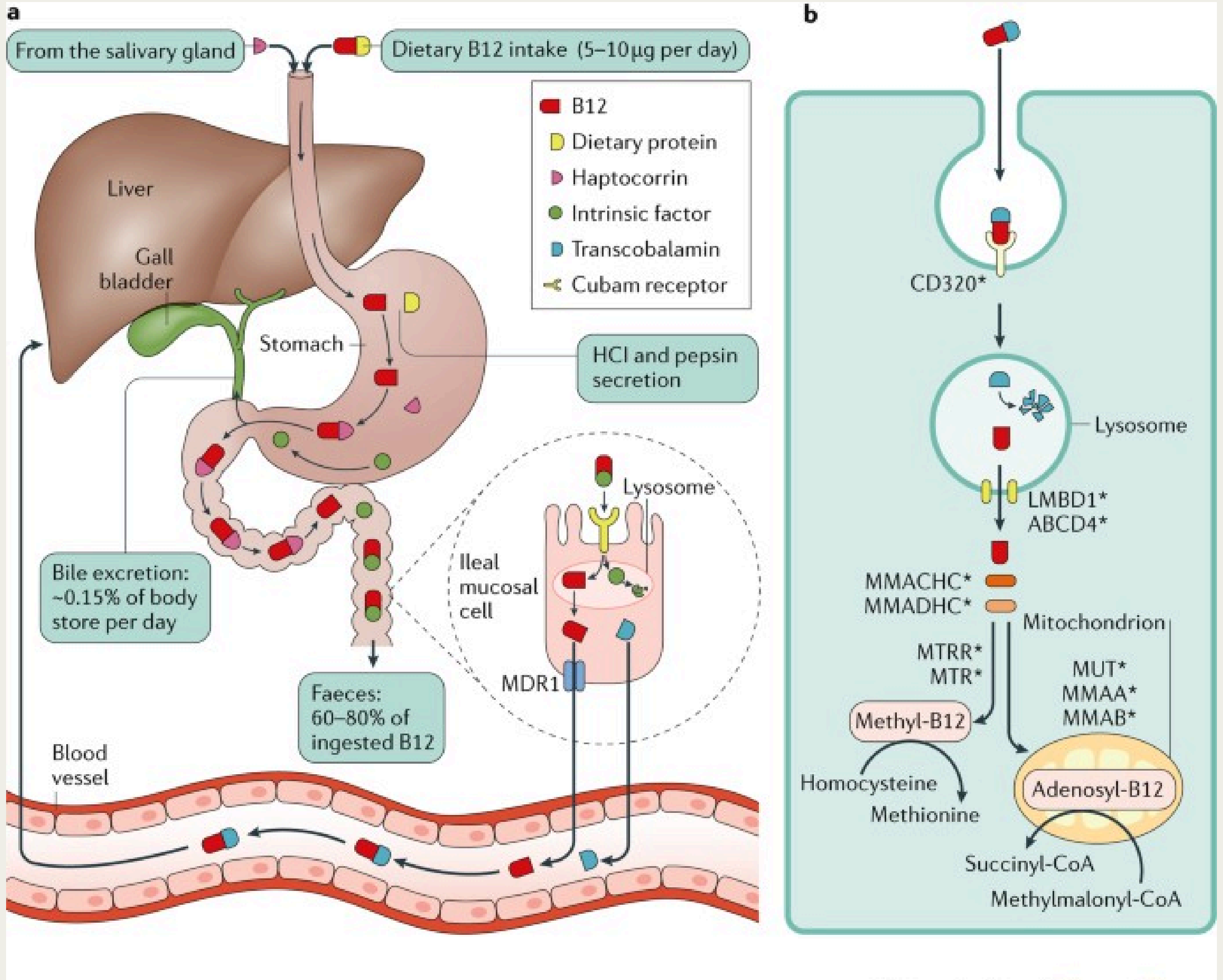
Bernhardt C, Zhu X, Schütz D, Fischer M, Bisping B. Cobalamin is produced by Acetobacter pasteurianus DSM 3509. Appl Microbiol Biotechnol. 2019;103(9):3875-3885. doi:10.1007/s00253-019-09704-3

B12

- Gut Bacteria Contribution:
  - **Some gut bacteria** (e.g., in colon) produce B12, but it's not absorbed (absorption occurs in ileum, upstream).
  - No significant endogenous synthesis contributes to human needs.
- Vitamin **B12 is assimilated and transported** by complex mechanisms that involve **three transport proteins**, intrinsic factor (IF), haptocorrin (HC) and transcobalamin (TC) and their respective membrane receptors.
- .https://pubmed.ncbi.nlm.nih.gov/35337622
- **What does this mean?** poor health, medications, lack of foods rich in B12 can all contribute to deficiency
  -

B12

- **Dietary Intake:**
- B12 in food is bound to proteins, released by stomach acid and pepsin.
- Stomach:
- Parietal cells secrete intrinsic factor (IF), a glycoprotein, and hydrochloric acid.
- B12 binds to haptocorrin (R-protein) in saliva/stomach to protect it from acid.
- **Small Intestine**:
- In duodenum, pancreatic enzymes (trypsin) degrade haptocorrin, freeing B12.
- B12 binds to intrinsic factor in jejunum/ileum.
- IF-B12 complex is absorbed via specific receptors (cubilin, amnionless) in the ileum's enterocytes.



https://www.nature.com/articles/nrdp201740

GENES THAT AFFECT B12

- MTHFR (C677T, A1298C): Affects folate cycle, linked to B12 use. Homozygous C677T reduces methylation efficiency, increasing B12 needs (methylcobalamin preferred).
- TCN2: Encodes transcobalamin II. Variants (e.g., rs1801198) impair B12 transport, lowering bioavailability — may need higher doses.
- FUT2: Influences gut absorption via haptocorrin. Non-secretor variants reduce B12 uptake, favoring injections.
- MMAA, MMAB, MUT: Mutations disrupt adenosylcobalamin/methylcobalamin synthesis, requiring specific forms (e.g., hydroxocobalamin).
- GIF: Codes for intrinsic factor. Rare mutations cause pernicious anemia, necessitating injections.

MTHFR

- **MTHFR defects:** Methylcobalamin bypasses methylation blocks, better for neurological symptoms.
- **Mitochondrial disorders** (MMAA/MUT): Adenosylcobalamin targets energy defects.
- **Absorption issues** (GIF, FUT2): Hydroxocobalamin or injections avoid gut barriers.
- **Dosage Impact:**
- **Genetic inefficiencies** (e.g., TCN2, MTHFR) may require 500-2000 mcg/day (oral/sublingual) vs. standard 2.4 mcg.
- **Severe defects** (e.g., pernicious anemia): 1000 mcg injections weekly, then monthly

Temova Rakuša Ž, Roškar R, Hickey N, Geremia S. Vitamin B12 in Foods, Food Supplements, and Medicines-A Review of Its Role and Properties with a Focus on Its Stability. Molecules. 2022;28(1):240. Published 2022 Dec 28. doi:10.3390/molecules28010240

Best Ways to Get Vitamins

Source	Advantages	Examples
Whole Foods	Naturally balanced, includes cofactors and fiber	Colorful fruits and vegetables, organ meats, oily fish, legumes
Fortified Foods	Easy to integrate into picky diets	Cereals, plant milks, nutritional yeast, enriched pastas
Liquid Supplements	Ideal for children with pill aversion or texture sensitivity	Multivitamin liquids, zinc drops, DHA emulsions
Powdered Supplements	Can be mixed into preferred foods	Glutamine, magnesium, B-complex blends
Gummies/Chewables	Palatable and familiar	Omega-3s, multivitamins, vitamin D3
Liposomal Formulas	Enhanced absorption, gut-friendly	Liposomal C, glutathione, B12
Topical or Transdermal	Bypasses GI system for sensitive kids	Magnesium oil, patch vitamins (B12, D3)
IV or IM Nutrients (clinical setting)	For severe deficiencies or absorption issues	Vitamin C, B12, magnesium, glutathione (under supervision)

Supplements in Functional Medicine

MACRONUTRIENTS

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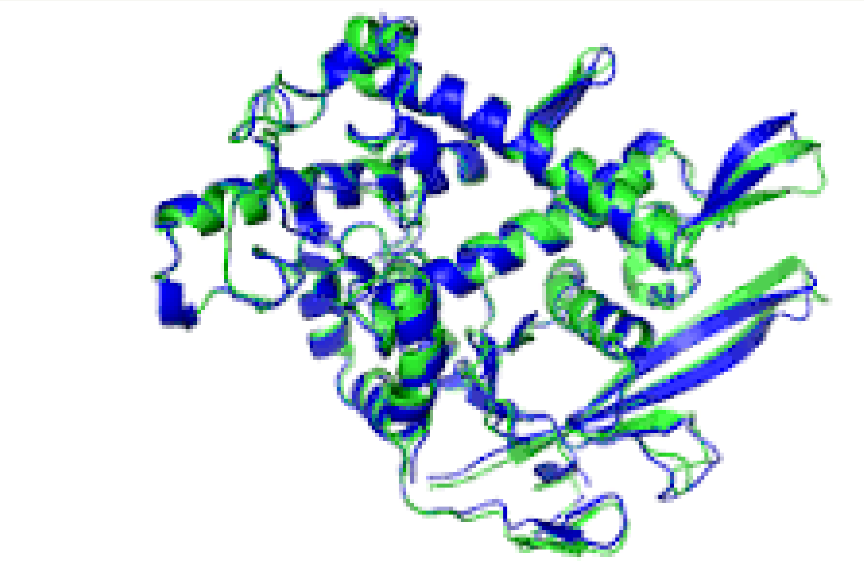
MACRONUTRIENTS

Daily Requirements:

- **Carbs**: 45-65% of calories (~130 g minimum for brain, 225-325 g on 2000 kcal diet).
- **Proteins**: 10-35% of calories (~0.8 g/kg body weight, 56 g for 70 kg person).
- **Fats**: 20-35% of calories (~44-78 g on 2000 kcal).
- **Water:** ~2.7 L (women), 3.7 L (men) from food/drinks.

https://www.cdc.gov/nchs/fastats/diet.htm

MEET THE TEAM HTTPS://WWW.CDC.GOV/NCHS/FASTATS/DIET.HTM



Proteins

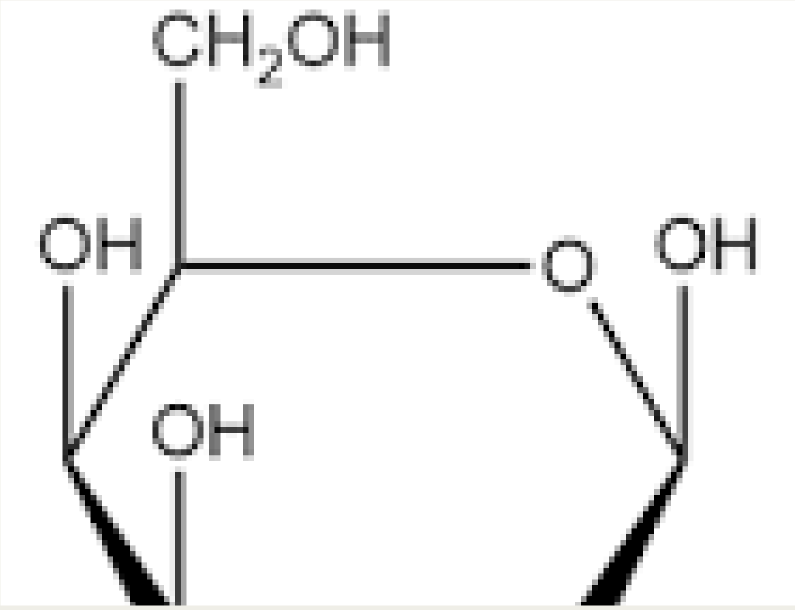
3D folded Amino Acid

DNA's Middleman: Your genes are just blueprints—proteins do the actual building, repairing, and running of your body

Fats

No fixed ratio

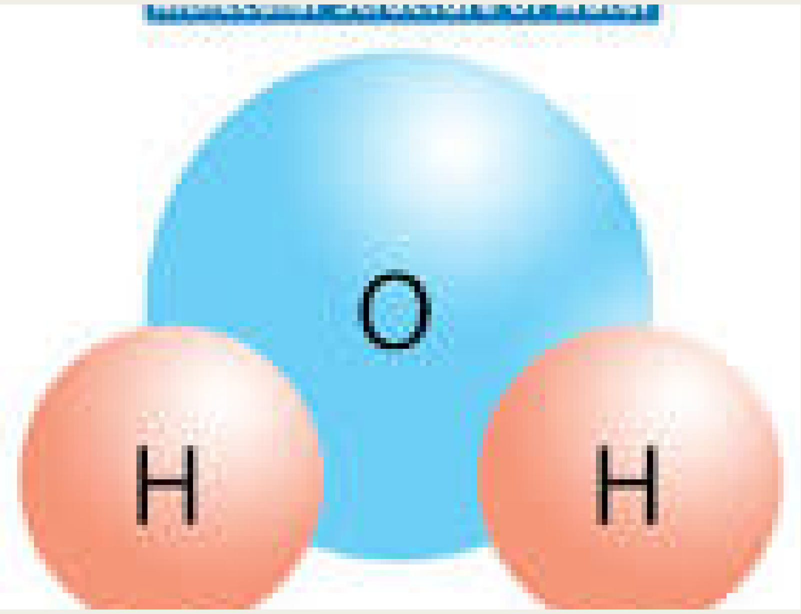
Hydrocarbon-rich, non-polar, and water-insoluble due to long chains with minimal oxygen-containing group



Carbohydrates

CHO 1:2:1

- Energy: Provide 4 kcal/g; .
- Storage
- Structural
- Gut Health



Water

your brain's 80% wet

Polarity: Oxygen attracts electrons more than hydrogen, creating a partial negative charge near oxygen and positive near hydrogen, enabling water to dissolve many substances (universal solvent).

WHY KNOW YOUR MACRONUTRIENTS

- **Water's Metabolic Bonus:** Your body makes ~300 mL of water daily just by burning carb and fats in mitochondria—like a tiny internal spring!
- **Carbs Power Your Nerves:** Glucose is the only fuel your brain and red blood cells prefer under normal conditions—your noggin slurps 120 g daily, but in starvation, fats (ketones) can pinch-hit, sparing protein breakdown.
- **Proteins Play Defense:** Beyond muscles, proteins like lactoferrin in breast milk steal iron from bacteria, starving invaders—nature's sneaky antibiotic trick, giving babies an immune edge.
- **Fats Fake Fullness:** Eating fats triggers your gut to release cholecystokinin (CCK), a hormone that screams "I'm full!" to your brain—why a spoonful of olive oil before dinner can stop you from overeating.
- **Macronutrient Shapeshifters:** Your body's a master recycler—excess carbs turn into fat, proteins can become glucose (gluconeogenesis), and fats can fuel almost anything, but water stays water, holding it all together.

PROTEIN FAQ

- **How much protein do we need?**
  - General guideline: **0.8 grams per kilogram of body weight per day for sedentary adults** (RDA, Recommended Dietary Allowance).
  - Example: A 70 kg (154 lb) person needs ~**56 grams/day.**
  - **Active** individuals, athletes, or those **recovering from illness** may need **1.2–2.0 g/kg/day**.
- **Does protein need change with age?**
  - Yes. Aging reduces muscle mass (sarcopenia), increasing protein needs to maintain strength.
  - **Older adults (65+): 1.0–1.2 g/kg/day**, sometimes up to 1.5 g/kg for those with acute or chronic conditions.
  - Children and teens need more for growth (see below).
- **Do men need more than women?**
  - Not inherently. Protein needs are based on body weight, activity level, and health status, not sex.
  - Men may need more if they have higher muscle mass or body weight, but this varies individually.
- **Do children need more than adults?**
  - Yes, due to growth and development:
    - Infants (0–12 months): 1.5–2.0 g/kg/day.
    - Children (1–13 years): 0.95–1.1 g/kg/day.
    - Adolescents (14–18 years): 0.85–0.95 g/kg/day.
  - **Their needs are higher per kg than adults but lower in total due to smaller body size.**
  - **https://www.cdc.gov/nchs/fastats/diet.htm**

PROTEINS

- **Protein needs at age 80**?
  - Recommended: 1.0–1.2 g/kg/day, potentially up to 1.5 g/kg for those with muscle loss or illness.
  - Example: An 80-year-old weighing 60 kg (132 lb) needs 60–72 grams/day, or up to 90 grams if health demands.

- **Best forms of protein in the diet?**
  - Animal sources: High-quality, complete proteins (contain all essential amino acids).
    - Eggs, lean meats (chicken, turkey, beef), fish (salmon, tuna), dairy (Greek yogurt, cottage cheese).
  - Plant sources: Often incomplete but can be combined (e.g., beans + rice) for complete proteins.
    - Legumes (lentils, chickpeas), tofu, tempeh, quinoa, nuts, seeds.
  - Supplements: Whey, casein, or plant-based protein powders for convenience, but whole foods are preferred.
  - Choose minimally processed sources and vary intake to balance nutrients.

PROTEINS

- **Markers in an OATS test for protein status**?
  - Organic Acids Test (OATS) measures metabolic byproducts in urine to assess nutrient status.
  - **Low protein intake markers**:
    - Low levels of amino acid metabolites (e.g.**, 2-oxoglutaric acid, pyroglutamic acid**).
    - Elevated markers of protein breakdown (e.g., **indican, suggesting gut dysbiosis from inadequate protein)**.
  - **Excessive protein intake markers:**
    - High levels of ammonia or urea cycle metabolites (e.g., **orotic acid, indicating liver stress).**
    - Elevated sulfate or organic acids from amino acid metabolism (e.g., **homovanillic acid**).
  - Interpretation requires context (diet, health, activity)

WHAT INTERFERES WITH PROTEIN ANALYSIS

- Dietary composition: **High-protein diets** (e.g., ketogenic or carnivore) can elevate ammonia, orotic acid, or sulfate levels, while low-protein or vegan diets may reduce amino acid metabolites like 2-oxoglutaric acid, skewing OATS results.
- Gut health: **Dysbiosis or poor digestion** (e.g., low stomach acid, SIBO) can increase indican or other protein breakdown markers, falsely suggesting inadequate protein intake despite sufficient consumption.
- Physical activity: **Intense exercise or muscle**-building activities increase protein turnover, potentially lowering amino acid metabolites (due to utilization) or raising urea cycle markers, reflecting higher protein needs.
- Liver or kidney function: **Impaired liver or kidney health** can disrupt ammonia or urea metabolism, elevating orotic acid or sulfate, which may mimic signs of excessive protein intake.
- Hydration status: **Dehydration concentrates urine,** artificially inflating organic acid levels (e.g., homovanillic acid, sulfate), while overhydration may dilute markers, masking true protein status

CARBOHYDRATES

- **Definition**: Carbohydrates are macronutrients providing energy, primarily in the form of sugars, starches, and fiber, found in foods like grains, fruits, vegetables, and legumes.
- **Types**: **Simple carbs** (sugars, e.g., glucose, fructose) are quickly digested; **complex** carbs (starches, fiber) take longer, providing sustained energy.
- **Energy Source**: Carbs are the body's preferred fuel, yielding **4 calories** per gram, used by the brain, muscles, and organs.
- **Digestion:** Begins in the mouth with salivary amylase, continues in the small intestine where enzymes break carbs into glucose for absorption.
- **Storage:** Excess glucose is stored as glycogen in the liver and muscles or converted to fat if glycogen stores are full.
- **Brain Function:** The brain relies heavily on glucose, requiring ~130 grams of carbs daily for optimal function in adults.

CARBOHYDRATES

- **Adults**:
- Recommended Dietary Allowance (RDA): **130 grams/day** to meet **brain** glucose needs.
- Dietary Guidelines: 45–65% of total calories from carbs (e.g., **225–325 gm for a 2,000**-calorie diet).
- Active individuals may need more (up to 60–70% of calories) for energy demands.
- **Children**:
- Ages 1–3: 130 grams/day (RDA), ~45–65% of calories.
- Ages 4–18: 130 grams/day, adjusted for growth and activity (e.g., 50–60% of calories).
- Higher per kilogram due to growth and higher metabolic rates.
- **Changes with Age:**
- Older adults (65+): Needs remain ~130 grams/day but may decrease slightly due to lower activity or muscle mass.
- Sarcopenia and reduced metabolism may shift focus to protein, but carbs remain essential for energy
- https://www.cdc.gov/diabetes/healthy-eating/choosing-healthy-carbs.html#:.

MICROBIOME DIVERSITY AND CARB ABSORPTION

- **Gut Microbiome Role**: Diverse gut bacteria ferment complex carbs and fiber, producing short-chain fatty acids (SCFAs) like butyrate, which support gut health and energy metabolism.
- **Impact of Diversity**: Higher microbiome diversity enhances fermentation efficiency, improving carb absorption and reducing digestive issues like bloating.
- **Low Diversity**: Poor microbiome diversity (e.g., from low-fiber diets) impairs fermentation, reducing SCFA production and potentially causing inefficient carb metabolism
- https://pmc.ncbi.nlm.nih.gov/articles/PMC4837298/

ABSORPTION: REAL VS. PROCESSED FOODS

- **Real Foods** (**Whole Foods**):
- Contain complex carbs and fiber (e.g., brown rice, vegetables), digested slowly, leading to **gradual blood sugar rises**.
- **Nutrient-dense**, providing vitamins, minerals, and antioxidants alongside carbs.
- **Absorbed efficiently** in the small intestine, with fiber aiding gut health.
- **Processed Foods**:
- High in simple sugars or refined starches (e.g., candy, white flour), rapidly digested, causing **quick blood sugar spikes**.
- Often lack fiber and nutrients, leading to overconsumption and **less satiety**.
- **Rapid absorption can overwhelm insulin response,** increasing risk of metabolic issues

4 INTERESTING AND LITTLE-KNOWN FACTS

- **Carb Timing and Sleep**: Consuming complex carbs in the evening (e.g., sweet potatoes) may boost serotonin production, potentially improving sleep quality by aiding melatonin synthesis.
- **Ancient Grains' Unique Carbs**: Grains like teff or amaranth contain resistant starches, which act like fiber, **feeding gut bacteria** and improving insulin sensitivity more than modern wheat.
- **Carb "Memory" in Muscles**: After intense exercise, muscles increase glycogen storage capacity for up to 48 hours, making post-workout carb intake more efficient for recovery.
- **Microbiome-Carb Specificity:** Certain gut bacteria preferentially ferment specific carbs (e.g., inulin from onions), meaning **dietary diversity** directly shapes bacterial populations and carb absorption efficiency

FAT FACTS

- Definition: Fats are energy-dense macronutrients (**9 calories/gram**) essential for hormone production, cell membrane structure, and absorption of fat-soluble vitamins (A, D, E, K).
- **Types**: Include **saturated**, **unsaturated** (monounsaturated, polyunsaturated), and **trans fats**, each with distinct health impacts.
- **Energy Storage**: Fats are the body's primary long-term energy reserve, stored as triglycerides in adipose tissue.
- **Dietary Sources:** Found in oils, nuts, seeds, avocados, dairy, meats, fish, and processed foods.

FATS BASIC FACTS

- **Essential Fatty Acids: Omega-3** (e.g., ALA, DHA, EPA) and **omega-6** (e.g., linoleic acid) **cannot be synthesized by the body** and must come from diet.
- **Hormone Regulation**: Fats are precursors for hormones like estrogen, testosterone, and cortisol, influencing metabolism and reproduction.
- **Brain Health**: ~60% of the brain's dry weight is fat; DHA (an omega-3) is critical for cognitive function and neural development.
- **Satiety**: Fats slow digestion, promoting fullness and stabilizing blood sugar when paired with carbs or protein.
- Recommended Intake: 20–35% of daily calories from fats (e.g., 44–78 grams for a 2,000-calorie diet), https://www.cdc.gov/nchs/fastats/diet.htm

FACTORS THAT CHANGE FAT ABSORPTION

- **Bile Production**: Adequate bile (from liver/gallbladder) is critical fo emulsifying fats; gallbladder issues or low-fat diets can impair absorption.
- **Gut Health**: A healthy gut microbiome aids fat metabolism; dysbiosis or conditions like celiac disease can reduce absorption efficiency.

4 INTERESTING AND LITTLE-KNOWN FACTS ABOUT FATS

- **Fat Taste (Oleogustus):** Fat is considered a **sixth basic taste**, detected by specific tongu receptors, influencing food preferences and satiety signals.
- **Brown Fat Activation:** Unlike white fat (storage), brown fat burns calories to generate heat; cold exposure or certain foods (e.g., capsaicin) can activate it, boosting metabolism https://www.frontiersin.org/journals/physiology/articles/10.3389/fphys.2018.01954/full
- **Fat as an Endocrine Organ**: Adipose tissue secretes hormones like leptin (regulates hunger) and adiponectin (improves insulin sensitivity), acting like an endocrine gland.
- **Omega-3s and Gene Expression**: DHA and EPA can influence gene expression, upregulating anti-inflammatory pathways and potentially reducing chronic disease risk.
- https://pmc.ncbi.nlm.nih.gov/articles/PMC3257651/

FATS

- **Enzyme Activity:** Pancreatic lipase insufficiency (e.g., pancreatitis, cystic fibrosis) hinders fat breakdown, leading to malabsorption and steatorrhea (fatty stools).
- **Diet Composition**: High-fiber meals slow fat absorption by binding bile acids; high-carb diets may prioritize glucose metabolism, delaying fat processing.
- **Cooking Methods:** Overheating oils (e.g., frying) can degrade fats, forming compounds like aldehydes that are harder to metabolize and potentially harmful. Seed oils can be problematic if overheated.

AVOCADO OIL (REFINED) 480-520°F.
SAFFLOWER OIL 450-500°F.
CANOLA OIL 400-475°F.
SOYBEAN OIL 450°F.
SUNFLOWER OIL (REFINED) 450°F.
PEANUT OIL (REFINED) 450°F.
COCONUT OIL (REFINED) 400-450°F

Supplements in Functional Medicine

ORGANIC ACID TESTING

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BASICS OF ORGANIC ACID TESTING (10 BULLET POINTS)

- **Definition:** Organic Acid Testing (OAT) is a urine-based test measuring metabolic byproducts (organic acids) to assess nutrient status, metabolic function, and health.
- **Purpose:** Provides insights into mitochondrial function, gut health, neurotransmitter metabolism, detoxification, and nutrient deficiencies.
- **Sample Collection:** Non-invasive, typically a first-morning urine sample, reflecting recent metabolic activity.
- **Markers Tested**: Includes 70–80 organic acids, such as those related to amino acid metabolism, fatty acid oxidation, and gut microbial activity.
- **Nutrient Insights**: Identifies deficiencies in vitamins (e.g., B vitamins, vitamin C) or cofactors by detecting elevated or low metabolites.
- **Gut Health**: Measures microbial overgrowth (e.g., yeast, bacteria) via markers like D-arabinitol or indican.
- **Energy Metabolism**: Assesses mitochondrial dysfunction through markers like succinic acid or citric acid cycle intermediates.
- **Detoxification**: Evaluates liver detox pathways (e.g., glucaric acid) and oxidative stress (e.g., 8-OHdG).
- **Personalized Medicine:** Results guide dietary, supplement, or lifestyle interventions tailored to metabolic imbalances.
- **Applications:** Used in functional medicine for chronic fatigue, autism, fibromyalgia, gut disorders, and unexplained symptoms.

10 LIMITATIONS OF ORGANIC ACID TESTING

- **Interpretation Complexity:** Results require expert analysis; non-specific markers can lead to misinterpretation without clinical context.
- **Snapshot Nature**: Reflects recent metabolism (hours to days), not long-term status, so results vary with diet or health changes.
- **Limited Standardization**: Reference ranges vary between labs, complicating comparisons and reliability.
- **Cost**: Expensive (often $200–$400), not typically covered by insurance, limiting accessibility.
- **False Positives/Negative**s: Medications, supplements, or diet (e.g., high-protein meals) can skew results, reducing accuracy.
- **Not Diagnostic Alone**: Cannot confirm specific diseases (e.g., cancer, diabetes); must be paired with other tests and clinical history.
- **Gut Microbiome Variability**: Microbial markers depend on individual gut flora, which fluctuates, affecting consistency.
- **Age and Population Bias**: Reference ranges are often based on adults, potentially less accurate for children or elderly.
- **Overreliance Risk:** Patients or practitioners may overemphasize results, leading to unnecessary treatments or overlooking other causes. MUST USE IN CONTEXT
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SCIENCE BEHIND ORGANIC ACID TESTING

- **Metabolic Pathways**: Organic acids are intermediate or end products of metabolism, produced during the breakdown of carbs, proteins, fats, and other compounds in pathways like the citric acid cycle, glycolysis, or amino acid metabolism.
- **Urine as a Matrix:** Urine concentrates these water-soluble byproducts, reflecting cellular and microbial activity more directly than blood, which tightly regulates metabolites.
- **Analytical Method**: Gas chromatography-mass spectrometry (GC-MS) or liquid chromatography-mass spectrometry (LC-MS) identifies and quantifies organic acids with high sensitivity.
- **Biomarker Specificity:** Each acid correlates with specific processes (e.g., 2-oxoglutaric acid for protein metabolism, homovanillic acid for dopamine turnover), though some markers are non-specific.
- **Microbial Contributions**: Gut bacteria produce unique organic acids (e.g., hippuric acid from polyphenol metabolism), revealing microbiome health.
- **Enzyme Dysfunction**: Elevated or low acids indicate enzyme inefficiencies or cofactor deficiencies (e.g., high methylmalonic acid suggests B12 deficiency).
- **Oxidative Stress:** Markers like 8-hydroxy-2'-deoxyguanosine (8-OHdG) reflect DNA damage from reactive oxygen species, linking metabolism to cellular health.

WHEN TO DO ORGANIC ACID TESTING

- **Chronic Unexplained Symptoms**: Fatigue, brain fog, or pain with no clear cause, to identify metabolic or nutrient issues.
- **Suspected Nutrient Deficiencies:** When blood tests are inconclusive but symptoms suggest B-vitamin, antioxidant, or cofactor shortages.
- **Gut Health Concerns**: Symptoms like bloating, IBS, or suspected dysbiosis, to assess microbial overgrowth or fermentation patterns.
- **Neurological or Behavioral Issues**: In autism, ADHD, or mood disorders, to evaluate neurotransmitter metabolism or oxidative stress.
- **Mitochondrial Dysfunction:** For conditions like chronic fatigue syndrome or fibromyalgia, to check energy production pathways.
- **Detoxification Assessmen**t: When liver function or toxin exposure (e.g., heavy metals, pesticides) is a concern.
- **Personalized Wellness:** For optimizing health in functional medicine, especially for athletes or those with high metabolic demands.
- **Pediatric Cases**: In children with developmental delays or metabolic disorders, to guide early interventions.

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MICRONUTRIENTS, MACRONUTRIENTS, ORGANIC ACID TESTS

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Thank you!

MY MISSION IS TO HEAL AND TRANSFORM LIVES BY RECONNECTING PEOPLE—ESPECIALLY THE MOST VULNERABLE—TO THE WISDOM OF THEIR BODIES WITH THE POWER OF NUTRITION

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