



Oregon State University
Linus Pauling Institute

Aging Well: Role of Micronutrients in Older Adults

Emily Ho, PhD

Endowed Chair & Director, Linus Pauling Institute

Co-Director, Center for Healthy Aging Research,
College of Public Health and Human Sciences

CHRONIC DISEASES IN AMERICA

6 IN 10

Adults in the US
have a **chronic disease**



4 IN 10

Adults in the US
have **two or more**

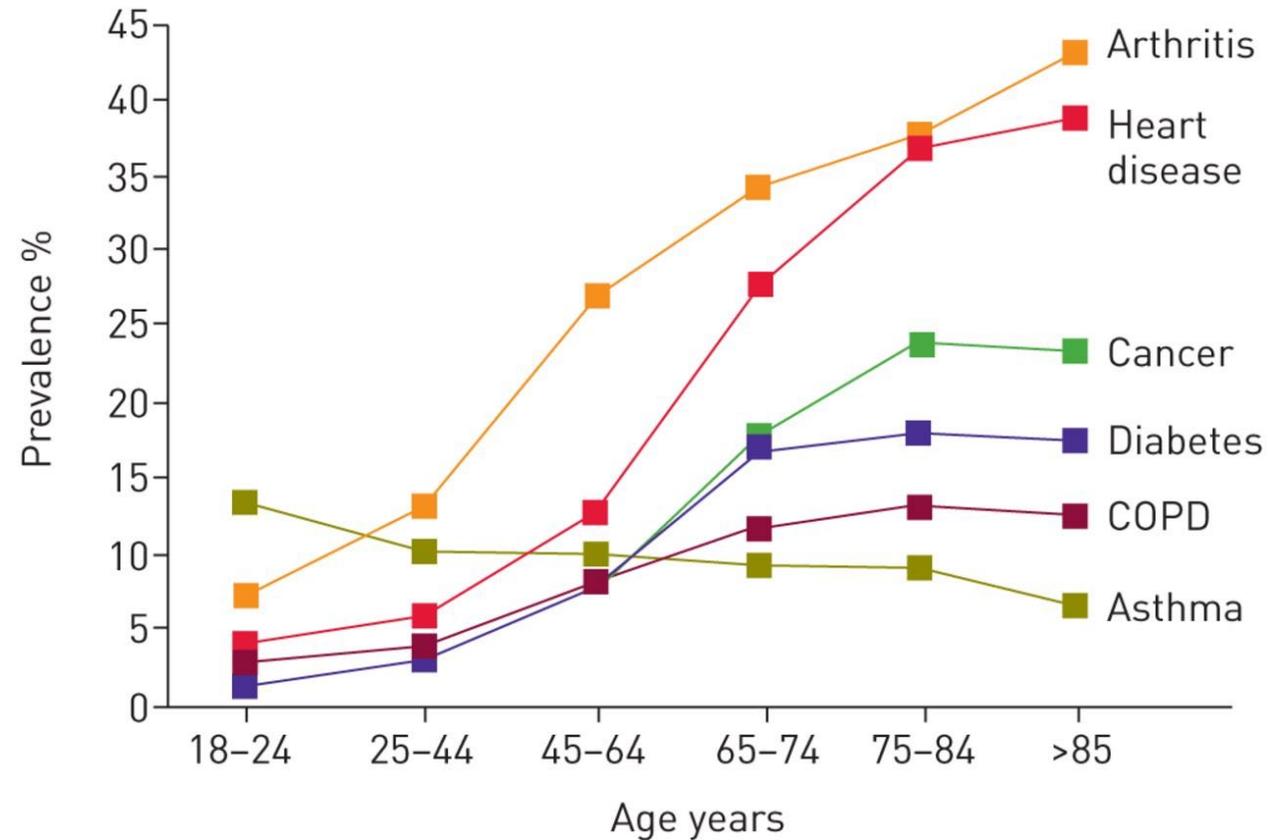
THE LEADING CAUSES OF DEATH AND DISABILITY
and Leading Drivers of the Nation's **\$3.5 Trillion** in Annual Health Care Costs



With Age, Comes the Risk for Chronic Diseases

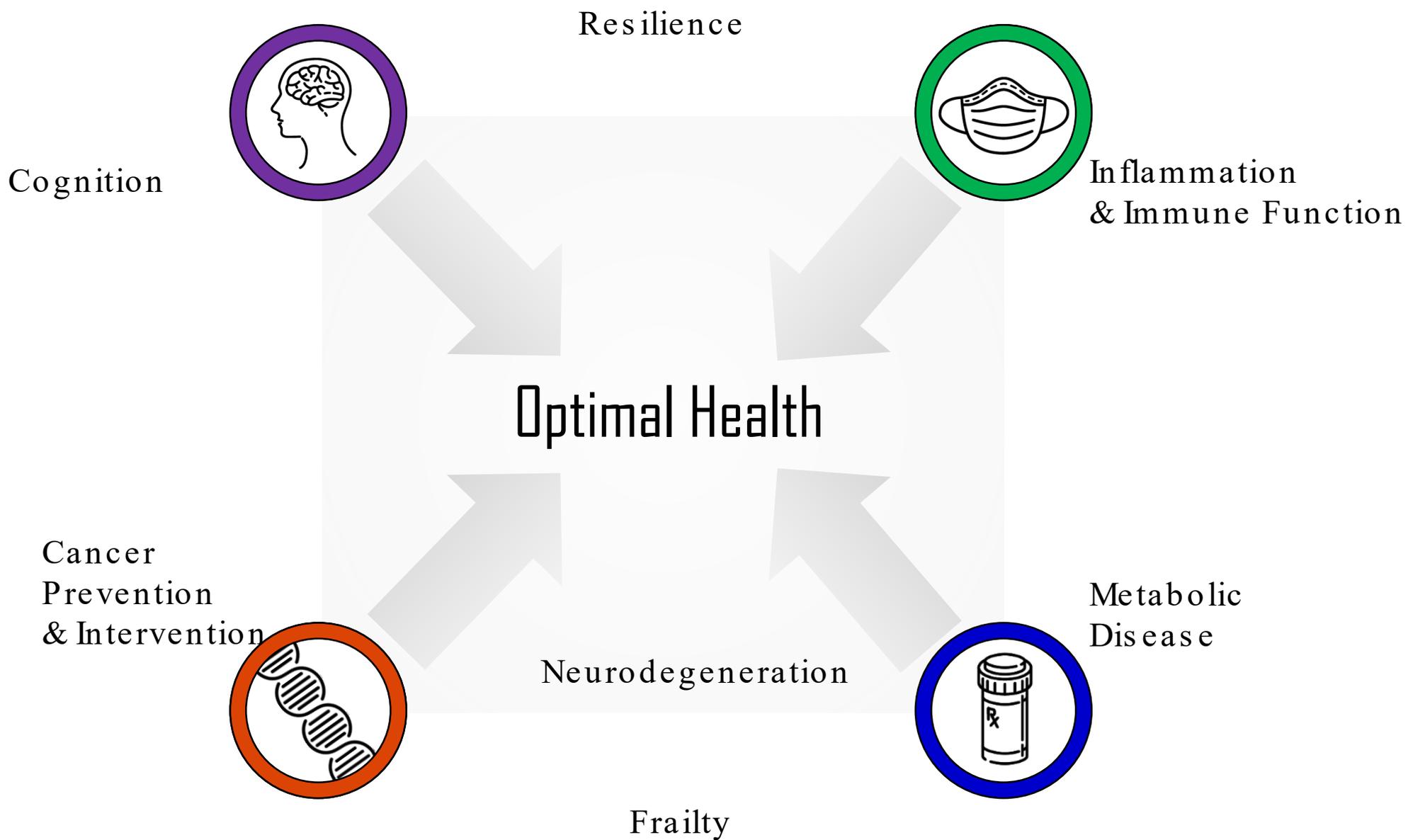


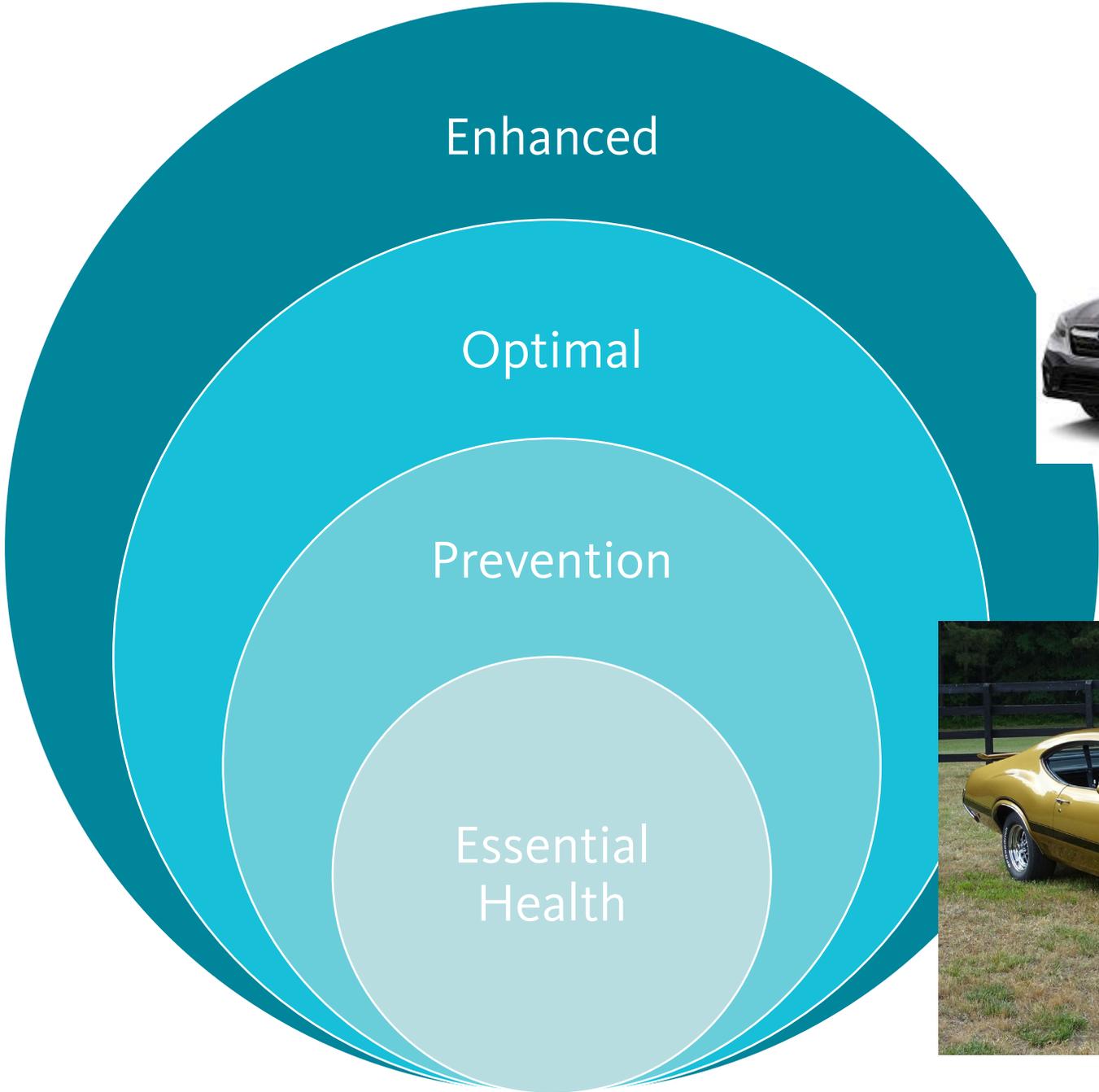
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The force of senescence (a natural process) leads to increased risk for chronic diseases

Adapted from Dillin A, Gottschling DE, Nystrom T. *Curr Opin Cell Biol* 2014; **26**: 107-112; and from William MacNee, Roberto A. Rabinovich, Gourab Choudhury, *European Respiratory Journal* 2014 44: 1332-1352







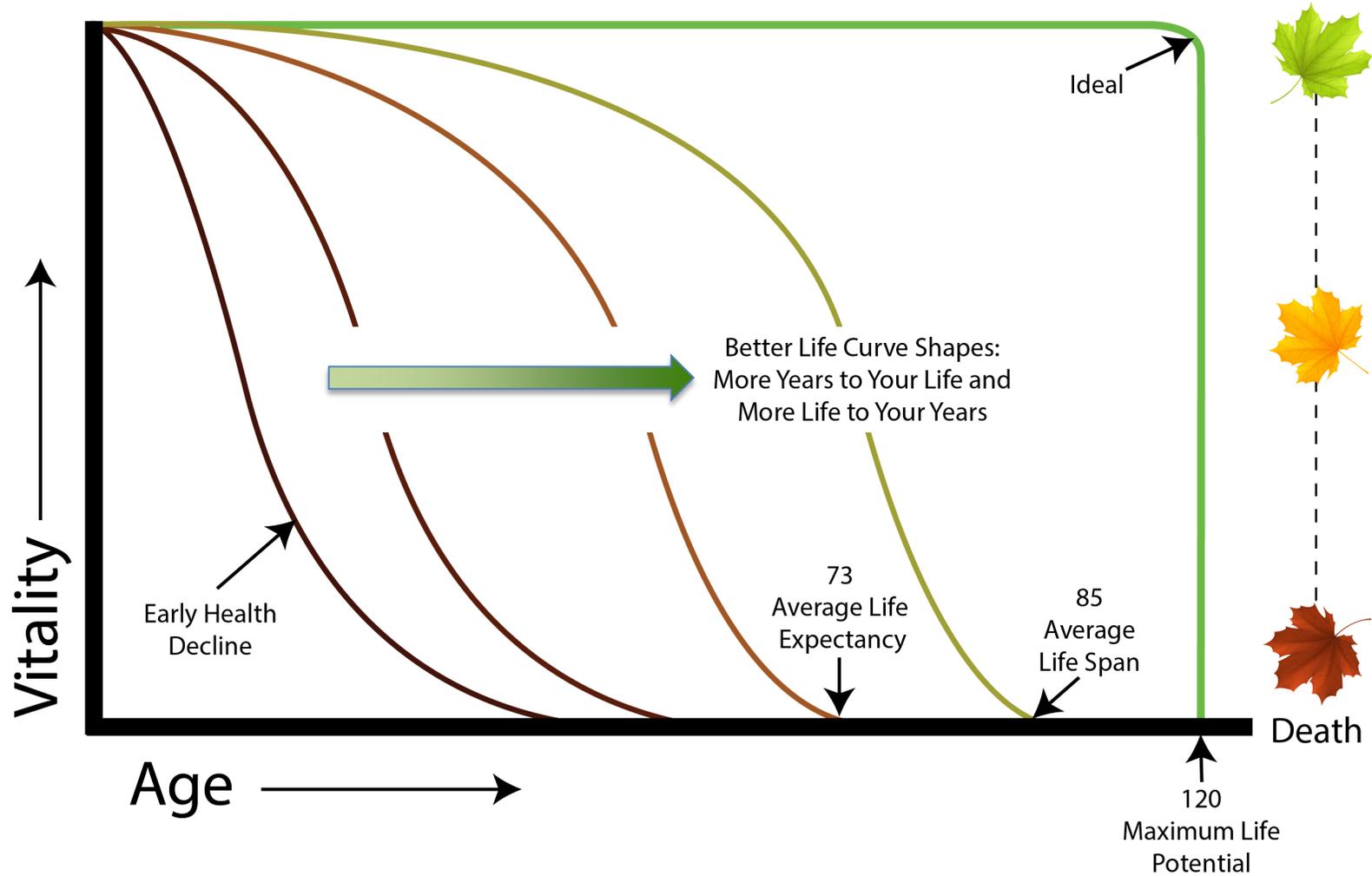
How to Live Longer
and Feel Better

LINUS PAULING

Is There a Way to Bridge the Gap
Between Lifespan and Healthspan?

Helping you live better
longer...

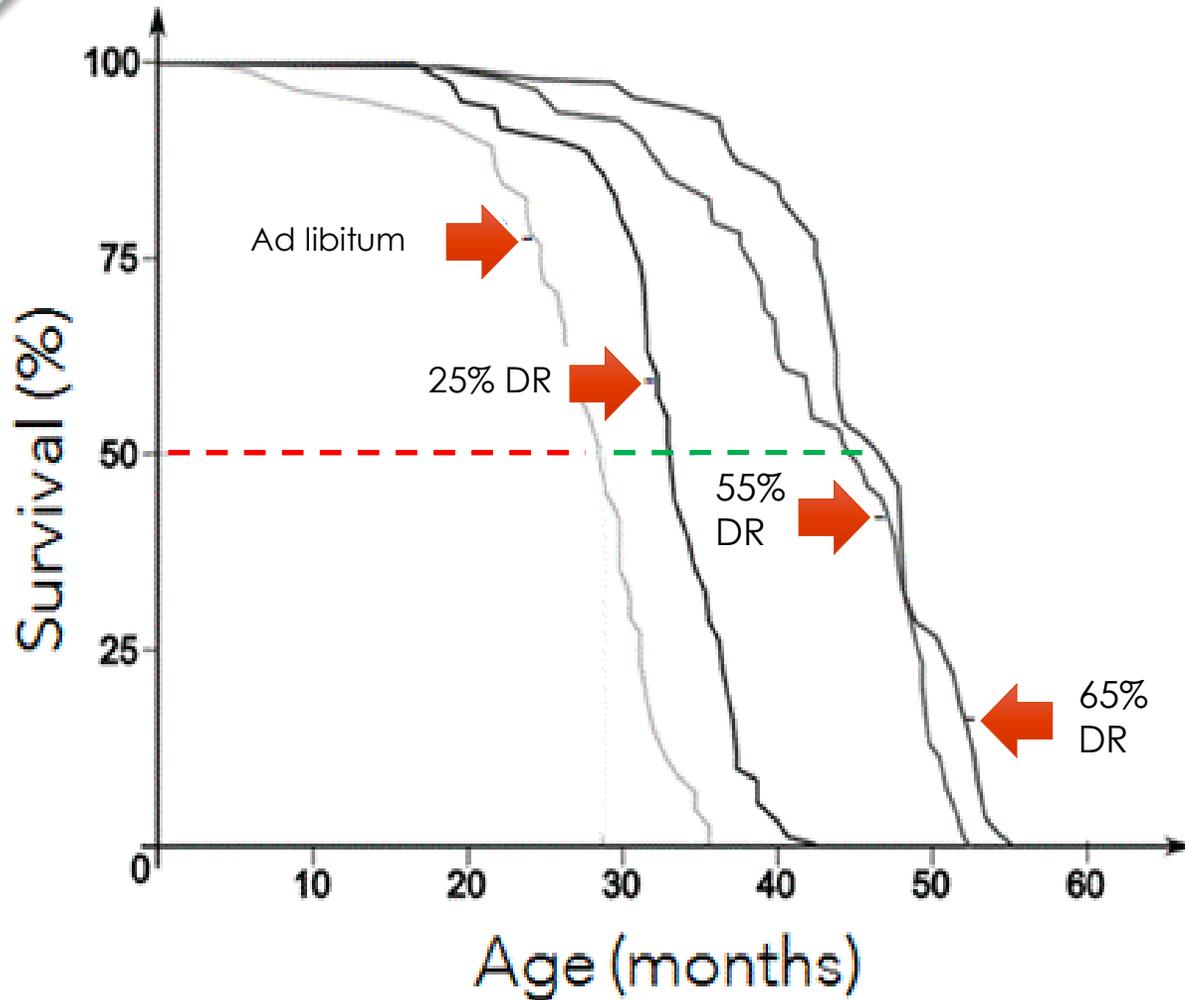
Improving Healthspan



Diet Directly Influences Many of the “Big Five” Risk Factors to Healthspan



Dietary Restriction (DR)
& Lifespan



Nutrient influence on healthy aging is being extensively studied in humans and in many animal models of aging

Dietary-restricted old mouse

Ad libitum fed old mouse

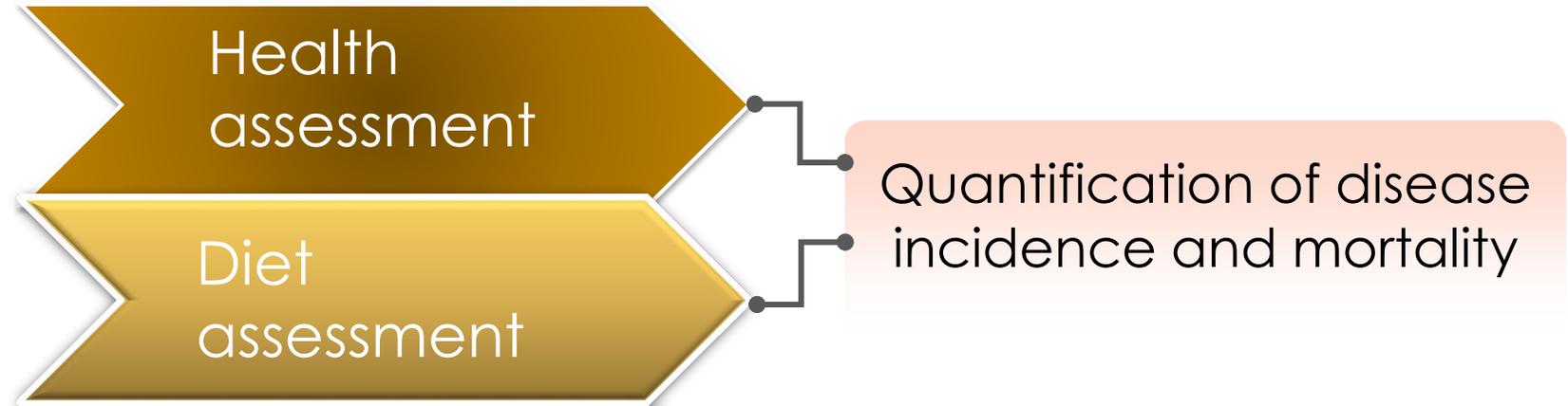


Food Quality Matters for Healthy Aging!

Those with an HEI of >80 (17% of the total) had fewer cardiovascular events, cancers, and diabetes than those with a poor HEI

Monitored over 13 year period

For Older Adults at least 65 years old at start:



Benefits of a quality (high HEI) vs. a poor diet (low HEI)

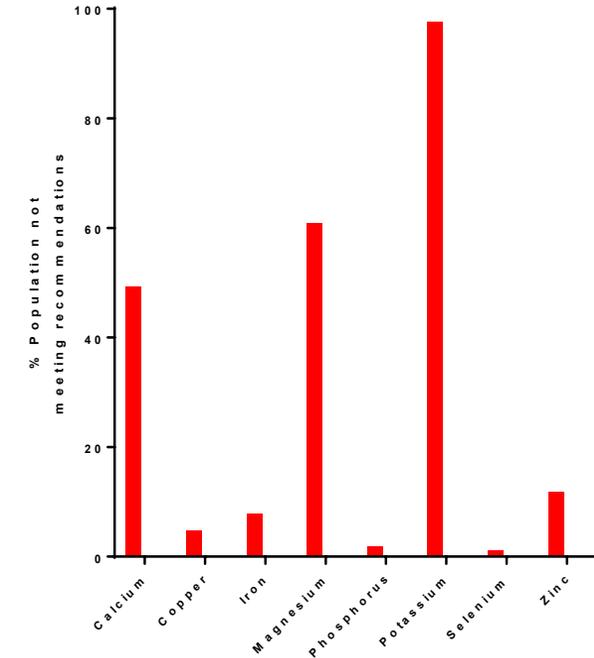
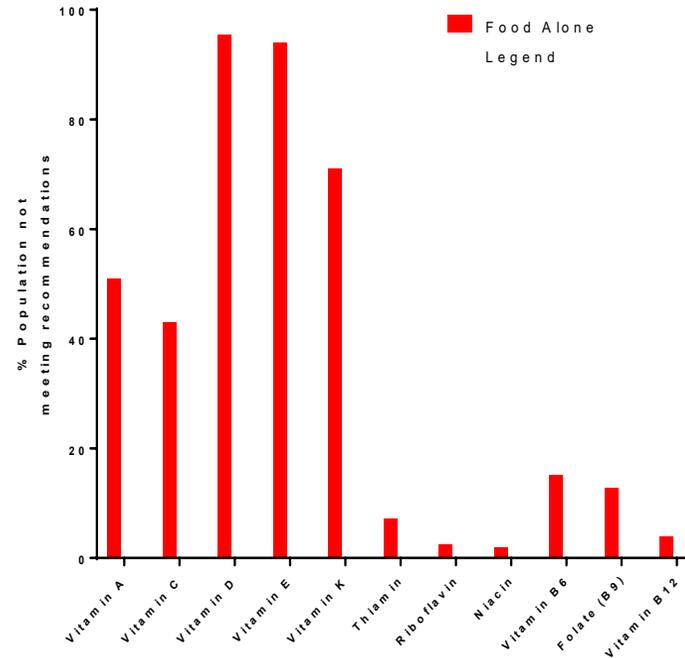
- 37% decrease in mortality incidence
- Lower mortality correlated with lower incidence of cardiovascular diseases, diabetes, and cancers



Quality Foods Also Supply Vitamins and Minerals Too!

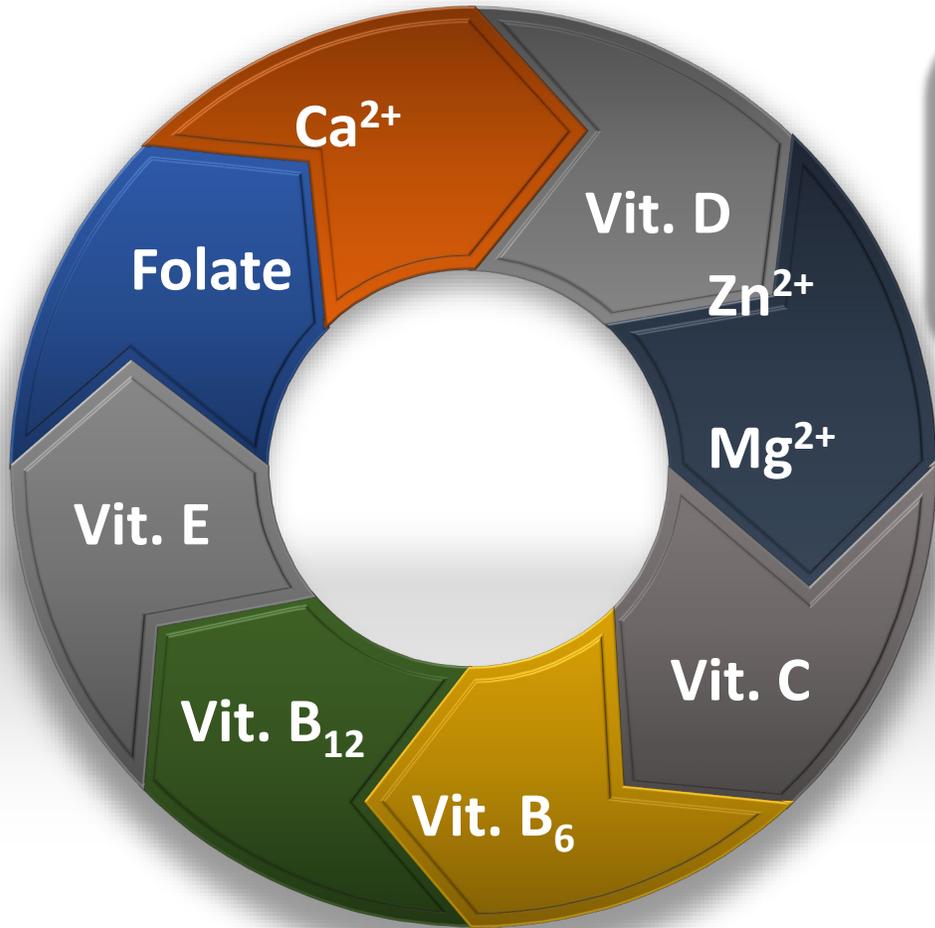
- Metabolism
- Energy
- Antioxidants
- Blood clotting
- Immune response

% Population Not Meeting Est.
Average Requirement



But even a high-quality diet isn't absolute assurance of an adequate intake of certain vitamins and minerals

Nutrient Shortfalls -People Experience Micronutrient Deficiencies Especially as we Age



- Anemia
- Immune Senescence
- "Inflamm-aging"
- Bioenergetic deficits



- ❖ Neuro-cognitive diseases
- ❖ Chronic infections
- ❖ Frailty syndromes
- ❖ Osteoporosis

Foundation for Healthy Aging

The LPI recommendations listed here are for men above the age of 50 and for postmenopausal women. These recommendations are from food and dietary supplements combined, unless otherwise indicated.

Vitamin B₆

Men and Women:
2 mg/day

Folate

Men and Women:
400 mcg/day of
supplemental folate
or folic acid

Vitamin B₁₂

Men and Women:
100-400 mcg/day
of supplemental B₁₂

Vitamin C

Men and Women:
At least 400 mg/day

Vitamin D

Men and Women:
2,000 IU/day from
dietary supplements

Vitamin E

Men and Women:
15 mg/day

Vitamin K

Men: 120 mcg/day
Women: 90 mcg/day

Calcium

Men (51+): 1000 mg/day
Men (71+): 1200 mg/day
Women: 1200 mg/day

Potassium

Men: 3400 mg/day
Women: 2600 mg/day

Zinc

Men: 11 mg/day
Women: 8 mg/day

Vitamin A

Men: 900 mcg/day
Women: 700 mcg/day
(limit retinol intake to
1500 mcg/day)

Iron

Men and Women:
8 mg/day
(no dietary supplements
containing iron)

Magnesium

Men: 420 mg/day
Women: 320 mg/day
(no more than 350 mg/day
in magnesium supplements)

Sodium

Men and Women:
2300 mg/day or less

EPA and DHA

Men and Women: Oily
fish twice/wk
Alternatively, 1 g/day
EPA/DHA supplements

The Immune System Foundation

The LPI recommendations are for adult men and adult women who are not pregnant or breast-feeding. These recommendations are from food and dietary supplements combined.

Vitamin A (including beta carotene)

Men: 900 µg/day
Women: 700 µg/day

Vitamin B₆

Men and Women:
1.3 mg/day

Vitamin E

Men and Women:
15 mg/day

DHA

Eat oily fish
2 times per week

Vitamin B₁₂

Men and Women:
2.4 µg/day

Folate

Men and Women:
400 µg/day

Copper

Men and Women:
900 µg/day

Selenium

Men and Women:
55 µg/day

Vitamin C

Men and Women:
400 mg/day

Vitamin D

Men and Women:
2,000 IU/day

Iron

Men: 8 mg/day
Women: 18 mg/day
(See note below)

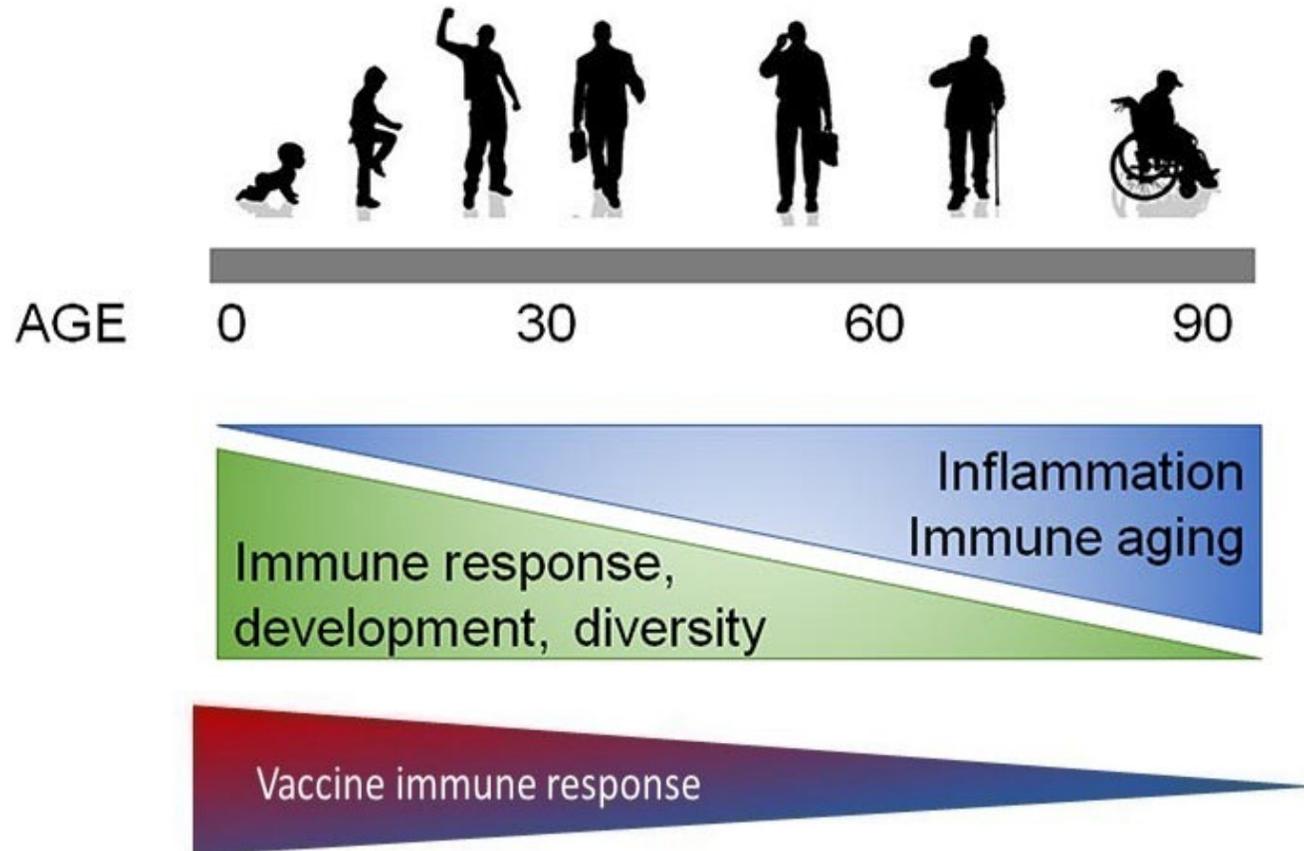
Zinc

Men: 11 mg/day
Women: 8 mg/day

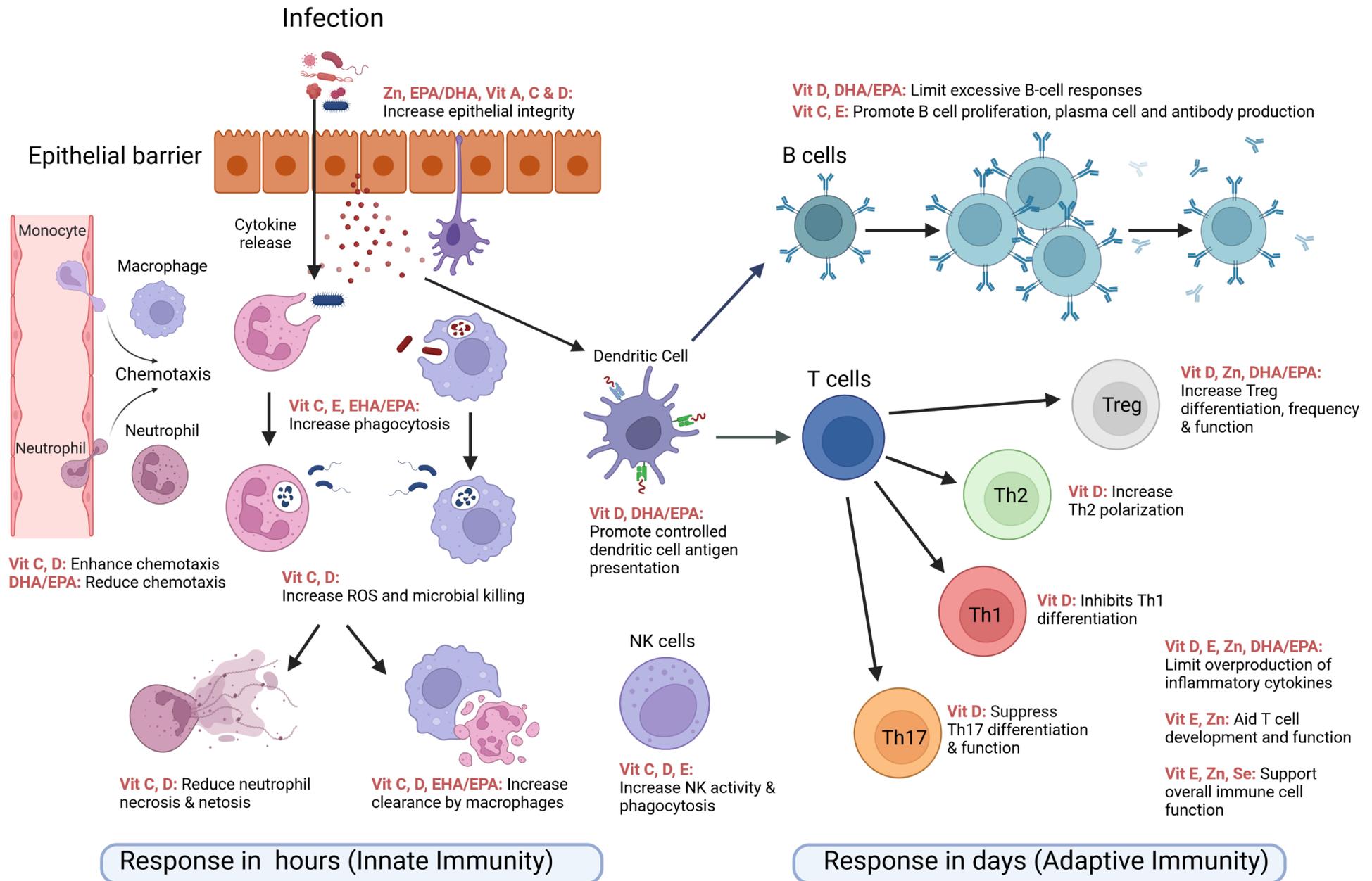
Special note:

Before menopause, women need 18 mg of iron per day. Following menopause, this recommendation decreases to 8 mg per day.

Aging is associated with compromised immune system

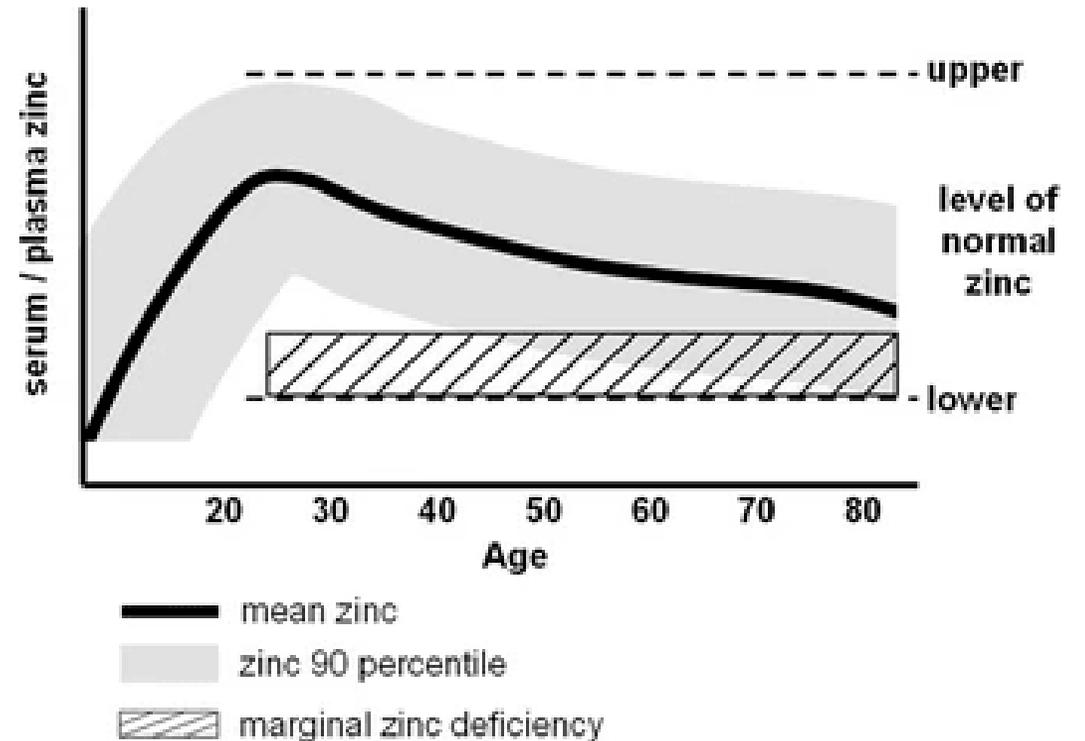


- Increased susceptibility to infectious diseases
- Reduced vaccine efficacy
- Increased chronic inflammation



Aging is associated with reduced zinc status

- Prevalence of inadequate zinc intake is higher in older adults
- Possible age-related changes in absorption and/or retention



The immune system provides three levels of defense against disease-causing organisms:

1

BARRIERS

Prevent entry

- Skin and mucus membranes
- Stomach acid and digestive enzymes
- Beneficial bacteria that live in the colon (the gut microbiota)

2

INNATE IMMUNITY

General defense

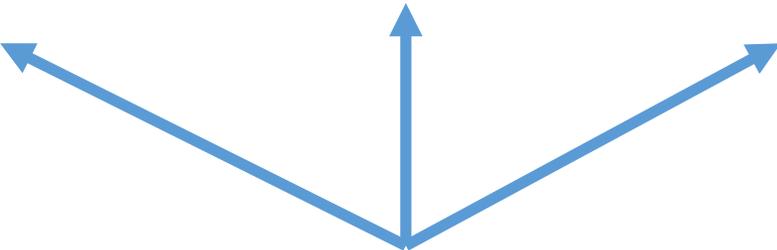
WBCs called neutrophils and macrophages engulf and destroy foreign invaders and damaged cells

3

ACQUIRED IMMUNITY

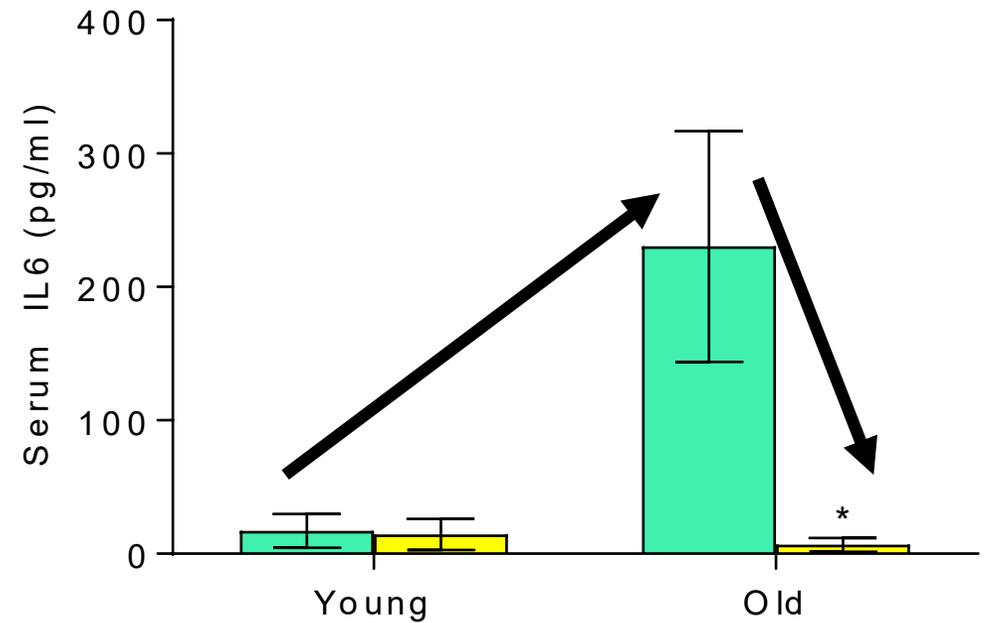
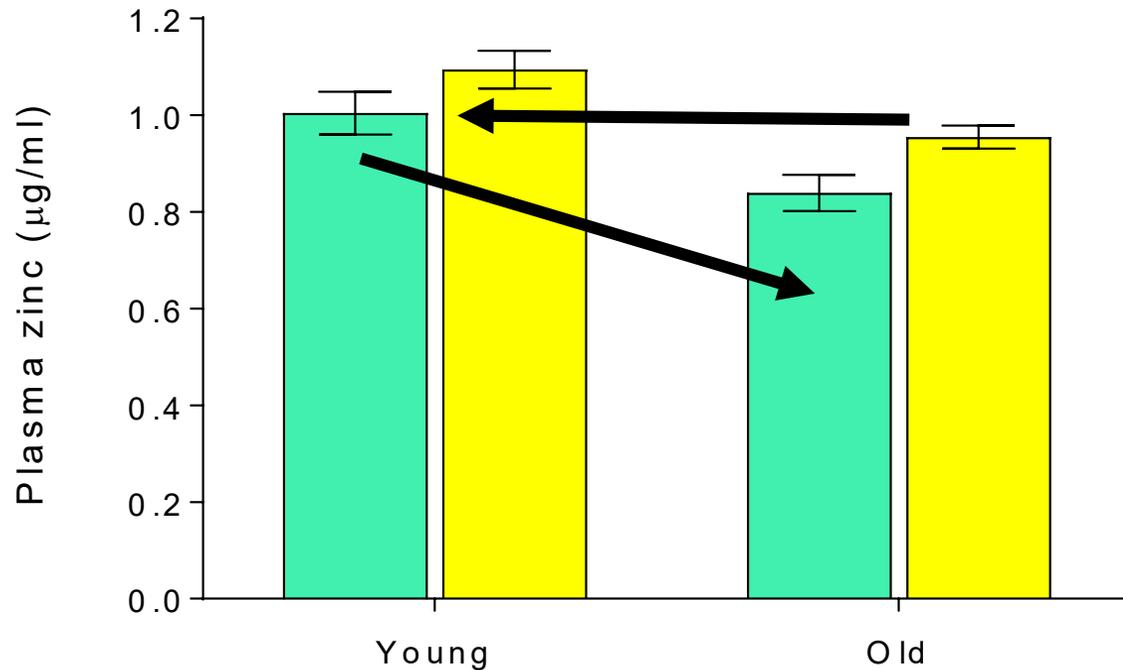
Specific defense

- WBCs called T lymphocytes (T cells) target and destroy infected or cancerous cells
- WBCs called B lymphocytes (B cells) and plasma cells produce antibodies that target and destroy infected or cancerous cells

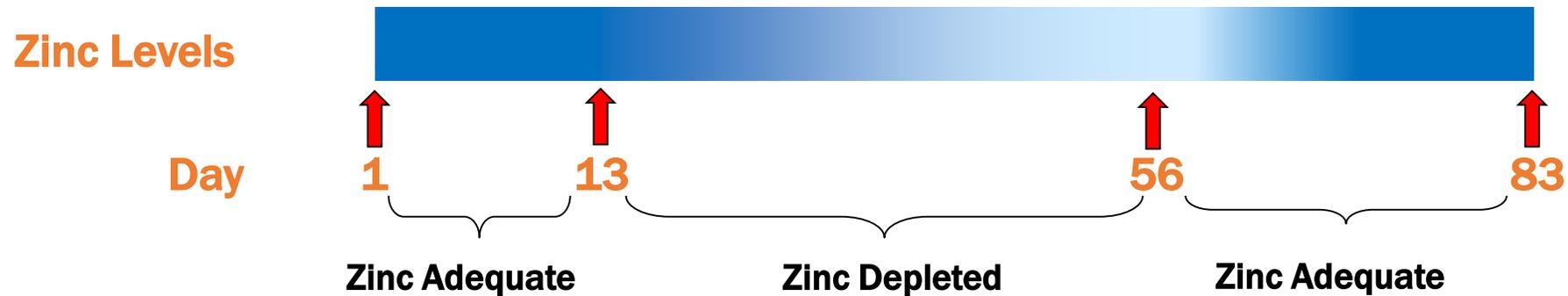


ZINC is critical for each of these functions!

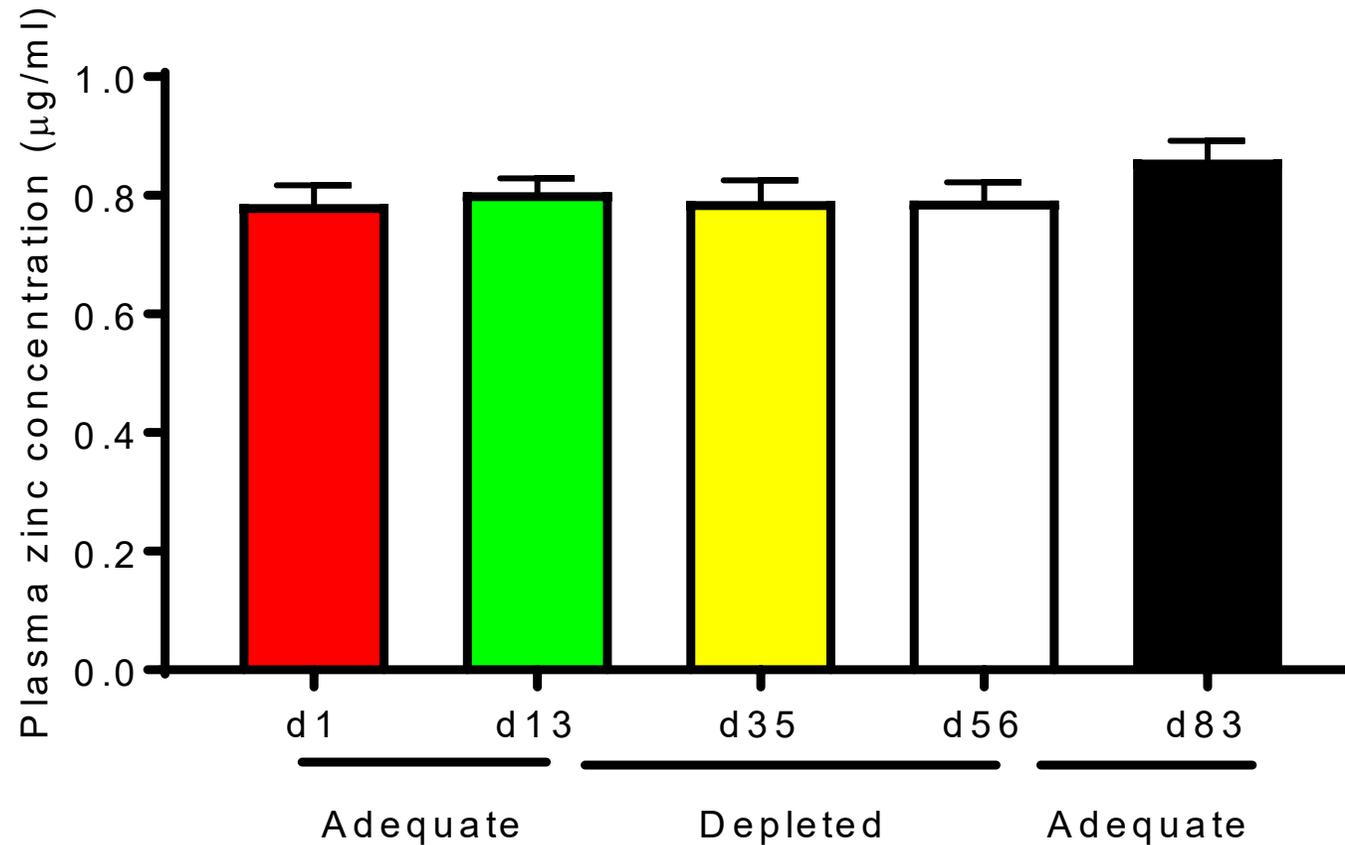
Dietary zinc supplementation reduces age-associated inflammation



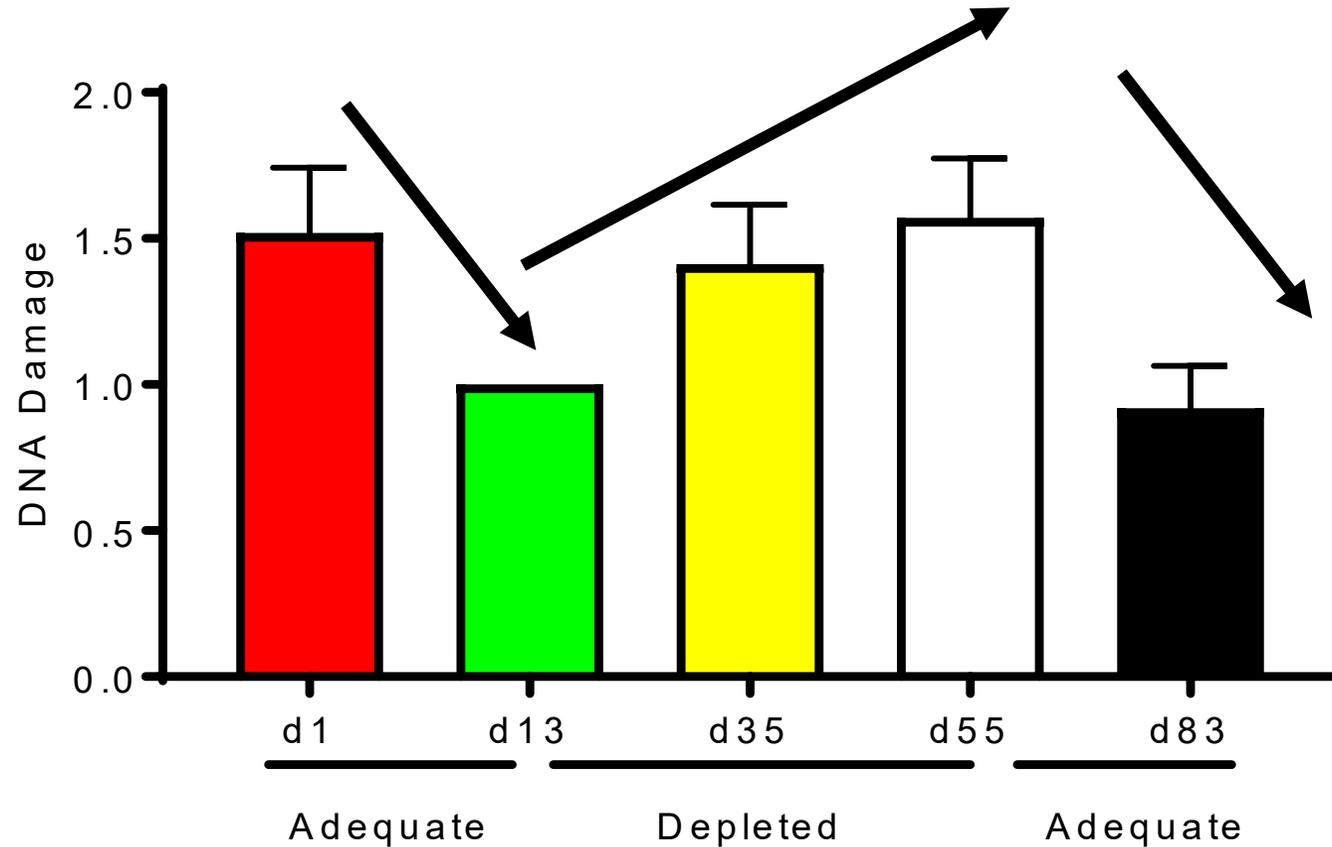
Challenge #1 – Identifying markers of nutrient status: example zinc deficiency



No change in plasma zinc!



But lack of zinc does cause some functional changes...



Zinc

Zn

up to **40 mg**
per day

Immune functions:

Zinc is required for the growth and development of immune cells. Zinc is a structural component of proteins critical for normal immune function. It is also important for the synthesis of antibodies.

Why take a supplement?

Extra zinc might help if you feel a cold coming on. Older adults are more susceptible to zinc deficiency.

Caution:

Try not to exceed 40 mg of zinc a day from a combination of diet and supplements.

Article

The Effect of a Multivitamin and Mineral Supplement on Immune Function in Healthy Older Adults: A Double-Blind, Randomized, Controlled Trial

Mary L. Fantacone ¹, Malcolm B. Lowry ², Sandra L. Uesugi ³, Alexander J. Michels ³ ,
Jaewoo Choi ³, Scott W. Leonard ³, Sean K. Gombart ³, Jeffrey S. Gombart ³, Gerd Bohe ^{4,†} 
and Adrian F. Gombart ^{1,*†} 

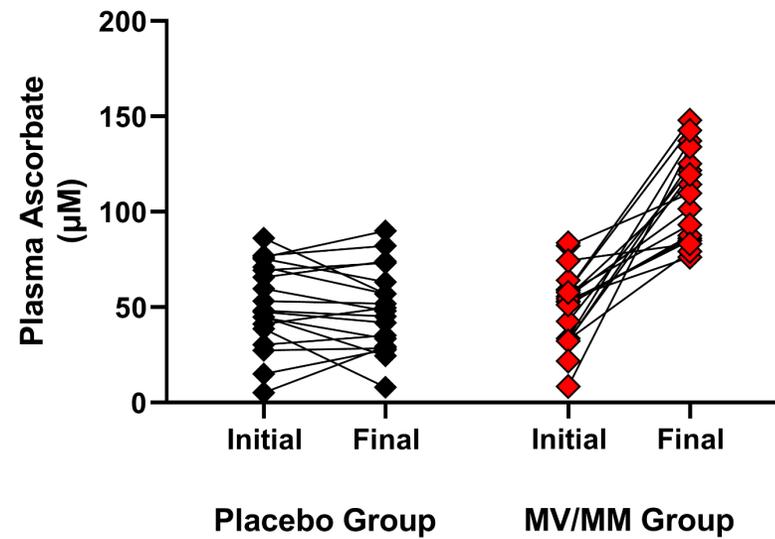
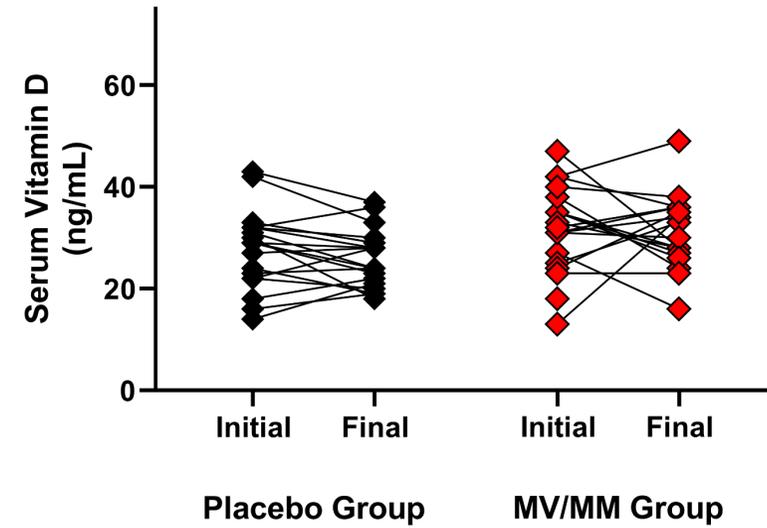
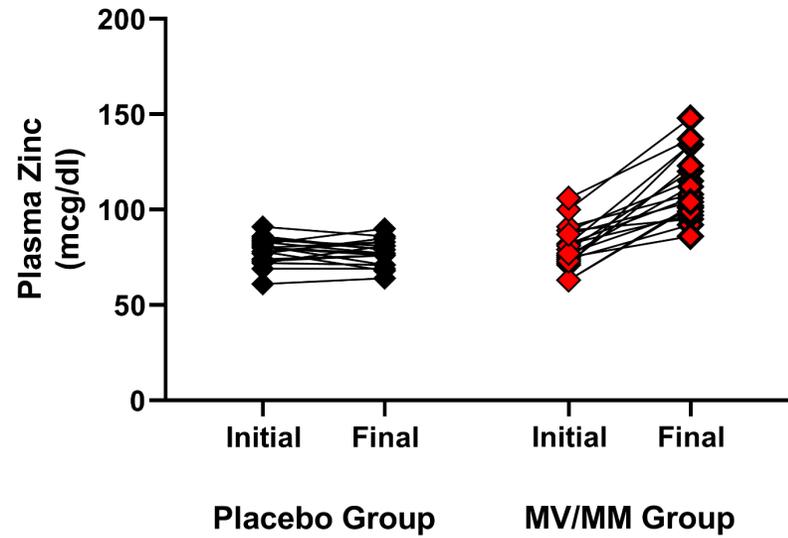
MultiVitamin/MultiMineral Older Adult Study

- Relatively healthy population of men and women
- 55-75 years of age
- Vitamin D > 25ng/dl
- Daily MVM supplement for 12 weeks

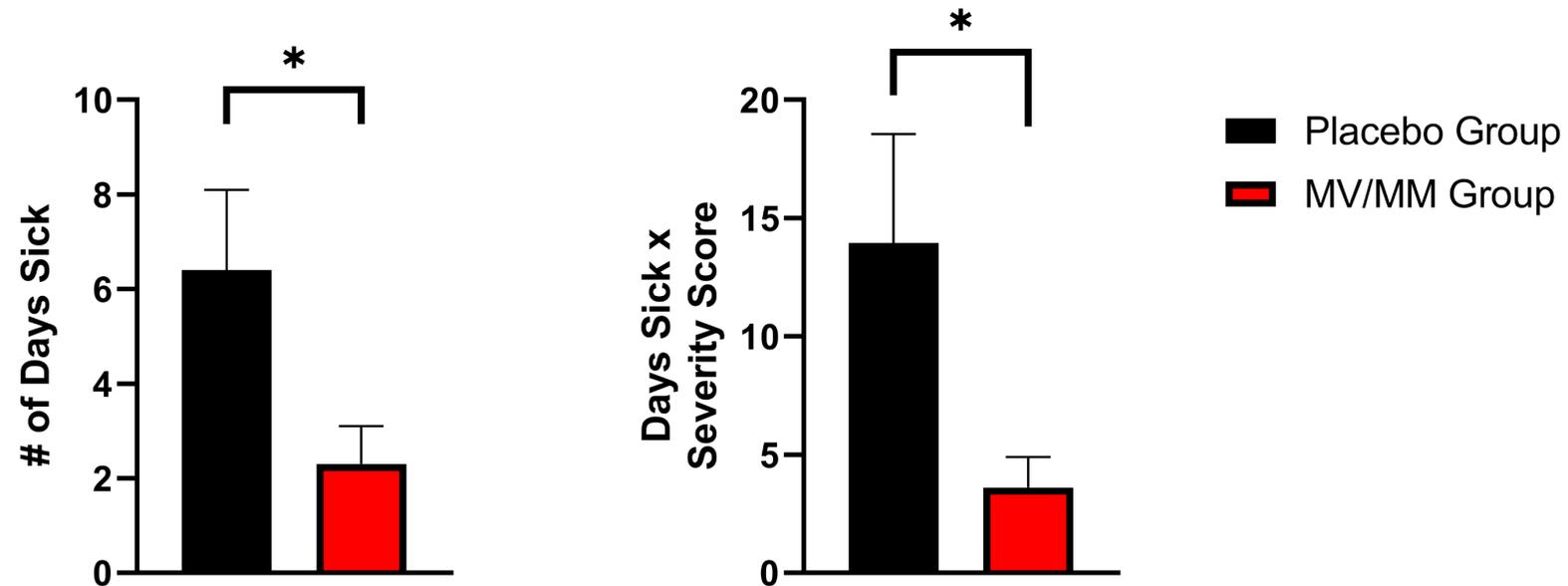
- Cold symptoms assessed by Wisconsin Upper Respiratory Symptom Survey

Redoxon®

Active Ingredients	Units	Amount	RDA	UL
Vitamins				
Vitamin A	µg	700	700	3000
Vitamin D	IU	400	600	4000
Vitamin E	mg	45	15	1000
Vitamin B6	mg	6.6	1.3	100
Folate	µg	400	400	1000
Vitamin B12	µg	9.6	2.4	-
Vitamin C	mg	1000	75	2000
Trace Elements				
Iron	mg	5	18	45
Copper	mg	0.9	0.9	10
Zinc	mg	10	8	40
Selenium	µg	110	55	400
Other Ingredients				
Microcrystalline cellulose, magnesium stearate, hydroxylpropylmethylcellulose, hydroxypropylcellulose hypromellose, titanium dioxide, microcrystalline cellulose, iron oxide yellow, sodium croscarmellose, and talc.				



MVM supplementation decreased self-reported illness



MVM supplementation in older adults

- Healthy population of older men
 - All above the age of 67
 - Generally healthy diet, tended to be active
 - 6 month intervention
-
- Some inadequacies, but more suboptimal blood nutrients biomarkers

Supplementary Table 1. Active Ingredients in Centrum Silver Men's Formula

Nutrient	Amount Per Tablet	% Daily Value	Nutrient	Amount Per Tablet	% Daily Value
Vitamin A	1050 mcg ¹	117%	Calcium	210 mg	16%
Vitamin C	120 mg	133%	Phosphorus	20 mg	2%
Vitamin D	25 mcg	125%	Iodine	150 mcg	100%
Vitamin E	?-40-? mcg	200%	Magnesium	75 mg	18%
Vitamin K	60 mcg	50%	Zinc	15 mg	100%
Thiamin	1.5 mg	125%	Selenium	21 mcg	38%
Riboflavin	1.7 mg	131%	Copper	0.5 mg	56%
Niacin	20 mg	125%	Manganese	4 mg	174%
Vitamin B ₆	6 mg	353%	Chromium	60 mcg	171%
Folate	300 mcg	125%	Molybdenum	50 mcg	111%
Vitamin B ₁₂	100 mcg	4167%	Chloride	72 mg	3%
Biotin	30 mcg	100%	Potassium	80 mg	2%
Pantothenic Acid	10 mg	200%	Nickel	5 mcg	- ²
Lutein	300 mcg	- ²	Silicon	2 mg	- ²
Lycopene	600 mcg	- ²	Vanadium	10 mcg	- ²

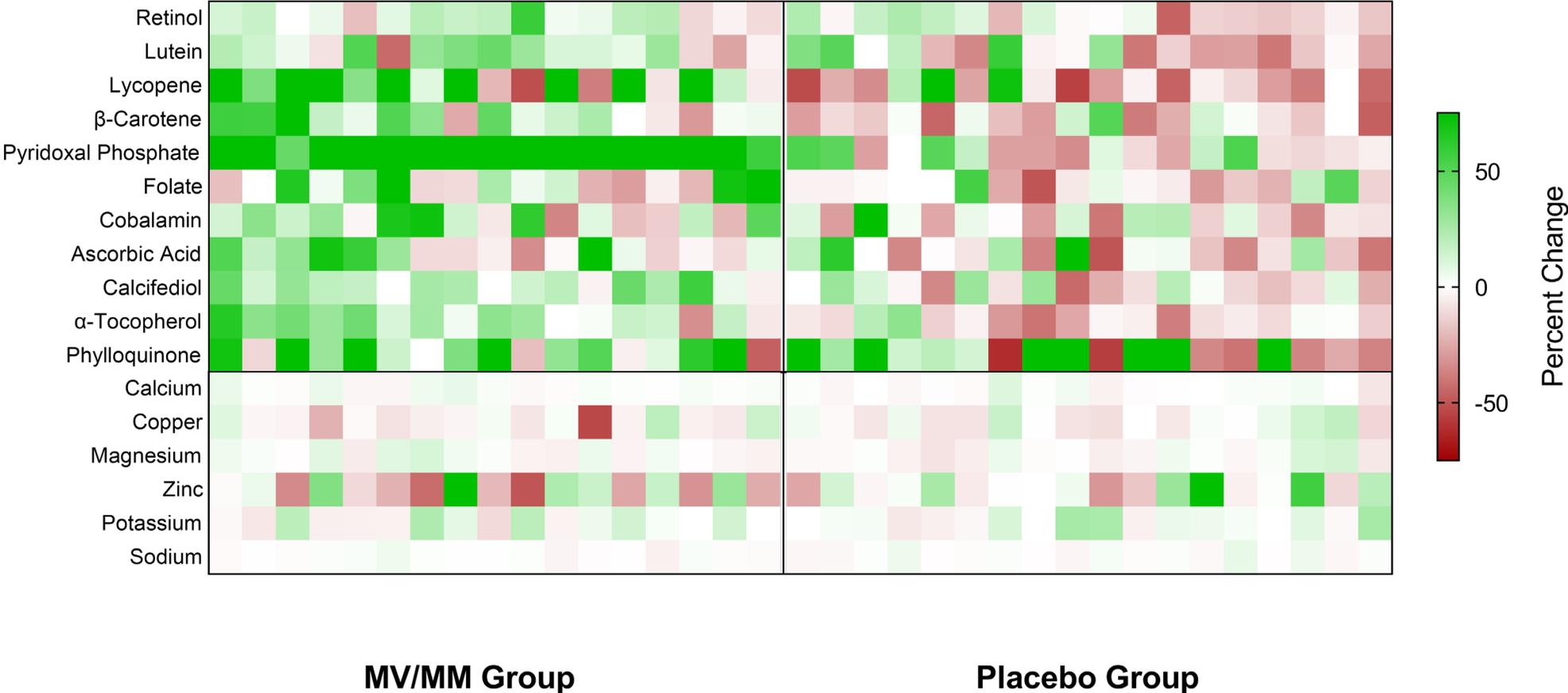
¹29% of the Daily Value for vitamin A is present as β -carotene

²Daily Value not established for these factors

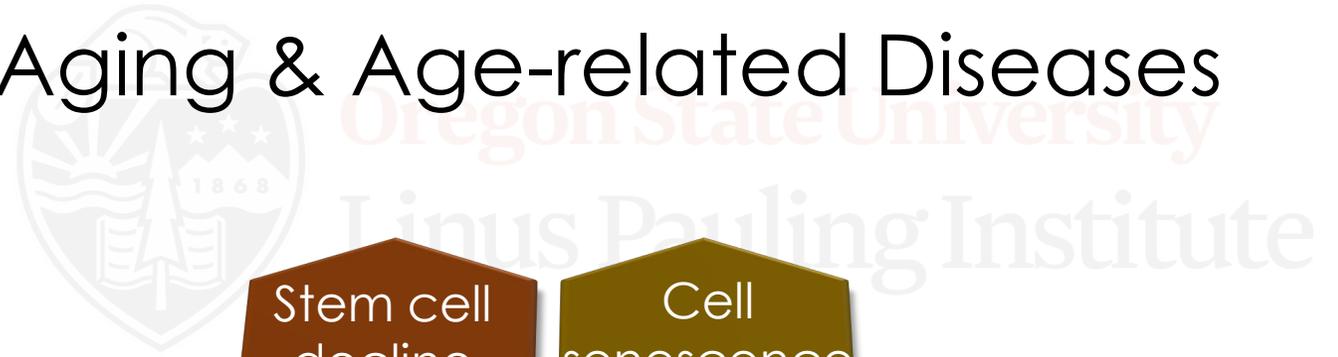
Estimated Micronutrient Intakes for Study Participants

Micronutrient	Average Intake	% below RDA
Vitamin D	8.4 ± 4.7 µg	100%
Vitamin E	12.3 ± 3.0 mg	79%
Choline	424 ± 116 mg	85%
Potassium	4092 ± 941 mg	76%
Calcium	1464 ± 521 mg	33%
Magnesium	466 ± 102 mg	33%
Vitamin A	1307 ± 607 mg RAE	21%
Vitamin C	149 ± 62 mg	15%
Pantothenic Acid	7.4 ± 1.9 mg	12%
Vitamin B ₁₂	7.4 ± 3.4 mcg	12%
Zinc	15.1 ± 3.8 mg	9%
Folate	727 ± 288 mg	6%
Selenium	122 ± 35 mcg	3%

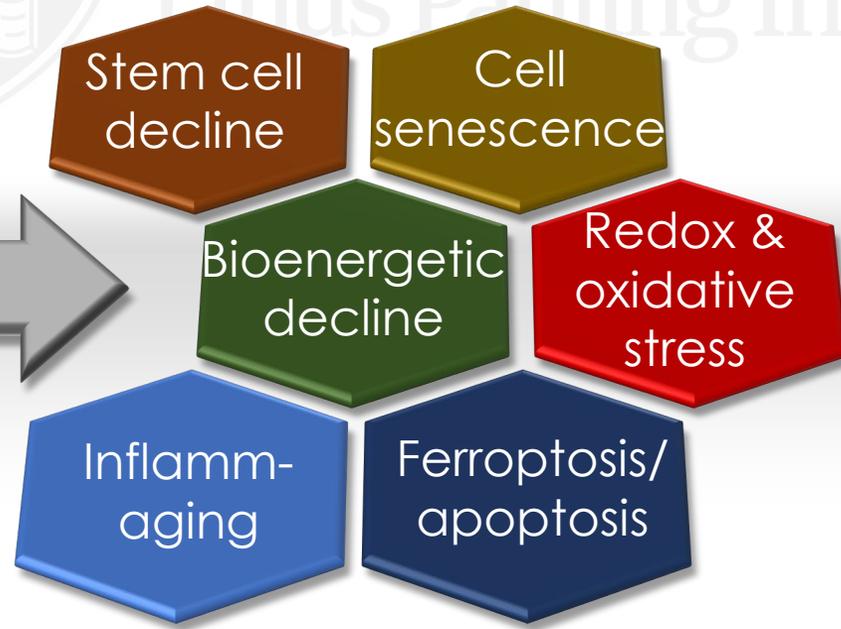
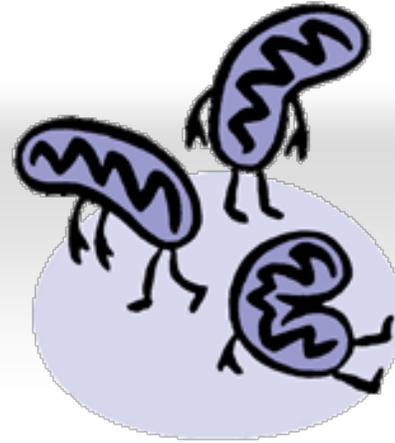
Changes in blood micronutrient concentrations



Mitochondrial Decay in Aging & Age-related Diseases



Mitochondrial decay



Micronutrients



Mitochondria

What is holding us back in realizing optimal health as we age?

- Need for better biomarkers of nutrient status
- Need for better biomarkers of healthspan and optimal health
- It's COMPLICATED!!
 - Precision Nutrition and Health

CURRENT DISCRETE CLINICAL DATA

EMERGING HIGH-THROUGHPUT DATA

ENVIRONMENT

Drugs prescribed



Survey instruments



Clinical labs



Interpreted variants in single genes



Diagnostic imaging



Family History Pedigree



Patient signs and symptoms



GENETICS

PHENOTYPIC FEATURES

Diet



Exercise



Biomonitoring



Environmental Exposures



Wearables



Microbiome



Metabolomics



Epigenomics
Gene panels
Exomes (WES)
Genomes (WGS)

Pedigree analysis



ONE SIZE DOES NOT FIT ALL

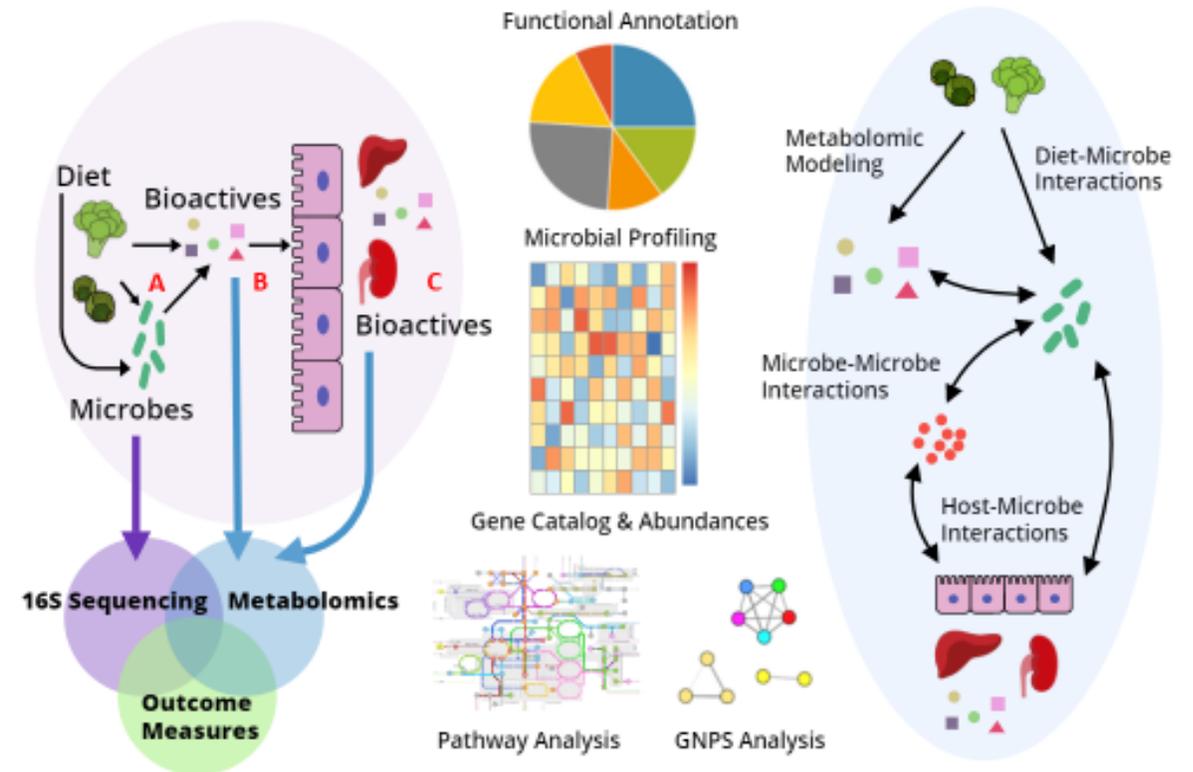
Precision Health

COLLABORATION INTEGRATION



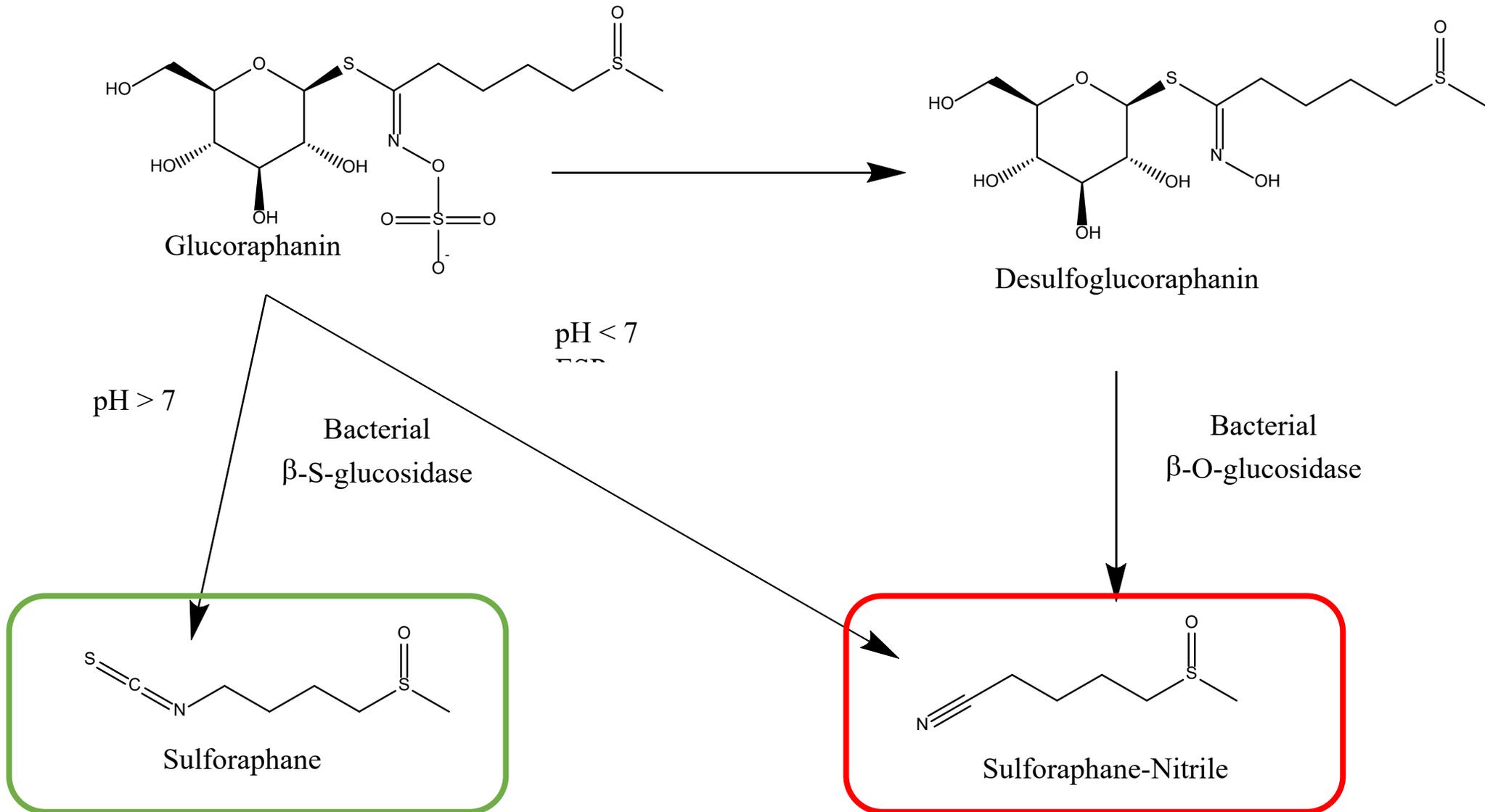
Personalized Health - The Human Microbiome

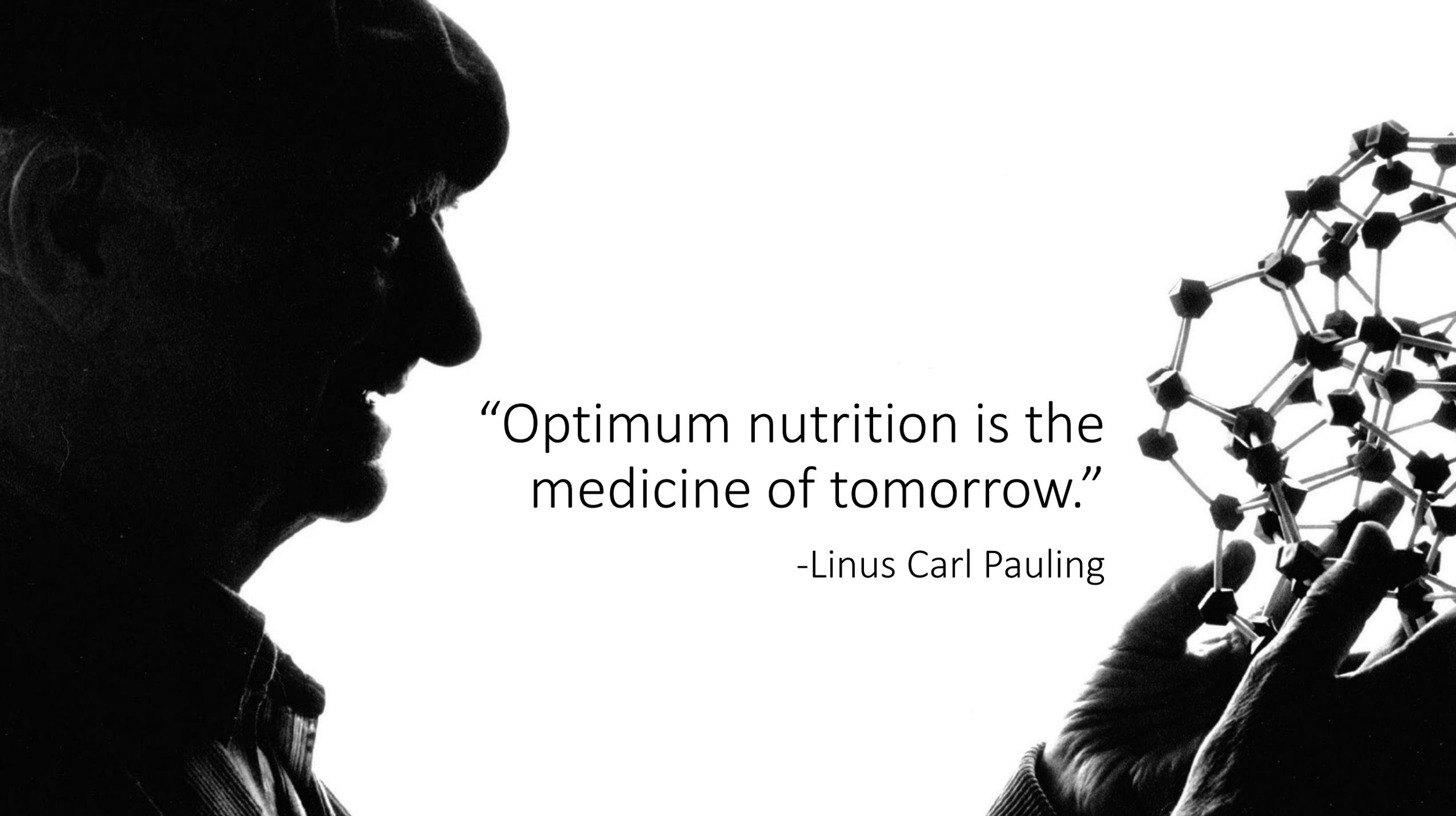
- The microbiome is an umbrella term for the community of microbes which live on and in us
- A growing body of evidence implicates the gut microbiome as playing an intimate role in human health





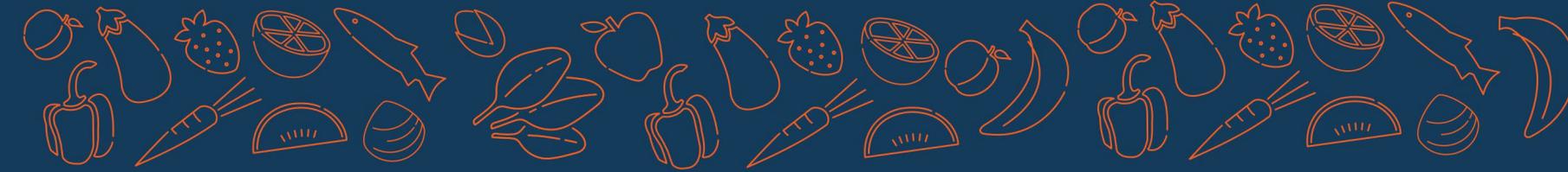
The Microbiome Determines Bioactivity





“Optimum nutrition is the
medicine of tomorrow.”

-Linus Carl Pauling



Continuing Education Courses from the Micronutrient Information Center

MEETING MICRONUTRIENT NEEDS

Learn who is at risk for vitamin and mineral inadequacies and the remedy.

LENGTH:
2 hours

PRICE:
\$20



MICRONUTRIENTS AND BONE HEALTH

Learn about the roles of micronutrients in achieving and maintaining optimal bone health throughout the lifespan.

LENGTH:
1.5 hours

PRICE:
\$15

CREDITS (each course):
National Academy of Sports Medicine: **0.2 CEUs**
Athletics and Fitness Association of America: **2 CEUs**

lpi.oregonstate.edu/cpe

ACCREDITATIONS:



Micronutrient Information Center

- 1.5+ million users from 230 countries
- Three languages: English, Spanish, and Japanese
- One of the most visited sites at Oregon State University
- Most popular articles: Essential Fatty Acids, Glycemic Index, and Vitamin C



<https://lpi.oregonstate.edu/MIC>

Oregon State University
Linus Pauling Institute » **Micronutrient Information Center**

ABOUT ARTICLES RESOURCES HEALTH & DISEASE GIVING ESPAÑOL 日本語

Other Nutrients » Essential Fatty Acids

Essential Fatty Acids

Contents

- Summary
- Introduction
- Metabolism and Bioavailability
- Biological Activities
 - Membrane structure and function
 - Vision
 - Nervous system
 - Synthesis of lipid mediators
 - Regulation of gene expression
- Deficiency
 - Essential fatty acids
 - Omega-3 fatty acid deficiency
 - Omega-3 index

日本語

Summary

- Linoleic acid (LA), an omega-6 fatty acid, and alpha-linolenic acid (ALA), an omega-3 fatty acid, are considered essential because they cannot be synthesized by humans (*More information*)
- The long-chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), can be synthesized from ALA but due to low conversion efficiency, it is recommended to consume foods rich in EPA and DHA. (*More information*)
- Both omega-6 and omega-3 fatty acids are important components of cell membranes, serve as precursors of lipid mediators, and provide a source of energy. Long-chain omega-3 polyunsaturated fatty acids (PUFA) in particular exert anti-inflammatory effects; it is recommended to increase their presence in the diet. (*More information*)
- Both dietary intake and endogenous metabolism influence whole

IODINE

MAIN FUNCTIONS

- Structural component of thyroid hormones
- Thus, important for the regulation of body temperature, basal metabolic rate, growth, and reproduction

DAILY RECOMMENDATION

150 µg

All Adults

Seafood
fish · shrimp · seaweed
• Cod, 3 ounces, 99 µg

GOOD SOURCES
Dairy milk
• Cow's milk, 1 cup, 16 µg

SPECIAL CONSIDERATIONS
• Seafood is rich in iodine but avoid iodine from seawater.
• The Recommended Dietary Allowance (RDA) for iodine is significantly increased during pregnancy (220 µg/day) and breast-feeding (290 µg/day).

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Table 6. Adequate Intake (AI) for Omega-6 Fatty Acids (1)

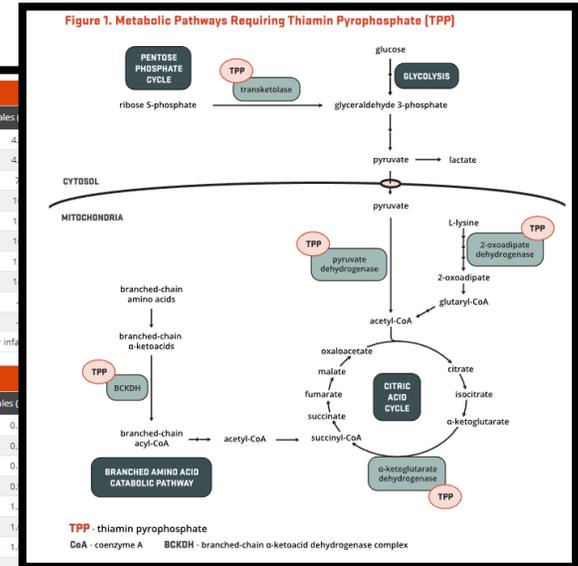
Life Stage	Age	Source	Males (g/day)	Females (g/day)
Infants	0-6 months	Omega-6 PUFA*	4	4
Infants	7-12 months	Omega-6 PUFA*	4	4
Children	1-3 years	LA#	5	5
Children	4-8 years	LA	9	9
Children	9-13 years	LA	11	11
Adolescents	14-18 years	LA	13	13
Adults	19-50 years	LA	17	17
Adults	51 years and older	LA	17	17
Pregnancy	all ages	LA	17	17
Breast-feeding	all ages	LA	17	17

*The various omega-6 polyunsaturated fatty acids (PUFA) present in human milk can contribute to the AI for infants.

Table 7. Adequate Intake (AI) for Omega-3 Fatty Acids (1)

Life Stage	Age	Source	Males (g/day)	Females (g/day)
Infants	0-6 months	ALA, EPA, DHA*	0.5	0.5
Infants	7-12 months	ALA, EPA, DHA	0.5	0.5
Children	1-3 years	ALA	0.5	0.5
Children	4-8 years	ALA	0.9	0.9
Children	9-13 years	ALA	1.1	1.1
Adolescents	14-18 years	ALA	1.3	1.3
Adults	19 years and older	ALA	1.6	1.6
Pregnancy	all ages	ALA	1.6	1.6
Breast-feeding	all ages	ALA	1.6	1.6

*All omega-3 polyunsaturated fatty acids present in human milk can contribute to the AI for infants. ALA, alpha-linolenic acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.



Biochemical pathways & Function

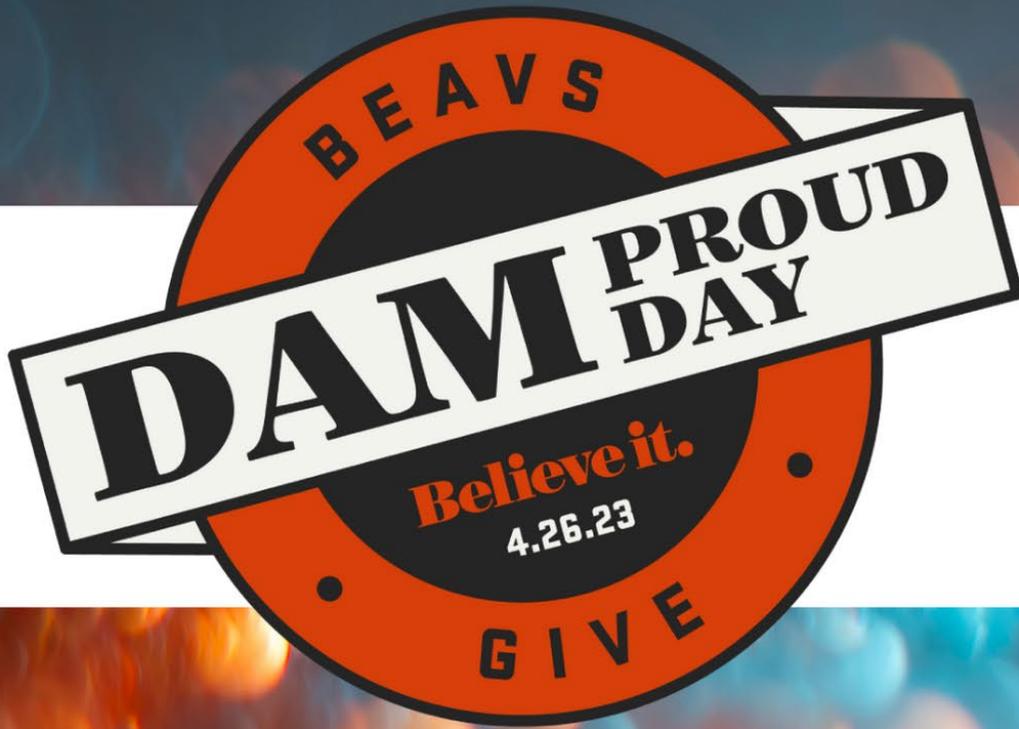
Dietary Reference Tables

Nutrient Flashcards & Infographics

Find out more!

- Subscribe to our [newsletter and email updates](#)
- Check out the **Micronutrient Information Center** and the **LPI Webinar Series**

All this and more at:
lpi.oregonstate.edu



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All gifts received on **April 26th** will help make Dam Proud Day a success!

Participate in our
24 hour challenge
on April 26th!



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For more information see: lpi.pub/DamProud

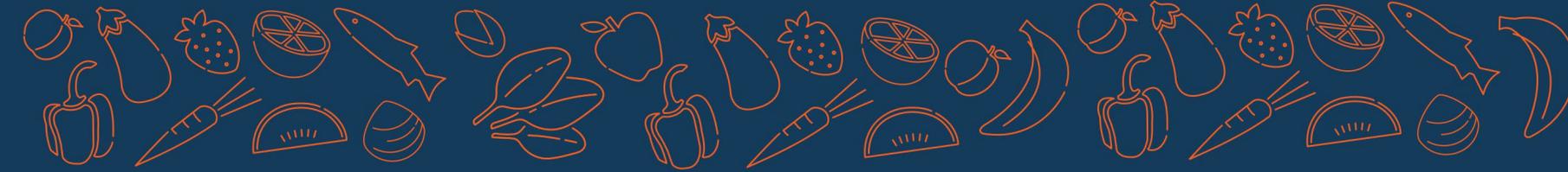
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