The Vital Fat-Soluble Vitamins

Presented by Chris Masterjohn, PhD

September, 2013 Regional Wise Traditions Conference
Portland, OR

The Major Sources of Vitamins A and D

Liver – Vitamin A

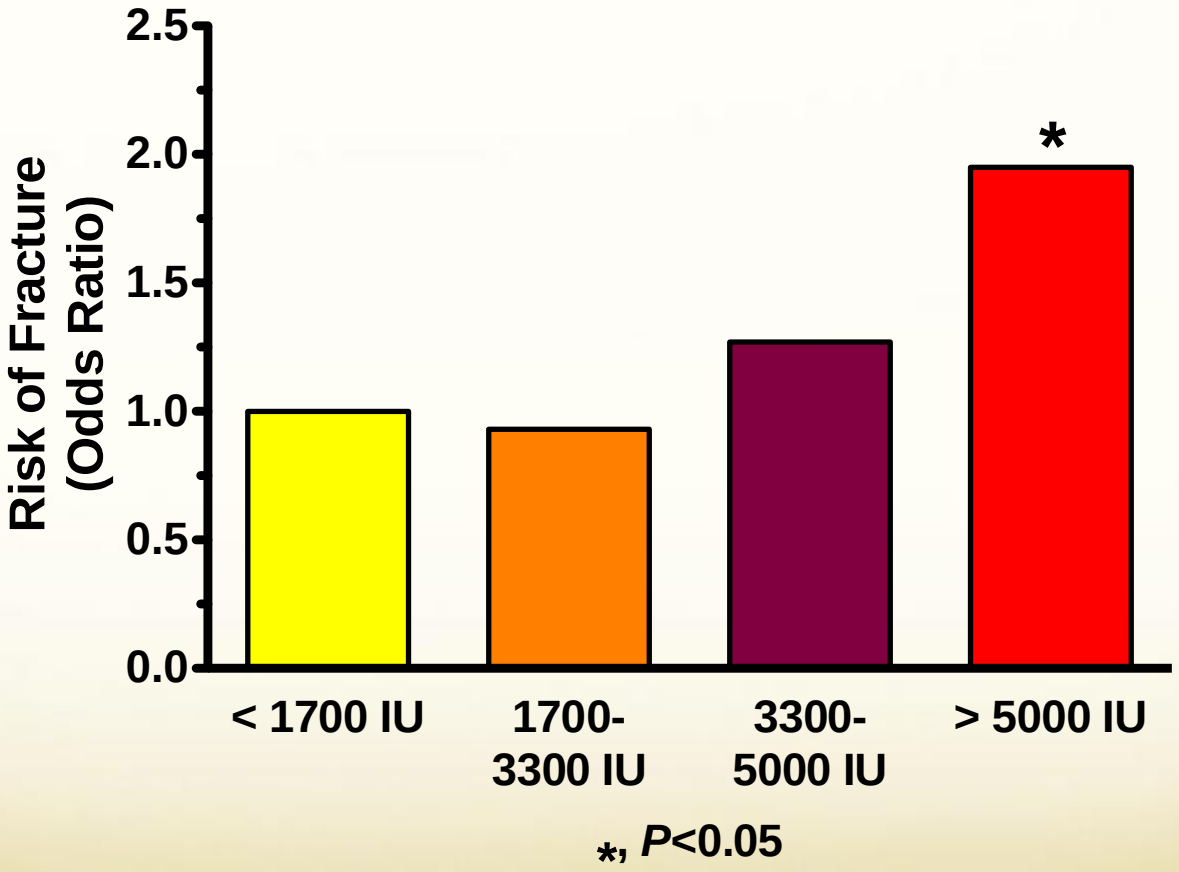
Sunshine – Vitamin D

Cod Liver Oil –
Vitamins A and D

My *Wise Traditions* Articles Through Spring, 2007

- **Fall, 2004** – Vitamin A: The Forgotten Bodybuilding Nutrient
- **Spring, 2005** – The China Study
- **Fall, 2005** – Dioxins in Animal Foods: A Case for Vegetarianism?
- **Winter, 2005/Spring, 2006** – Vitamin A on Trial: Does Vitamin A Cause Osteoporosis?
- **Fall, 2006** – From Seafood to Sunshine: A New Understanding of Vitamin D Safety
- **Spring, 2007** – On the Trail of the Elusive X-Factor: A 62-Year Mystery Finally Solved

Vitamin A Intake Greater Than 5,000 IU Associated With the Risk of Hip Fracture in Sweden

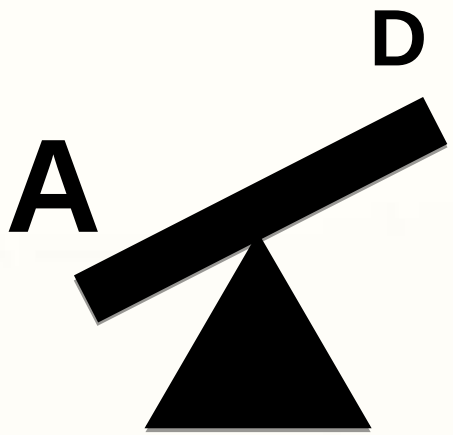


Melhus et al. Excessive dietary intake of vitamin A is associated with reduced bone mineral density and increased risk for hip fracture. Ann Intern Med. 1998;129(10):770-8.

Vitamins A and D Protect Against Each Other's Toxicity and Increase the Need for Each Other

- Massive doses of vitamin A cause bone loss in animals, but massive doses of vitamin D offer complete protection.
- Massive doses of vitamin D cause soft tissue calcification in animals, but massive doses of vitamin A offer complete protection.
- Even modest amounts of one vitamin can deplete the storage supply of the other.
- These interactions occur even if vitamin D is provided by ultraviolet light or both vitamins are provided by injection.

Vitamin A Contributes to Bone Loss Only When Vitamin D Is Limiting



Elevated Phosphorus
Depressed Calcium

Bone Loss

The Major Sources of Vitamins A and D

Liver – Vitamin A

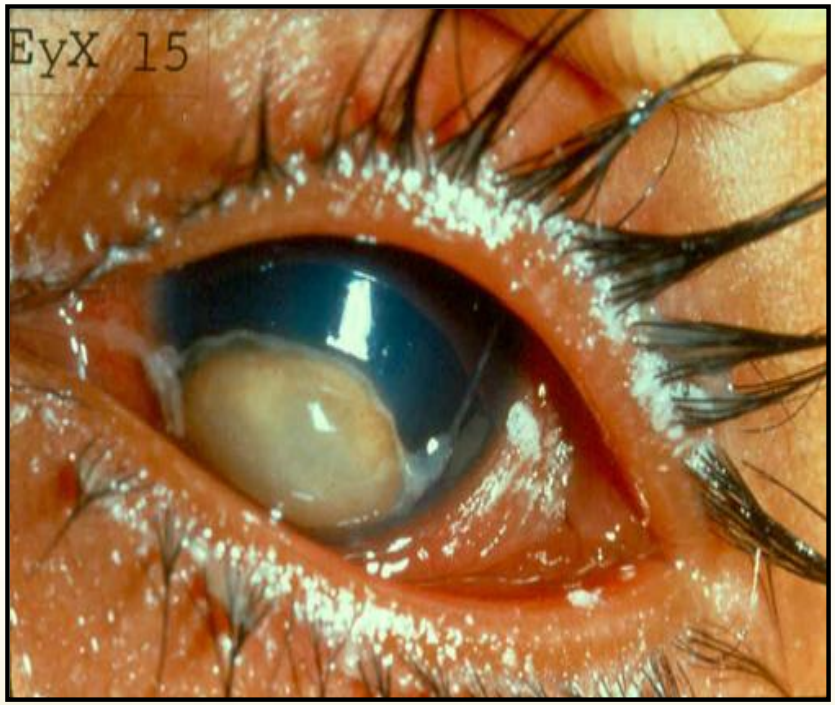
Sunshine – Vitamin D

Cod Liver Oil –
Vitamins A and D

Good Vitamin, Bad Vitamin:

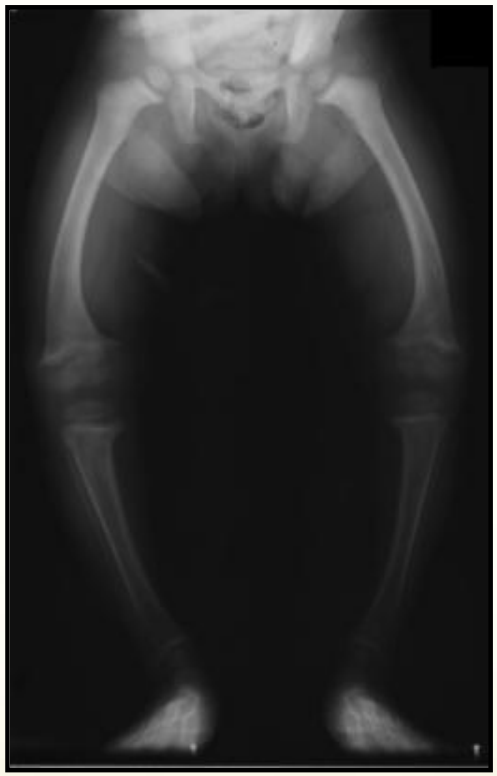
Repeating A Historical Mistake?

Cod Liver Oil Prevented and Cured Deficiencies of Both Vitamins A and D



Corneal ulceration due to **xerophthalmia,** prevented by vitamin A..

This is rare!



Bowed and poorly mineralized legs due to **rickets,** prevented by vitamin D.

This is important!

Dogs Fed Vitamin A-Deficient Diets Developed Pneumonia

Olive Oil

→ Soft bones, bronchial pneumonia.

Butter (A)

→ Soft bones, free of infection.

Cod Liver Oil (A+D)

→ Well mineralized bones, free of infection.

Green HN, Mellanby E. Vitamin A as an Anti-Infective Agent. BMJ. 1928;2:691-6.

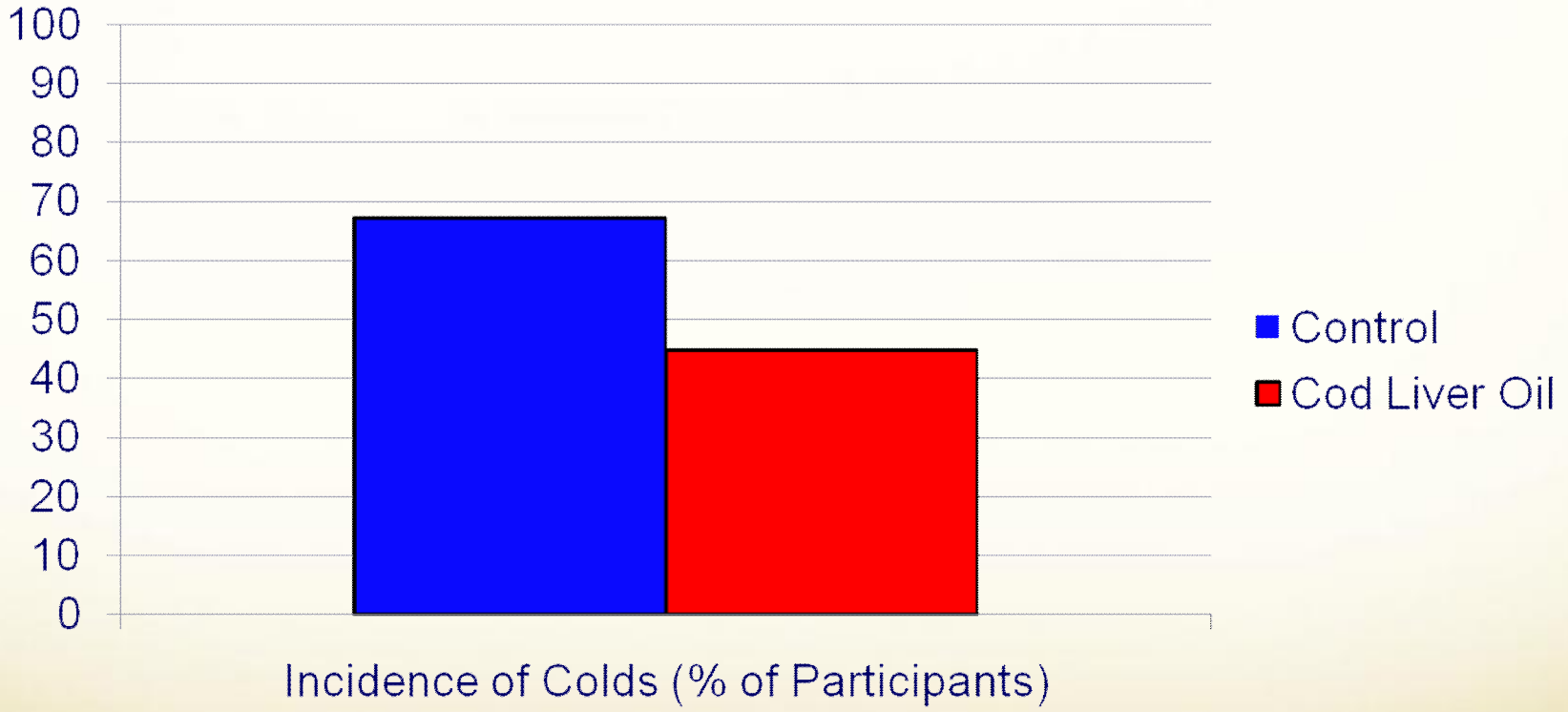
Vitamin A, Not Vitamin D, Protected Against Infection in Rats

"The importance of vitamin D has attracted great attention recently, and it has even been suggested that preparations of vitamin D can be safely substituted for cod-liver oil in medical treatment. The work above described shows that this teaching is erroneous, and that, although vitamin D controls, probably absolutely, the calcification of bones and teeth, it has no direct power to promote resistance to infection in the same way as vitamin A. If a substitute for cod-liver oil is given it ought to be at least as powerful as this oil in its content of both vitamins A and D."

Vitamin A **Is the Anti-Infective Vitamin!**

Green HN, Mellanby E. Vitamin A as an Anti-Infective Agent. BMJ. 1928;2:691-6.

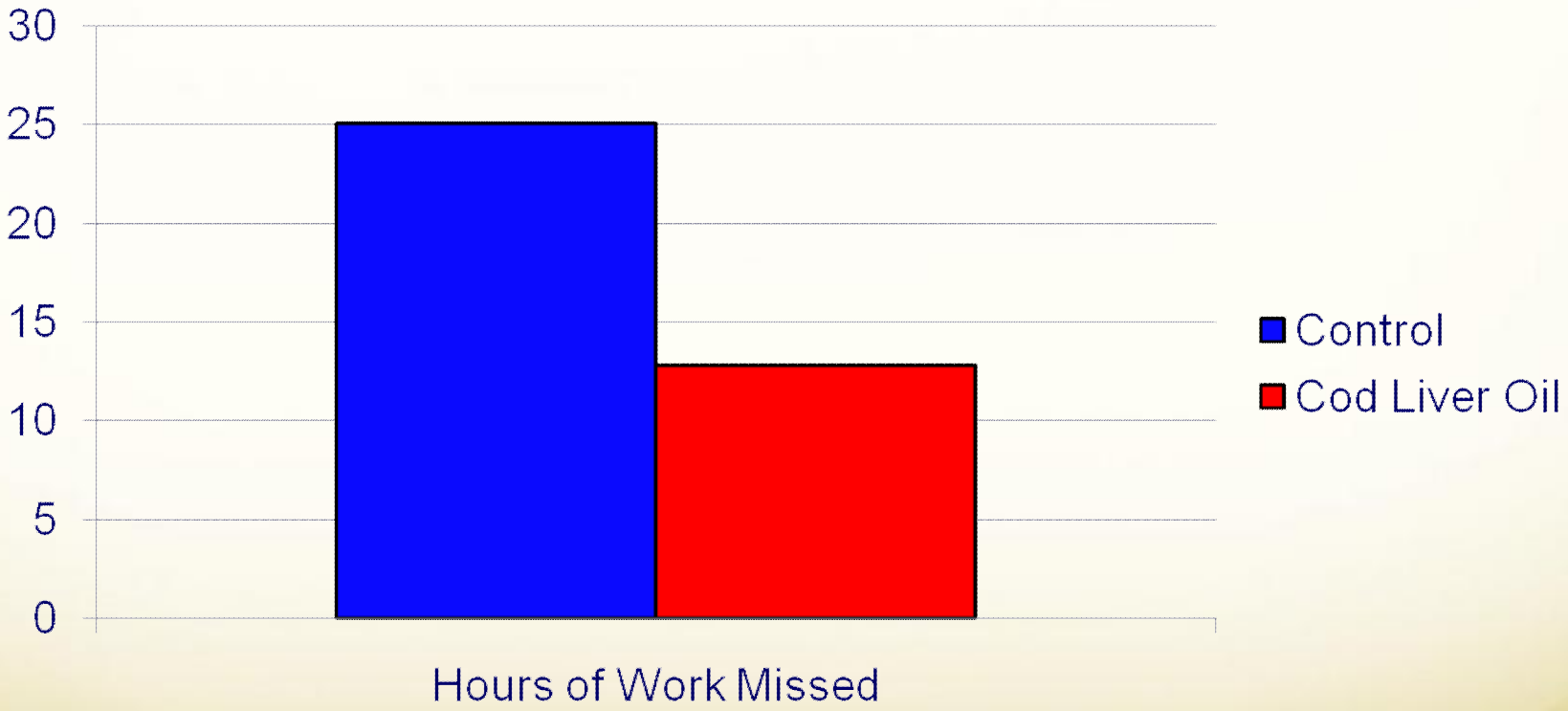
Cod Liver Oil Decreases the Incidence of Colds



One tbsp CLO (15,000 IU A; 2,000 IU D) per day, Dec-March, n=313.

Holmes AD, Pigott MG, Sawyer WA, Comstock L. Vitamins Aid Reduction of Lost Time in Industry. Indust Eng Chem. 1932;24:1058-60.

Cod Liver Oil Decreases Time Missed From Work



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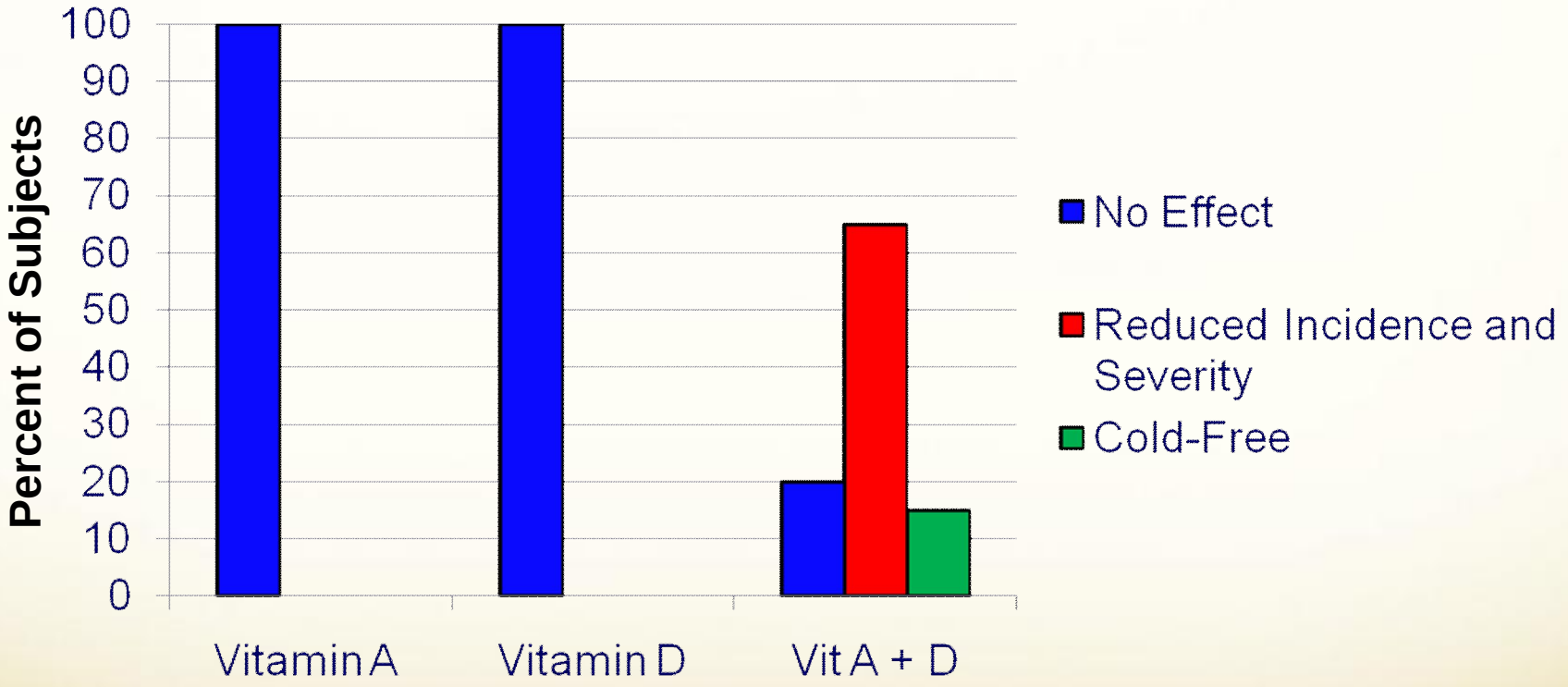
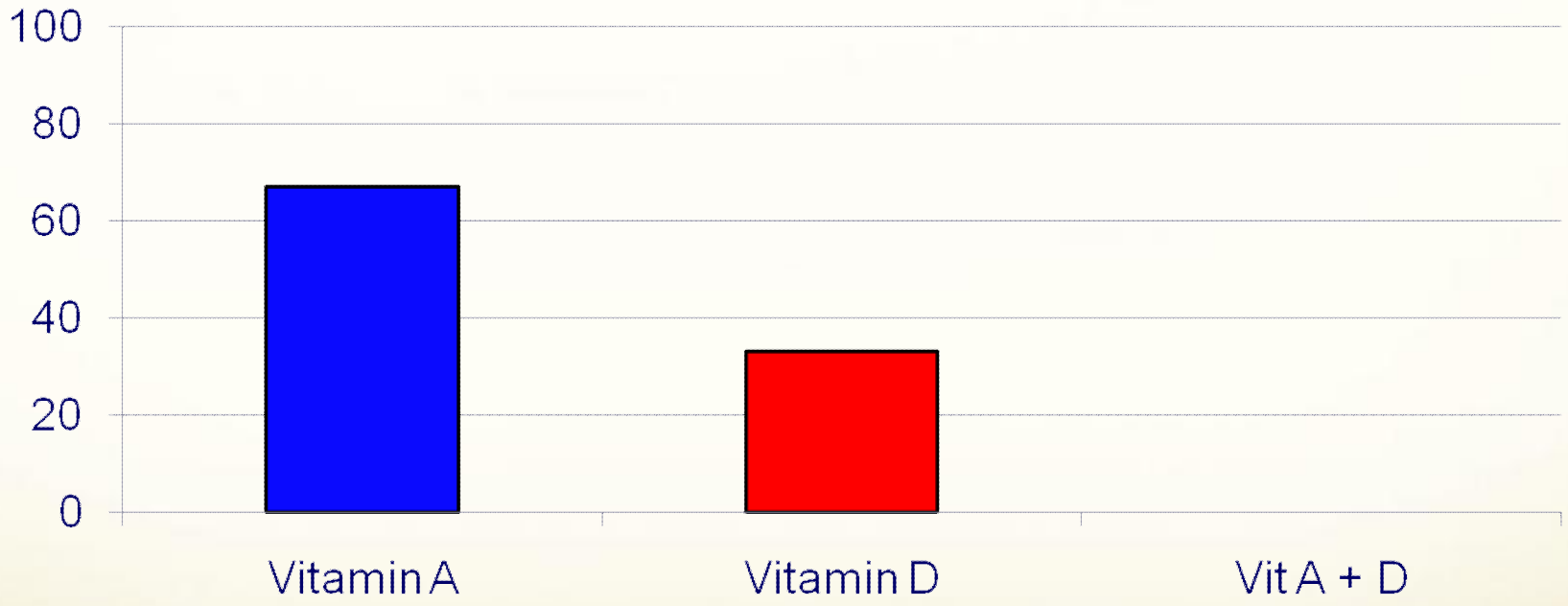
Vitamins A and D Only Protect Against Colds When Combined



54 “chronic or frequent cold sufferers” aged 7-49 given 9,000-40,000 IU A, 120,000-300,000 IU D, or both, daily Sept-June for three years.

Spiesman IG. Massive does of vitamins A and D in the prevention of the common cold. Arch Otolaryngol.1941;34(4):787-791.

Vitamins A and D Proved Toxic Alone But Not in Combination

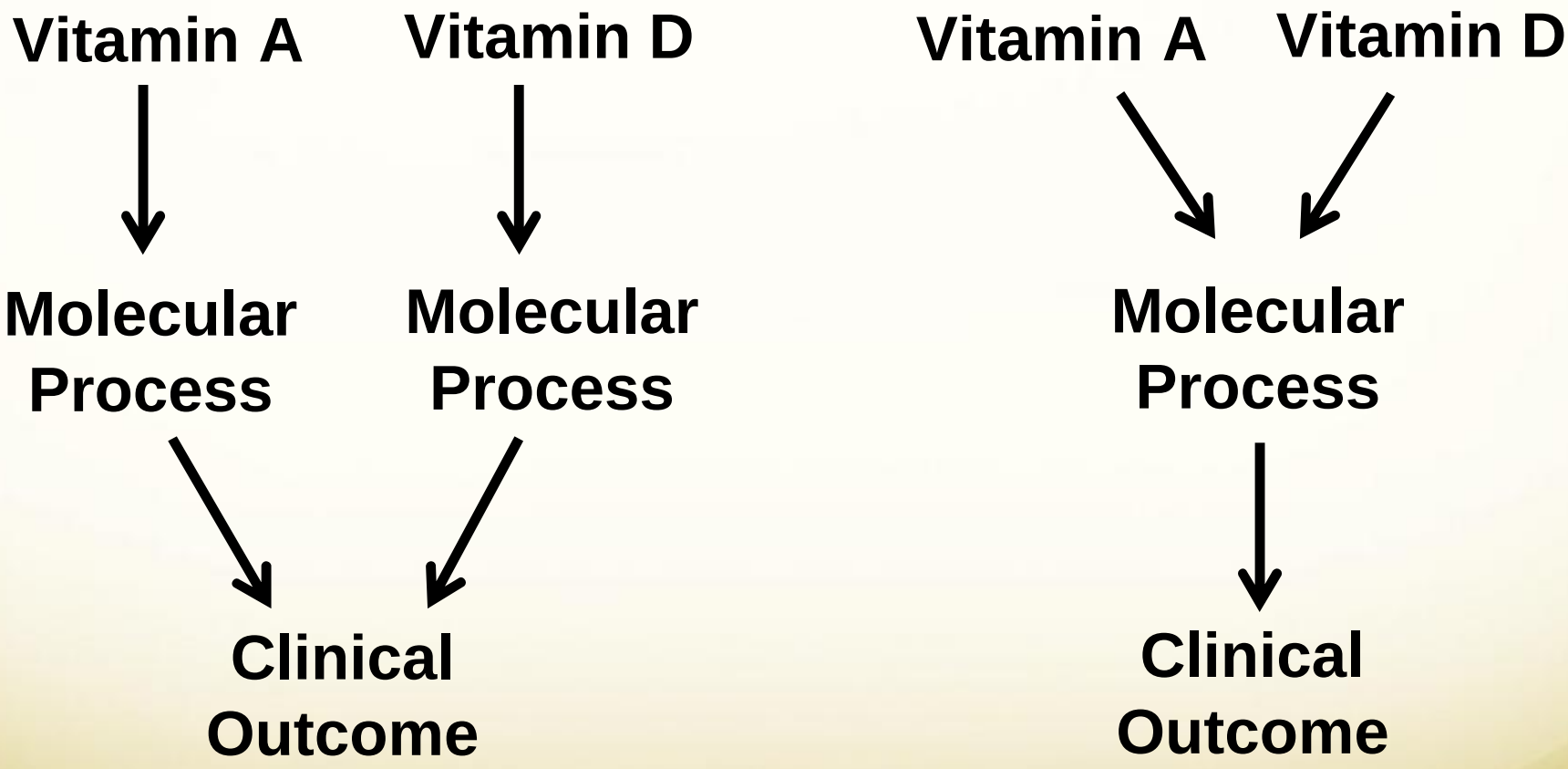


Percentage of Subjects Who Developed Symptoms of Toxicity

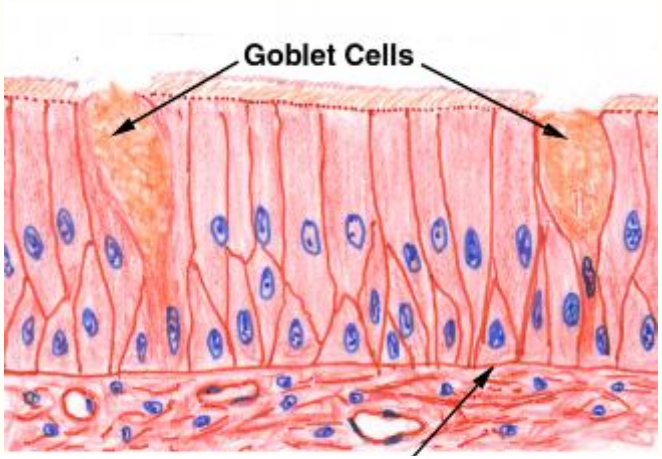
54 “chronic or frequent cold sufferers” aged 7-49 given 9,000-40,000 IU A, 120,000-300,000 IU D, or both, daily Sept-June for three years.

Spiesman IG. Massive does of vitamins A and D in the prevention of the common cold. Arch Otolaryngol.1941;34(4):787-791.

Two Models of Synergy

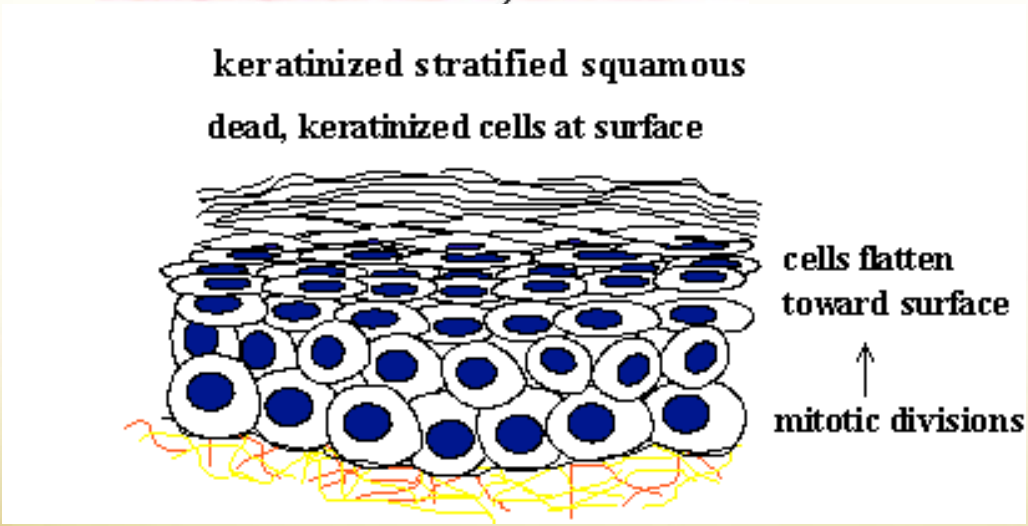


Vitamin A Deficiency: Replacement of Normal Epithelial Tissue With Keratinized Tissue Sabotages Defense Against Pathogens



Normal Pseudo-stratified Columnar

- Ciliated
- Goblet cells produce mucous
- Defense against pathogens



Replacement w/ Keratinized In Deficiency

- Hyperkeratosis
- Loss of normal tissue function, including the first line of immune defense.
- Xerophthalmia

Goldblatt H, Benischek M. Vitamin A Deficiency and Metaplasia. J Exp Med. 1927;46:699-707.

Vitamin A Supports the Immune System in Many Ways

Vitamin A also does the following:

- **Supports Natural Killer Cell Activity**
- **Enhances T Cell Proliferation**
- **Supports Killer T Cell Function**
- **Supports Helper T Cell Activity**
- **Regulates Activation, Proliferation, and Survival of B Cells**
- **Increases Production of Zinc-Dependent Metalloproteinases**

Mora JR, Iwata M, von Andrian UH. Vitamin effects on the immune system: vitamins A and D take centre stage. Nat Rev Immunol. 2008;8(9):685-98.

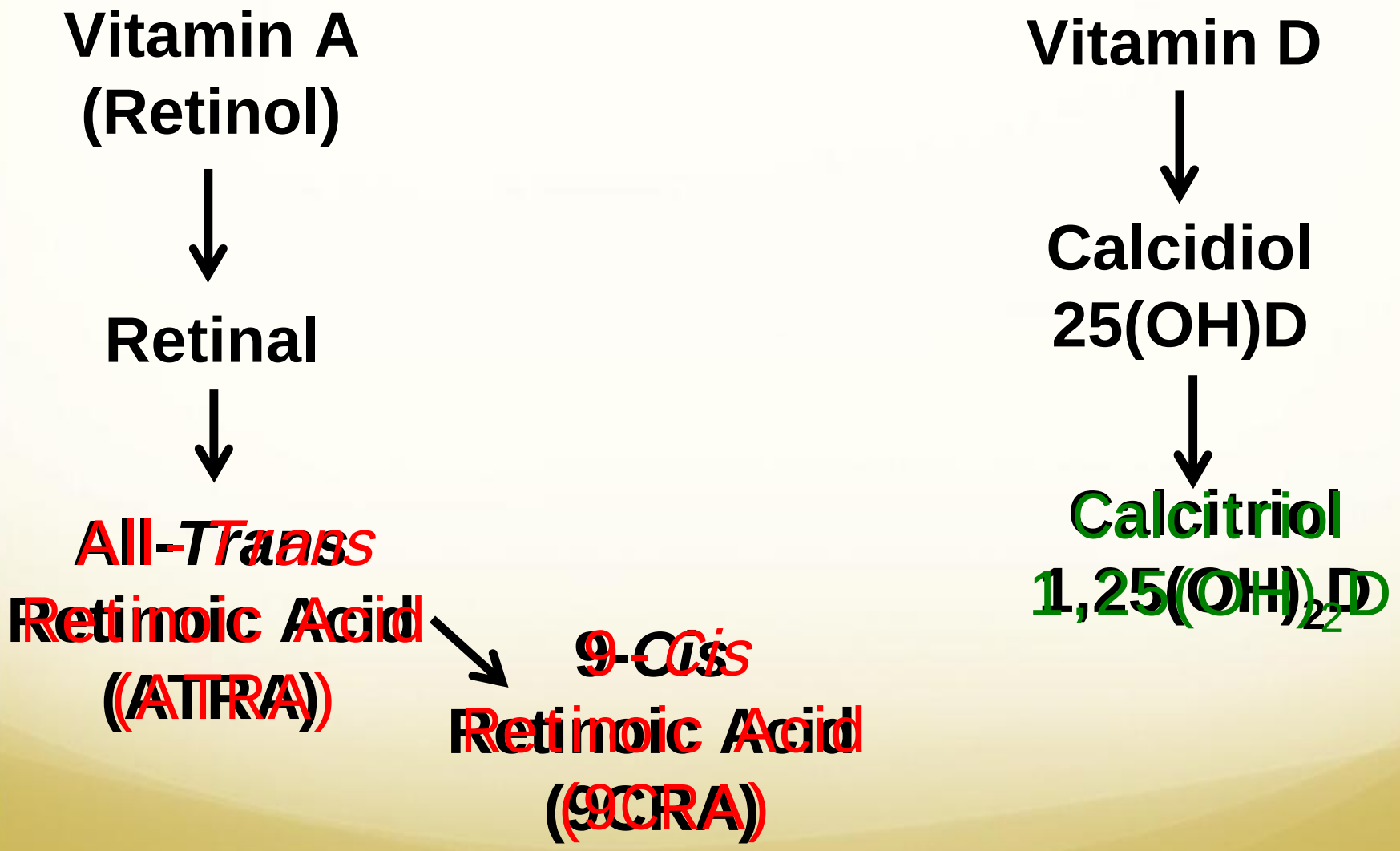
Vitamin D Stimulates Production of Antimicrobial Peptides

Cathelicidins and their derivatives are also effective against:

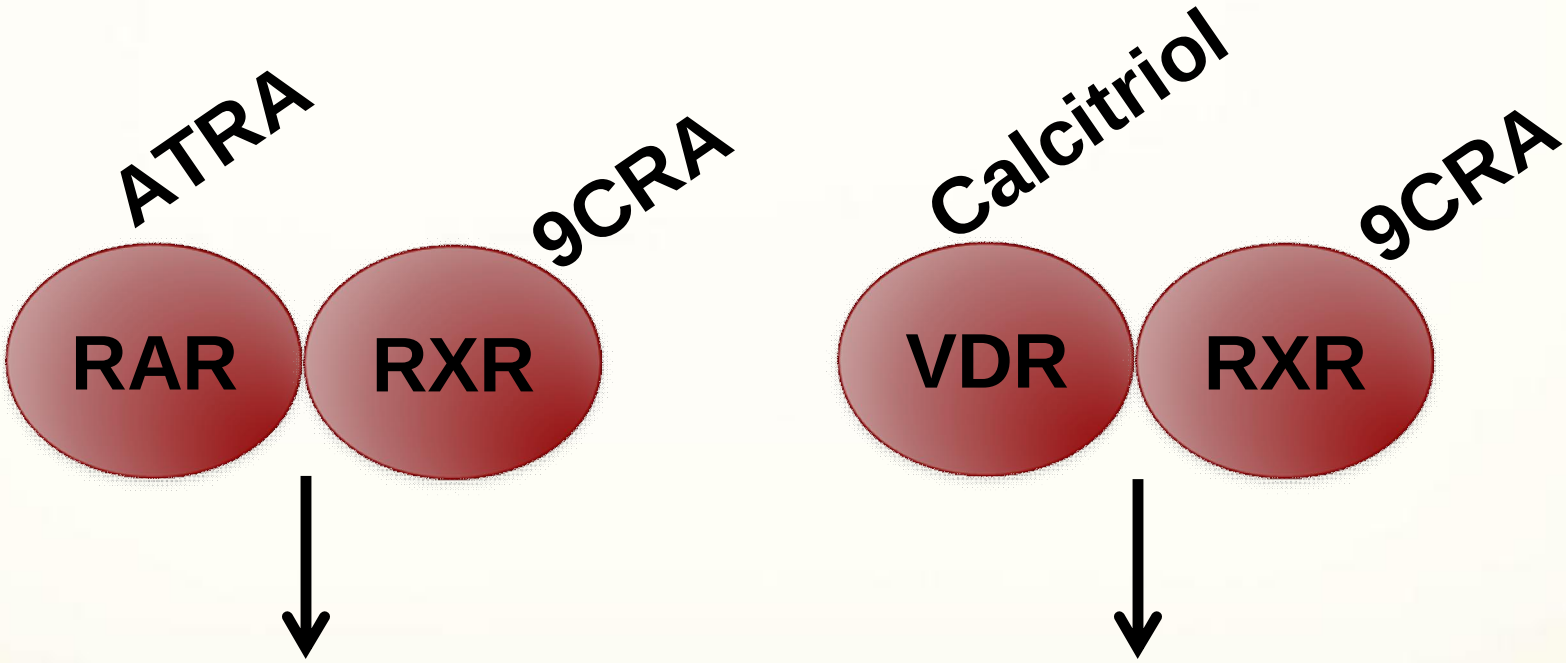
- ***Candida albicans***
- ***Streptococcus aureus***
- **Group A *Streptococcus (S. pyogenes* or GAS)**
- ***E. faecalis***
- ***Pseudomonas aeruginosa***
- ***E. coli***
- **lentiviruses and retroviruses (e.g. HIV)**

Liu PT, Krutzik SR, Modlin RL. Therapeutic implications of the TLR and VDR partnership. Trends Mol Med. 2007;13(3):117-24.

Activation of Vitamins A and D



Vitamins A and D Are Molecular Partners

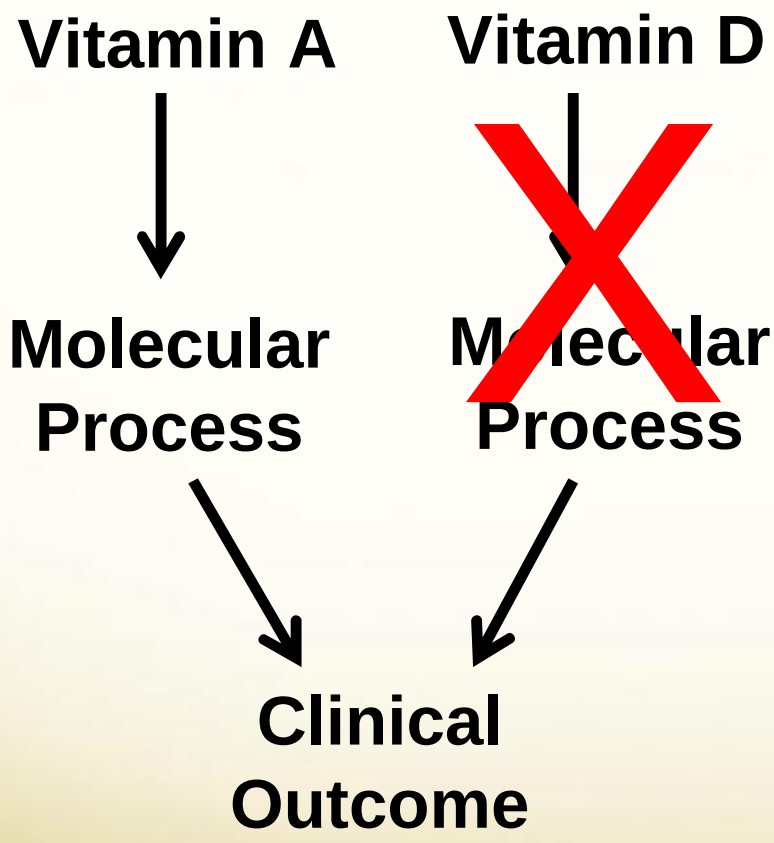


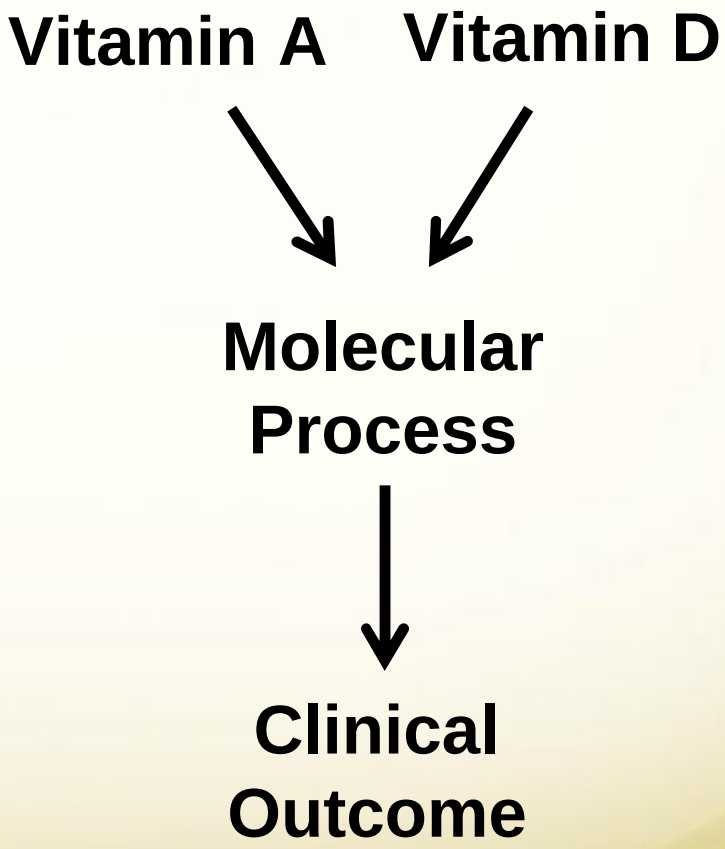
Regulation of Vitamin A-Responsive Genes

Regulation of Vitamin D-Responsive Genes

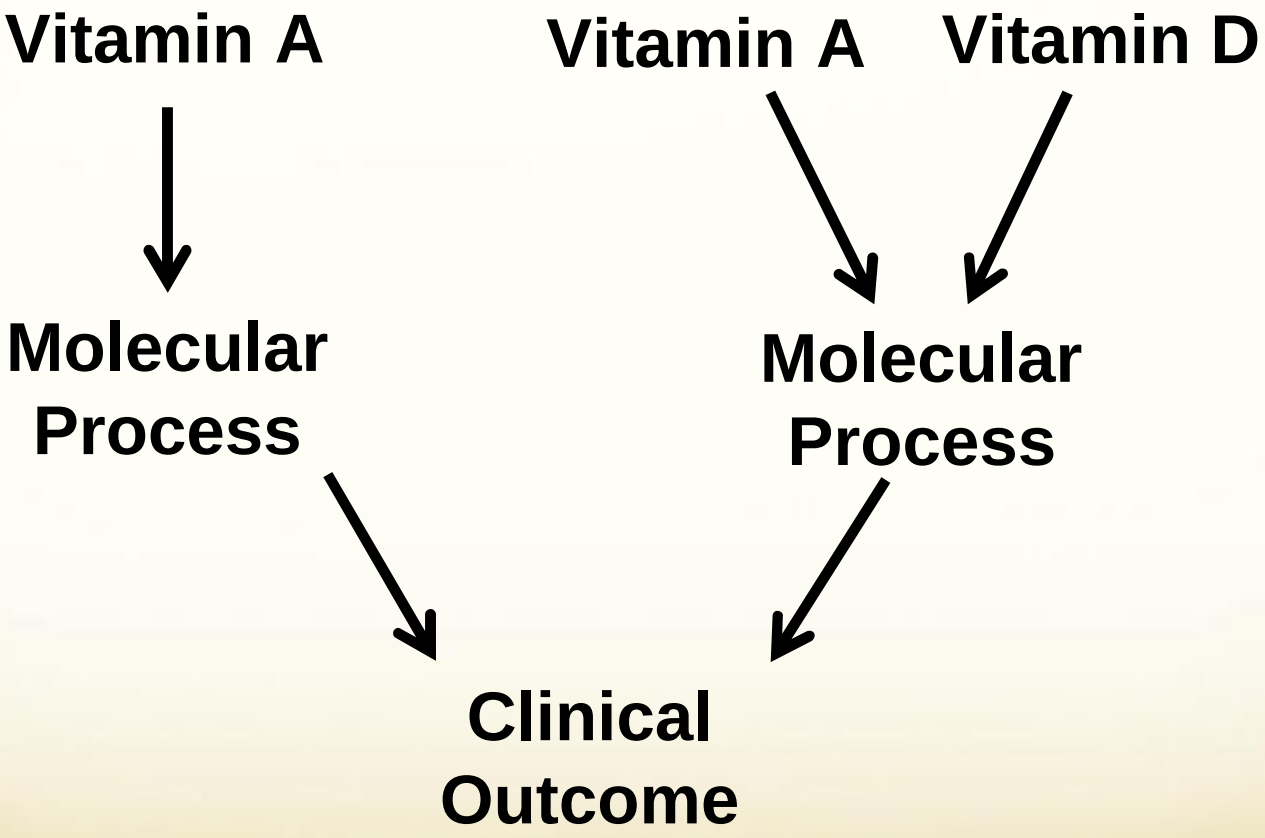
RAR – Retinoic Acid Receptor; VDR – Vitamin D Receptor; RXR – Retinoid X Receptor

Two Models of Synergy

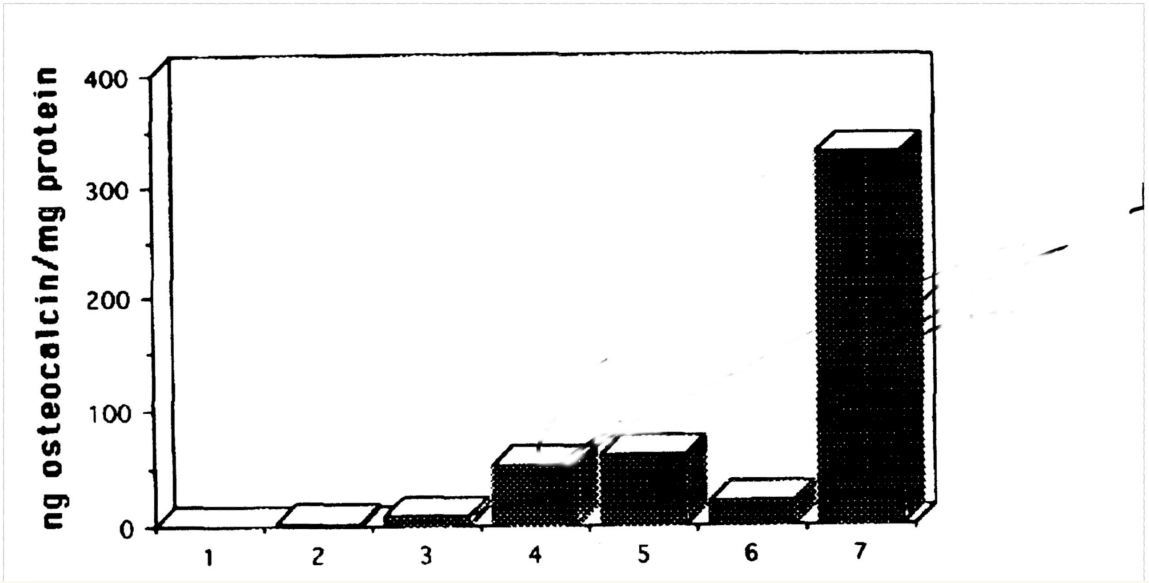




A Revised Model of Synergy



Vitamins A and D Synergistically Increase the Production of Osteocalcin

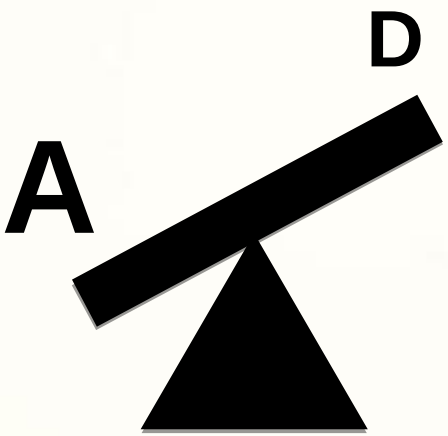


A D A+D A D A+D

Low Dose High Dose

Oliva A, Ragione FD, Fratta M, Marrone G, Palumbo R, Zappia V. Effect of retinoic acid on osteocalcin gene expression in human osteoblasts. Biochem Biophys Res Commun. 1993; 191(3): 908-14.

Is the Mechanism of Vitamin D Toxicity Similar to That of Vitamin A But Reversed?



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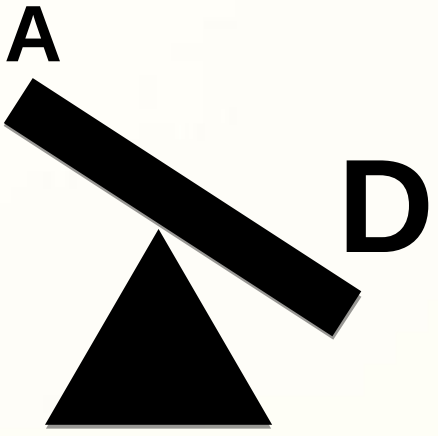
Elevated Phosphorus
Depressed Calcium

↓

Bone Loss



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Hypercalcemia

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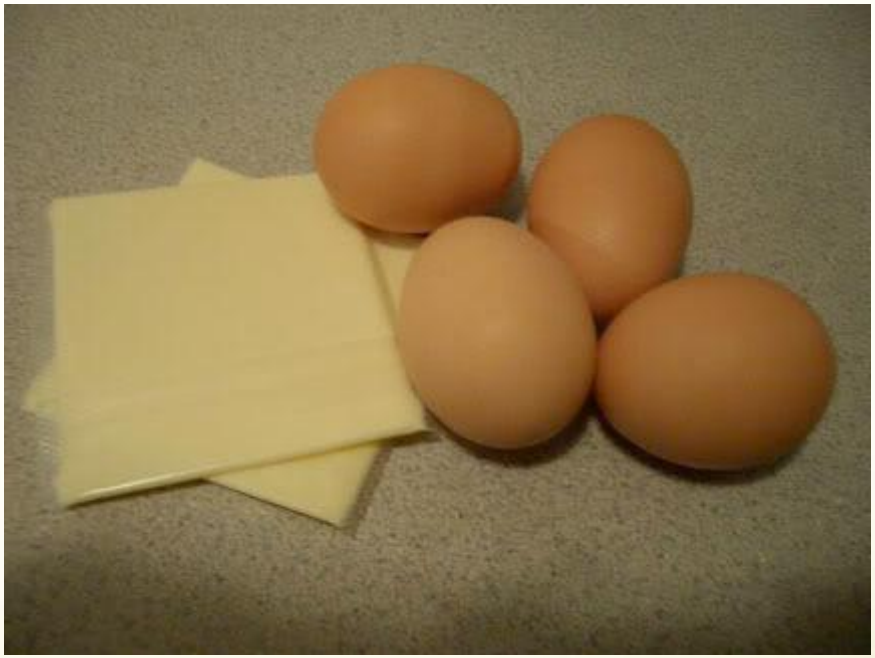
Soft Tissue Calcification

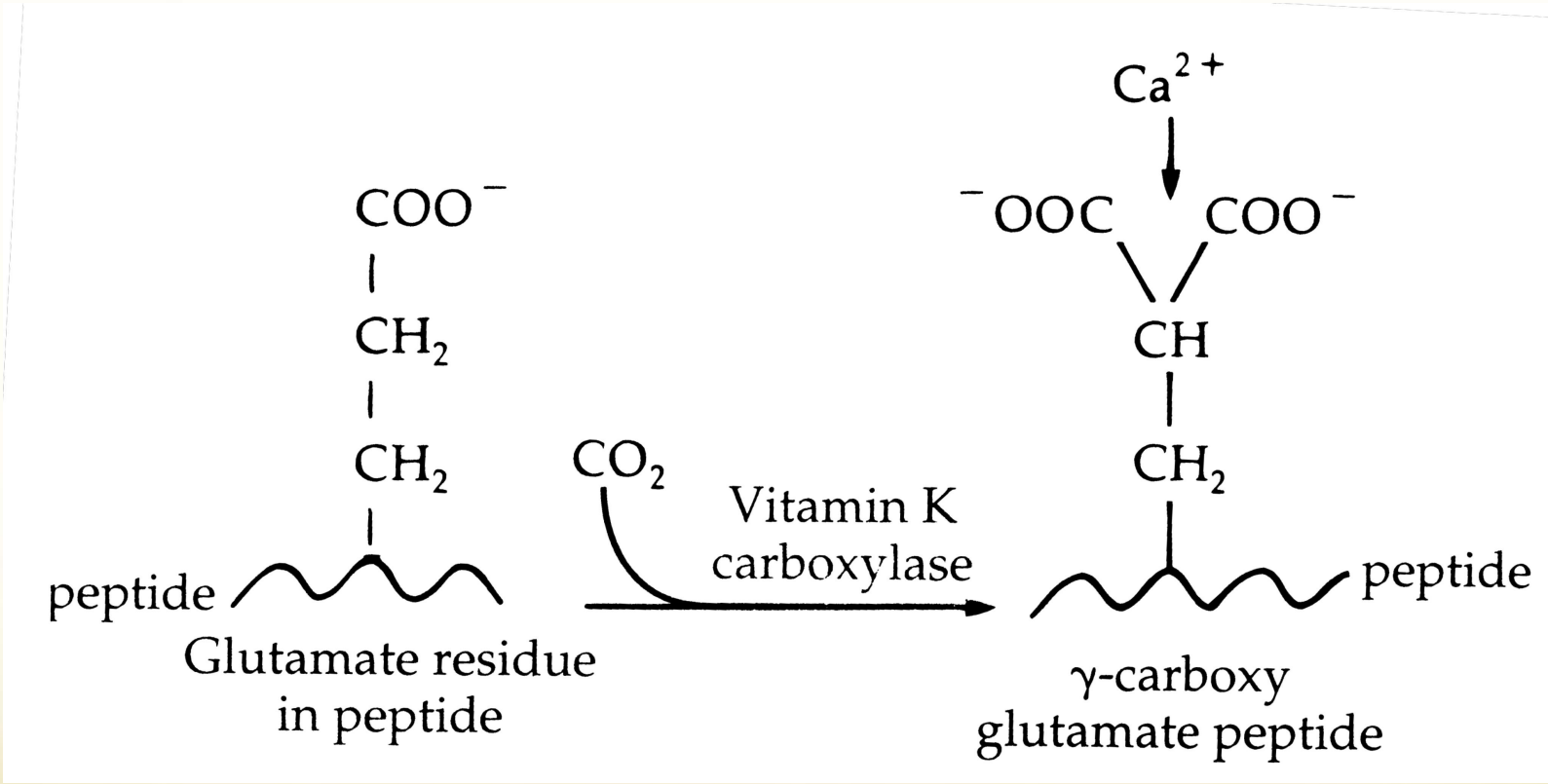
A Third Synergistic Partner: Vitamin K_2!

Leafy Greens – Vitamin K_1



Animal Fats and
Fermented Foods – Vitamin K_2

Vitamin K Activates Proteins By Giving Them the Ability to Bind Calcium



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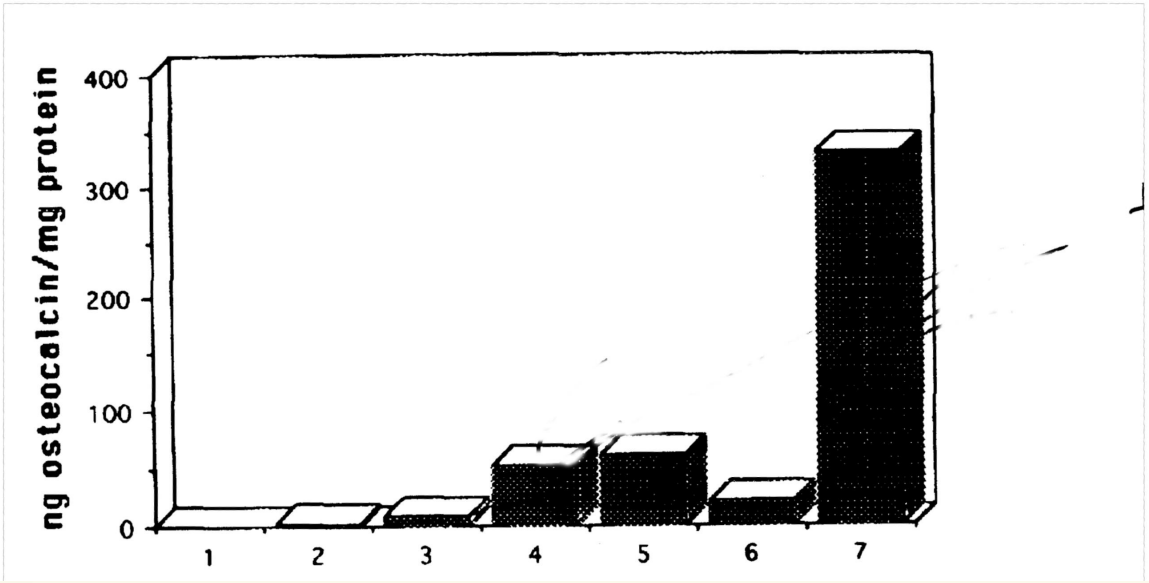

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Low Dose High Dose

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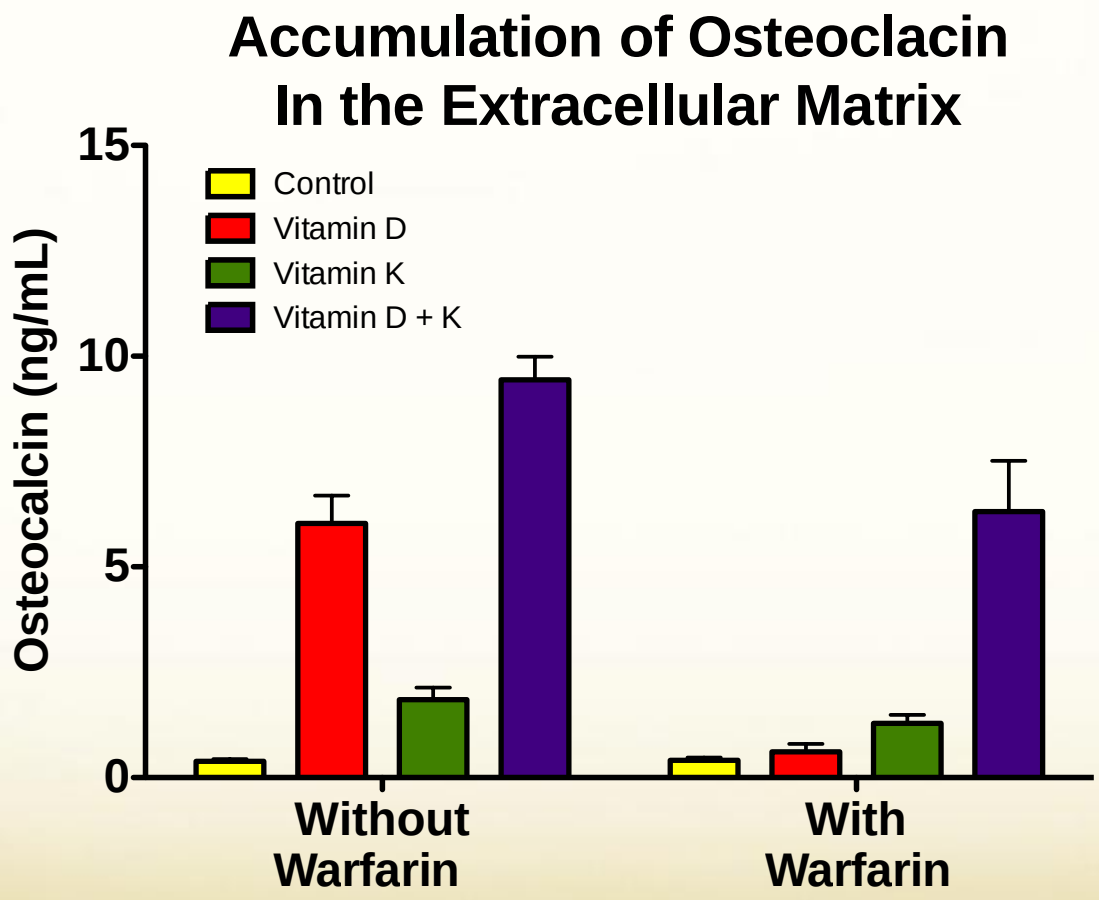
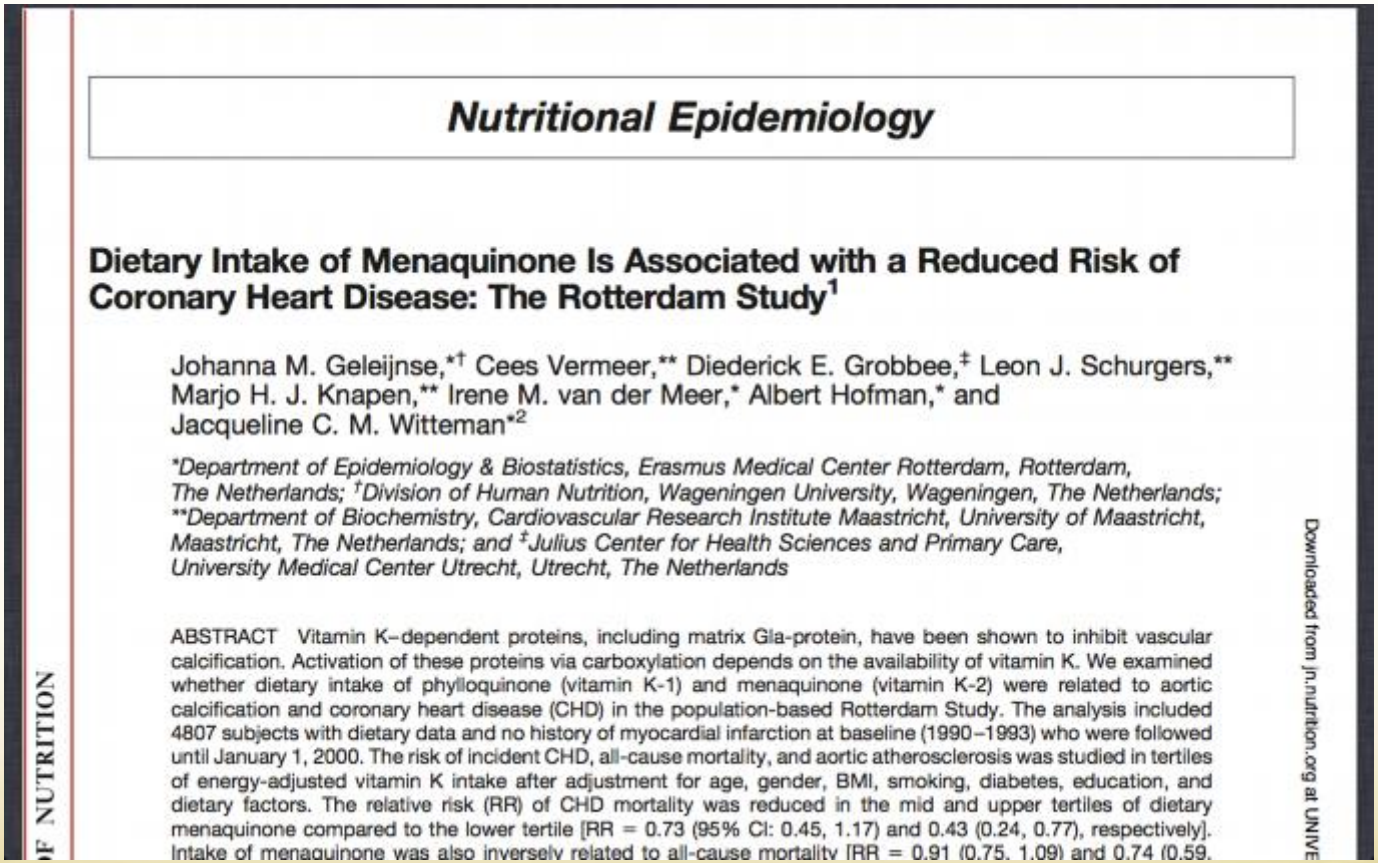
Osteocalcin Only Accumulates in Bone Matrix After Activation by Vitamin K



Koshihara Y.. Vitamin K2 enhances osteocalcin accumulation in the extracellular matrix of human osteoblasts in vitro. J Bone Miner Res. 1997; 12(3): 431-8.

Vitamin K_2 Protects Against Calcification of Blood Vessels and Heart Valves



Nutritional Epidemiology

Dietary Intake of Menaquinone Is Associated with a Reduced Risk of Coronary Heart Disease: The Rotterdam Study[1]

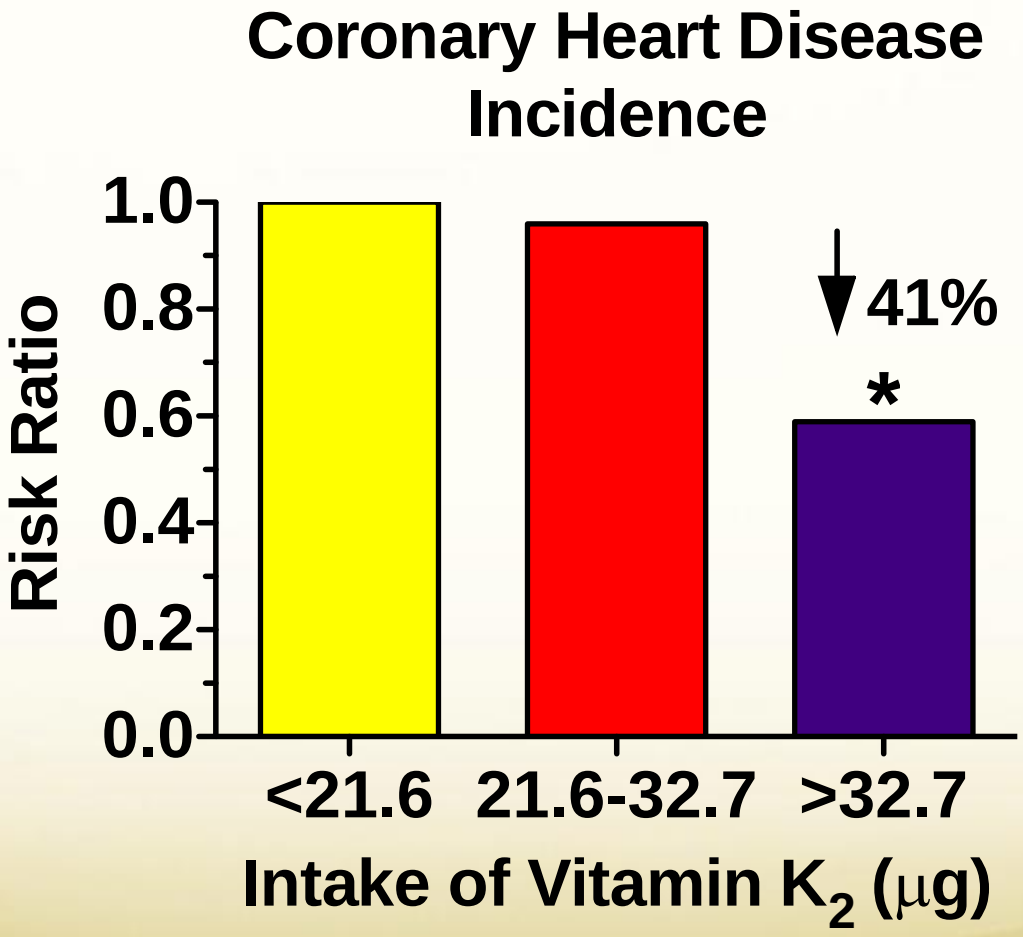
Johanna M. Geleijnse,*† Cees Vermeer,** Diederick E. Grobbee,‡ Leon J. Schurgers,** Marjo H. J. Knapen,** Irene M. van der Meer,* Albert Hofman,* and Jacqueline C. M. Witteman*[2]

**Department of Epidemiology & Biostatistics, Erasmus Medical Center Rotterdam, Rotterdam, The Netherlands; †Division of Human Nutrition, Wageningen University, Wageningen, The Netherlands; **Department of Biochemistry, Cardiovascular Research Institute Maastricht, University of Maastricht, Maastricht, The Netherlands; and ‡Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, The Netherlands*

ABSTRACT Vitamin K–dependent proteins, including matrix Gla-protein, have been shown to inhibit vascular calcification. Activation of these proteins via carboxylation depends on the availability of vitamin K. We examined whether dietary intake of phylloquinone (vitamin K-1) and menaquinone (vitamin K-2) were related to aortic calcification and coronary heart disease (CHD) in the population-based Rotterdam Study. The analysis included 4807 subjects with dietary data and no history of myocardial infarction at baseline (1990–1993) who were followed until January 1, 2000. The risk of incident CHD, all-cause mortality, and aortic atherosclerosis was studied in tertiles of energy-adjusted vitamin K intake after adjustment for age, gender, BMI, smoking, diabetes, education, and dietary factors. The relative risk (RR) of CHD mortality was reduced in the mid and upper tertiles of dietary menaquinone compared to the lower tertile [RR = 0.73 (95% CI: 0.45, 1.17) and 0.43 (0.24, 0.77), respectively]. Intake of menaquinone was also inversely related to all-cause mortality [RR = 0.91 (0.75, 1.09) and 0.74 (0.59,

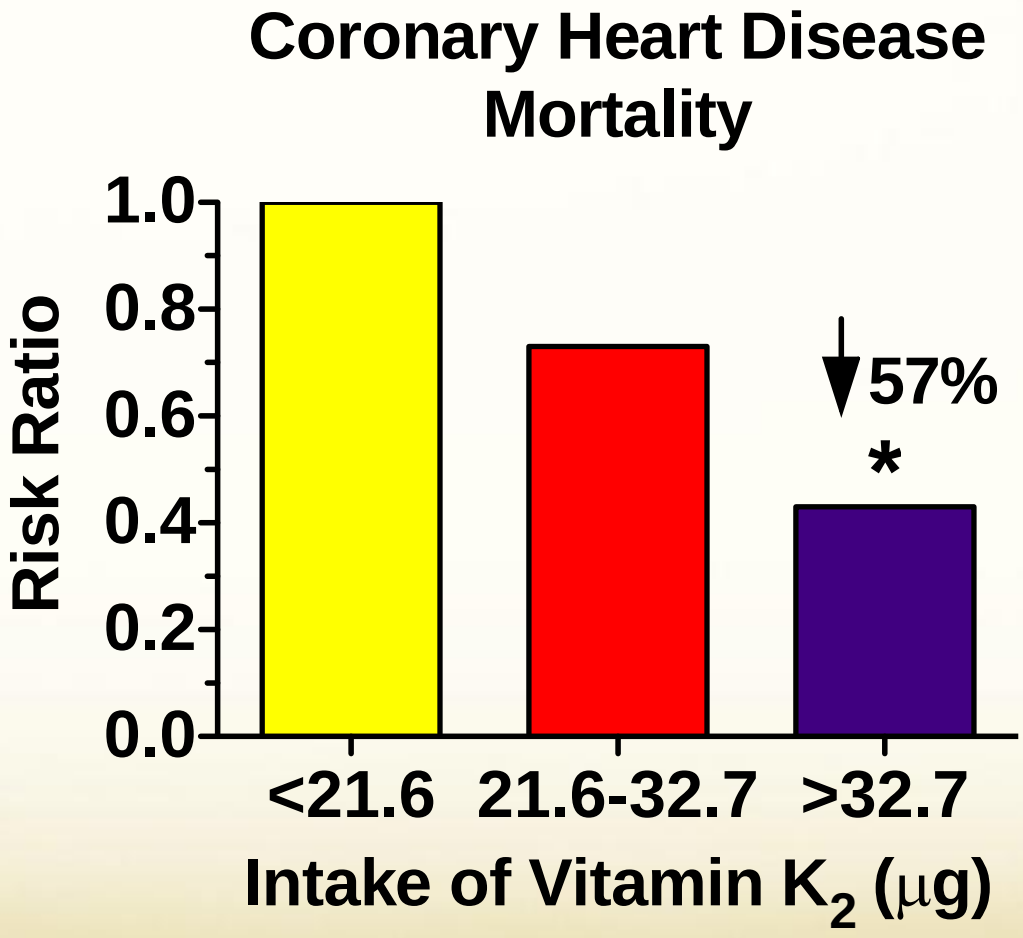
OF NUTRITION

Vitamin K_2 Intake Is Associated With a Reduced Incidence of CHD



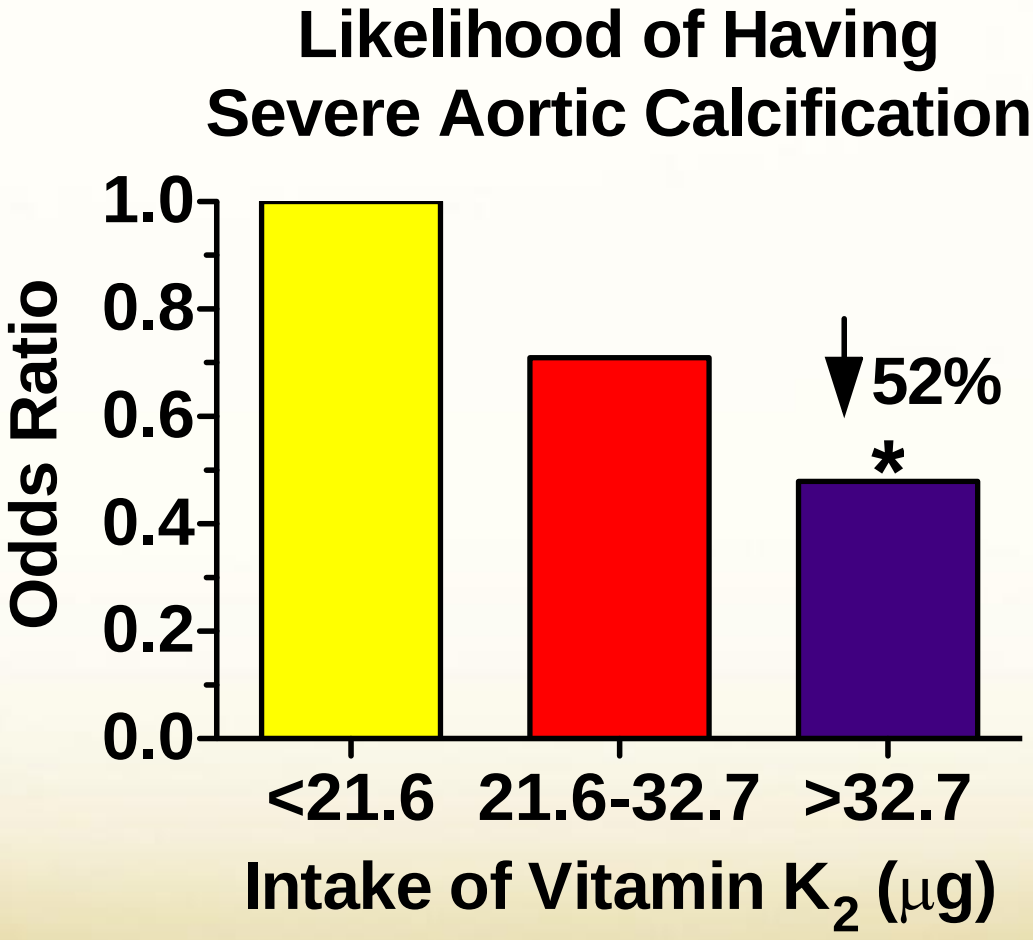
Geleijnse et al. Dietary Intake of Menaquinone Is Associated with a Reduced Risk of Coronary Heart Disease: The Rotterdam Study. J Nutr. 2004:3100-5.

Vitamin K_2 Intake Is Associated With a Reduced Incidence of CHD



Geleijnse et al. Dietary Intake of Menaquinone Is Associated with a Reduced Risk of Coronary Heart Disease: The Rotterdam Study. J Nutr. 2004:3100-5.

Vitamin K_2 Intake Is Associated With Reduced Aortic Calcification



Geleijnse et al. Dietary Intake of Menaquinone Is Associated with a Reduced Risk of Coronary Heart Disease: The Rotterdam Study. J Nutr. 2004:3100-5.

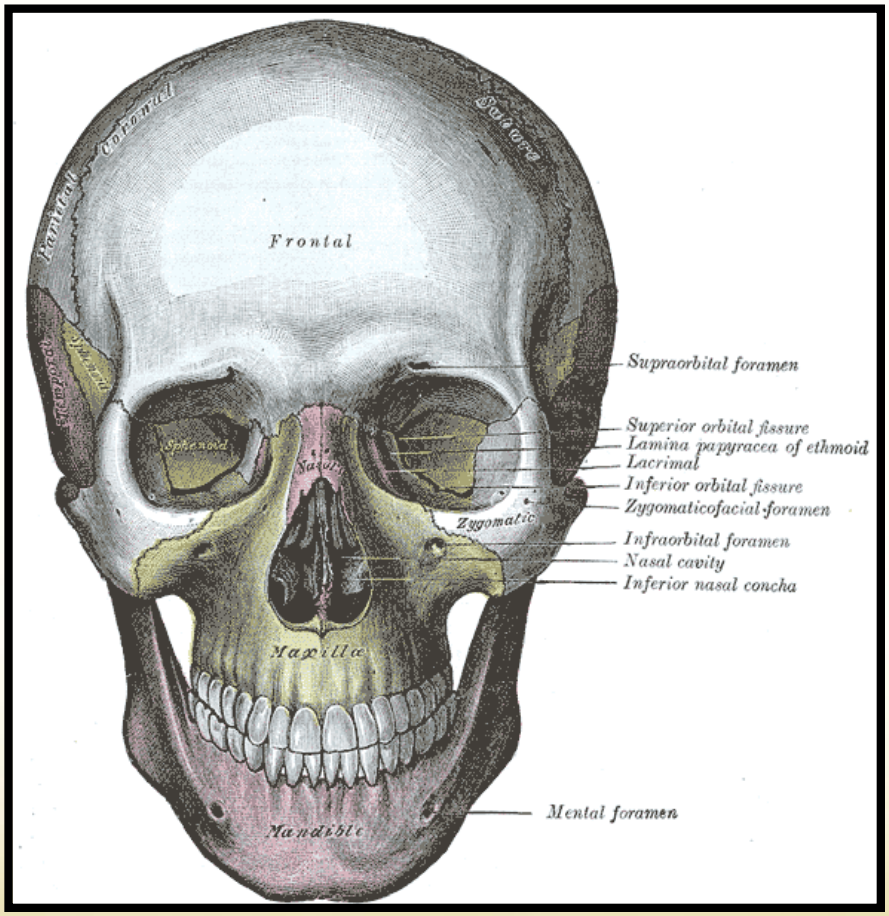
MGP Knockout Mouse Is Shorter In Stature Than Normal Mouse and Suffers From Soft Tissue Calcification and Spontaneous Fractures

Luo et al. Spontaneous calcification of arteries and cartilage in mice lacking matrix Gla protein. Proc Natl Acad Sci USA. 1997;94(6):2227-32.

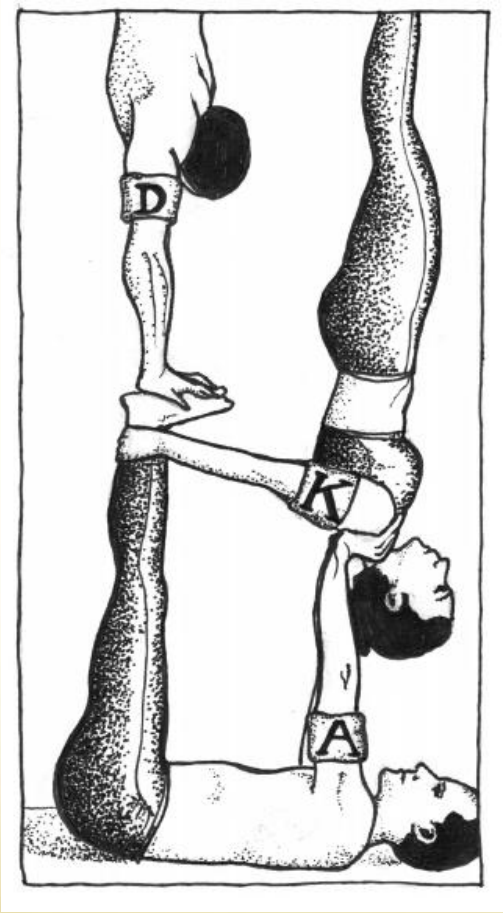
Warfarin During Pregnancy Causes Underdevelopment of Middle Third of the Face

Howe et al. Severe Cervical Dysplasia and Nasal Cartilage Calcification Following Prenatal Warfarin Exposure. Am J Med Genet. 1997;71:391-6.

The Maxilla Constitutes the "Middle Third of the Face"



Synergy Between Vitamins A, D, and K_2



- Vitamins A and D cooperate to tell cells which proteins to make, and how much of them to make.
- Vitamin K2 activates those proteins by giving them the ability to bind calcium.

Redefining Vitamin D Toxicity

Medical Hypotheses (2007) **68**, 1026–1034

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medical hypotheses

http://intl.elsevierhealth.com/journals/mehy

Vitamin D toxicity redefined: Vitamin K and the molecular mechanism

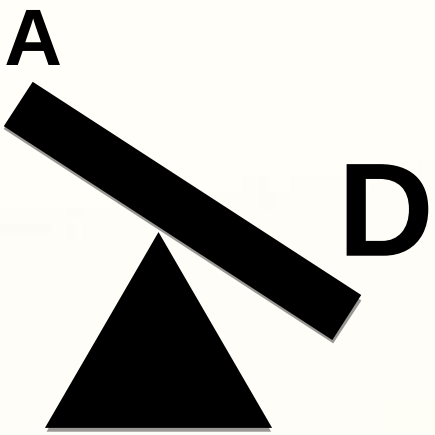
Christopher Masterjohn *

Weston A. Price Foundation, 4200 Wisconsin Ave., NW, Washington DC 20016, United States

Received 13 September 2006; accepted 14 September 2006

Summary The dose of vitamin D that some researchers recommend as optimally therapeutic exceeds that officially recognized as safe by a factor of two; it is therefore important to determine the precise mechanism by which excessive doses of vitamin D exert toxicity so that physicians and other health care practitioners may understand how to use optimally therapeutic doses of this vitamin without the risk of adverse effects. Although the toxicity of vitamin D has

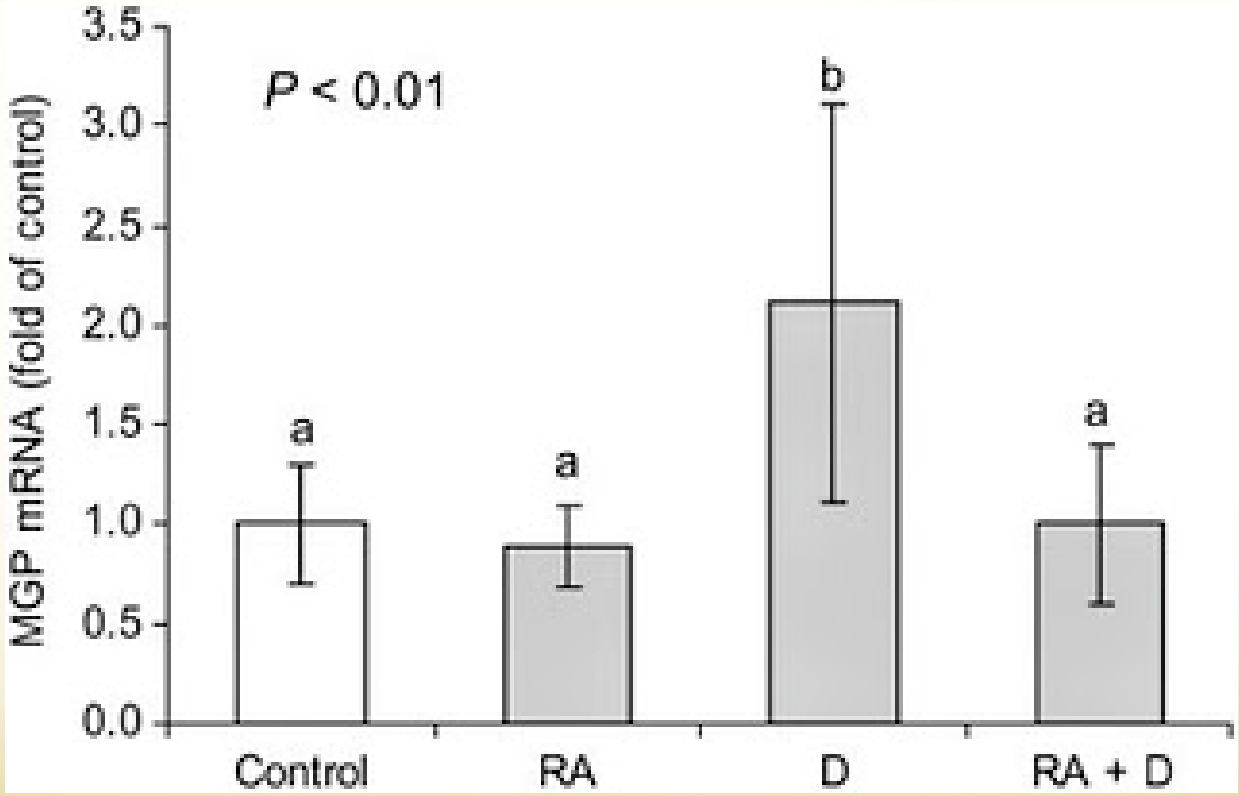
My Hypothesis



Overproduction of Defective Vitamin K-Dependent Proteins

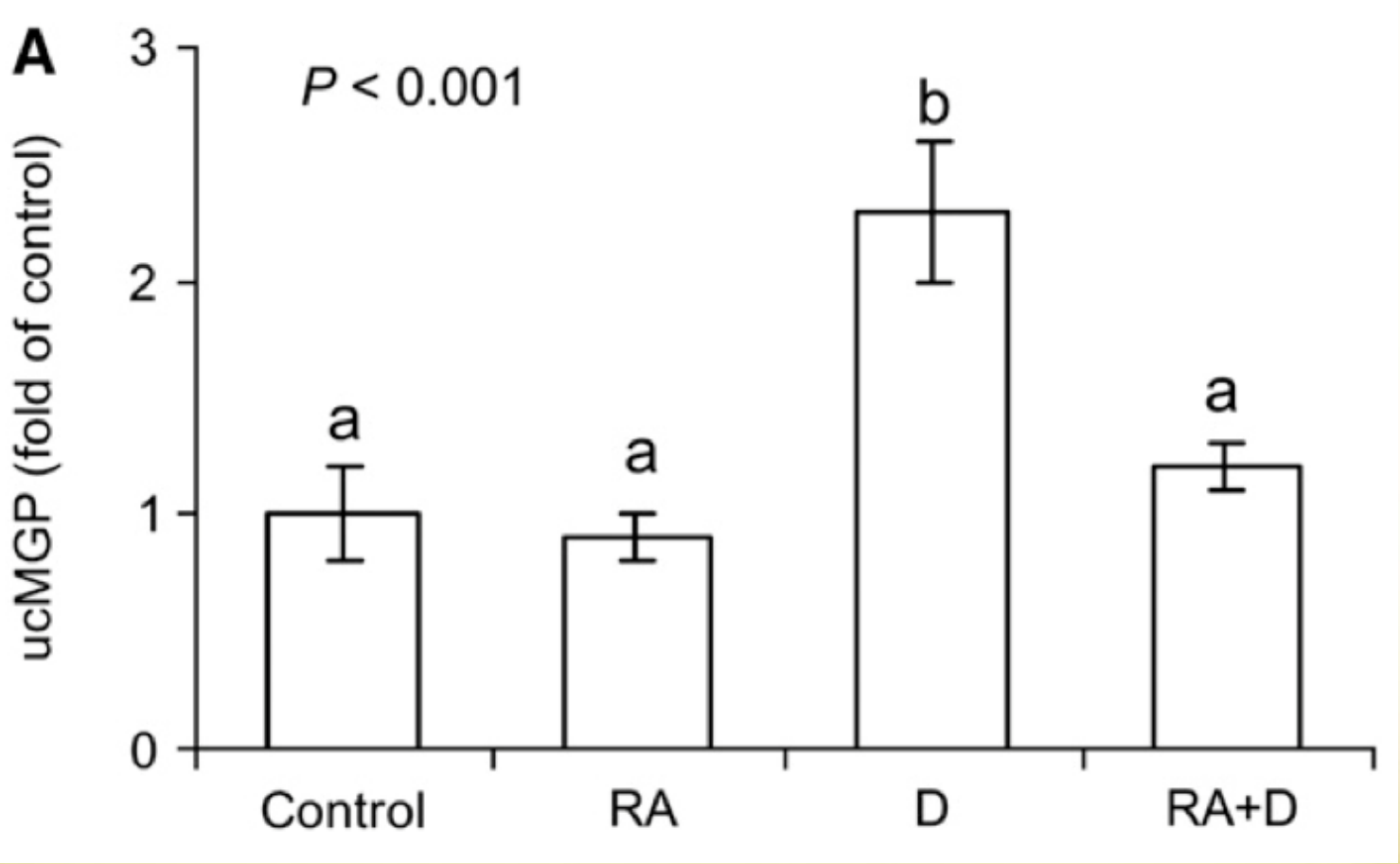
Soft Tissue Calcification

Tufts Confirms: Vitamin A Curbs The Excessive Production of Vitamin K-Dependent Proteins Otherwise Induced by Vitamin D



Fu et al. 9-Cis Retinoic Acid Reduces 1alpha,25-Dihydroxycholecalciferol-Induced Renal Calcification by Altering Vitamin K-Dependent gamma-Carboxylation of Matrix gamma-Carboxyglutamic Acid Protein in A/J Male Mice. J Nutr. 2008;138:2337-2341.

Vitamin A Normalizes the Production of *Defective* MGP That Otherwise Increases With Vitamin D



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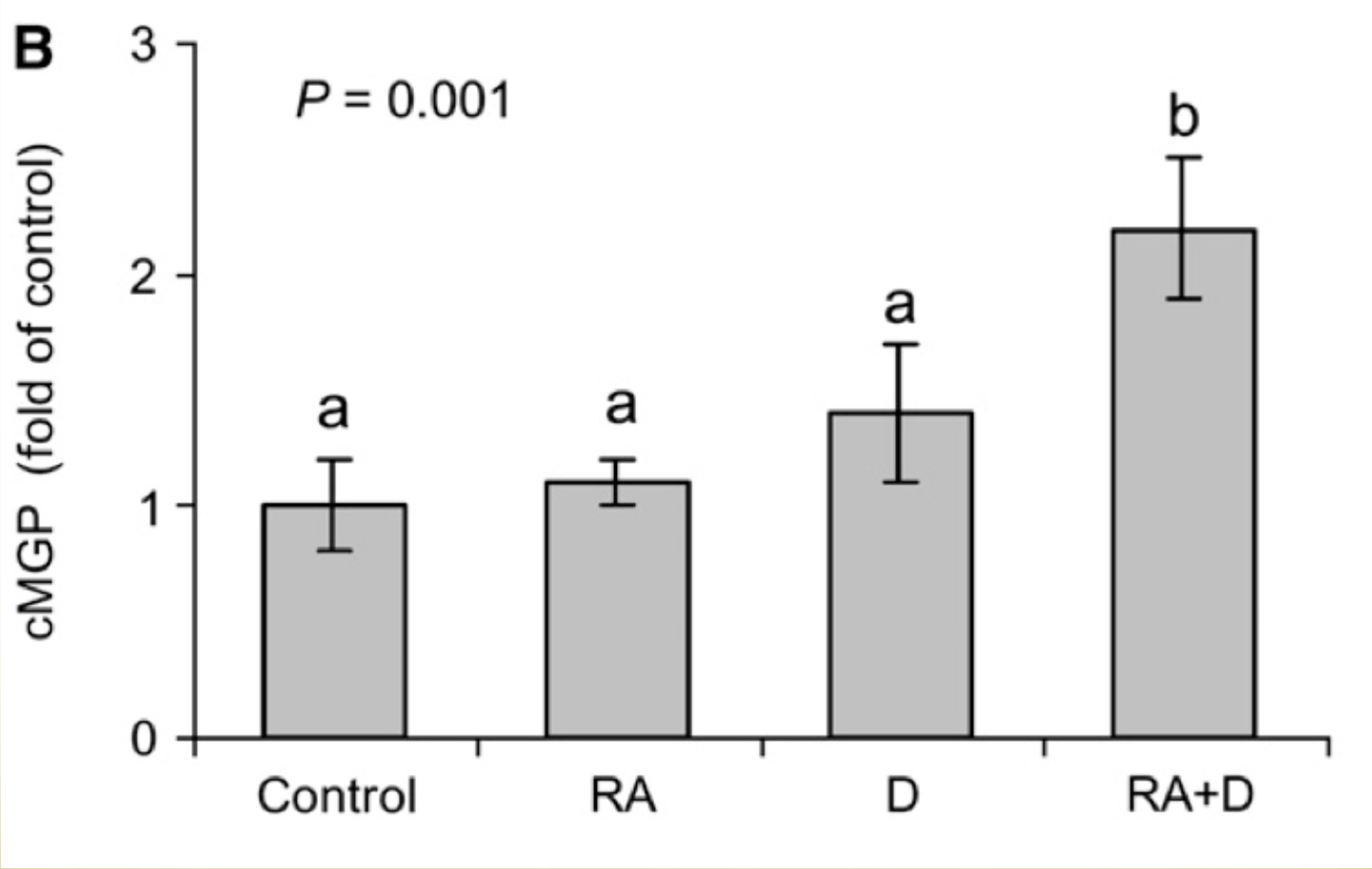
Vitamins A and D Synergize to Maximize the Amount of *Active* MGP Produced



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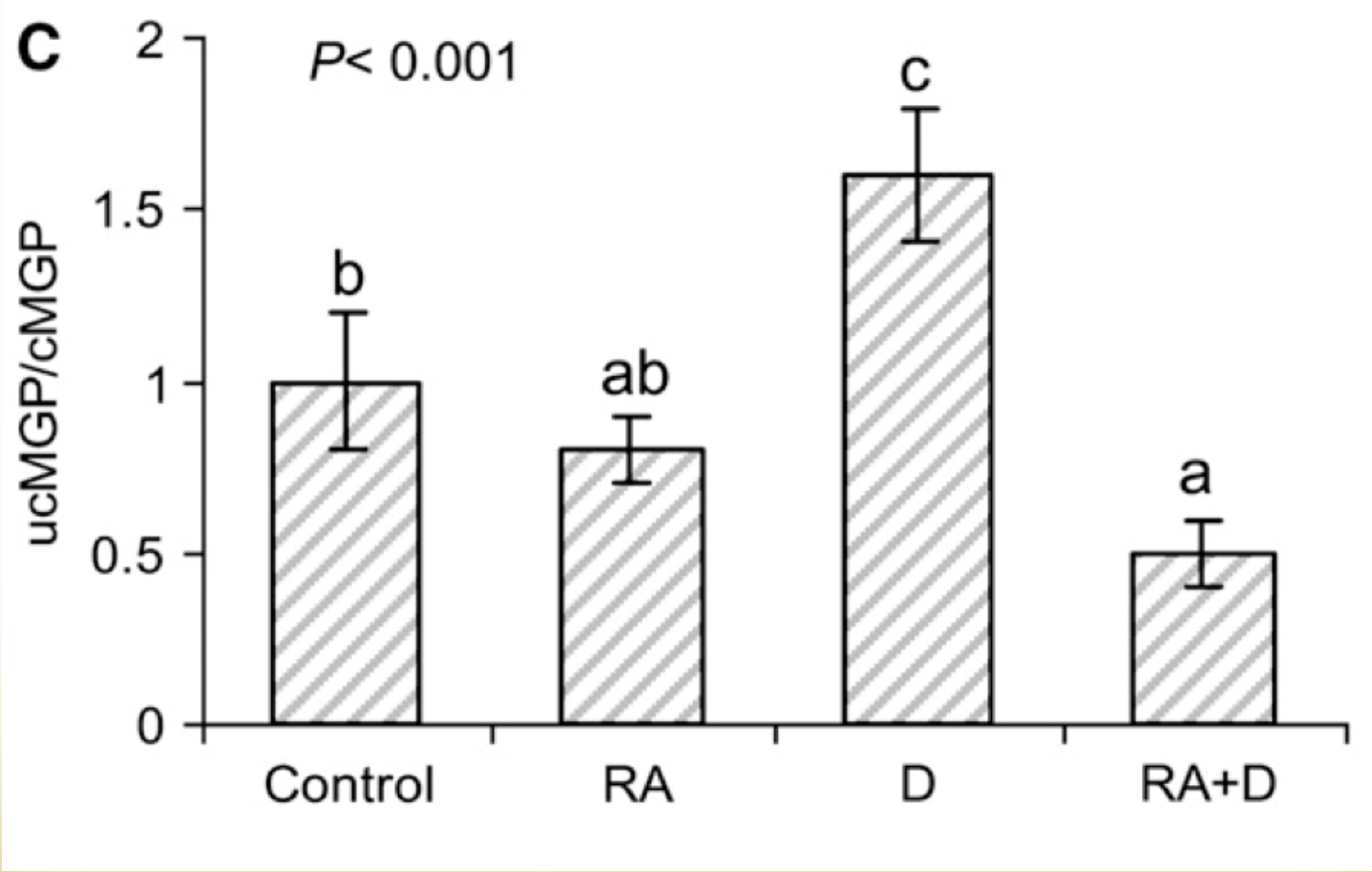
Vitamins A and D Synergize to Minimize the *Proportion* of MGP That Is *Defective*



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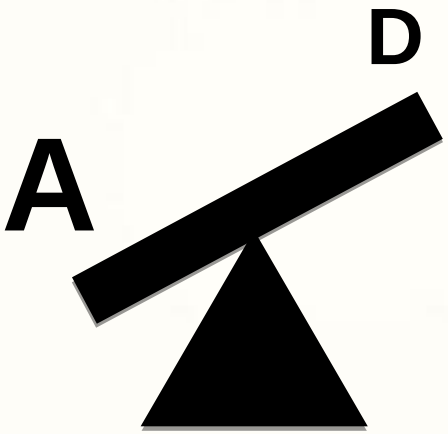
A New Model of Vitamin D Toxicity
Toxicity of Vitamins A and D Due to Imbalance



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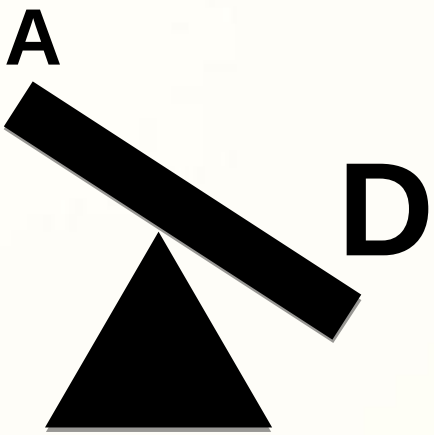
Elevated Phosphorus
Depressed Calcium

↓

Bone Loss



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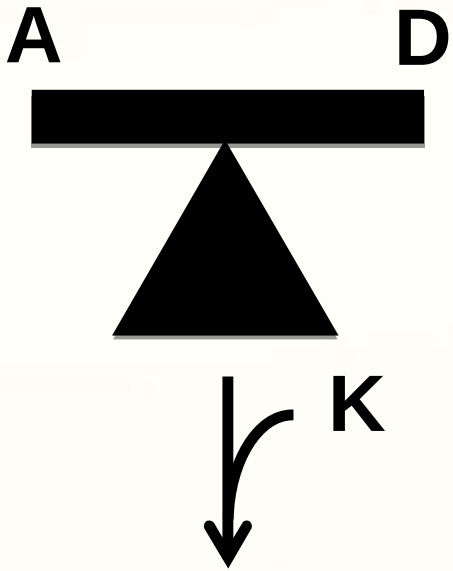
Overproduction of
Defective Vitamin K-Dependent
Proteins

↓

Soft Tissue
Calcification

Synergy Between Vitamins A, D, and K_2



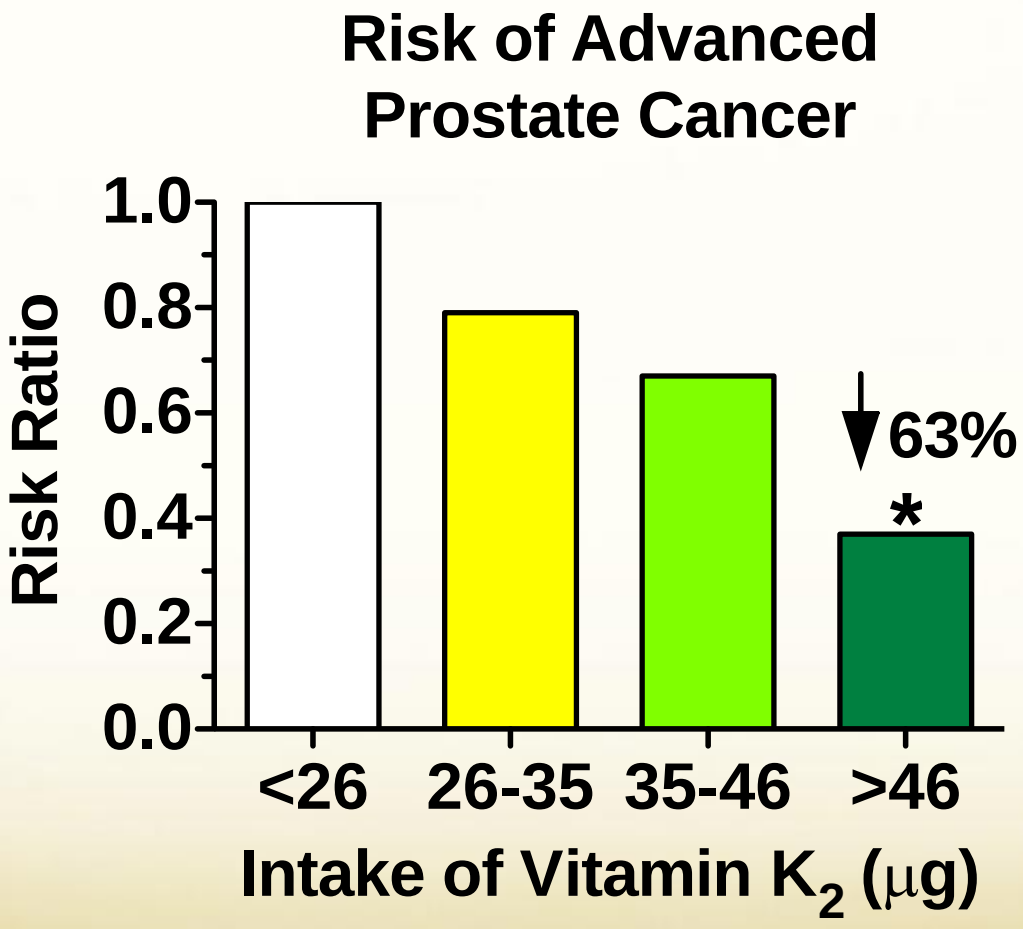
Activated Vitamin K-Dependent Proteins

Strong Bones and Teeth
Protection Against Soft Tissue Calcification
Adequate Growth

Unanswered Questions

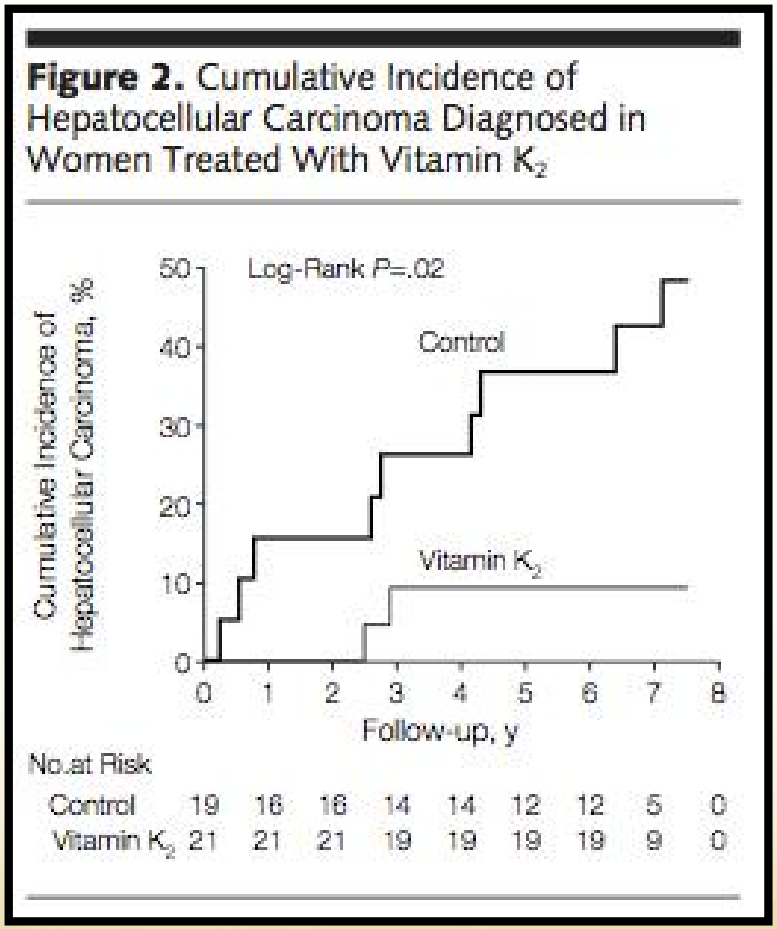
- Can the mechanistic understanding generated by the Tufts study be replicated in a study using dietary vitamins rather than the activated hormone forms?
- Does vitamin K protect against vitamin D toxicity like vitamin A does? Or is it the vitamin K-dependent enzyme rather than the amount of vitamin K that is limiting?
- Can this be replicated in other species?

Vitamin K_2 Intake Associated With a Reduced Risk of Advanced Prostate Cancer



Niptsch et al. Dietary Intake of vitamin K and risk of prostate cancer in the Heidelberg cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Heidelberg). Am J Clin Nutr. 2008;87:985-92.

Vitamin K_2 Reduces the Risk of Liver Cancer in Women by 87%



Habu et al. Role of Vitamin K2 in the Development of Hepatocellular Carcinoma in Women With Viral Cirrhosis of the Liver. JAMA. 2004;292:358-61.

The Many Functions of Vitamin A

- Essential to good vision, especially night vision.
- Essential to male and female reproduction.
- Essential to proper development of organs and tissues.
- Aids in the production of steroid hormones.
- Protects against kidney stones.
- May protect against asthma.
- Supports dopamine signaling; may protect against depression and support focused, goal-oriented behavior.
- Protects against fatty liver disease.
- Protects against oxidative stress and exposure to environmental toxins.

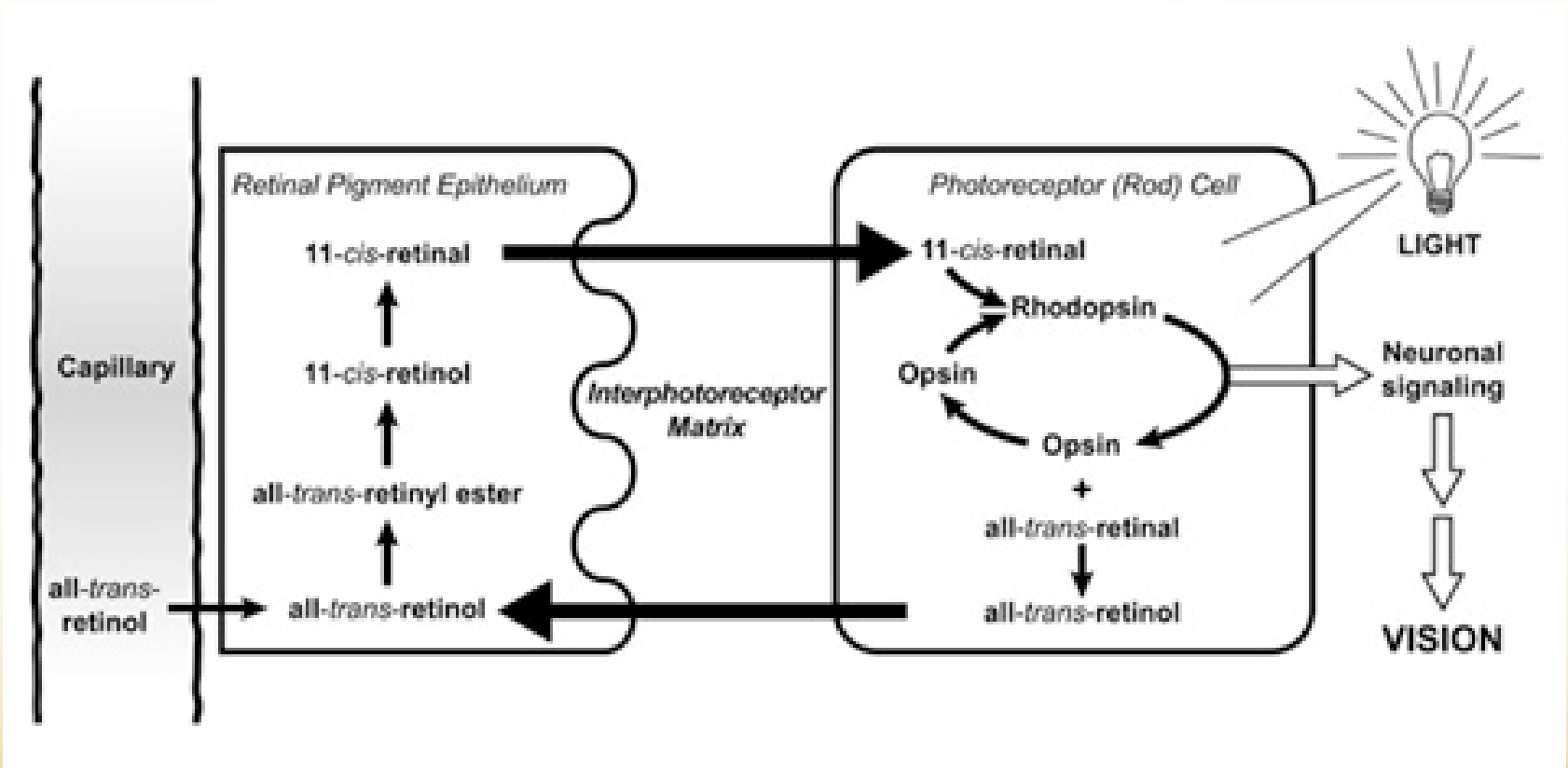
Many Roles for Vitamin D?

- **Rickets and osteomalacia**
- **Hypocalcemia**
- **Convulsions, tetany and heart failure in the newborn**
- **Osteoporosis**
- Heart Disease
- High blood pressure
- Obesity
- Arthritis
- Mental Illness
- Chronic Pain
- Muscular weakening
- Radiation poisoning
- Diabetes
- Multiple sclerosis
- Other autoimmune diseases

Making the Most of the Fat-Soluble Vitamins: Zinc, Magnesium, Fat, Carbs, Carbon Dioxide, and Thyroid!

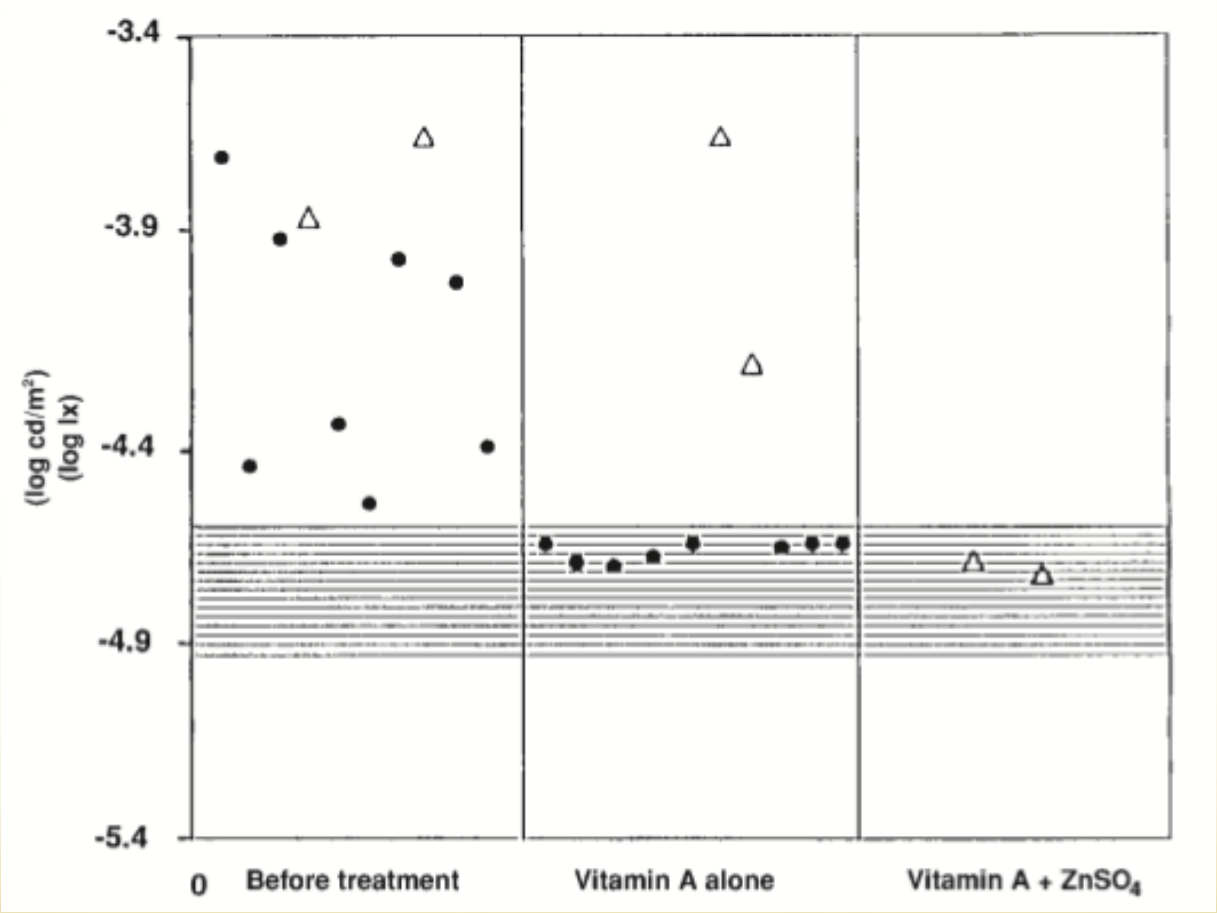
(Oh my!)

Vitamin A Helps Convert Impulses of Light Into Visual Images



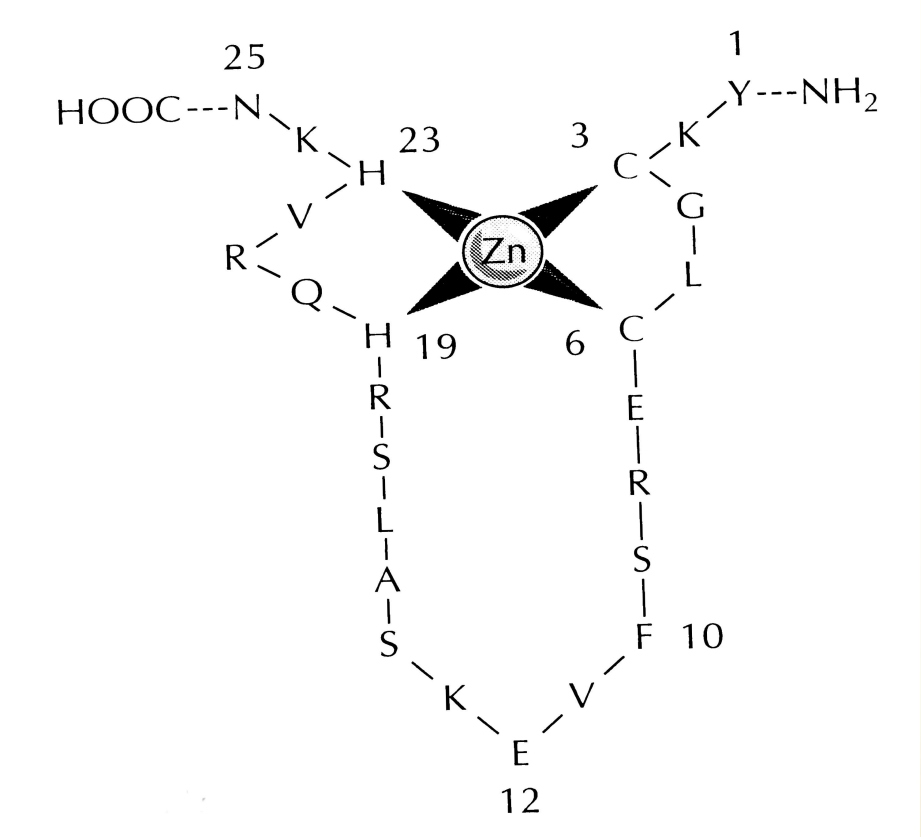
http://lpi.oregonstate.edu/infocenter/vitamins/vitaminA/visualcycle.html

Zinc Is Sometimes Necessary to Correct Vitamin A-Related Visual Function

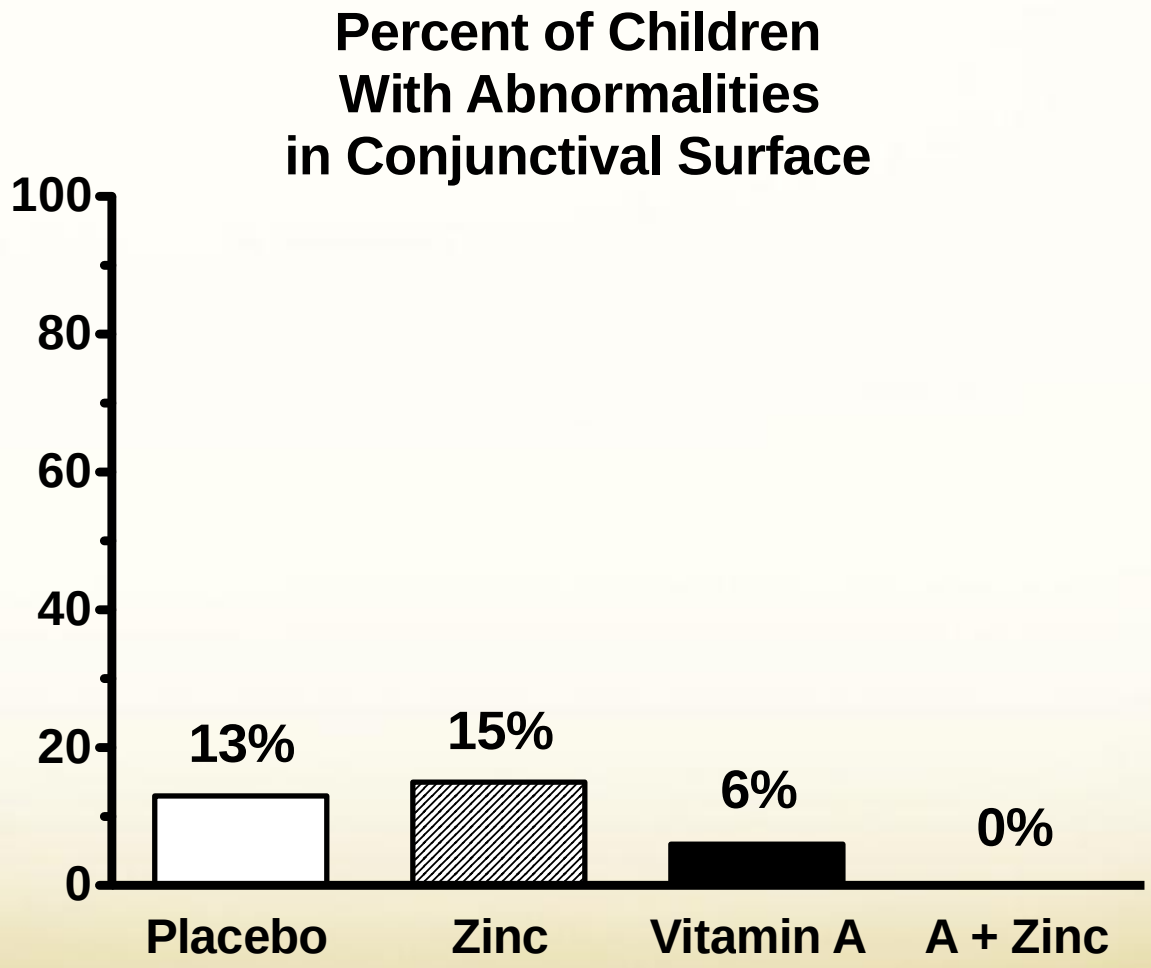


Russell RM. The vitamin A spectrum: from deficiency to toxicity. Am J Clin Nutr. 2000;71:878-84.

A “Zinc Finger Motif” Activates the Nuclear Receptors For the Fat-Soluble Vitamins



Zinc Is Needed For Vitamin A to Promote Proper Eye Development



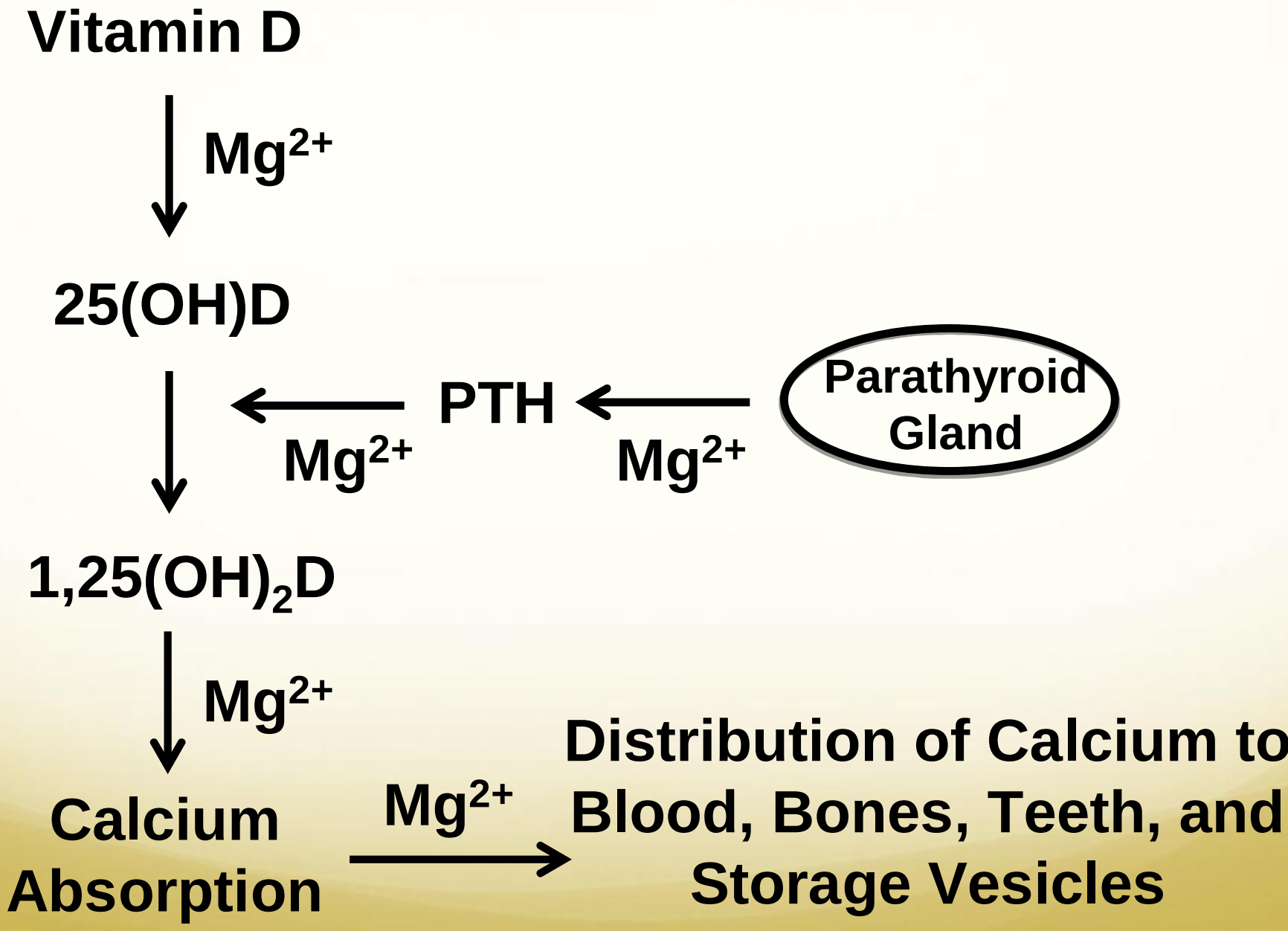
Udomkesmalee E, Dhanamitta S, Sirisinha S, Charoenkiatkul S, Tuntipopipat S, Banjong O, Rojroongwasinkul N, Kramer TR, Smith JC. Effect of vitamin A and zinc supplementation on the nutriture of children in Northeast Thailand. *Am J Clin Nutr.* 1992;56:50-7.

Zinc is Found Most Abundantly in Oysters, Beef, and Cheese

Food	Zinc (mg/100 g)
Oysters	17-91
Ground Beef	3.9-4.1
Liver	3.1-3.9
Cheese	2.8-3.2
Chicken	1.0-2.0
Eggs	1.1
Legumes	0.6-1.0
Milk	0.4
Grains and Cereals	0.3-1.0
Vegetables	0.1-0.7
Fruit	<0.1

From Groff and Gropper, *Advanced Nutrition and Human Metabolism,* 2005.

The Role of Magnesium

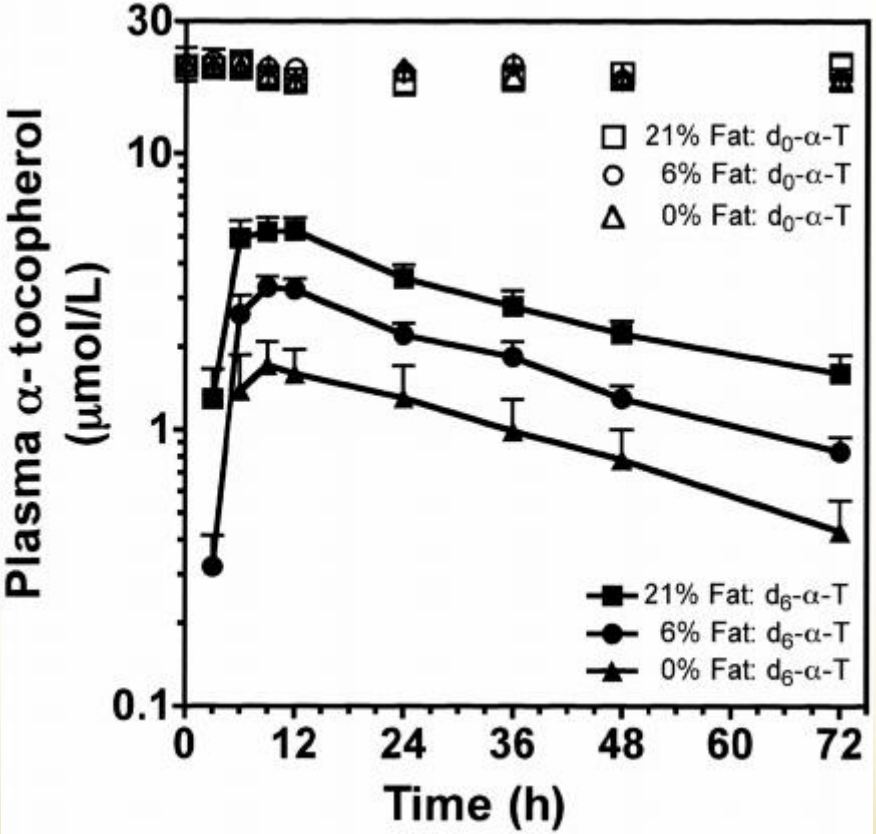


Magnesium is Rich in Many Foods, But Not Meat Or Refined Carbs

Food	Magnesium (mg/100 g)
Pumpkin and Squash Seeds	534
Brazil Nuts	376
Caviar	300
Buckwheat	231
Tomatoes	194
Kidney Beans	140
Whole Wheat	126
Hamburger	27
Liver	18
Enriched White Flour	16
Table Sugar	9

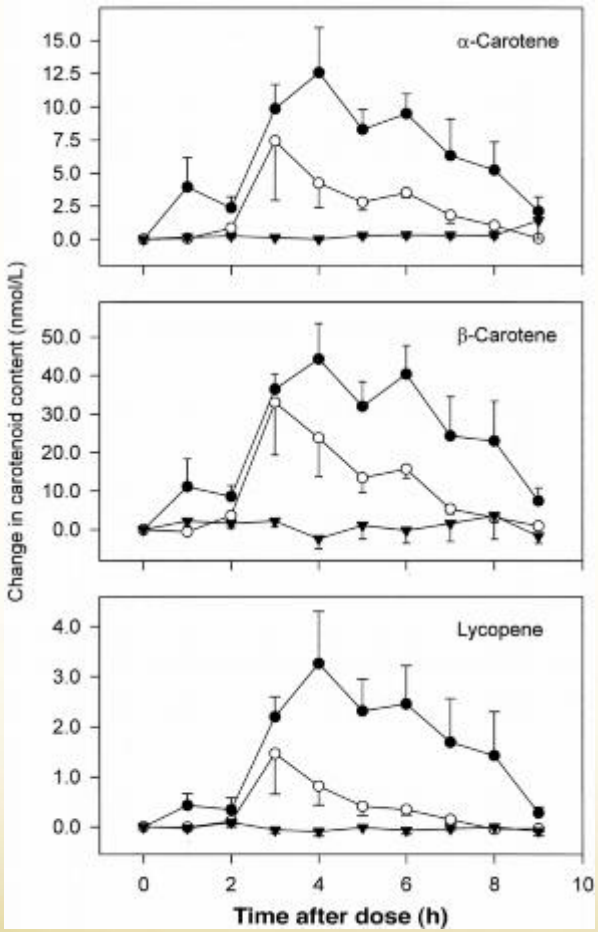
www.nutritiondata.com

Butterfat Increases the Absorption of Vitamin E



Bruno et al. Human vitamin E requirements assessed with the use of apples fortified with deuterium-labeled alpha-tocopheryl acetate. Am J Clin Nutr. 2006;83(2):299-304.

Canola Oil Increases Absorption of Carotenes From Salad



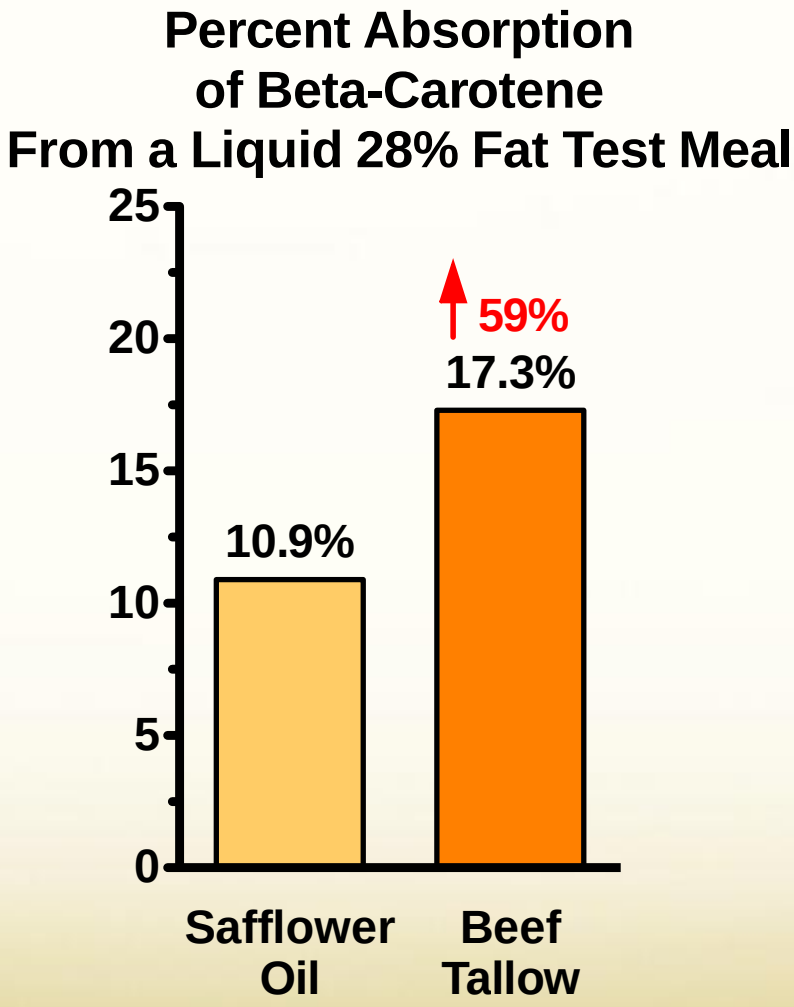
28 grams of fat

6 grams of fat

0 grams of fat

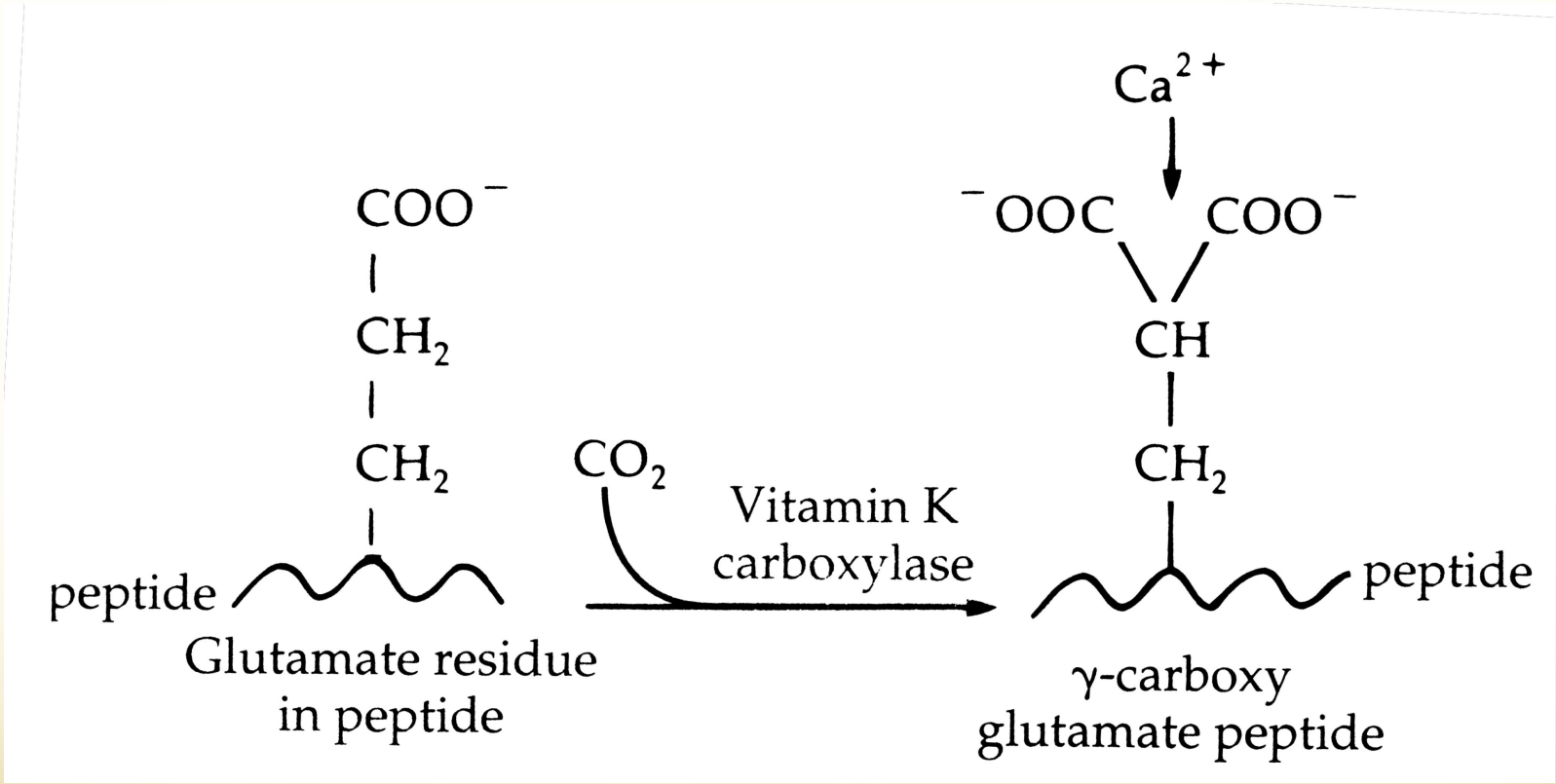
Brown et al. Carotenoid bioavailability is higher from salads ingested with full-fat than with fat-reduced salad dressings as measured with electrochemical detection. Am J Clin Nutr. 2004;80(2):396-403.

Saturated Fats Are Superior At Promoting Fat-Soluble Vitamin Absorption

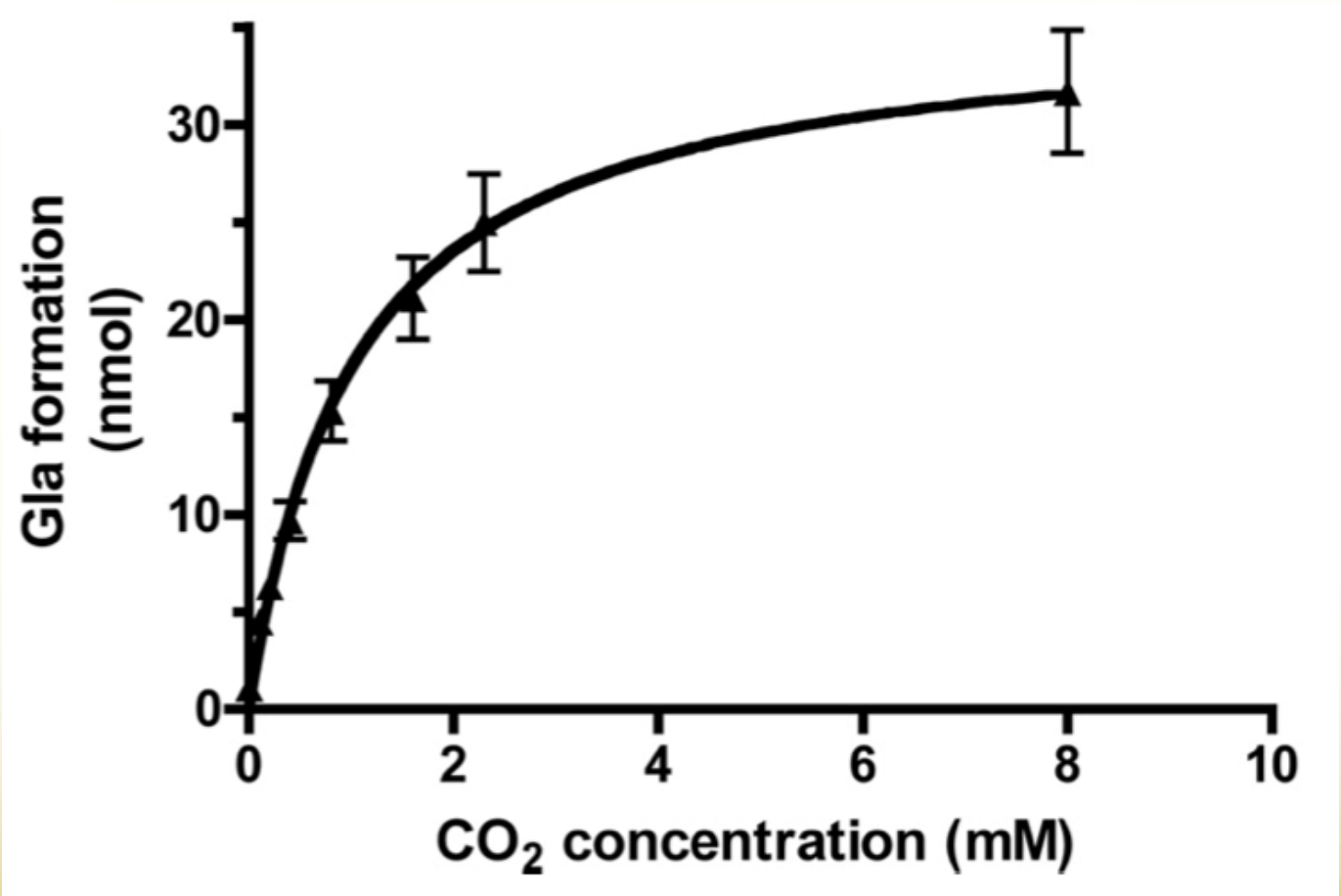


Hu X, Jandacek RJ, White WS. Intestinal absorption of [beta]-carotene ingested with a meal rich in sunflower oil or beef tallow: postprandial appearance I triacylglycerol-rich lipoproteins in women. *Am J Clin Nutr.* 2000;71:1170-80.

Vitamin K Activates Proteins With Carbon Dioxide, Giving Them the Ability to Bind Calcium



Activation of Vitamin K-Dependent Proteins Depends on the Concentration of CO_2



Rishavy et al. The Vitamin K-dependent Carboxylase Generates [gamma]-Carboxylated Glutamates by Using CO2 to Facilitate Glutamate Deprotonation in a Concerted Mechanism That Drives Catalysis. J Biol Chem. 2011;286(52):44821-32.

Blood Results for Gary Taubes

03/30/2011 07:16AM QUEST DIAGNOSTICS FAX REPORT PAGE 2 OI

QUEST DIAGNOSTICS INCORPORATED

PATIENT INFORMATION
TAUBES,GARY

DOB: 04/30/1956 AGE: 54
GENDER: M FASTING: U

ID:
PHONE: [redacted]

REPORT STATUS **FINAL** RI

ORDERING PHYSICIAN
NAGLER,BILL

CLIENT INFORMATION
4207630
NAGLER,BILL
16311 MIDDLEBELT
LIVONIA,MI 48154

SPECIMEN INFORMATION
SPECIMEN: BA3869843
REQUISITION: SCRIPT,

COLLECTED: 03/22/11 16:16
RECEIVED: 03/22/11 16:18
REPORTED: 03/30/11 07:15

COMMENTS: The original copy of this report was printed on: 03/25/11 at 04:35

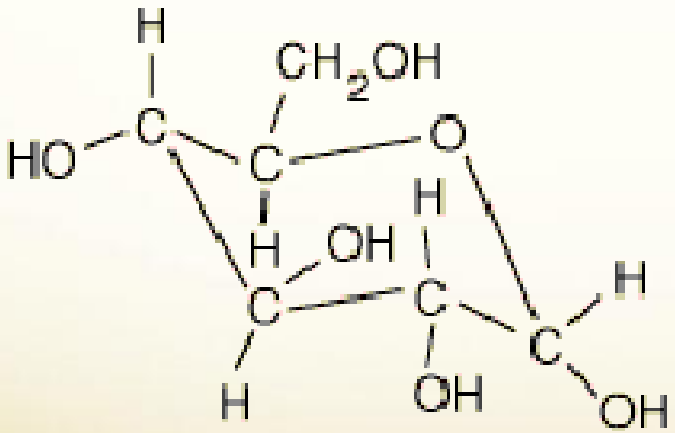
Test Name	In Range	Out of Range		Reference Range
COMPREHENSIVE METABOLIC PANEL				
COMPREHENSIVE METABOLIC PANEL				
SODIUM, SERUM	143			135-146 mmol/L
POTASSIUM, SERUM	4.3			3.5-5.3 mmol/L
CHLORIDE, SERUM	107			98-110 mmol/L
CARBON DIOXIDE (CO2)		**19**	**L**	21-33 mmol/L
UREA NITROGEN,BLOOD (BUN)	24			7-25 mg/dL
CREATININE, SERUM	1.08			0.76-1.46 mg/dL
eGFR	>60			SEE BELOW

http://garytaubes.com/2011/04/before-sugar-were-talking-about-cholesterol/

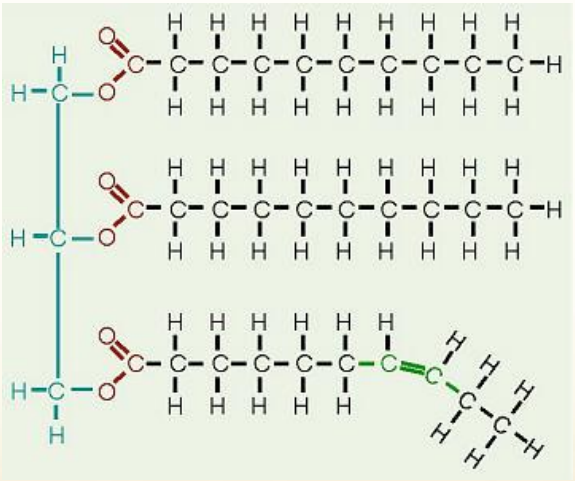
Carbon Dioxide – What's the Limiting Atom?

CO_2

Carbon Dioxide

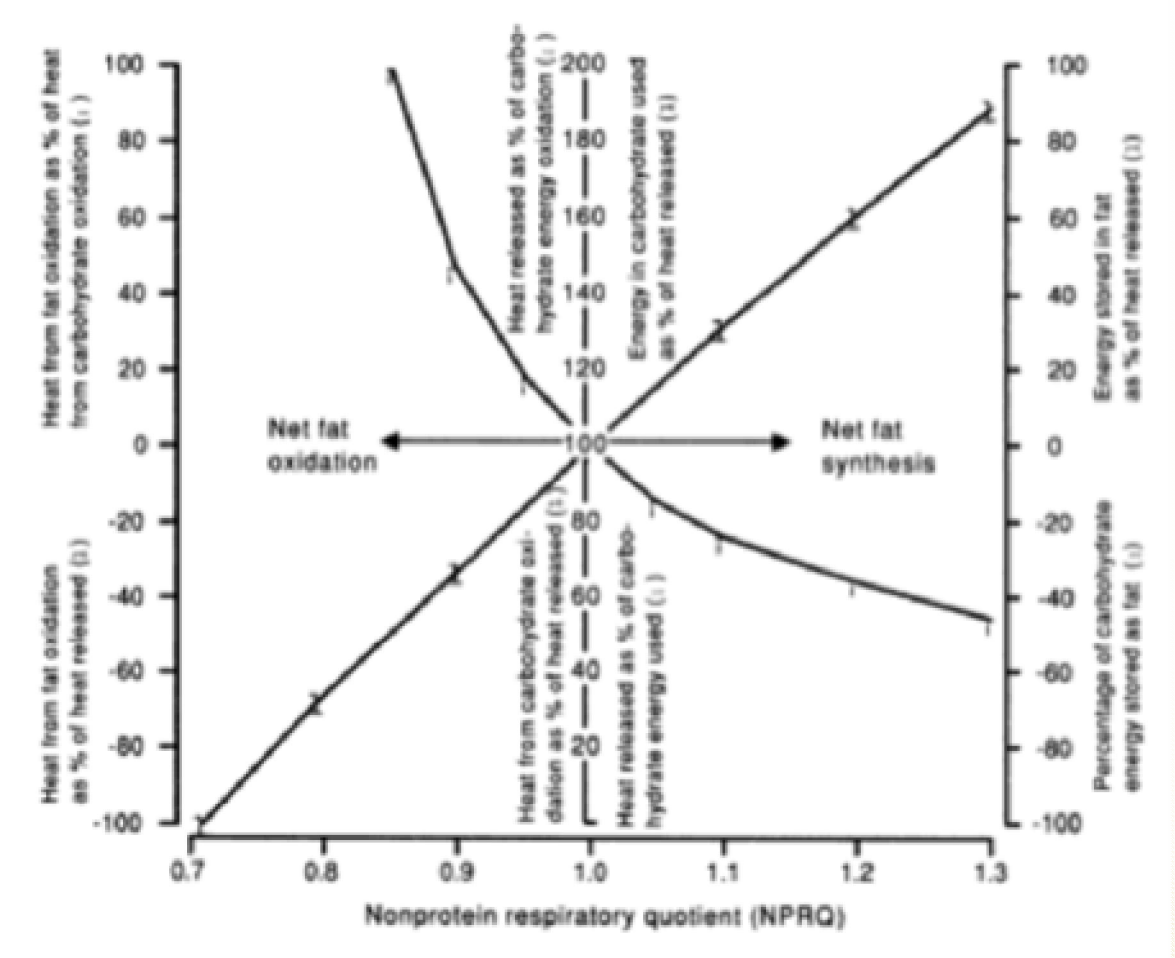


Glucose

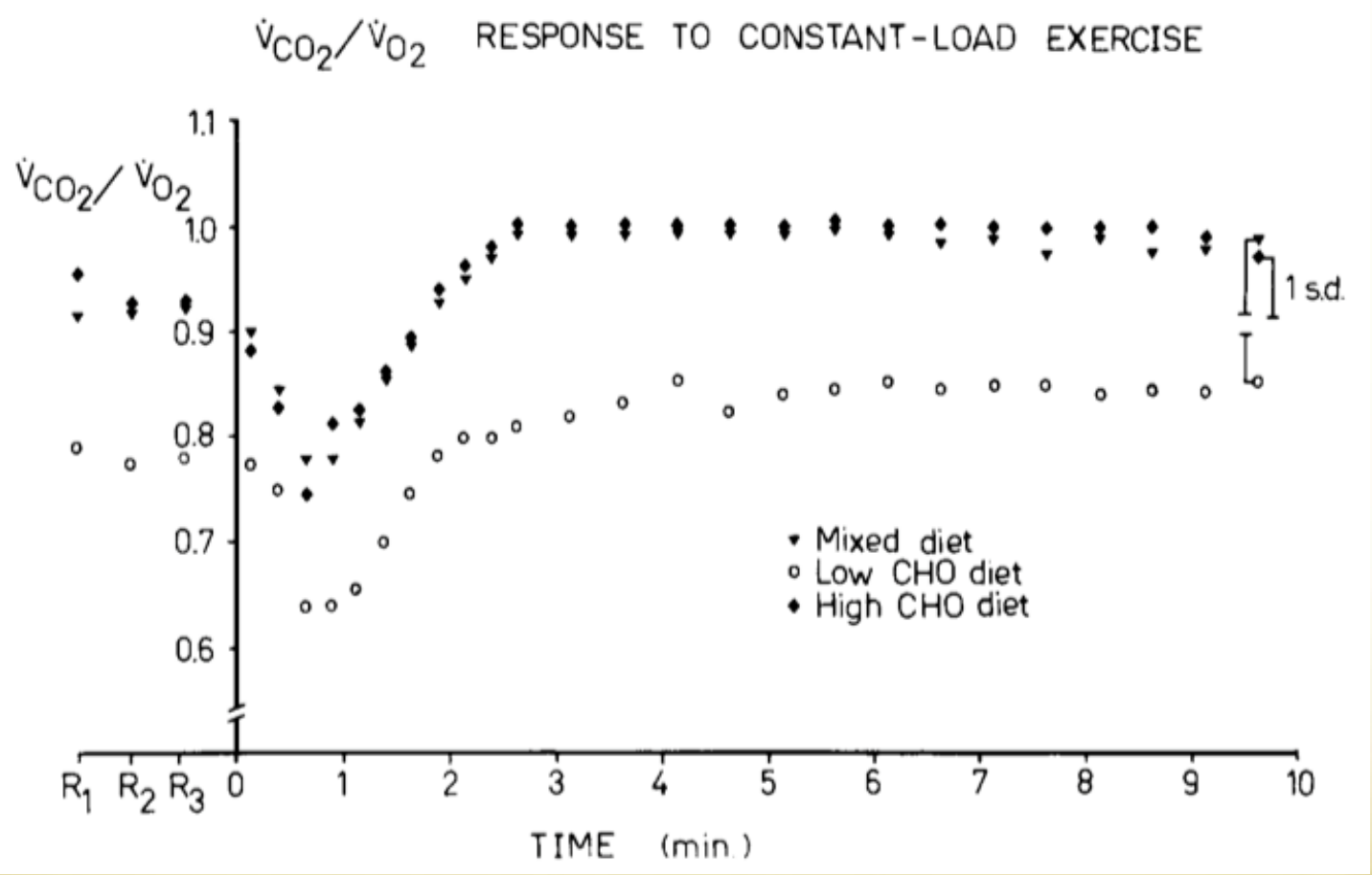


Fat

The Respiratory Quotient (CO_2/O_2) Increases Proportionally With Carbohydrate Utilization

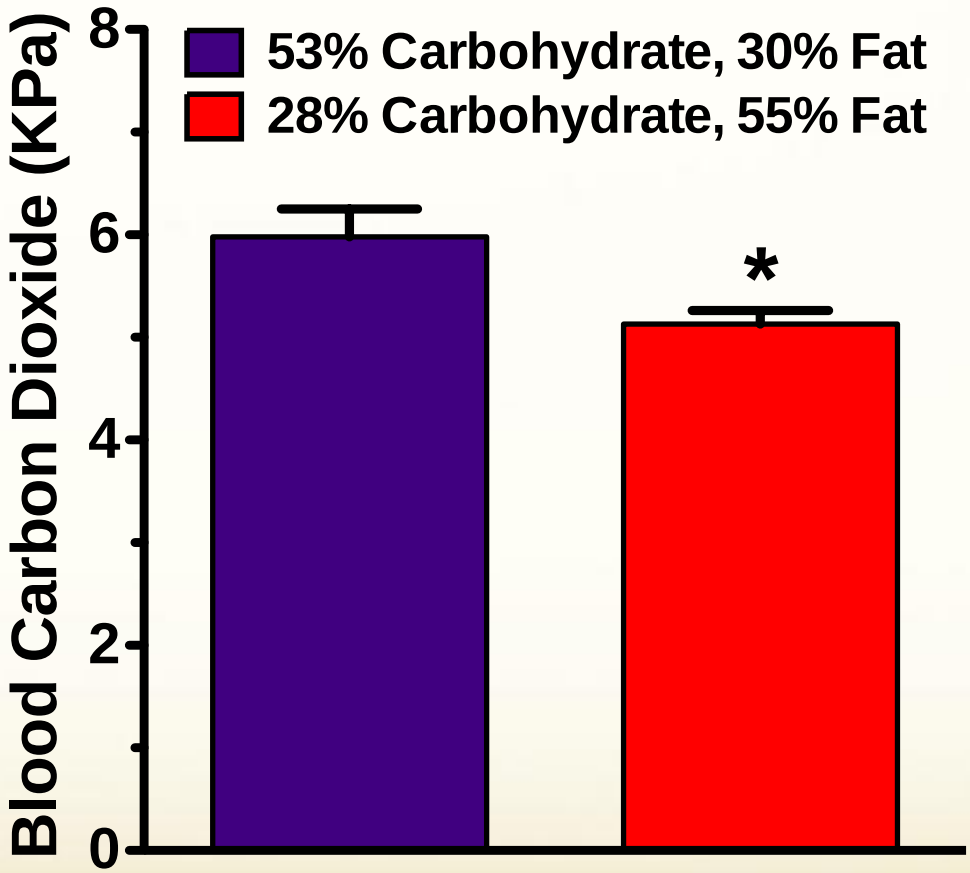


Production of CO_2 Declines on a Low-Carbohydrate Diet



Hughson and Kowalchuk. Influence of Diet on CO2 Production and Ventilation in Constant-Load Exercise. Respiration Physiology. 1981;46:149-160.

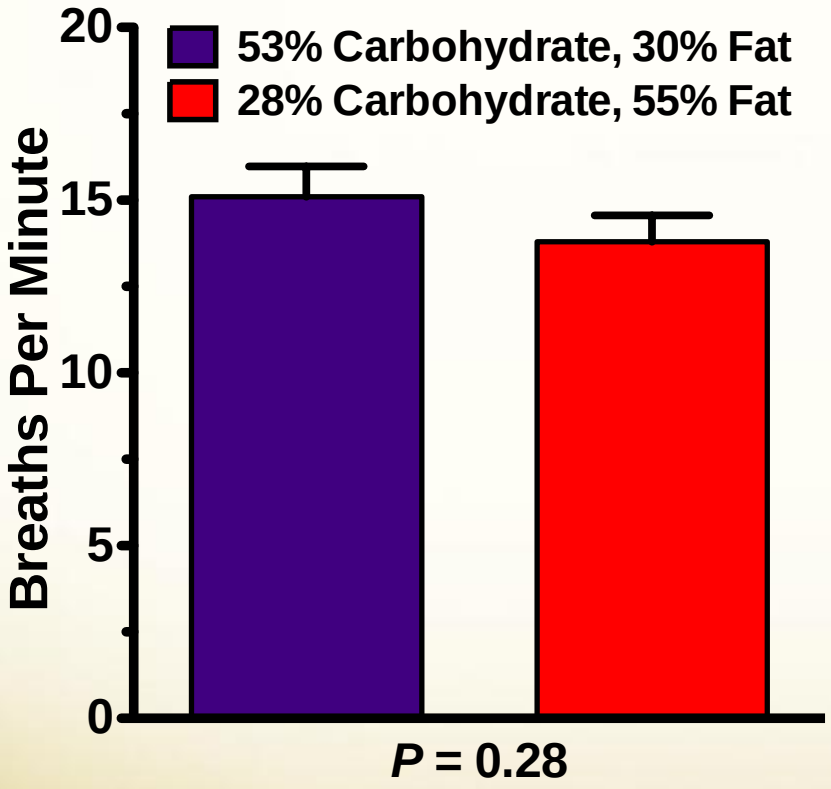
Low-Carbohydrate Diets Lower Blood Levels of Carbon Dioxide

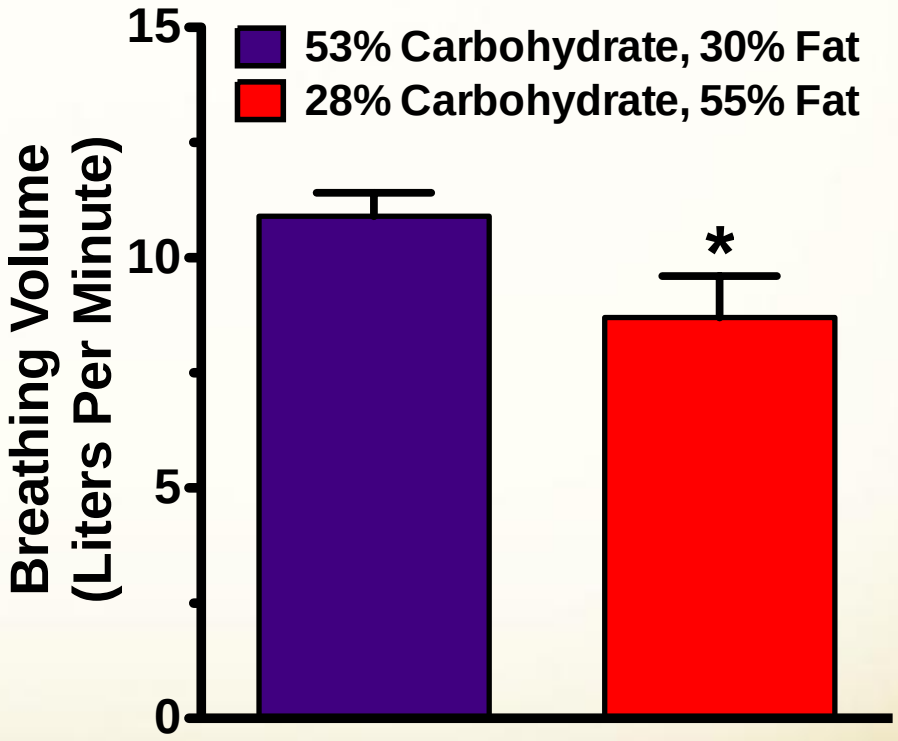


20 adult patients requiring artificial ventilation fed a standard or low-carb, high-fat diet through a feeding pump

Al-Saady et al. High-fat, low carbohydrate, enteral feeding lowers PaCO2 and reduces the period of ventilation in artificially ventilated patients. Intensive Care Med. 1989;15:290-295.

Low-Carbohydrate Diets Lower the Breathing Rate





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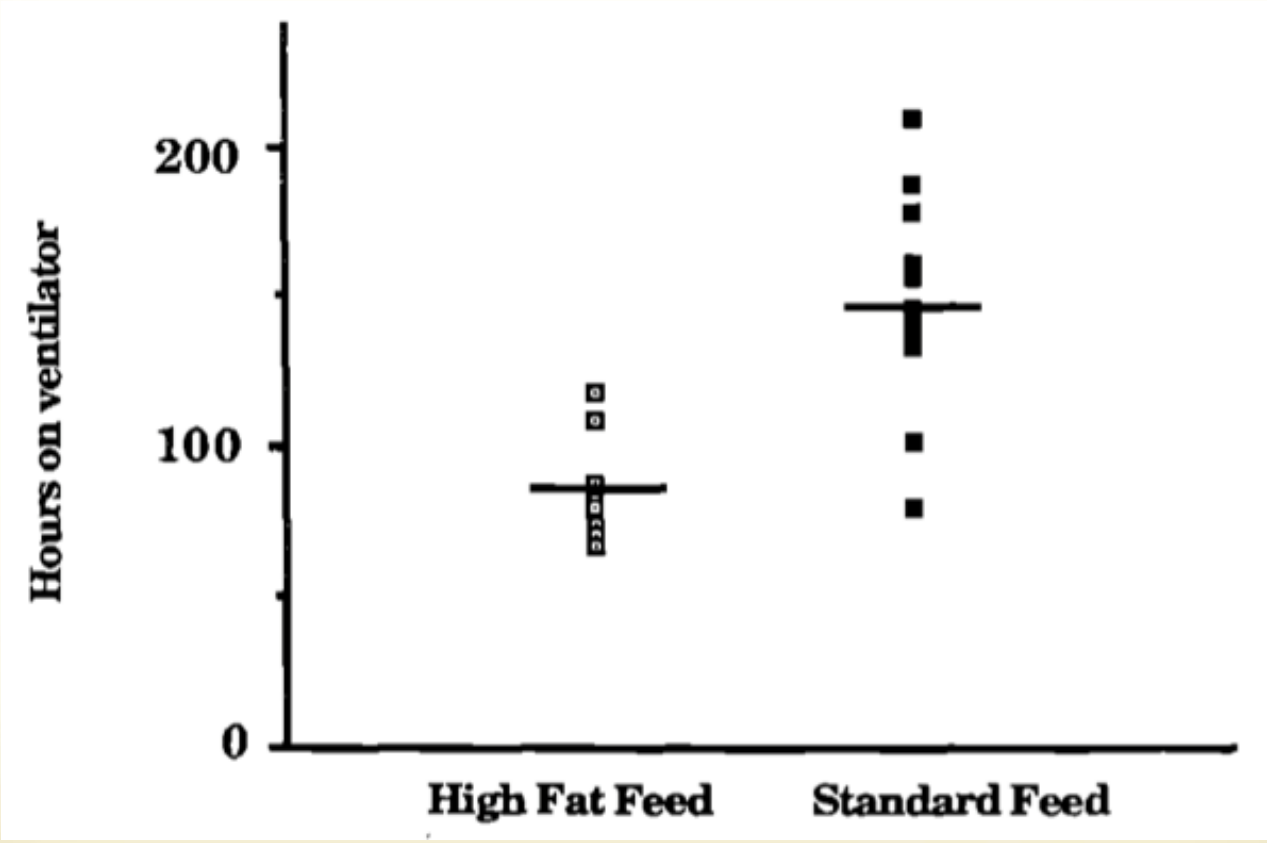
Al-Saady et al. High-fat, low carbohydrate, enteral feeding lowers PaCO2 and reduces the period of ventilation in artificially ventilated patients. Intensive Care Med. 1989;15:290-295.

Low-Carbohydrate Diets Reducing Breathing Rate and Time on Ventilator



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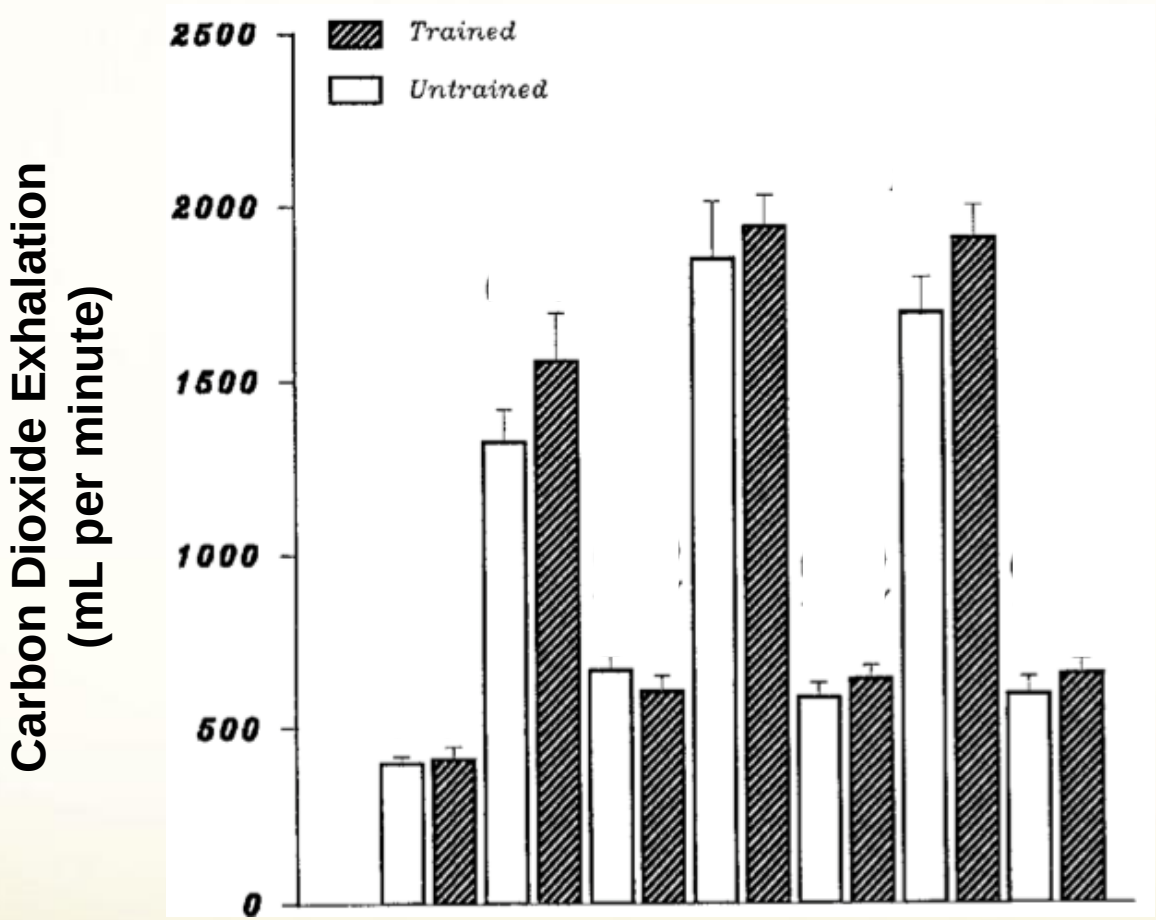
Al-Saady et al. High-fat, low carbohydrate, enteral feeding lowers PaCO2 and reduces the period of ventilation in artificially ventilated patients. Intensive Care Med. 1989;15:290-295.

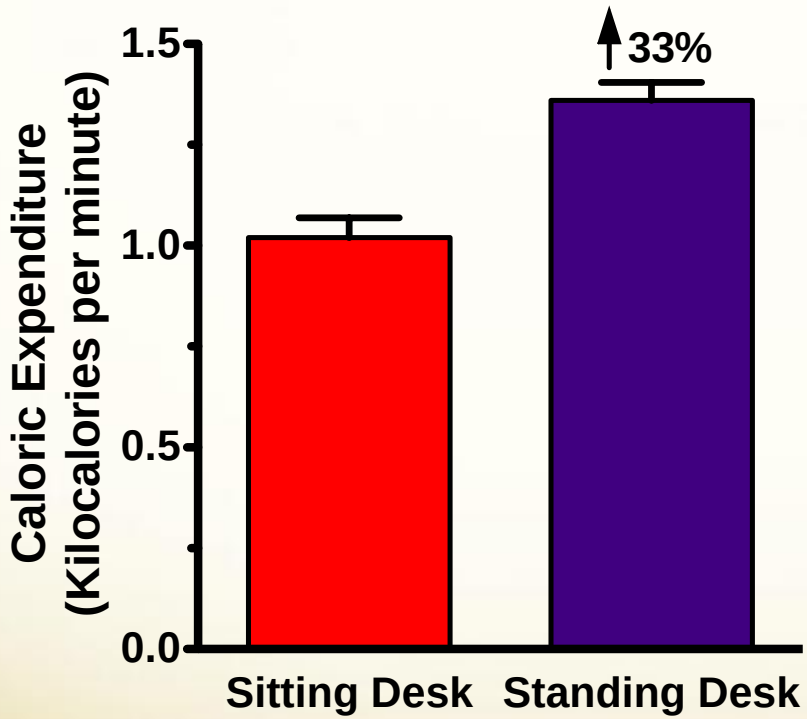
Intense Exercise Increases Carbon Dioxide

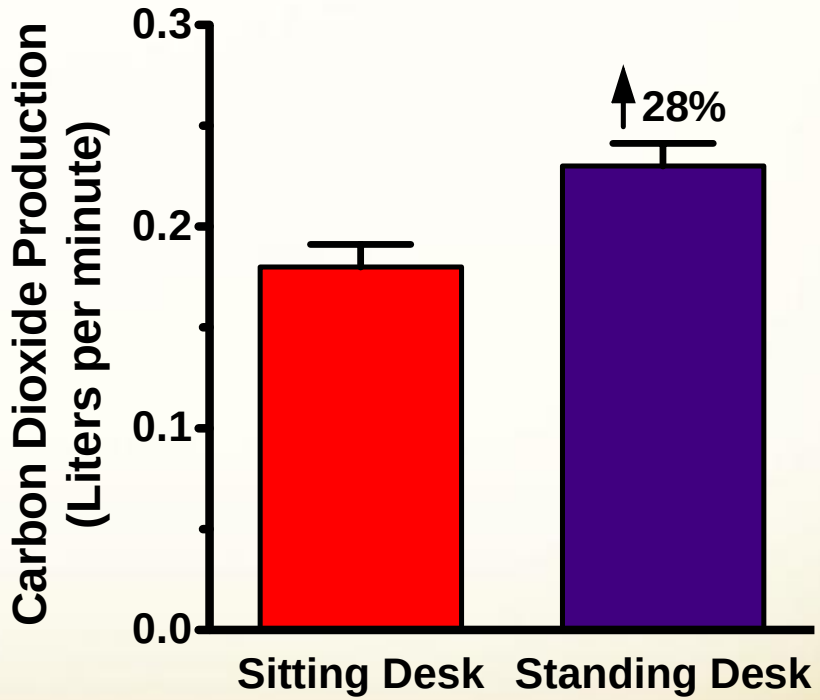


Pre-exercise, followed by three six-second periods of intense cycling interspersed by five-minute periods of rest, among 18 trained or untrained healthy men ages 18-33.

Chamari et al. Pulmonary gas exchange and ventilatory responses to brief intense intermittent exercise in young trained and untrained adults. Eur J Appl Physiol. 1995;70:442-450.

Working at a Standing Desk Increases Carbon Dioxide Production

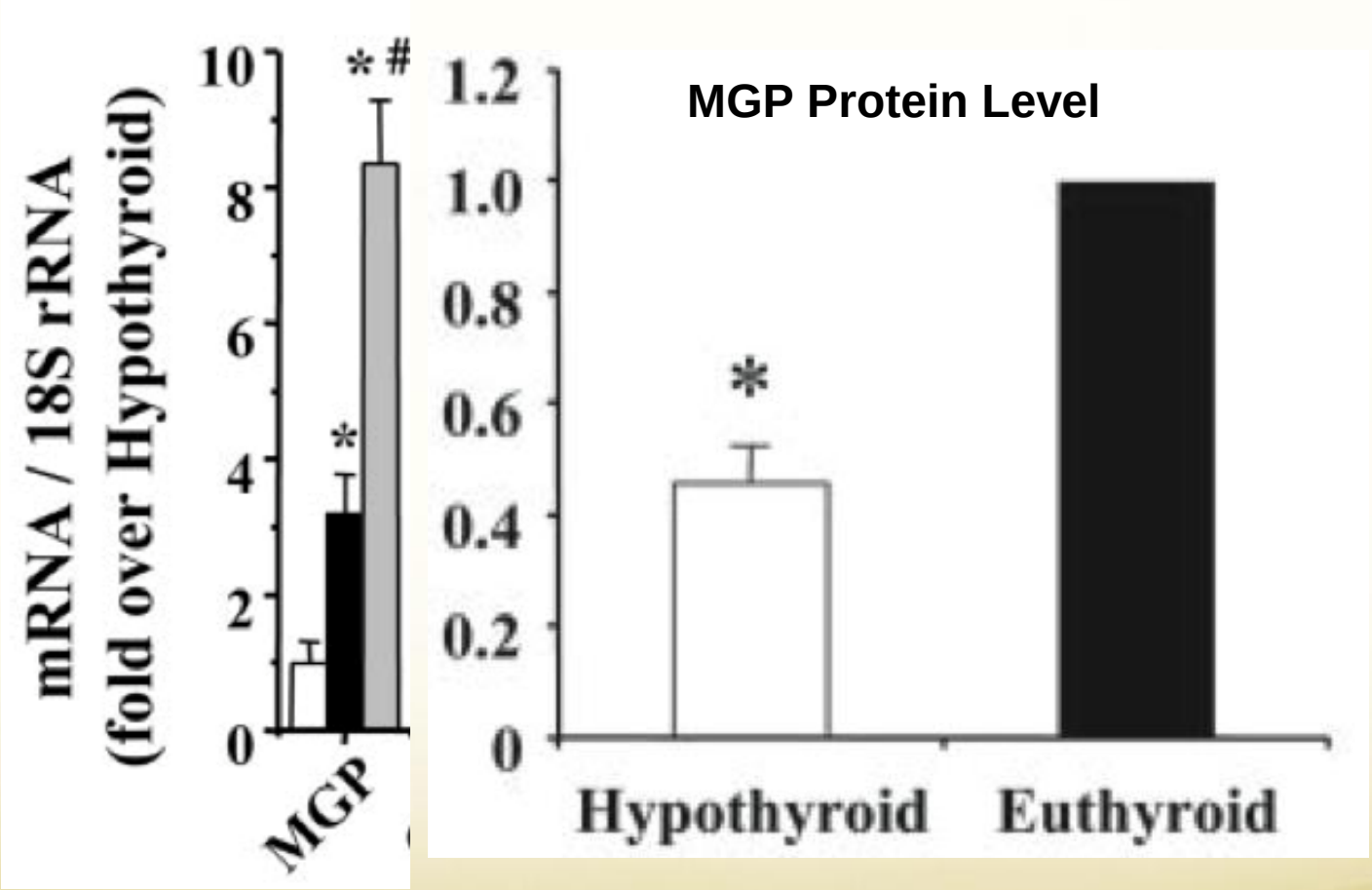




20 healthy young adult men and women performed crossword puzzles and wordfinds for 45 minutes.

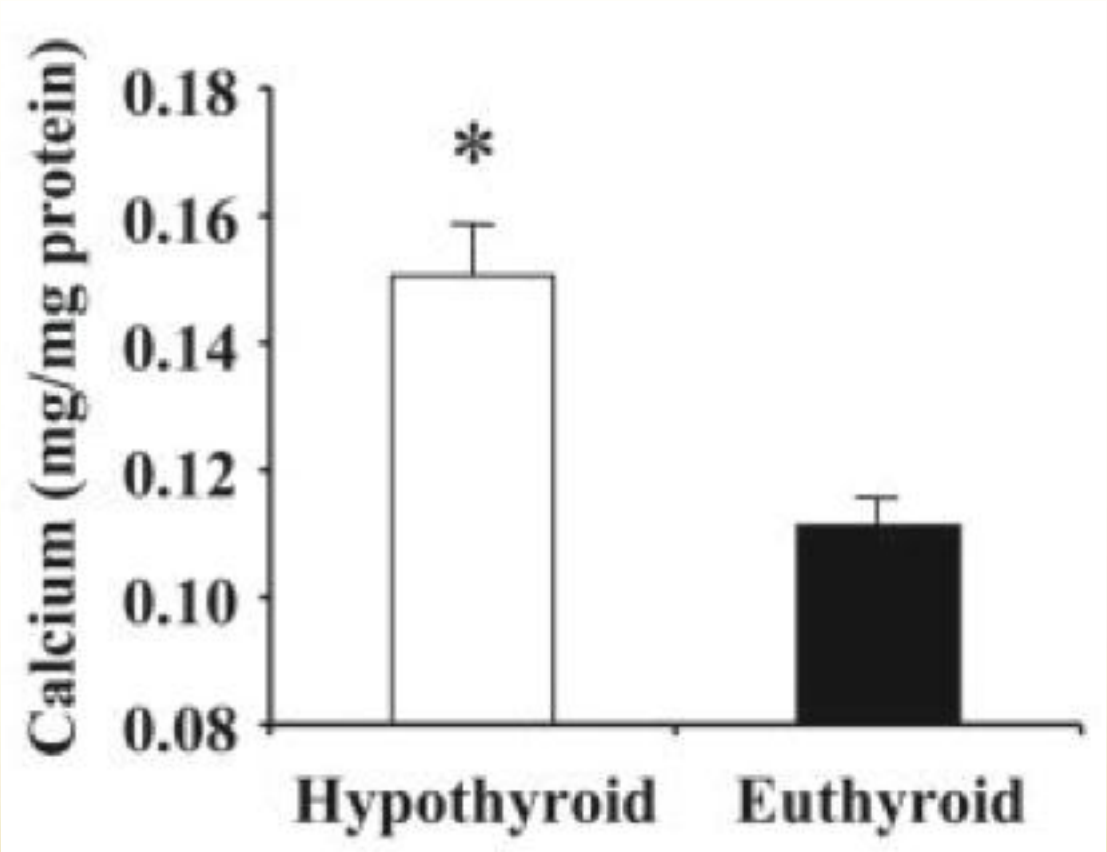
Reiff C, Marlatt K, Dengel DR. Difference in caloric expenditure in sitting versus standing desks. J Phys Act Health. 2012;9(7):1009-11.

Thyroid Hormone Increases the Production of Vitamin K-Dependent Proteins in Rats



Sato et al. Thyroid hormone targets matrix Gla protein gene associated with vascular smooth muscle calcification. Circ Res. 2005;97(6):550-7.

Thyroid Hormone Prevents Blood Vessel Calcification



Sato et al. Thyroid hormone targets matrix Gla protein gene associated with vascular smooth muscle calcification. Circ Res. 2005;97(6):550-7.

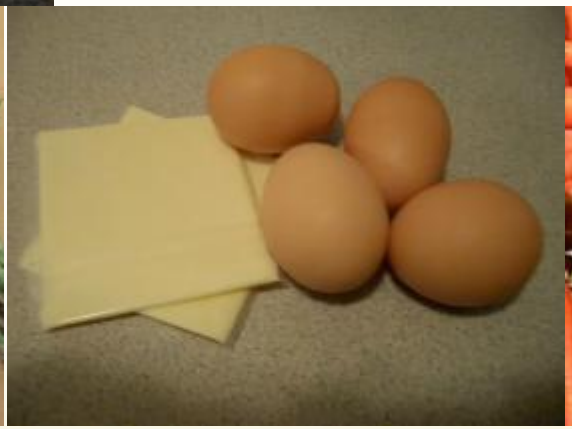
Conclusions

- Vitamins A, D, and K_2 cooperate together to protect soft tissues from calcification, provide for adequate growth, and nourish strong bones and teeth.
- Vitamin A is found primarily in liver and cod liver oil, while carotene-rich plant foods can also support vitamin A status.
- Vitamin D is found primarily in cod liver oil and fatty fish, and obtained from sunshine.
- Vitamin K_2 is found primarily in animal fats and fermented foods, especially egg yolks and hard cheeses.
- Zinc and magnesium are needed to support the fat-soluble vitamins. The best way to obtain these minerals is to eat a diet inclusive of both animal foods and plant foods but devoid of refined carbohydrates.
- Fat is necessary to absorb fat-soluble vitamins, while carbohydrate, thyroid hormone, and exercise may help optimize carbon dioxide production for the activation of vitamin K-dependent proteins.

Thank You!








Chris Masterjohn, PhD
Blog: *The Daily Lipid*
http://blog.cholesterol-and-health.com