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Micronutrients: Vitamin B1 - Thiamin

Dr. Ritamarie Loscalzo

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B Vitamins At a Glance

Letter	Names	Notes/Actions
B1	Thiamin, Benfotiamine	Energy, heart, muscle, and nerve function
B2	Riboflavin, R 5'-Phosphate	Energy, red blood cells, vision
B3	Niacin, Nicotinic Acid, Niacinamide	Energy, nerve function, circulation and heart
B4	Choline, Adenine, Carnitine	Loosely considered as B vitamins - cell membranes, memory, neuromuscular
B5	Pantothenic Acid	Coenzyme A, adrenals, skin
B6	Pyridoxine, Pyridoxal 5'-Phosphate	Brain and nerve, hormones, protein synthesis
B7	Biotin	Hair, metabolism
B8	Inositol	Loosely considered a B vitamin
B9	Folate, Methylfolate, Folinic Acid	Red blood cell production, DNA repair, brain
B10	Pteroylmonoglutamic Acid (PABA – Para-aminobenzoic Acid)	Really a form of folate, skin protector
B11	Salicylic Acid	Not technically a vitamin, loosely categorized
B12	Cobalamin	Red blood cells, DNA repair, nervous system

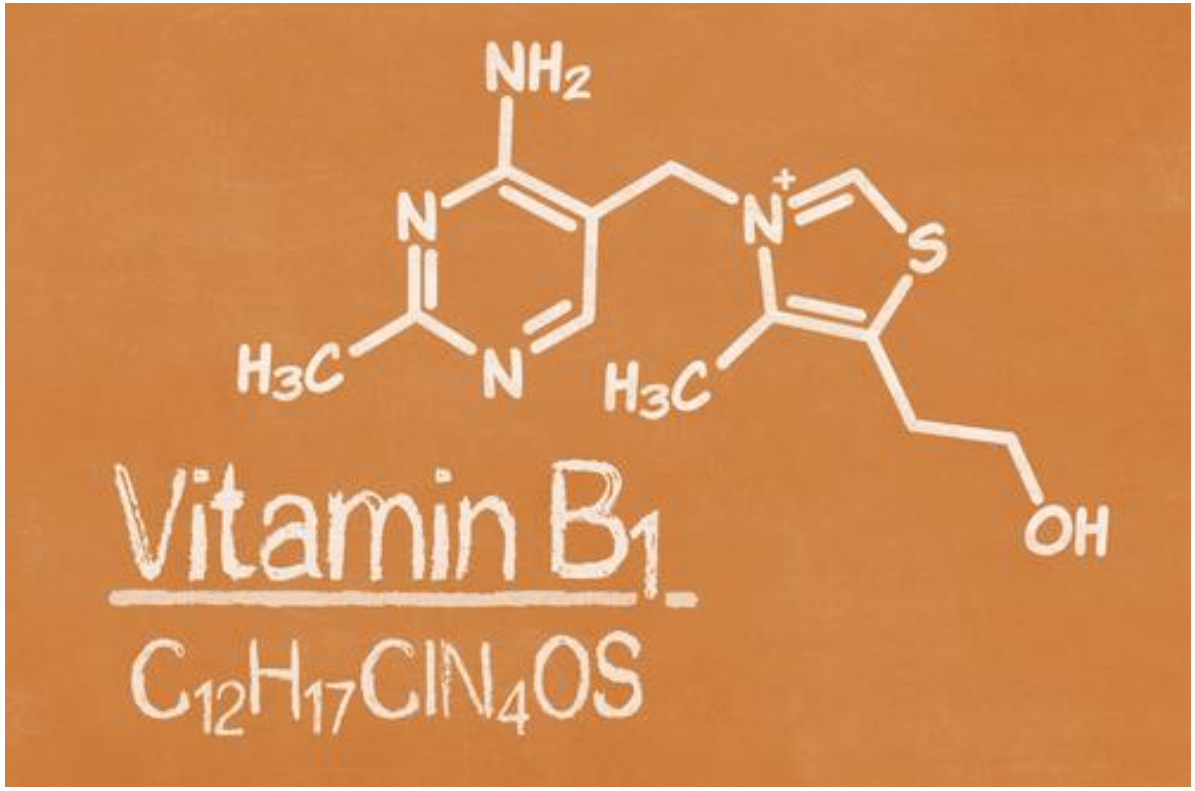
General Info - Thiamin

- ✓ The first vitamin isolated in pure form
- ✓ Water soluble
- ✓ Free form in plants
- ✓ Phosphorylated form in animal sources: thiamin diphosphate (TDP) and thiamin pyrophosphate (TPP)

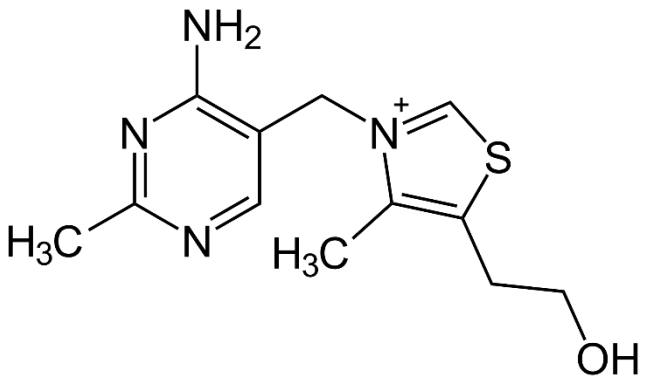
- ✓ Thiamin hydrochloride (HCl) and mononitrate in supplements
- ✓ Benfotiamine is a fat-soluble form which lasts longer, yielding potentially therapeutic benefits over ordinary thiamin

Thiamin Chemistry

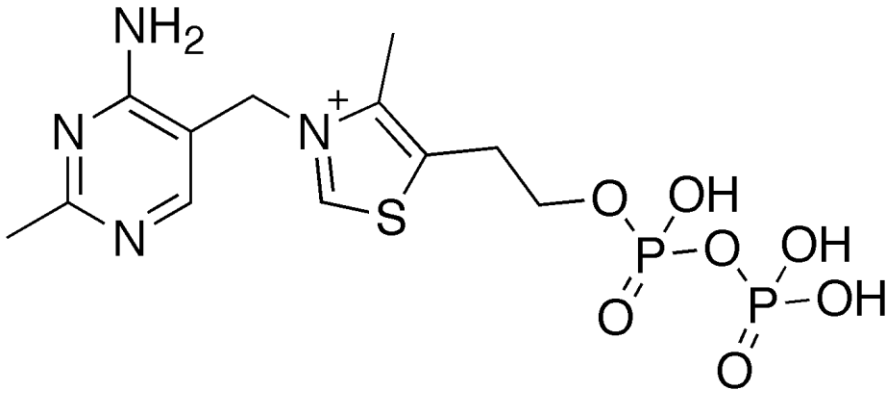
- ✓ Oxidative phosphorylation of keto acids and 2-keto sugars
- ✓ Pyrimidine ring plus thiazole ring linked by a methylene (CH2) bridge



Thiamin Forms

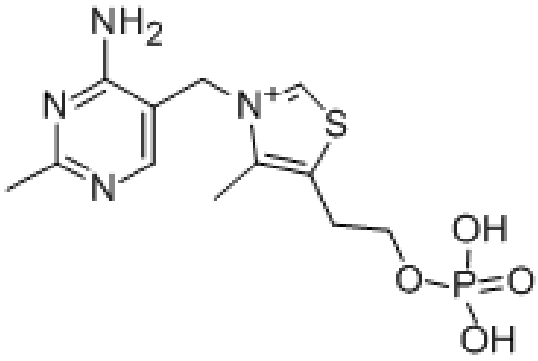


Free form

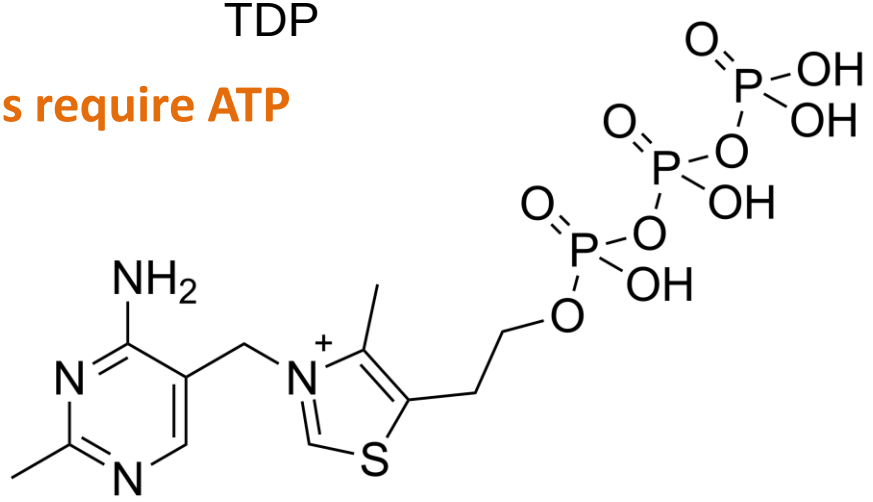


TDP

Conversions require ATP



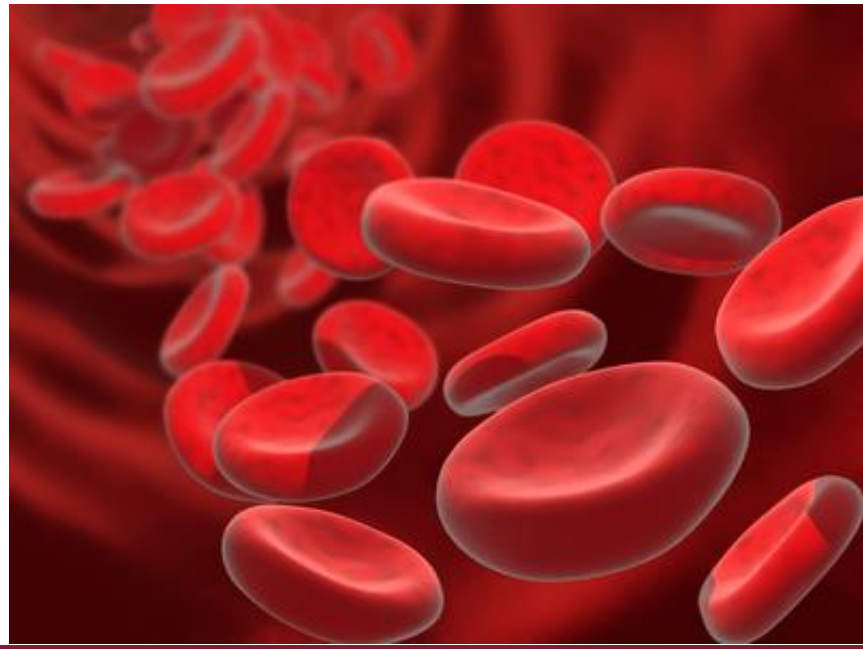
TMP



TTP

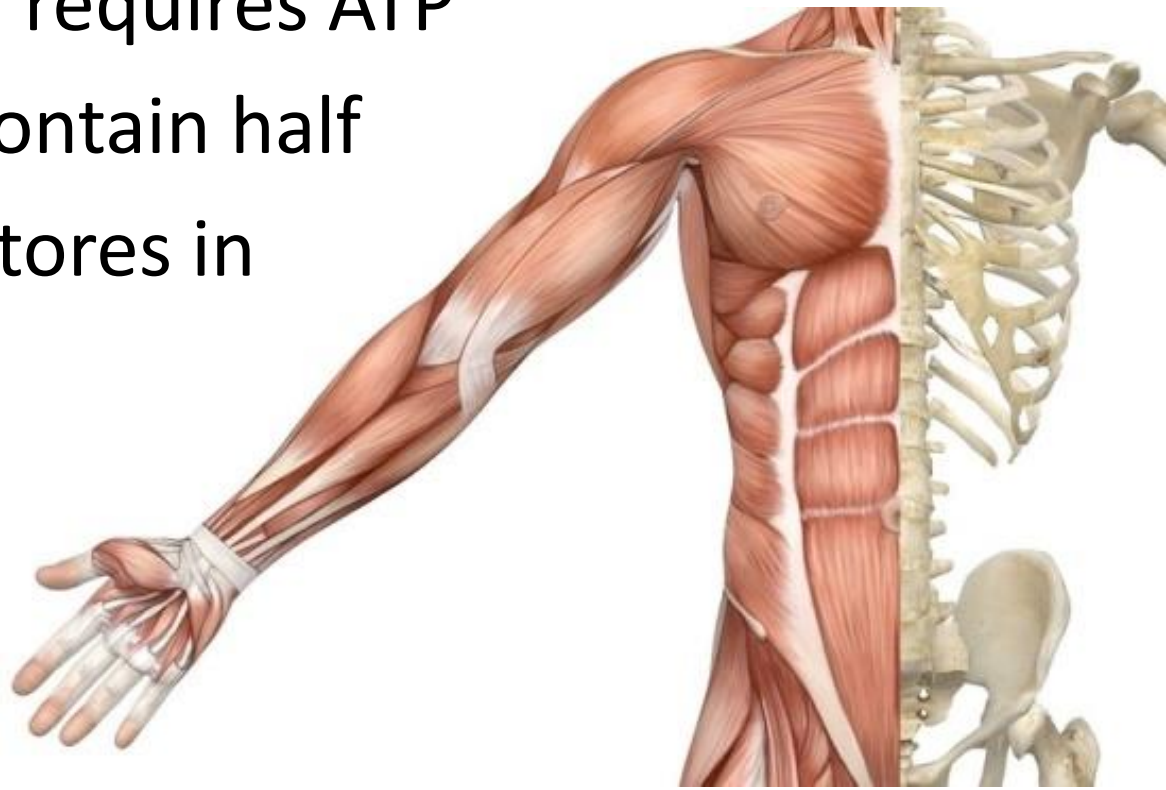
Thiamin Transport

- ✓ Transported in blood **mostly as free form** or bound to albumin
- ✓ Some transported as **thiamine monophosphate**
- ✓ **90% is in the blood cells**, not the plasma
- ✓ In red blood cells, **most thiamin is as TDP** with smaller amounts as TMP or free



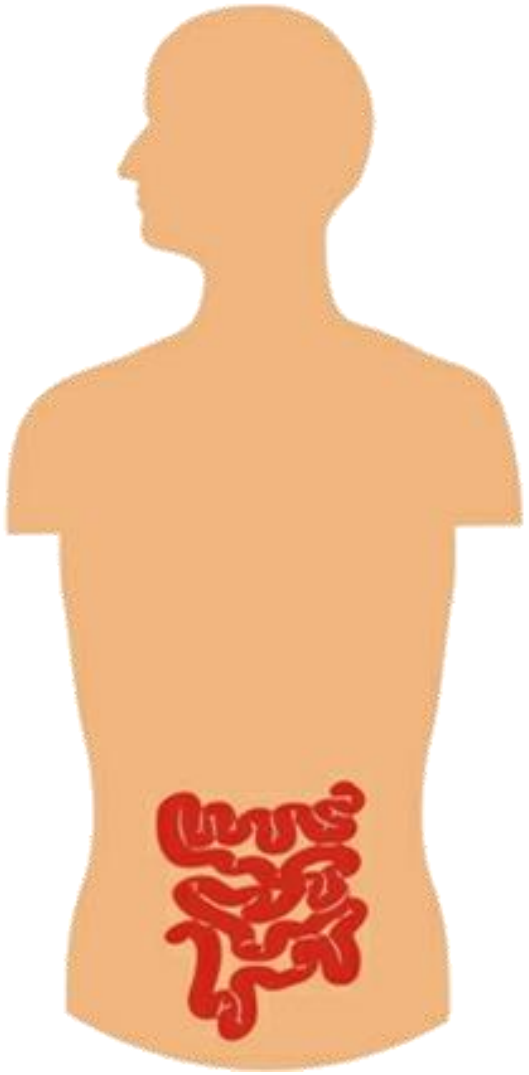
Thiamin Storage

- ✓ Humans store approximately 30 mg
- ✓ 80% of all thiamin in body is thiamin diphosphate (TDP)
- ✓ Conversion to TDP requires ATP
- ✓ Skeletal muscles contain half
- ✓ Other significant stores in
  - ➢ Liver
  - ➢ Brain
  - ➢ Heart
  - ➢ kidneys



Thiamin Absorption

- ✓ Free form absorbed
- ✓ Mainly in jejunum, somewhat in ileum and duodenum
- ✓ Absorbed via active transport (sodium dependent) at low intakes
- ✓ Absorbed via diffusion at higher levels



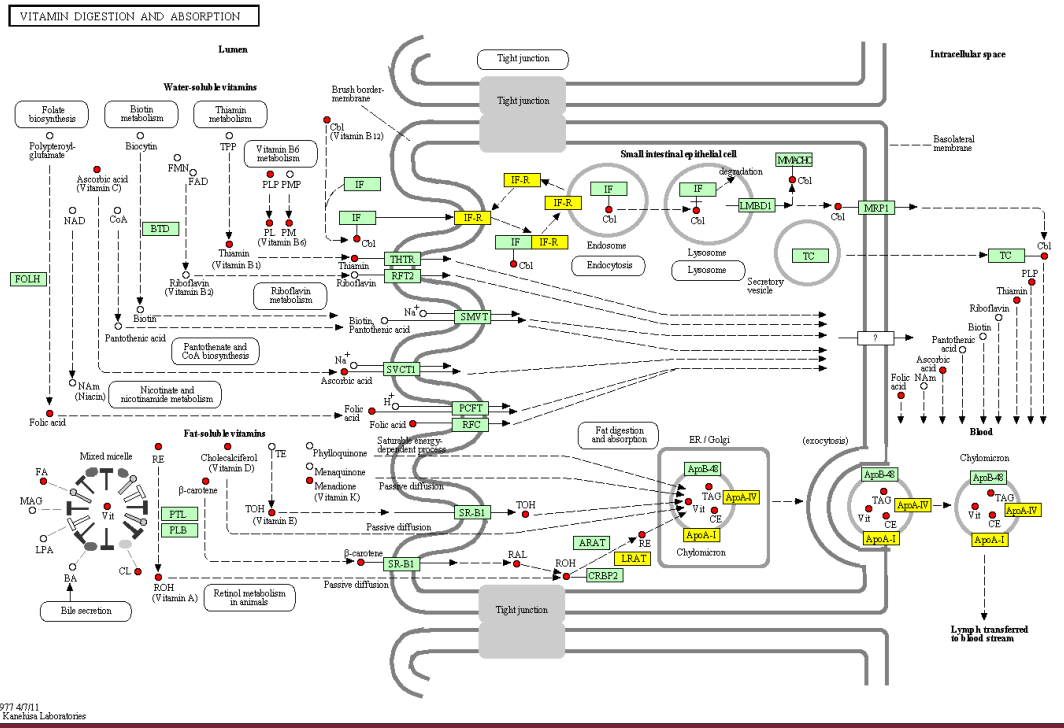
Influences on Thiamin Absorption

Decreases

- ✓ Ethanol
- ✓ Thiaminases in raw fish and raw horsetail
- ✓ Polyhydroxyphenols
  - ➢ Tannic acid
  - ➢ Caffeic acid
  - ➢ Tea
  - ➢ Coffee
  - ➢ Blueberries
  - ➢ Brussels sprouts
  - ➢ Red cabbage
- ✓ Calcium and magnesium with polyhydroxyphenols

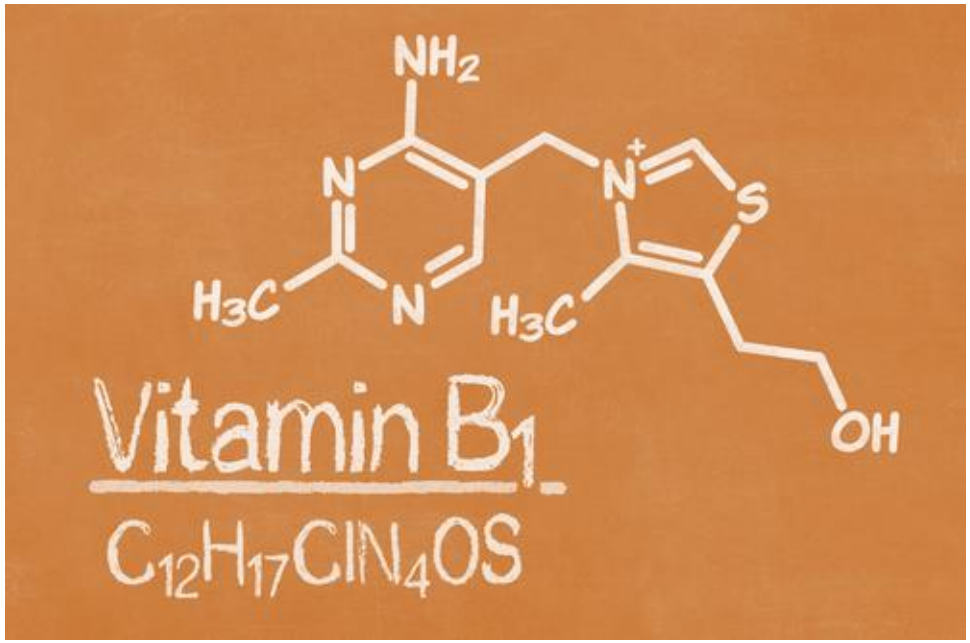
Increases

- ✓ Vitamin C: deactivates effect of polyhydroxyphenols
- ✓ Citric acid: deactivates effect of polyhydroxyphenols



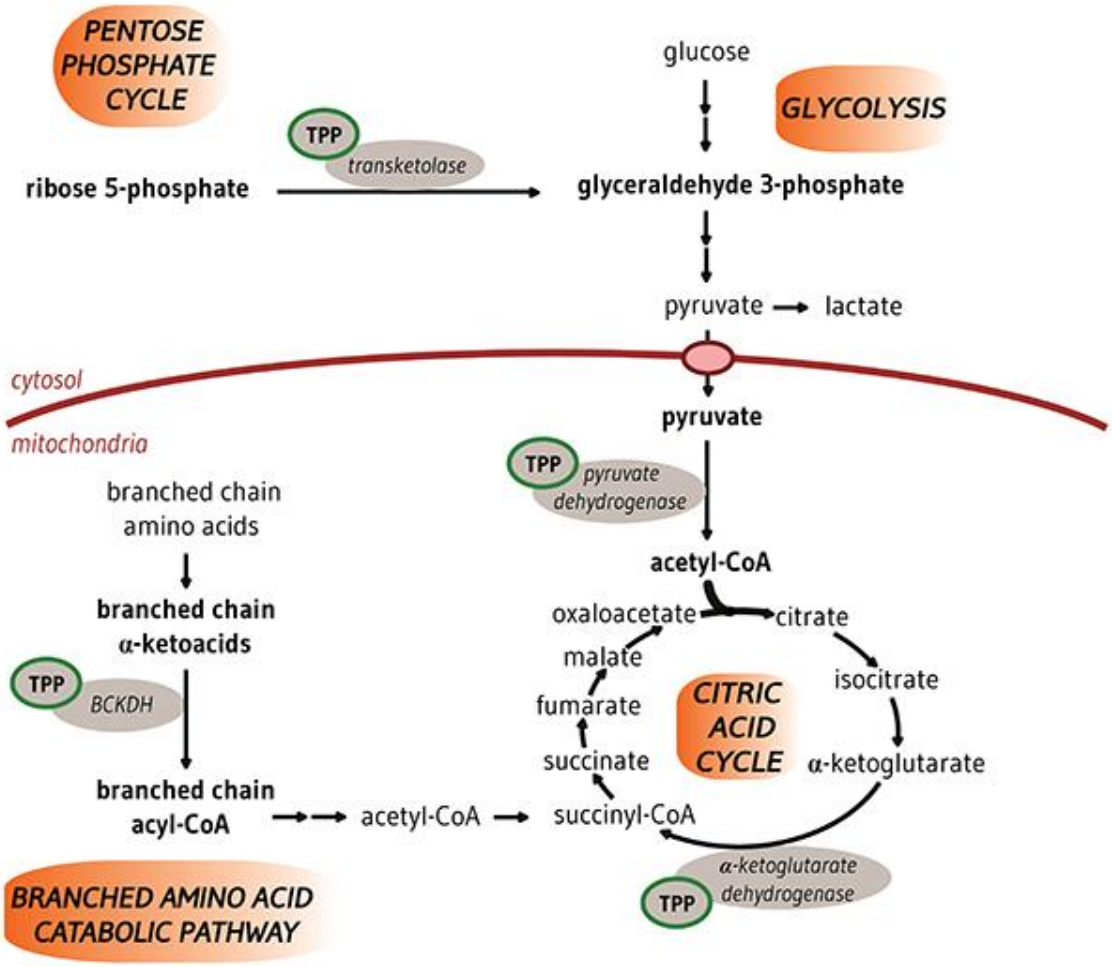
Main Thiamin Functions

- ✓ Coenzyme for energy transformation
- ✓ As a coenzyme for synthesis of pentoses and nicotinamide adenine dinucleotide (NADPH)
- ✓ Membrane and nerve conduction in a non-coenzyme capacity



Thiamine Biochemistry

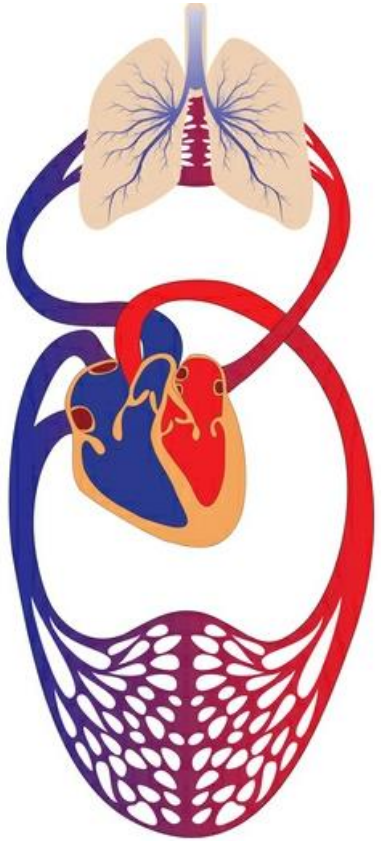
Figure 1. Metabolic Pathways Requiring Thiamin Pyrophosphate



BCKDH, branched chain α-ketoacid dehydrogenase complex; CoA, coenzyme A; TPP, thiamin pyrophosphate.

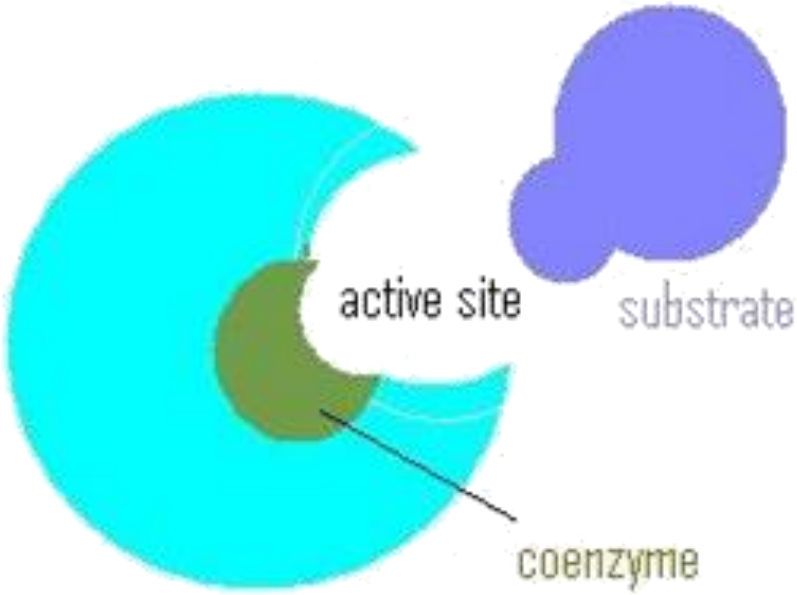
Thiamin Functions

- ✓ Enhances circulation
- ✓ Assists in blood formation
- ✓ Important in carbohydrate metabolism
- ✓ Role in the production of hydrochloric acid
- ✓ Optimizes cognitive activity and brain function
- ✓ Important co-factor in the Kreb's cycle (energy)
- ✓ Needed for proper muscle tone of the intestines, stomach, and heart
- ✓ Acts as an antioxidant
- ✓ Role in appetite regulation
- ✓ Helps as part of a leaky gut protocol to rebuild mucosa
- ✓ Role in immune function and protection from stress response



Thiamin as a Coenzyme in Kreb's Cycle

- ✓ Pyruvate decarboxylase complex
- ✓ Alpha ketoglutarate dehydrogenase
- ✓ Branched chain alpha keto acid dehydrogenase
- ✓ Transketolase needed for pentoses and NADPH



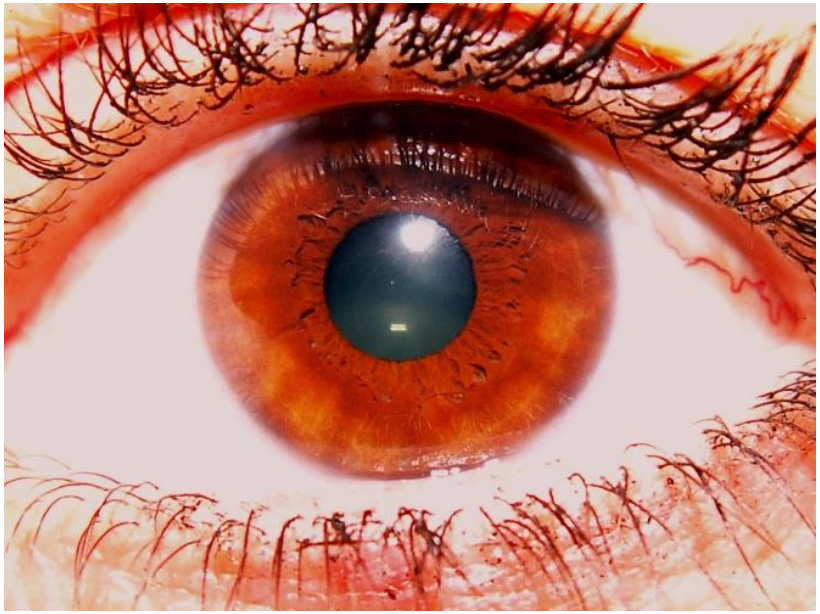
Thiamin and Blood Sugar Balance

- ✓ Coenzyme for transketolase (T*k*), pyruvate dehydrogenase and α-ketoglutarate dehydrogenase complexes - intracellular glucose metabolism
- ✓ Thiamine levels and thiamine-dependent enzyme activities are reduced in diabetics
- ✓ Genetics link thiamine and diabetes: T*k*, *SLC19A2* gene, transcription factor *Sp1*, α-1-antitrypsin, and *p53*
- ✓ Deficiency has a definitive role in diabetic complications: endothelial vascular diseases, lipid profile, retinopathy, nephropathy, cardiopathy, and neuropathy

The Impact of Thiamine Treatment in the Diabetes Mellitus, Khanh vinh quoc Luonga,b and Lan Thi Hoang NguyenaJ Clin Med Res. 2012 Jun; 4(3): 153–160. May 2012.

Cataracts and Thiamin

- ✓ Thiamine, along with other nutrients, may lower risk of cataracts
- ✓ People with plenty of protein and vitamins A, B1, B2, and B3 (or niacin) in their diet are less likely to develop cataracts



- ✓ Getting enough vitamins C, E, and B complex vitamins -- particularly B1, B2, folate, and B12 -- may further protect the lens

Alzheimer's Disease and Thiamin

- ✓ Lack of thiamine can cause dementia
- ✓ Oral thiamine has been shown to improve cognitive function of patients with Alzheimer's
- ✓ Absorption of thiamine is poor in elderly individuals

Thiamin Effects on Heart and Brain Health

- ✓ Diuretic use in people with CHF may deplete thiamin; taking thiamine supplements may help
- ✓ Low levels of thiamine are associated with depression

Things That Deplete Thiamin

- ✓ Gluten
- ✓ Processed and overly cooked foods – they strip minerals from the body
- ✓ Alcohol
- ✓ Herbicides and pesticides
- ✓ Refined sugar, corn syrup and artificial sweeteners
- ✓ Prolonged stress
- ✓ Table salt
- ✓ Tap water - sodium fluoride
- ✓ Unfermented soy products
- ✓ Regular and decaffeinated coffee or black tea
- ✓ Excess zinc and vitamin D

Causes of Thiamin Deficiency

- ✓ Health Conditions:
  - ➢ Alcoholism
  - ➢ Crohn's disease
  - ➢ Anorexia
  - ➢ Kidney dialysis
- ✓ Deficient soil
- ✓ Processed foods
- ✓ Fluoride in water
- ✓ Drugs: antibiotics, Dilantin, phenytoin, sulfa drugs, oral contraceptives
- ✓ Heavy caffeine consumption
- ✓ High carbohydrate diet

Impact of Thiamin Deficiency

- ✓ Headache
- ✓ Nausea
- ✓ Fatigue
- ✓ Irritability
- ✓ Depression
- ✓ Abdominal discomfort
- ✓ Difficulty digesting carbohydrates leading to pyruvic acid build up resulting in:
  - ➢ Loss of mental alertness
  - ➢ Difficulty breathing
  - ➢ Heart damage
- ✓ Extreme deficiency is beriberi

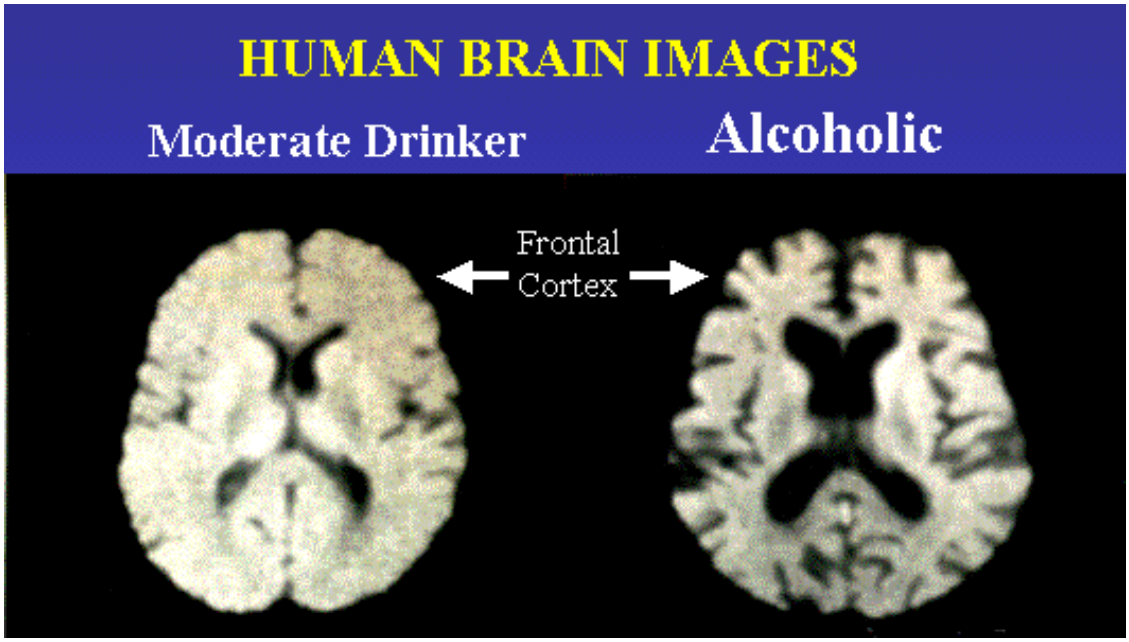
Thiamin Deficiency: Beriberi

- ✓Wet (edema) and dry (emaciation/body wasting)
  - ❑ Confusion
  - ❑ Trouble breathing because of fluid in the lungs
  - ❑ Uncontrolled eye movements (nystagmus)
  - ❑ Anorexia and weight loss
  - ❑ Neurological: apathy, confusion, short-term memory loss, irritability
  - ❑ Cardiac: hypertrophy and altered heart rate - may lead to death from heart failure
  - ❑ Swelling, tingling, or burning sensation in the hands and feet

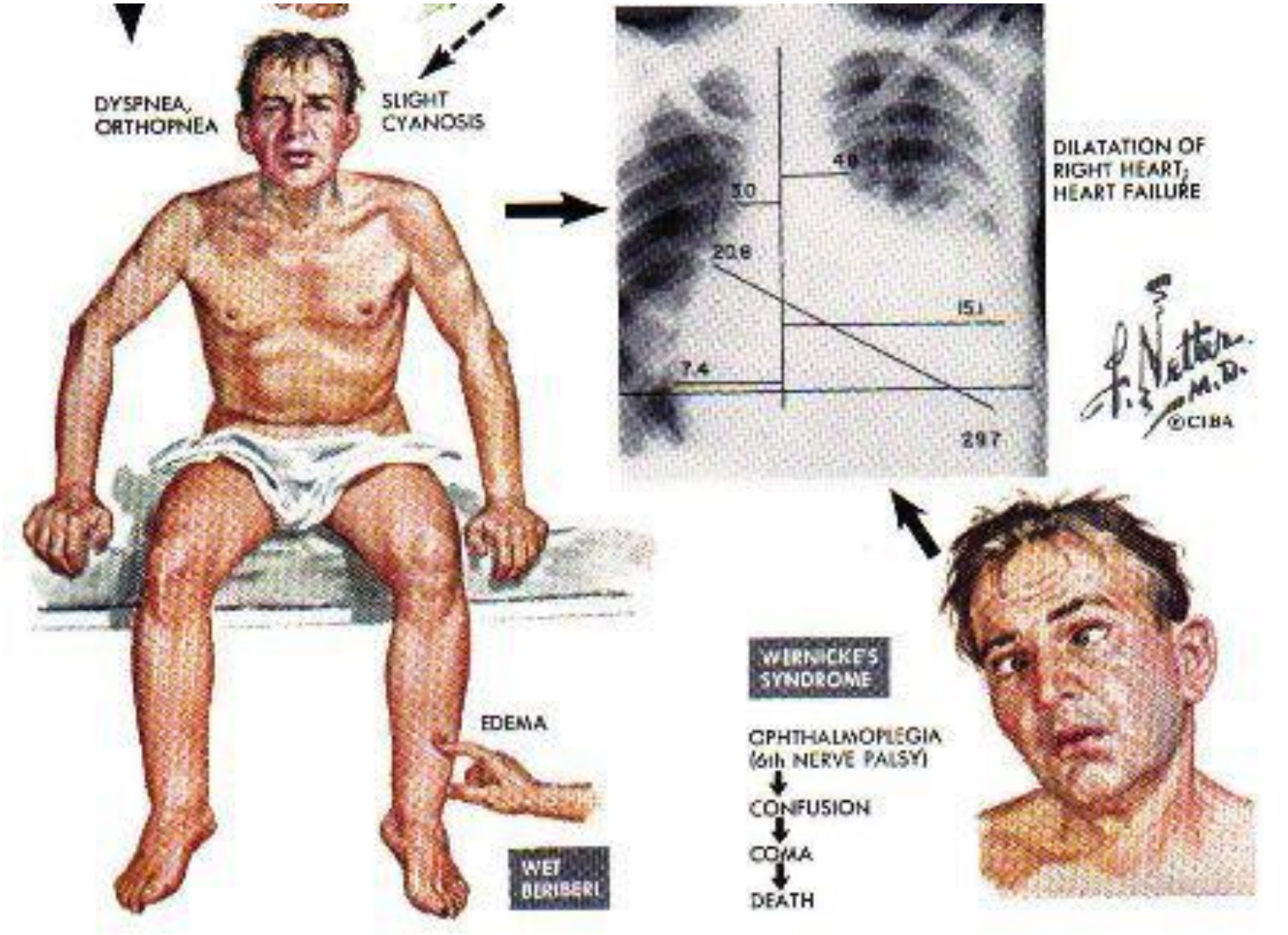
- ❑ Rare in developed world
- ❑ Occurs in alcoholics

Thiamin Deficiency: Wernicke-Korsakoff Syndrome

- ✓ Common in alcohol abusers
  - ❑ Short-term memory loss
  - ❑ Jerky eye movement
  - ❑ Staggering gait
  - ❑ Encephalopathy
  - ❑ Nystagmus
  - ❑ Ataxis
  - ❑ Opthamoplegia



Thiamin Deficiency Diseases



Deficiency Signs From Nutrient Assessment Chart

Vitamin B1	❑ Anxiety ❑ Depression ❑ Hysteria ❑ Loss of appetite; in extreme cases beriberi (mostly in alcoholics). ❑ Muscle cramps

Impact of Thiamin Excess

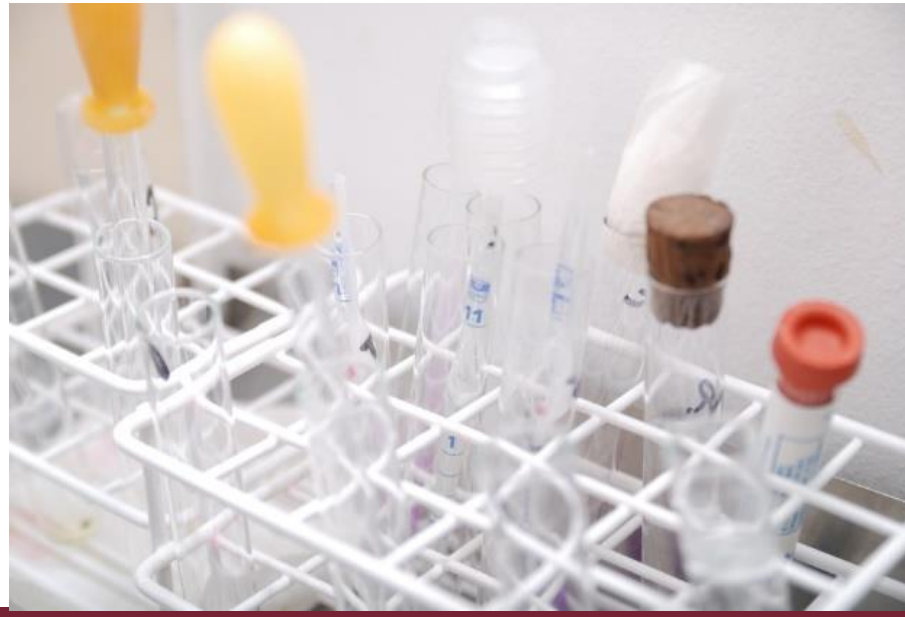
- ✓ Little risk of toxicity
- ✓ Studies done with 500 mg per day or more
- ✓ 100x RDA parenterally have induced:
  - ➢ Headache
  - ➢ Convulsions
  - ➢ Arrhythmia
  - ➢ Anaphylactic shock

Thiamin Drug/Herb Interactions

- ✓ **Horsetail (Equisetum arvense L.):** Contains thiaminase, an enzyme which inhibits thiamine
- ✓ **Digoxin:** May reduce the ability of heart cells to absorb and use vitamin B1, particularly when digoxin is combined with Lasix, aka furosemide, a diuretic
- ✓ **Diuretics, particularly Lasix:** Reduce levels of vitamin B1
- ✓ **Phenytoin (Dilantin):** Some people have lower levels of thiamine in their blood, which may contribute to the side effects of the drug

Assessing Thiamin Status

- ✓ Serum is not accurate
- ✓ Spectracell
- ✓ Erythrocyte transketolase
- ✓ NutrEval by Genova / Metametrix
- ✓ Questionnaires and good history taking for signs and symptoms



Thiamin RDA

Table 1. Recommended Dietary Allowance (RDA) for Thiamin			
Life Stage	**Age**	**Males (mg/day)**	**Females (mg/day)**
Infants	0-6 months	0.2 (AI)	0.2 (AI)
Infants	7-12 months	0.3 (AI)	0.3 (AI)
Children	1-3 years	0.5	0.5
Children	4-8 years	0.6	0.6
Children	9-13 years	0.9	0.9
Adolescents	14-18 years	1.2	1.0
Adults	19 years and older	1.2	1.1
Pregnancy	all ages	-	1.4
Breast-feeding	all ages	-	1.4

Methods of Repletion

- ✓Food and herbs
- ✓Oral supplements
- ✓Intravenous (Myer's cocktail)
- ✓Intramuscular

Thiamin Food Sources

- ✓ Brown rice
- ✓ Egg yolks
- ✓ Fish
- ✓ Legumes
- ✓ Liver
- ✓ Peanuts
- ✓ Peas
- ✓ Pork
- ✓ Poultry
- ✓ Whole grains
- ✓ Sunflower seeds
- ✓ Macadamia nuts
- ✓ Most nuts
- ✓ Asparagus
- ✓ Brewer's yeast
- ✓ Broccoli
- ✓ Dulse
- ✓ Kelp
- ✓ Squash
- ✓ Brussels sprouts
- ✓ Oatmeal
- ✓ Plums
- ✓ Dried prunes
- ✓ Raisins
- ✓ Spirulina
- ✓ Watercress

Herbs High In Thiamin

- ✓ Alfalfa
- ✓ Bladderwrack
- ✓ Burdock root
- ✓ Catnip
- ✓ Cayenne
- ✓ Chamomile
- ✓ Chickweed
- ✓ Dandelion
- ✓ Eyebright
- ✓ Fennel seed
- ✓ Fenugreek
- ✓ Hops
- ✓ Horsetail
- ✓ Lemongrass
- ✓ Licorice
- ✓ Mullein
- ✓ Nettle
- ✓ Oat straw
- ✓ Paprika
- ✓ Parsley
- ✓ Peppermint
- ✓ Raspberry leaf
- ✓ Red clover
- ✓ Rose hips
- ✓ Sage
- ✓ Shepherd’s purse
- ✓ Yarrow
- ✓ Yellow dock

WHFoods.com Thiamin Chart

World's Healthiest Foods ranked as quality sources of vitamin B1						
Food	Serving Size	Cals	Amount (mg)	DRI/DV (%)	Nutrient Density	World's Healthiest Foods Rating
Asparagus	1 cup	39.6	0.29	24.17	11.0	excellent
Sunflower Seeds	0.25 cup	204.4	0.52	43.33	3.8	very good
Green Peas	1 cup	115.7	0.36	30.00	4.7	very good
Flax Seeds	2 TBS	74.8	0.23	19.17	4.6	very good
Spinach	1 cup	41.4	0.17	14.17	6.2	very good
Brussels Sprouts	1 cup	56.2	0.17	14.17	4.5	very good
Cabbage	1 cup	43.5	0.11	9.17	3.8	very good
Eggplant	1 cup	34.6	0.08	6.67	3.5	very good
Romaine Lettuce	2 cups	16.0	0.07	5.83	6.6	very good
Mushrooms, Crimini	1 cup	15.8	0.07	5.83	6.6	very good

http://www.drritamarie.com/go/ThiaminFoods

Forms of Supplementation

Absorption of oral magnesium supplements vary from 4% absorbed to about 50%.

Thiamine HCl

- ✓ Most common form
- ✓ Least expensive form

Thiamin Pyrophosphate

(aka cocarboxylase)

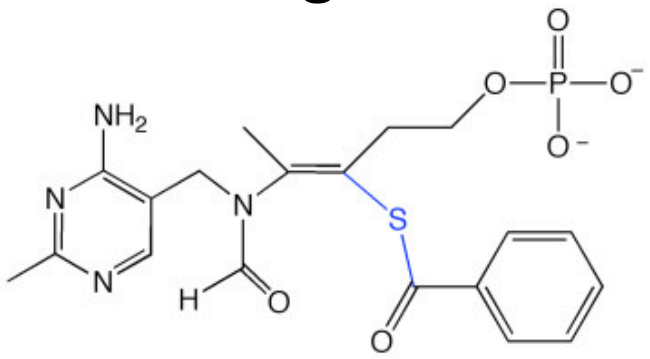
- ✓ Active form
  - ➢ Pyruvate dehydrogenase
  - ➢ Pyruvate decarboxylase in ethanol fermentation
  - ➢ Alpha-ketoglutarate dehydrogenase
  - ➢ Branched-chain amino acid dehydrogenase
  - ➢ 2-hydroxyphytanoyl-CoA lyase
  - ➢ Transketolase

Benfotiamine

- ✓ Lipid soluble form of thiamine
- ✓ Helpful in diabetic neuropathy
- ✓ Reduces microvascular damage from high blood sugar
- ✓ Transketolase activator – reduces AGEs by directing to the pentose phosphate pathway

Benfotiamine: Absorption and Structure

- ✓ Absorption approximately 5-fold Thiamin and 3.7-fold Thiamin Hydrochloride
- ✓ Serum increases detected in serum within one hour
- ✓ S-{(Z)-2-{(4-amino-2-methylpyrimidin-5-yl) methyl-formylamino}-5-phosphonooxypent-2-en-3-yl} benzenecarbothioate
- ✓ Common dose: 300-600 mg over the course of the day



Benfotiamine

Benfotiamine Research

- ✓ Alzheimer's
- ✓ Pain
- ✓ Cardiac tissue
- ✓ Glucose metabolism
- ✓ Skeletal muscle and bone
- ✓ Inflammation and immunology
- ✓ Oxidative stress protection
- ✓ Lungs
- ✓ Kidneys
- ✓ Eyes

http://examine.com/supplements/benfotiamine/

Benfotiamine Studies

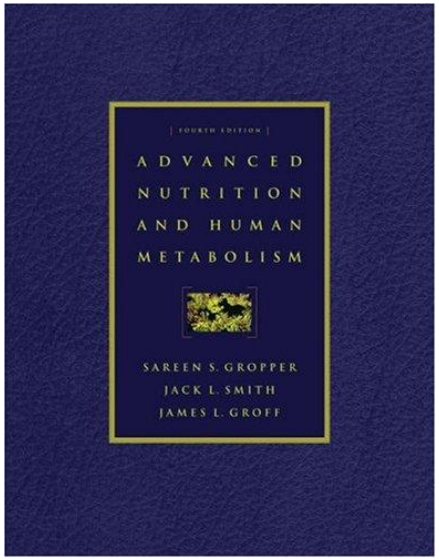
- ✓ Alzheimer's: Attenuates glucose-induced increase in β-amyloid protein synthesis and normalize the glutathione:glutathione disulfide (GSSG) ratio in the cerebral cortex

Sun XJ, et al Benfotiamine prevents increased β-amyloid production in HEK cells induced by high glucose . Neurosci Bull. (2012)

- ✓ Weakly attenuates Advanced Glycemic End product (AGE) bound to serum albumin (a complex known as AGE-alubmin) from activating macrophages and inducing oxidative stress
- ✓ Attenuates LPS induced mitochondrial membrane potential loss in the macrophages

Thiamin Resources

- ✓ *Advanced Nutrition and Human Metabolism – Gropper, Smith and Groff*
- ✓ Linus Pauling Institute: http://www.drritamarie.com/go/LPIThiamin
- ✓ http://www.drritamarie.com/go/UMMCThiamin
- ✓ http://www.drritamarie.com/go/ExamineBenfotiamine



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