LECTURE-1

VITAMINS

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VITAMINS

“A vitamin is substance that makes you ill if you don’t consume” Albert Szent, Noble Prize winner (1937)

DEFINATION OF VITAMIN

- **Vitamin is defined as organic compounds that can not be synthesized in adequate quantities by humans and therefore, must be supplied in the diet.**

Vitamins fall into two categories—fat soluble and water soluble.

Essential Vitamins (13)

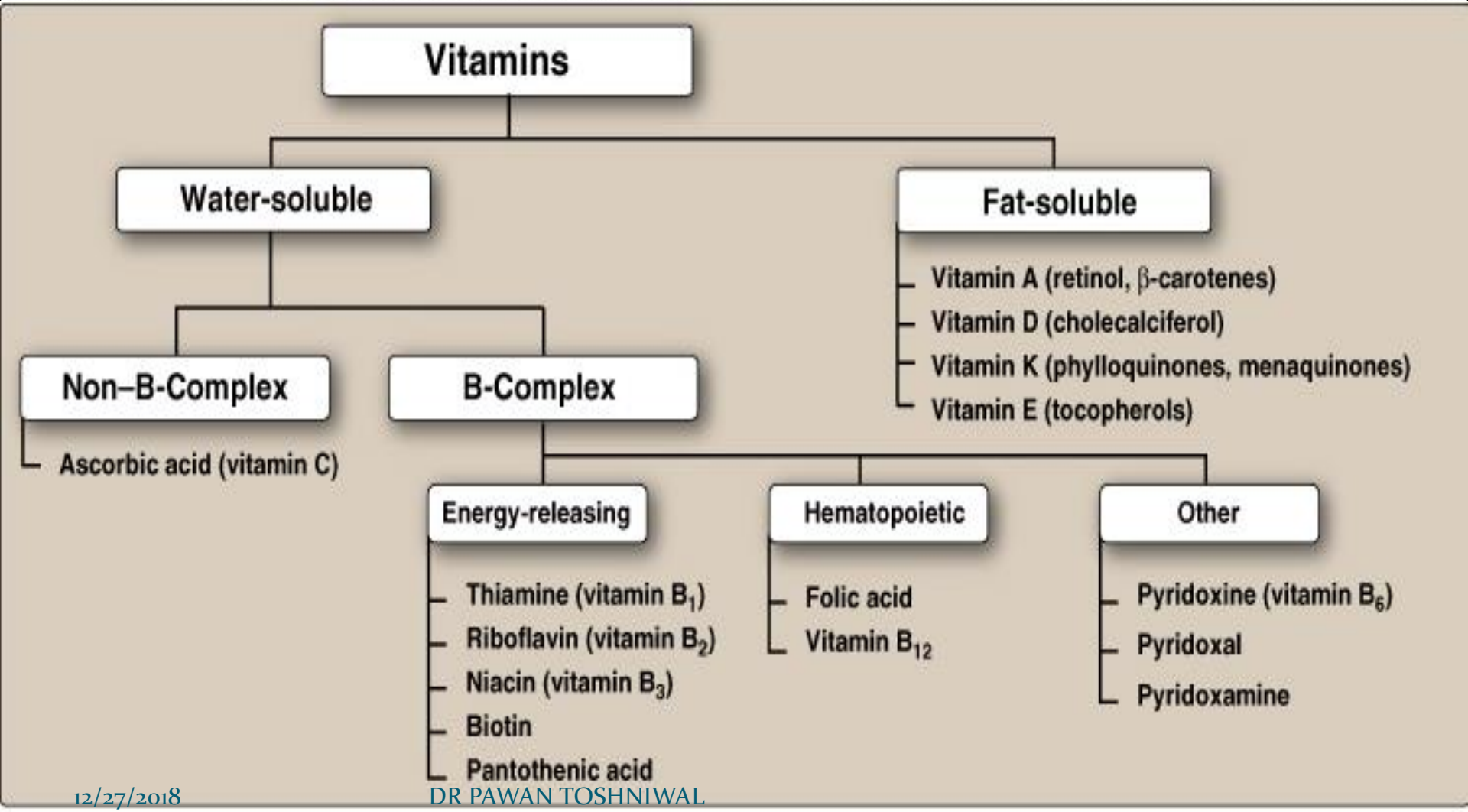
- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

Fat Soluble Vitamins

- Vitamin B1 (Thiamine, Thio-Sulphur contain)
- Vitamin B2 (Riboflavin, ribose sugar & yellow colour)
- Vitamin B3 (Niacin, Niacinamide, nicotinic acid)
- Vitamin B5 (Pantothenic acid, pantothenate)
- Vitamin B6 (Pyridoxine, pyridoxamine, pyridoxal-5-P)
- Vitamin B7 (Biotin, Vit. H)
- Vitamin B9 Folate (Folic Acid, Folacin, Vitamin M)
- Vitamin B12 (Cyanocobalamin, Hydroxycobalamin, Methylcobalamin, cobalt-containing vitamin)
- Vitamin C (Ascorbic Acid, Ascorbate)

Water Soluble Vitamins

Classification of Vitamins



VITAMINS

Difference b/w water soluble & fat soluble vitamins

	Water soluble vitamins	Fat soluble vitamins
Solubility	Water soluble	Fat soluble
Absorption	Simple	Along with lipids
Storage	*No storage	Stored in liver
Excretion	Excreted	Not excreted
Excess intake	Nontoxic	Toxic
Deficiency	Manifests rapidly	Manifests slowly
Treatment	Regular dietary supply	Single large dose

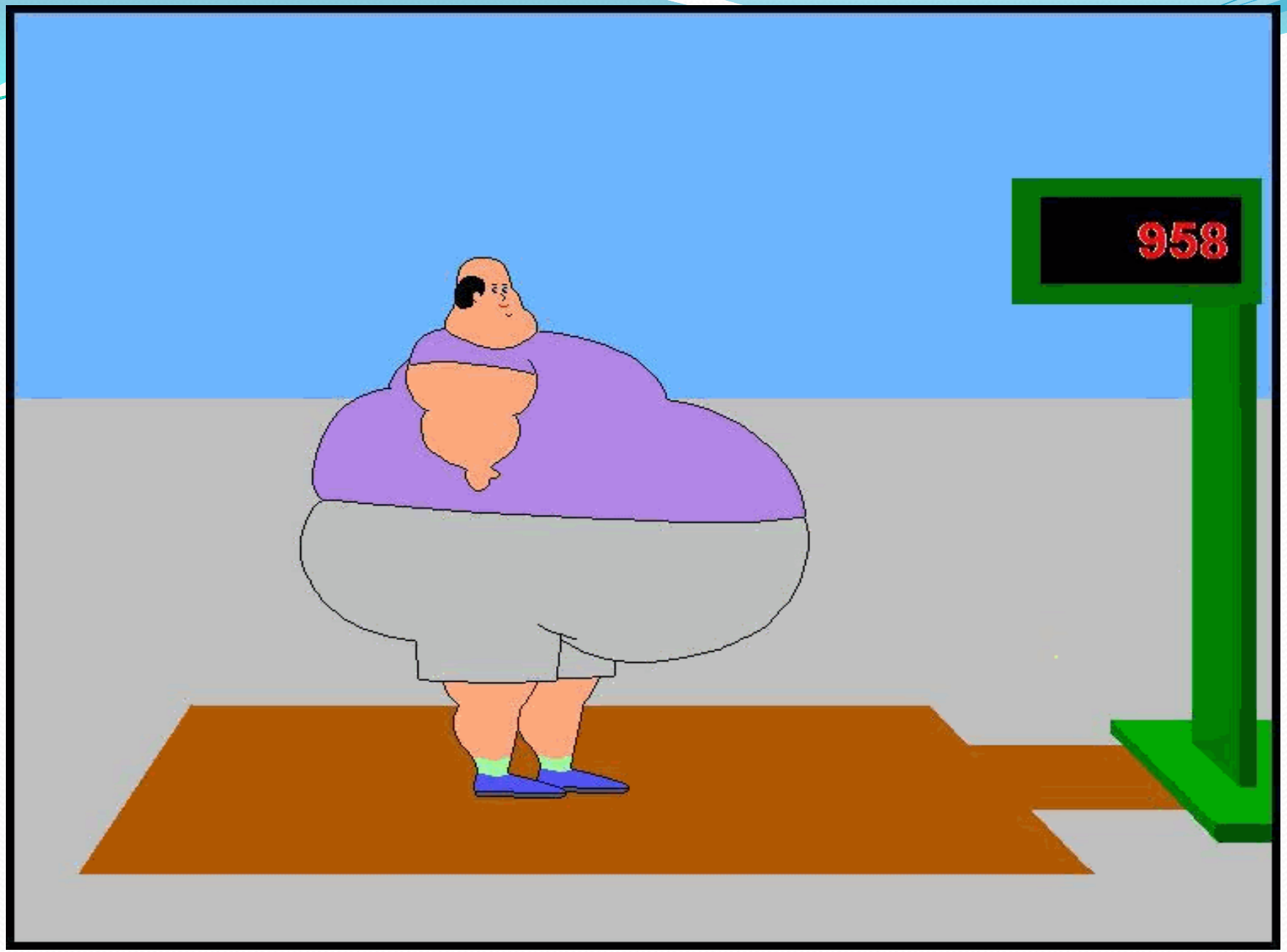
B Complex Vitamins: Key points

- Bioavailability
- Precursors
- Solubility
- Metabolic role
- Co-enzyme activity
- Deficiency manifestations
- Toxicity

- **If you take Excess what it will cause??**


Health
Diet
Obesity
Physical


HELP!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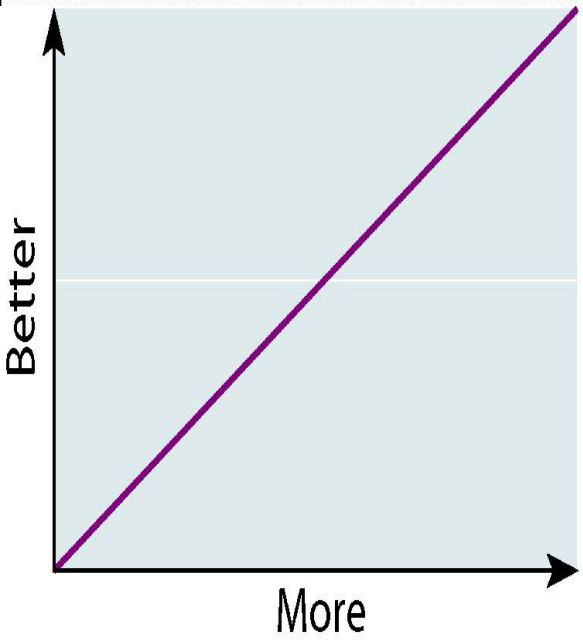
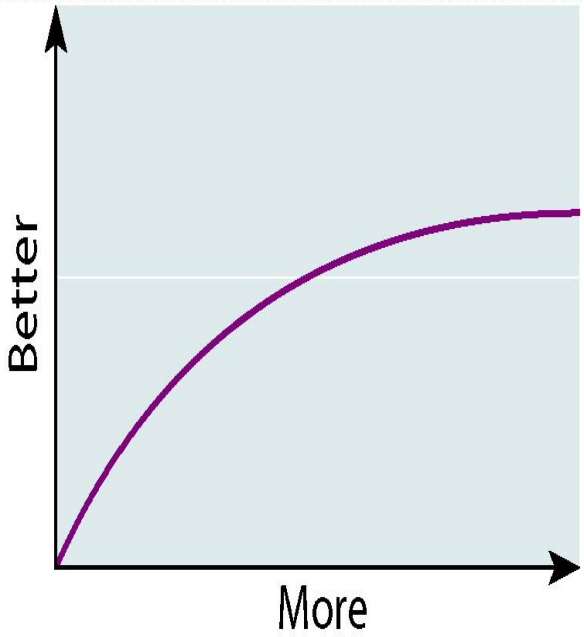
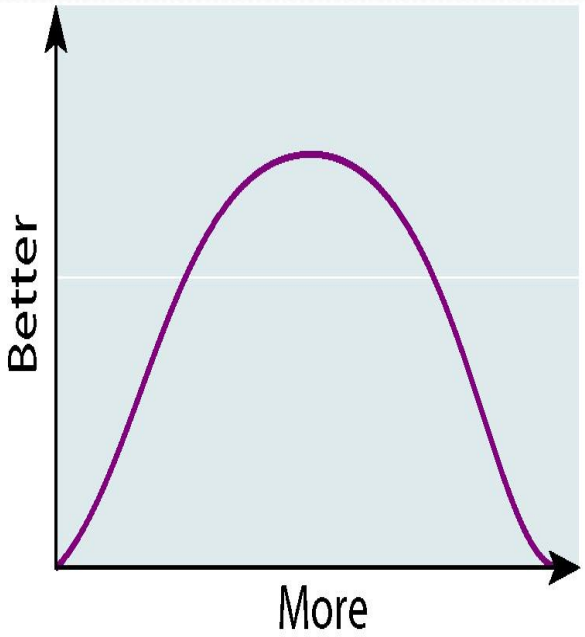
Vitamins kinetic & toxicity



As you progress in the direction of more, the effect gets better and better, with no end in sight (real life is seldom, if ever, like this).



As you progress in the direction of more, the effect reaches a maximum and then a plateau, becoming no better with higher doses.



As you progress in the direction of more, the effect reaches an optimum at some intermediate dose and then declines, showing that more is better up to a point and then harmful. That too much is as harmful as too little represents the situation with nutrients.

OVER VIEW OF WATER SOLUBLE VITAMINS

- Dissolve in water, chemically not related to each other
- Generally readily excreted through kidney
- Subject to cooking losses
- Function in the cells as coenzyme
- Participate in energy metabolisms
- 50-90% of B vitamins are absorbed in intestine
- Marginal deficiency more common

Thiamine
B-1
(Vitamin F)

Thiamine (Vit. B1)

- Thiamine is a colorless organo-sulfur compound contains sulfur and nitrogen group
- Called as anti-beriberi factor or anti-neuritis factor
- Thiamine is soluble in water, methanol and glycerol
- Destroyed by alkaline pH and heat
- Coenzyme form: Thiamine pyrophosphate (TPP)
  - Releases energy from carbohydrate

Food Sources of Thiamine

- Wide variety of foods
- Aleurone layer of cereals (food grains)
- Pork, hot dogs, meats, cold cereal
- Enriched breads and unpolished grains/ whole grains
- Green beans, milk, orange juice, peanuts, dried beans and seeds
- Thiaminase found in raw fish destroys Thiamine
- Partially destroyed by heat

RDA-Recommended Daily Allowance

- Depends on calorie intake
  - Men: 1.5 mg/day
  - Women: 1.1 mg/day
  - Additional 0.3 mg/day-pregnancy

ABSORPTION : INTESTINE

Digestion, Absorption & Excretion

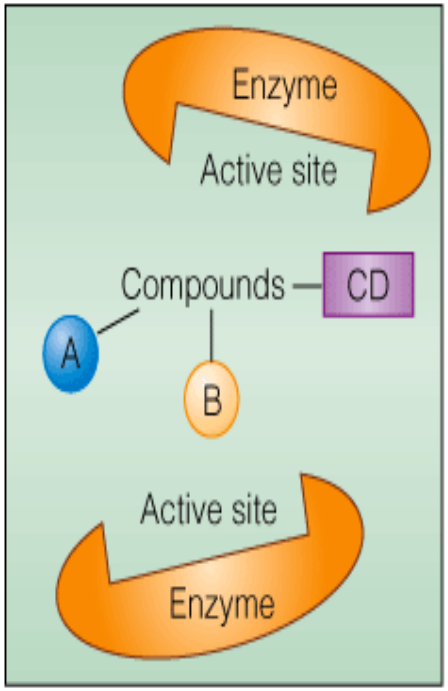
- Thiamine is released by the action of phosphatase and pyrophosphatase in the small intestine
- At low concentrations, the absorption is carrier-mediated (active) and at higher concentrations, absorption occurs via passive diffusion
- Uptake of Thiamine by cells in the blood and other tissues occurs via active transport and passive diffusion
- The brain requires a much greater amount of Thiamine than other cells of the body
- Thiamine and its acid metabolites are excreted in the urine

Role of TPP as coenzyme of Thiamine

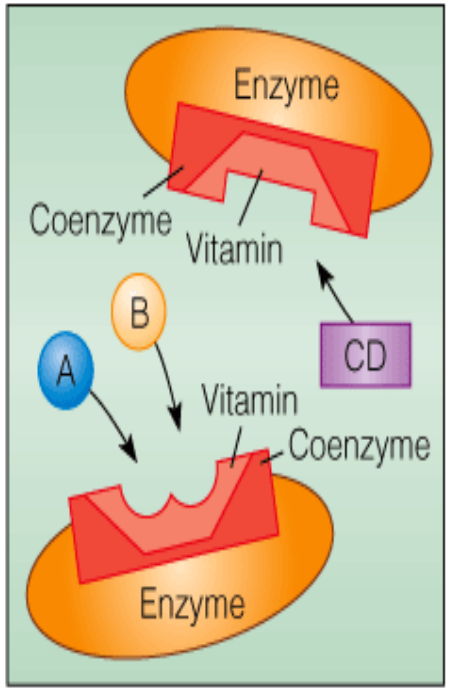
- Coenzymes are small molecules. They themselves cannot catalyze a reaction but they can help enzymes to do so. Coenzymes are organic non-protein molecules that bind with the protein molecule (apoenzyme) to form the active enzyme (holoenzyme).

The B Vitamins

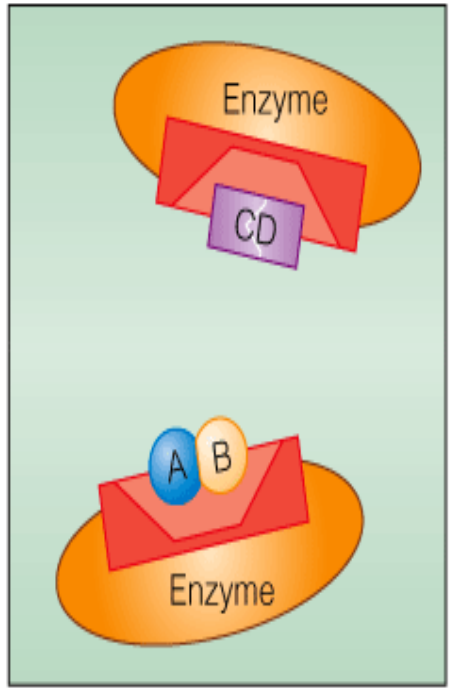
- **Coenzymes**



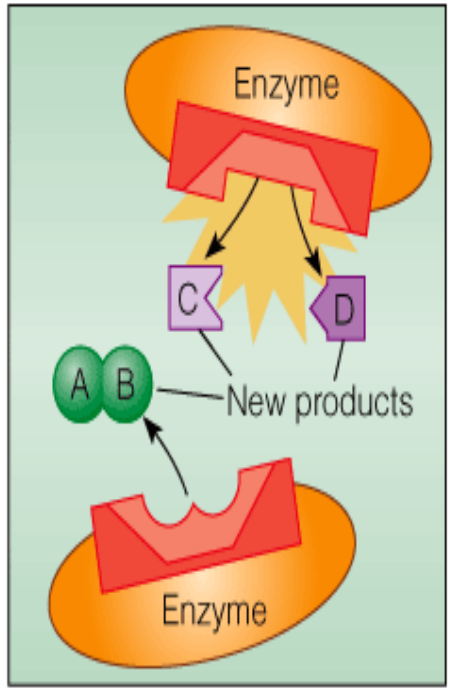
Without coenzymes, compounds A, B, and CD don't respond to their enzymes.



With the coenzymes in place, compounds are attracted to their sites on the enzymes . . .



. . . and the reactions proceed instantaneously. The coenzymes often donate or accept electrons, atoms, or groups of atoms.



The reactions are completed with either the formation of a new product, AB, or the breaking apart of a compound into two new products, C and D, and the release of energy.

Enzyme	Reaction	Pathway
Pyruvate DH Complex (3 enzy.+ 5 Co-enzy. TPP is one of them)	Pyruvate → Acetyl CoA	Cori's
α- keto-glutarate DH (3 enzy.+ 5 Co-enzy. TPP is one of them)	α- KG → Succinyl CoA	TCA
Transketolase	Ribose-5P + Xylulose-5P→ Sedoheptulose-7P + Gly-3P	HMP
α- keto acid DH	Valine→α- ketoisovalerate→ isobutryl CoA	Catabolism of Valine
α- keto acid DH	Leucine → α- ketoisoaproate→isovalenyl CoA	Catabolism of Leucine

Deficiency of Thiamine

Beriberi: It refers to a cluster of symptoms caused primarily by deficiency of vitamin B1 (Thiamine).

Causes: Dietary restrictions, long term renal dialysis (dialyzer effect), chronic fever, antacids, consuming raw fish (Thiaminase), polished rice as staple food.

Symptoms:

- **Weakness, nerve degeneration, irritability, poor arm/leg coordination, loss of nerve transmission**
- **Edema, enlarged heart, cardiac failure**
- **poor metabolism of glucose**
- **Depression and weakness can be seen after 10 days on a Thiamine less diet**

Wet beriberi: Wet beriberi affects the heart and circulatory system. It is sometimes fatal, as it causes a combination of heart failure and weakening of the capillary walls, which causes the peripheral tissues to become edematous (swelling).

Symptoms:

- Increased heart rate
- Vasodilatation leading to decreased systemic vascular resistance and high output cardiac failure
- Elevated jugular venous pressure
- Shortness of breath on exertion
- swelling of lower legs

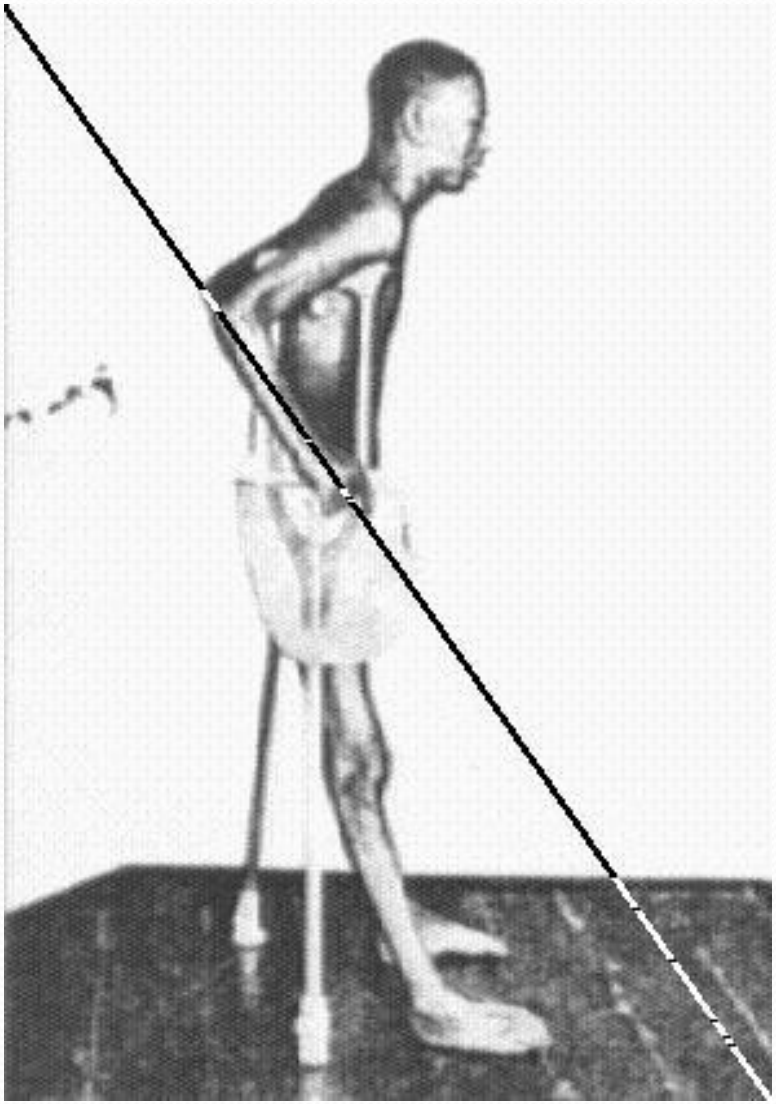
Wet beriberi

Dry beriberi : Dry beriberi causes partial paralysis resulting from damaged peripheral nerves. It is also referred to as endemic neuritis.

Symptoms:

- Difficulty in walking
- Tingling or loss of sensation (numbness) in hands and feet
- Loss of tendon reflexes
- Loss of muscle function or paralysis of the lower legs
- Mental confusion/speech difficulties
- Pain
- Involuntary eye movements
- Vomiting

Dry Beriberi



- **Infantile beriberi** occurs in infants breast-fed by Thiamine-deficient mothers. Infants may manifest cardiac disorder. Infants with cardiac beriberi frequently exhibit a loud piercing cry, vomiting and tachycardia. Convulsions and death may happen if Thiamine is not administered.
- **Gastrointestinal beriberi** is associated with nausea, vomiting, abdominal pain and lactic acidosis
- **Genetic beriberi** is a rare condition that prevents the body from absorbing thiamine.

Alcohol and Thiamine

- Alcoholics are at greatest risk for Thiamine deficiency because absorption and use of Thiamine are profoundly diminished and excretion is increased by alcohol consumption
- Poor quality diet makes it worse
- Little stored in body, so consistent alcohol consumption for 1-2 weeks may result in deficiency

Diagnosis of Beriberi

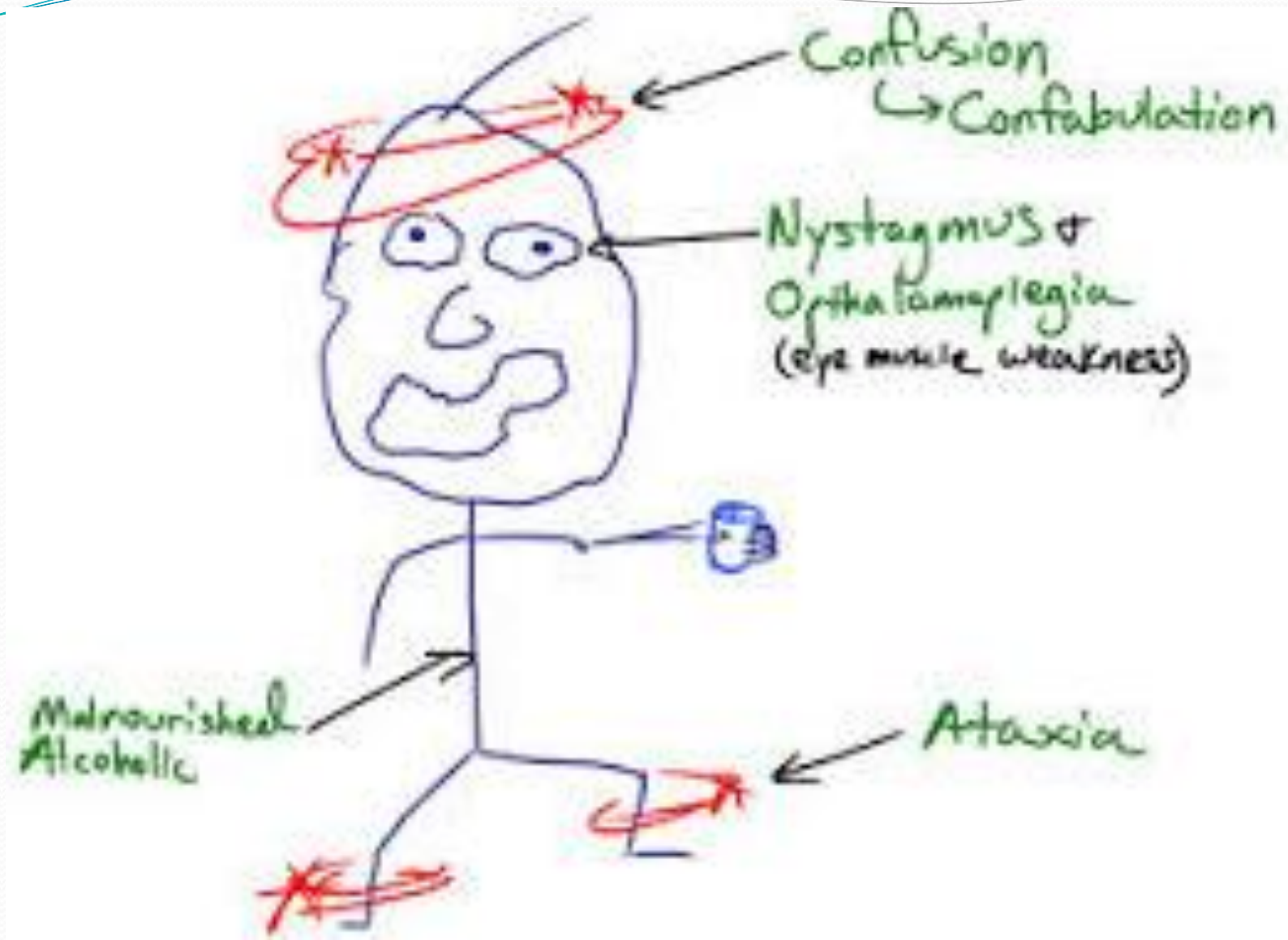
- Blood and urine tests will measure the levels of vitamin B1 or thiamine in your body, specifically erythrocyte transketolase activity.
- Neurological exam shows lack of coordination, difficulty walking, droopy eyelids and weak reflexes.
- Later stages of beriberi will show memory loss, confusion or delusions (Wernicke - Korsakoff syndrome or Cerebral beriberi).

Wernicke - Korsakoff syndrome

- Chronic memory disorder caused by severe deficiency of thiamine (vitamin B-1).
- Lack of vitamin B1 is common in people with alcoholism.
- It is also common in persons whose bodies do not absorb food properly (malabsorption), as sometimes occurs with a chronic illness or after bariatric surgery.

Symptoms of Wernicke - Korsakoff syndrome

- Confusion and loss of mental activity that can progress to coma and death
- Loss of muscle coordination (ataxia) that can cause leg tremor
- Vision changes such as abnormal eye movements (back and forth movements called nystagmus), double vision, eyelid drooping
- Inability to form new memories
- Loss of memory, can be severe
- Making up stories (confabulation)
- Seeing or hearing things that are not really there (hallucinations)


Confusion
↳ Confabulation
Nystagmus &
Ophthalmoplegia
(Eye muscle weakness)
Malnourished
Alcoholic
Ataxia

Who's at Risk?

- Homeless & Malnourished
- Alcoholics
- People with malabsorption conditions

B-1 is nontoxic even at high dosages

Riboflavin
B-2

Riboflavin (Vit. B2)

- The name “Riboflavin" comes from "ribose“ and "flavin", which imparts the yellow color to the oxidized molecule (*flavus*, "yellow“)
- Participate in many energy producing metabolic pathways
- Flavin mononucleotide (FMN) and

  Flavin adenine dinucleotide (FAD) are the co-enzyme forms of riboflavin

Food Sources of Riboflavin

Animal products

- Milk/ milk products
- Egg, liver, meat, etc

Plant products

- Whole grains and cereals
- Vegetables (broccoli, green leafy vegetables)

Recommendations

- Men - 1.5 mg/day
- Women - 1.0 mg/day

Additional 0.2 to 0.4 mg/day during pregnancy and lactation

FUNCTIONS

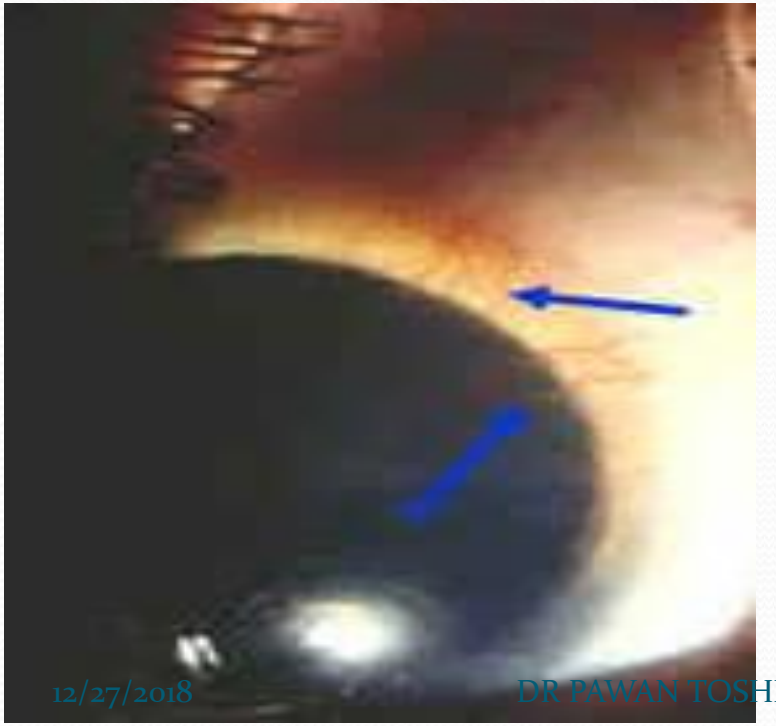
- Important in:
  - Energy production during metabolism
  - Formation of antibodies and red blood cells
  - Cell respiration
  - Maintenance of good vision, skin, nails and hair
  - Alleviating eye fatigue

Deficiency of Riboflavin

- Riboflavin deficiency (also called Ariboflavinosis) results in stomatitis including painful red tongue with sore throat, chapped and fissured lips (cheilosis) & inflammation of the corners of the mouth (angular stomatitis)
- Ariboflavinosis
  - Glossitis, cheilosis, seborrheic dermatitis, eye and throat disorder, nervous system disorder
- Due to interference with iron absorption, riboflavin deficiency results in an anemia with normal cell size.

c Dermatitls

Fig. 41. Angular cheilitis



Who's at Risk?

- **Alcoholics (more common) and pregnant lady**

TOXICITY

B-2 is nontoxic at supplemental and dietary levels.

Niacin
VIT-B3

Sources

- Milk, eggs, meat, poultry, fish
- Whole-grain and enriched breads and cereals
- Nuts
- All protein-containing foods
- 60mg tryptophan can be converted into 1 mg niacin; meets 50% of RDA

ABSORPTION: Stomach and small intestine;

NIACIN

- Other names
  - Nicotinic acid (Niacin)
  - Niacinamide (Nicotinamide)
  - Part of coenzymes NAD (nicotinamide adenine dinucleotide) and NADP (its phosphate form) used in energy metabolism

Recommendations

- **Men and women**

  20 mg/day

Additional requirement of 5.0 mg/day during pregnancy and lactation.

FUNCTIONS

- Important in:
  - energy production during metabolism
  - improves circulation
  - maintenance of nervous system

digestive track, skin and tongue

NAD (Nicotinamide adenine dinucleotide) dependent enzymes

NAD+	Reaction	Metabolic Pathway
Lactate DH	Pyruvate → Lactate	Glycolysis
α- ketoglutarate DH	α- KG → Succinyl CoA	TCA
β hydroxyacyl CoA DH	β hydroxyacyl CoA → β ketoacyl CoA	β oxidation
β hydroxybutrate DH	β hydroxybutrate → acetoacetate	Ketogenesis
Aldehyde DH	Acetaldehyde → acetate	Threonine catabolism
IMP-DH	Inosine MP → Xanthosine MP	Purine synthesis

NADP(Nicotinamide adenine dinucleotide phosphate) dependent enzymes

NADP+	Reaction	Metabolic Pathway
G-6 P DH	G-6-P →6- phosphogluconolactone	HMP pathway
Malate DH	Malate→ Pyruvate + CO2	FA synthesis

NADPH (nicotinamide adenine dinucleotide phosphate-oxidase) dependent enzymes

NADPH	Reaction	Metabolic Pathway
HMG CoA reductase	HMG CoA → Mevalonate	Cholesterol synthesis
Phenylalanine hydroxylase	Phenylalanine → tyrosine	Phenylalanine catabolism
Dihydrofolatereductase	Folic Acid → THF	1 C metabolism
Heme oxygenase	Heme → Biliverdin	Heme catabolism
Cholesterol hydroxylase	Cholesterol → cholic Acid	Bile Acid synthesis

B-3 Deficiency

- **Pellegra (THREE D'S DISEASES)**
- ***Dermatitis-dry, scaly, reddish skin***
- ***Dementia- loss of memory***
- ***Diarrhea-associated with mucous and blood***
- **4th D-Death if not treated**
- **gastrointestinal disturbance, loss of appetite**
- **headache, insomnia, mental depression**
- **fatigue and pains**
- **nervousness, irritability**

Bilateral symmetrical rash (sunlight exposure) of pellagra can be disturbing!

Pellagra

Casal's necklace

PELLAGRA

Niacin

- Toxicity symptoms
  - Painful flush, hives, and rash ("niacin flush")
  - Excessive sweating
  - Blurred vision
  - Liver damage,
  - impaired glucose tolerance

Who's at Risk?

- **Most people get plenty of B-3 from their diet because it is added to white flour.**

Nicotinamide is almost always safe to take, although a few cases of liver damage have been reported in doses of over 1000 mg/day.

QUESTIONS

Thank you beary much!

QUESTIONS?????

- 1) Which vitamin is water soluble ?
- A) A B) D C) K D) B3
- 2) In which vitamin deficiency edema is seen ?
- A) B2 B)B1 C) C D) B3
- Which diseases is called three D's disease ?
- A) B2 B)B1 C) B3 D) NONE
- In which vitamin deficiency Wernicke-korsakoff syndrome is found ?
- A) B1 B)B2 C) B3 D) NONE
- Casal's necklace is seen in the following disease
- A) Beriberi B) Scurvy C) Anemia D) None of above

ANSWERS

- 1) Which vitamin is water soluble ?
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