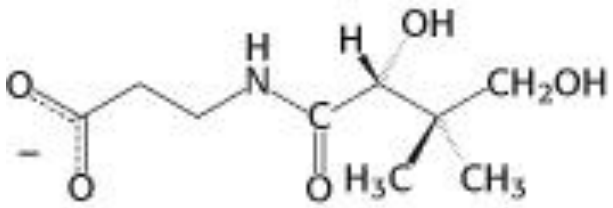
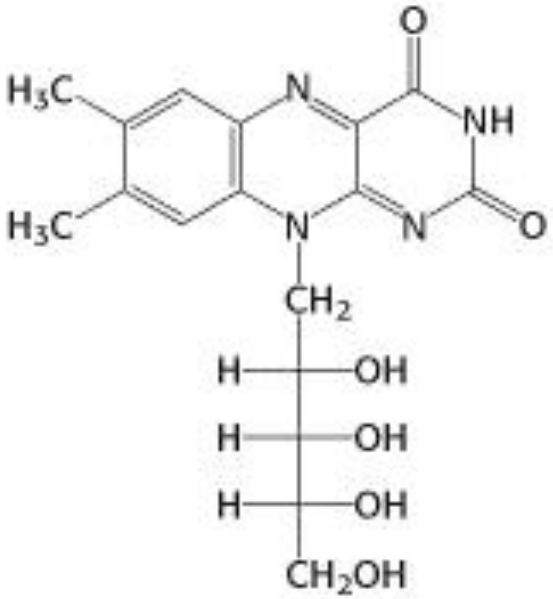
Fat Soluble vs Water soluble Vitamins

	Fat Soluble	Water Soluble
Absorption	Into lymphatic system (fat/bile)	Directly into blood stream
Storage	For future use	Note stored
Effect of Overdose	Toxic	Can be excreted
Stability	Less fragile	Easily destroyed on heating

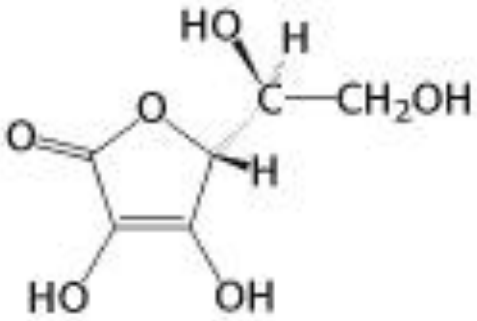
Water Soluble Vitamins



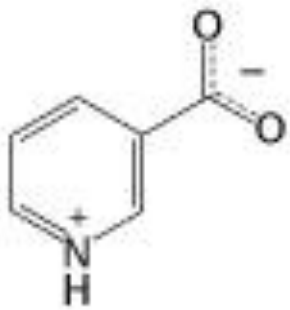
Vitamin B_5
(Pantothenate)



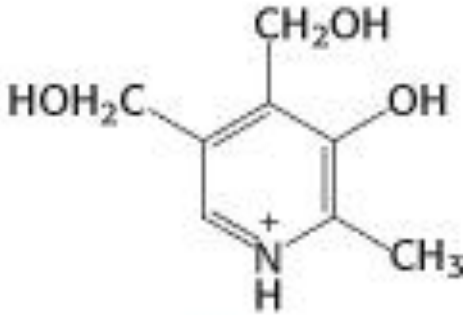
Vitamin B_2
(Riboflavin)



Vitamin C
(Ascorbic acid)



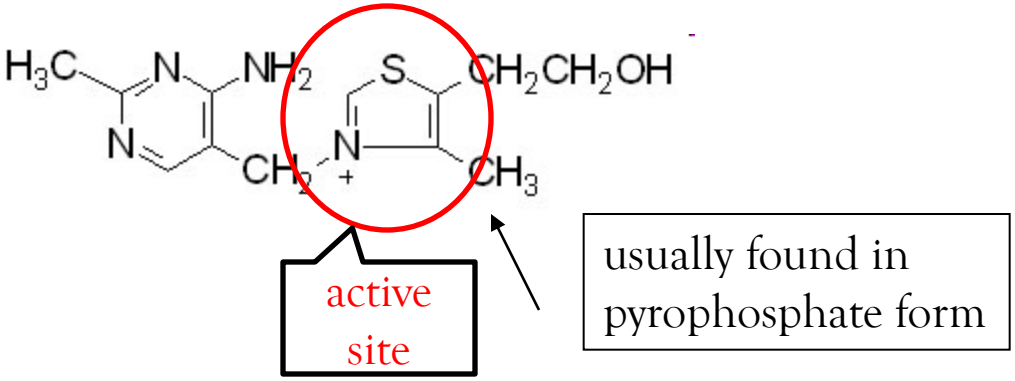
Vitamin B_3
(Niacin)

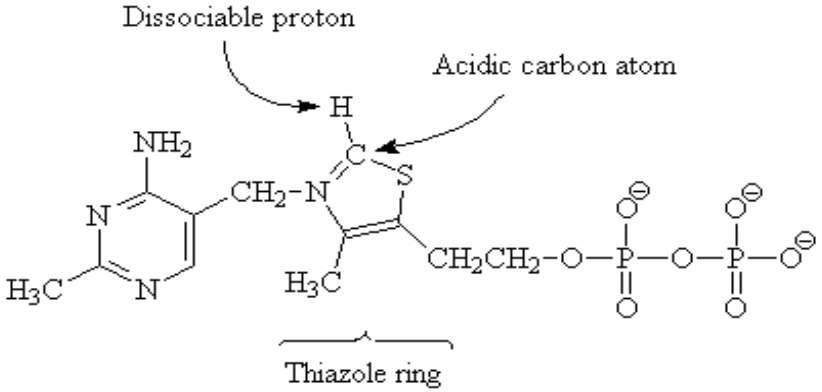


Vitamin B_6
(Pyridoxine)

Thiamine (B_1)

- Thiamine - a thiazole ring joined to a substituted pyrimidine by a methylene bridge





THIAMINE PYROPHOSPHATE (TPP)

- ❖TPP is the active form
- ❖Easily destroyed by heat

Thiamine pyrophosphate

TPP is the active form

Functions:

- Energy metabolism
  - required for the normal metabolism of -CHO.
    - catalyzes decarboxylations of α-keto acids e.g.
      - pyruvic acid → acetaldehyde in glycolysis
      - pyruvic acid → acetyl-CoA
  - formation and cleavage of α -hydroxyketones
- Supports nervous system
- Daily requirements
  - men: 1.2 mg/day
  - women: 1.1 mg/day

Thiamine Sources

- Occur in both plant & animal sources

Animal:

- Pork, milk Liver, eggs, rumen

Plants:

- Whole/enriched grains
  - Esp seed coats & embryos; eg. wheat germ
- fresh green forage
- yeast

Deficiency symptoms of Thiamine

1. Beriberi

- Anorexia: loss of appetite
- severe nervous disorders
- General &muscular weakness
- tissue wasting & edema
- Dyspepsia (indigestion)
- Needle –like feeling under the skin

- **Three types of beriberi**
  - Dry beriberi- adults
  - Wet beriberi – youth
  - Infantile beriberi- infants

Deficiency symptoms of Thiamine

2. Warnicke-Korsakoff Syndrome

- Korsakoff's psychosis –
  - confused state- characterized by
  - confabulation
  - memory loss of recent events /non-impairment of past events
- Wernicke encephalopathy-
  - Neurological charcterised by
  - Nystagmus (involuntary spasmodic movement of eye ball
  - Ocular palsy

Chronic peripheral neuritis

- Neurological problems eg. confusion and ataxia
- Thiamine deficiency due to alcoholism
- TPP is required to metabolize energy
- Alcohol contains calories which must be metabolized but no thiamine,
- Leads to neurological problems

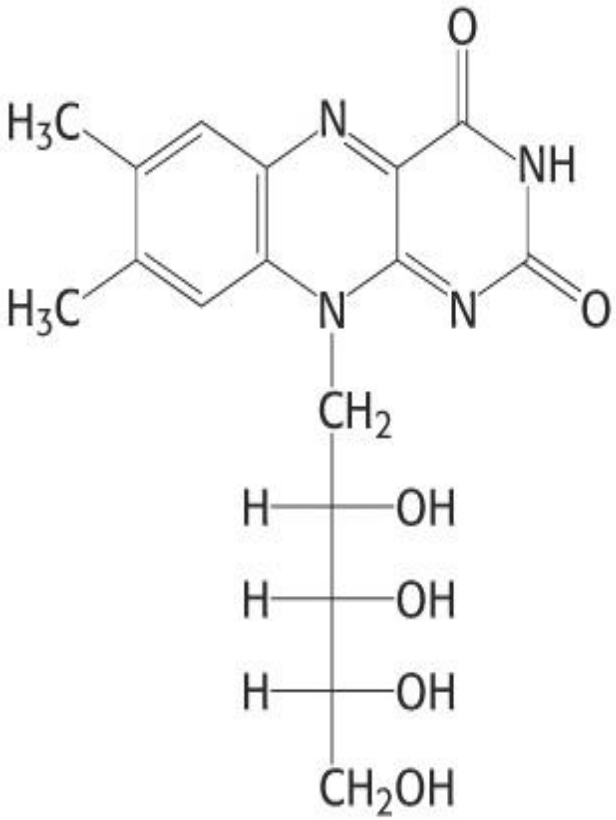
Risky groups

- Chronic alcoholics
- Population dependent on polished rice
- People who consume raw sea fish
- Rice & sea raw fish contain active thiaminase-enzyme destroys the vitamin

Riboflavin

Also known as vitamin B_2

- Contain ribitol & isoalloxazine (flavin) ring
- Coenzyme (Active form)
  - Flavin mononucleotide (FMN)
  - Flavin adenine dinucleotide (FAD)
- FMN &FAD not true nucleotides
  - Names are traditional and they persist!



Vitamin B_2 (Riboflavin)

Riboflavin Sources

Widely present in plants & animal sources

Animals:

- Milk & dairy products-yogurt, cheese, liver, meat, kidney, eggs

Plants:

- Enriched /whole grains-wheat bran
- Yeast
- Fresh vegetables
- Rumen synthesis

Functions of Riboflavin

Energy metabolism:

- part of FMN (Flavin Mononucleotide)
- FAD (Flavin Adenine Dinucleotide)

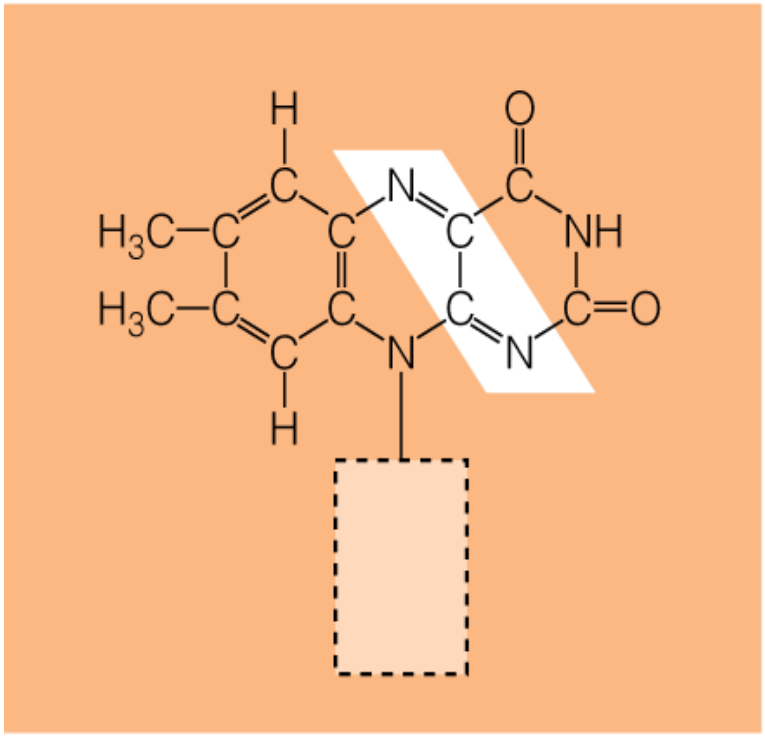
- Important coenzymes in energy metabolism
- catalyzes dehydrogenation rxns
- Important in the metabolism of a.a, fats & -CHO.

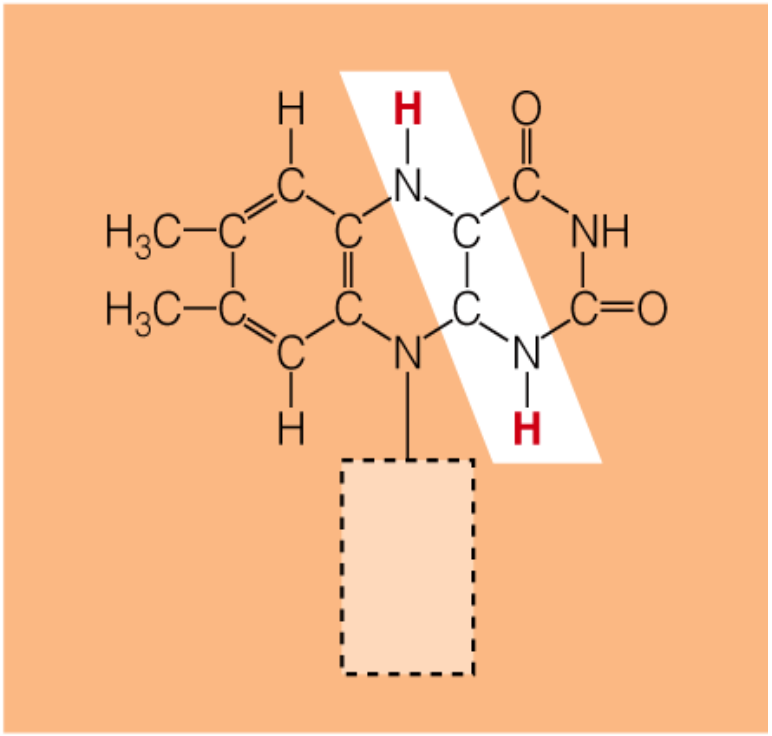
Promotes healthy skin & vision

Necessary for normal embryo development,

- Easily destroyed by ultraviolet light & irradiation
- Daily requirements
  - ❖ Men: 1.3 mg/day
  - ❖ Women: 1.1 mg/day

Riboflavin in redox reactions





FAD

$FADH_2$

During the TCA cycle, compounds release hydrogens, and the riboflavin coenzyme FAD picks up two of them. As it accepts two hydrogens, FAD becomes $FADH_2$.

$FADH_2$ carries the hydrogens to the electron transport chain. At the end of the electron transport chain, the hydrogens are accepted by oxygen, creating water, and $FADH_2$ becomes FAD again. For every $FADH_2$ that passes through the electron transport chain, 2 ATP are generated.

Vitamin B_2 : Deficiency symptoms:

Riboflavinosis (never fatal) characterised by

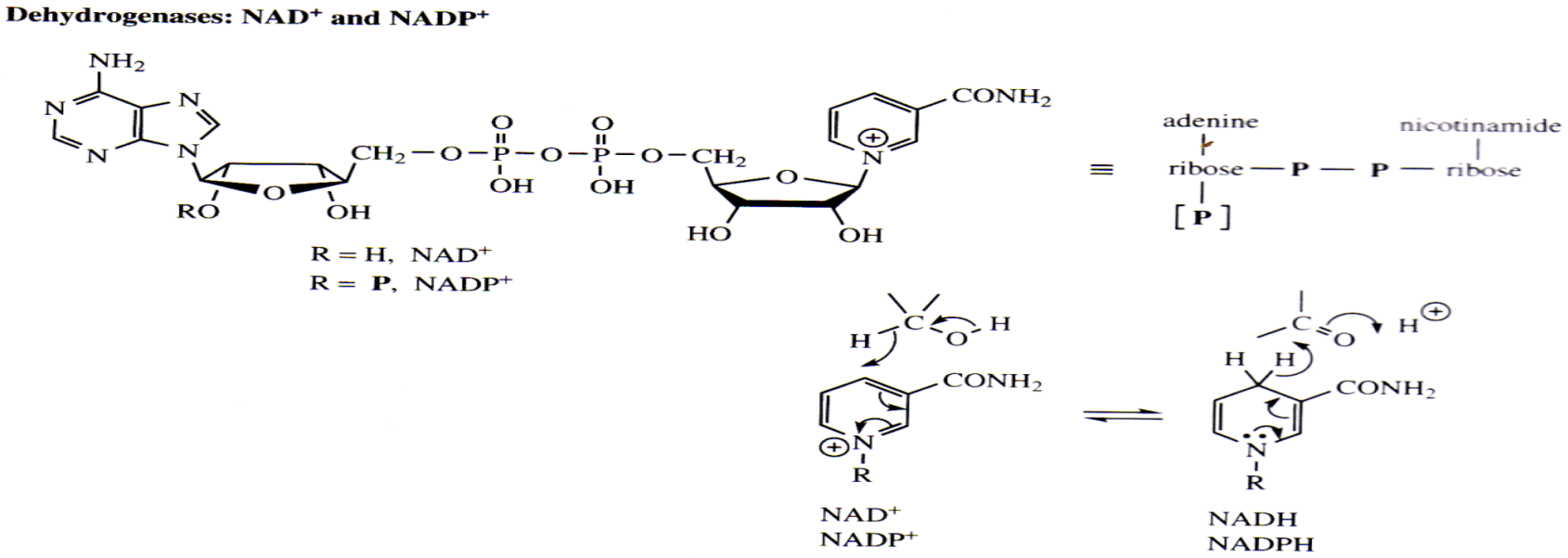
- Cheilosis- swelling and fissuring of lips
- Angular stomatitis- lessions at the margin of the mouth
- Painful desquamation of the tongue
    - (dry and atrophic) magenta tongue
- Scaly dermatitis
- Eye problems lead*in*g to
    - corneal vascularisation
    - inflammation with cloudiness of cornea
    - photophobia
    - cataract
- Skin disorders

Niacin (B_3)

Other names

- ❖ Nicotinic acid
- ❖ Nicotinamide
- ❖ Niacinamide

- Precursor: dietary **tryptophan**



Niacin Sources

- Both plant & animal sources
- Animal:
  - protein foods
    - Milk
    - eggs
    - meat
    - fish, poultry
- Plants
  - legumes
  - Enriched/whole grains
  - Nuts
  - Yeast

Functions of Niacin

- Energy metabolism:
  - Part of coenzymes NAD & NADP
    - catalyzes **redox** rxns of alcohols/carbonyl groups
    - Degradation of l-Trp → niacin

- General metabolism,
  - healthy skin,
  - nervous & digestive system

Niacin Deficiency

Pellagra characterized by 3Ds

- ❖diarrhea
- ❖dermatitis
- ❖ dementia
- ❖oral lesions

Toxicity symptoms

- ❖Painful flush,
- ❖hives
- ❖ rash (“niacin flush”)
- ❖Excessive sweating
- ❖Blurred vision
- ❖Liver damage, impaired glucose tolerance

RDA

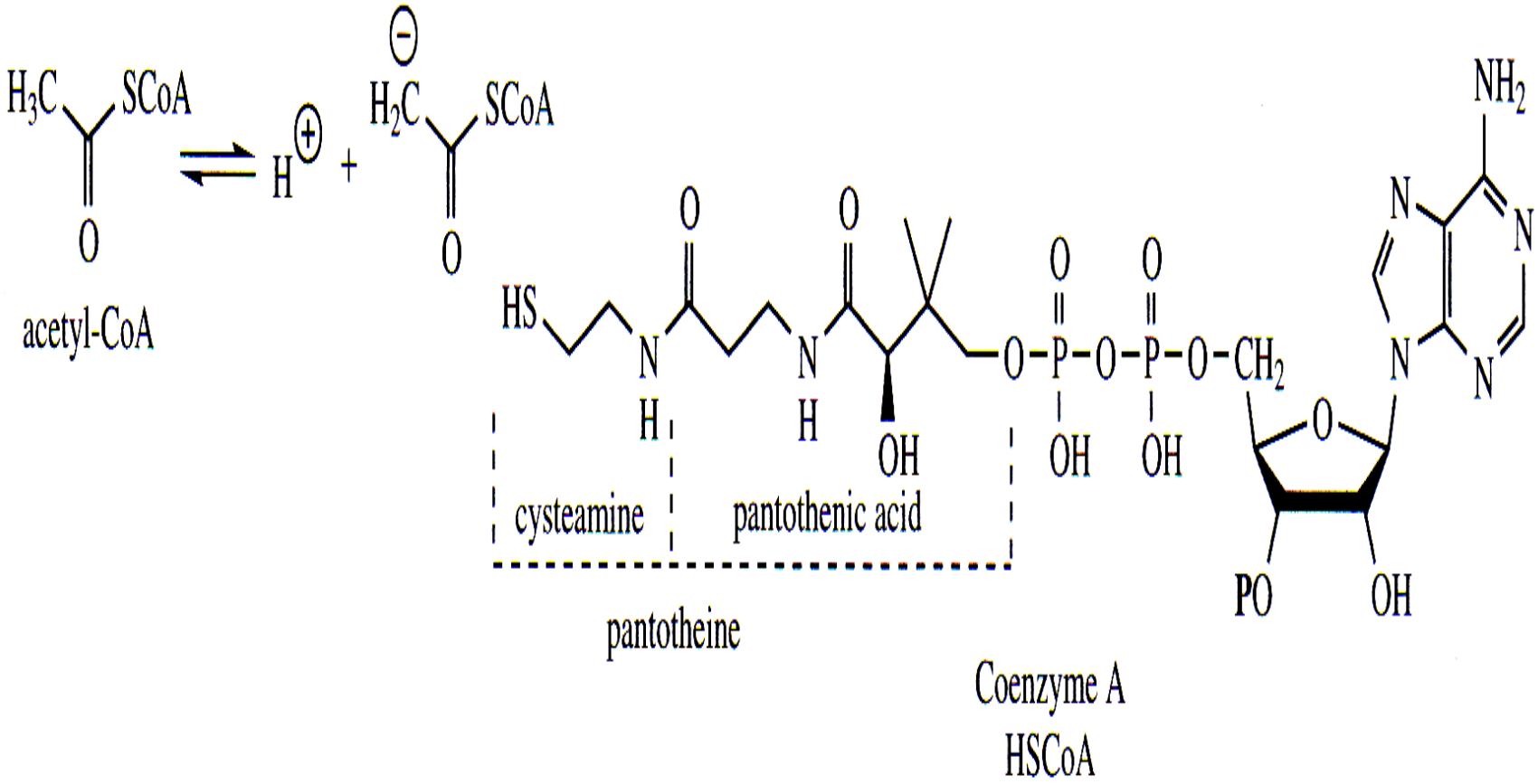
Men: 16 mg NE/day

Women: 14 mg NE/day

Upper level for adults: 35 mg/day

Pantothenic acid

- Also known as vitamin B_5
- Part of Coenzyme A



Functions of Pantothenic Acid

- Part of coenzyme A,
  - used in energy metabolism

- Easily destroyed by food processing

- 1998 adequate intake (AI)
  - Adults: 5 mg/day

Sources of Pantothenic Acid

- Widespread in foods- plants & animals

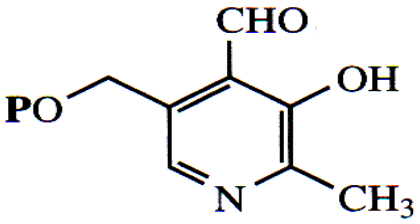
- Plants
  - Broccoli
  - Whole grains
  - Mushrooms
  - Avacado

- Animals
  - Organ meats
  - yeast
  - liver

Functions of Pantothenic acid

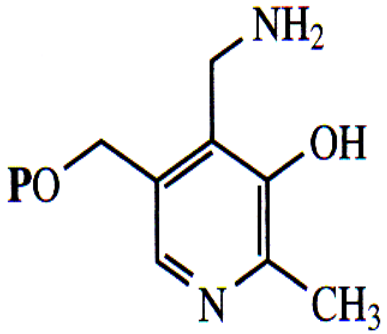
- Synthesis of fatty acids (acetate pathway),
- Synthesis of some peptides, isoprenoids phenylpropanoids
- Metabolism of fat, carbs and protein
- Vitamins B_3, B_5, B_6 and biotin are thought to promote healthy hair and prevent hair loss
- Deficiency is rare

Vitamin B_6



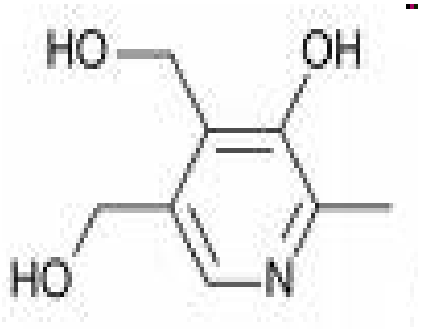
pyridoxal P
(PLP)

- Other names
  - Pyridoxine
  - Pyridoxal
  - Pyridoxamine



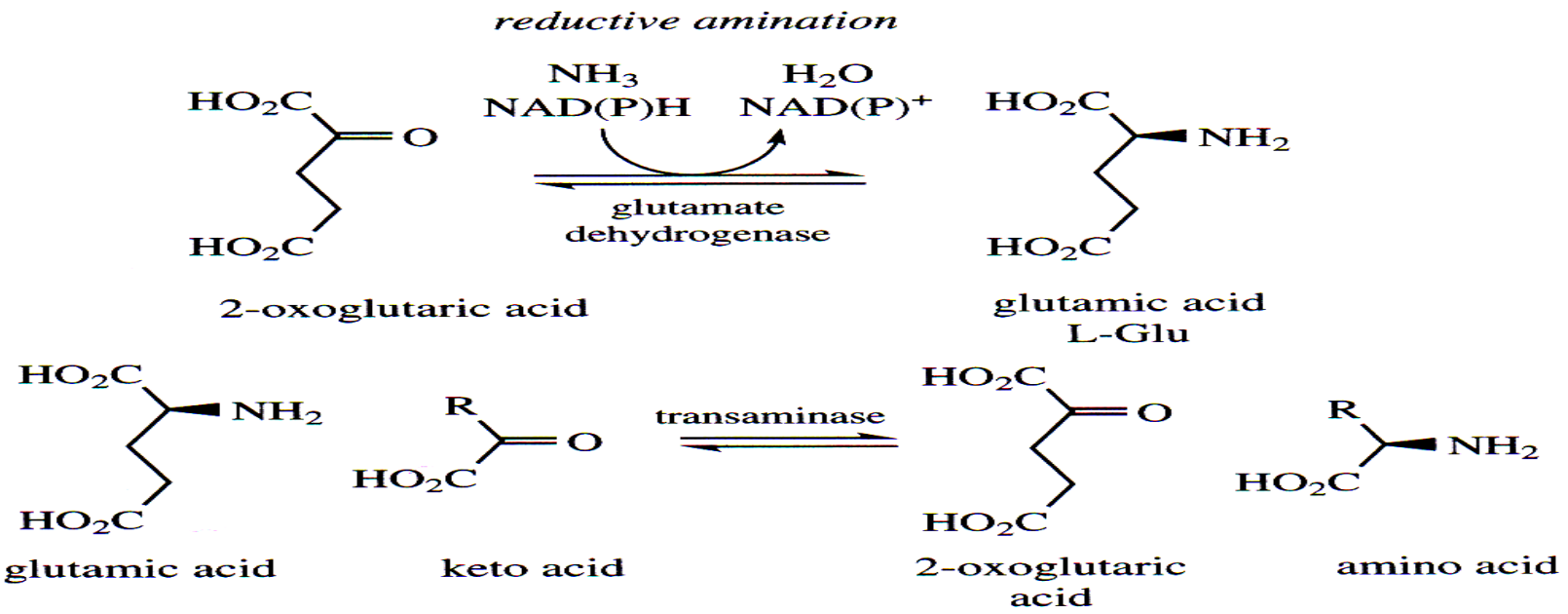
pyridoxamine P

- Coenzyme PLP, PNP or PMP
- Adults (19-50 years): 1.3 mg/day
- Upper level for adults: 100 mg/day



Function of vitamin B6

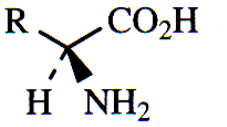
Amination reactions: Gain of N by a molecule
Reductive amination: N comes from ammonia
Transamination: NH_2 group is transferred from an a.a

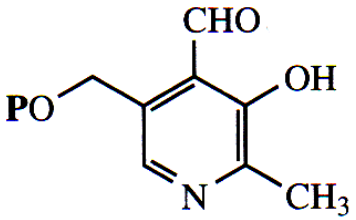


Product of Krebs cycle

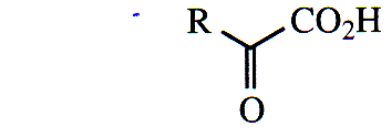
Loss of N:

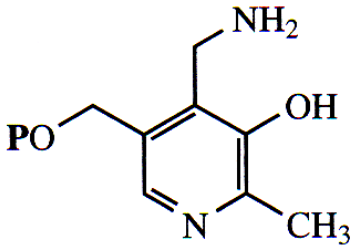
Deamination of an amino acid by Vitamin B_6 involves imine formation and hydrolysis





pyridoxal P (PLP)



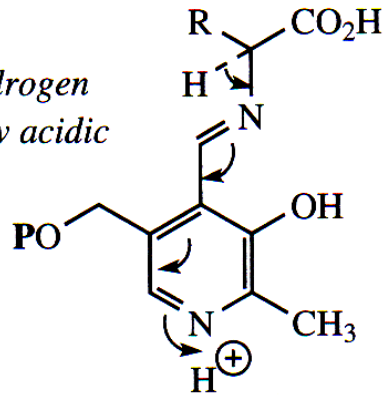


pyridoxamine P

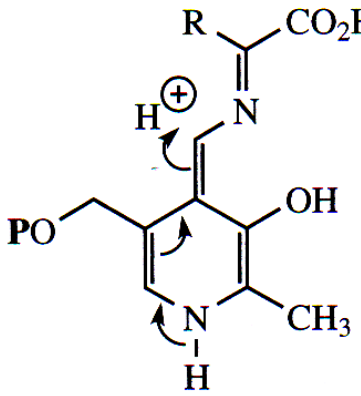
formation of imine from aldehyde and amino acid

hydrolysis of imine to keto acid and amine

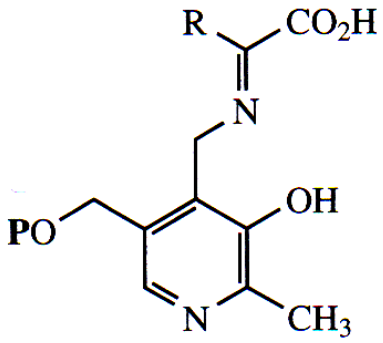
α-hydrogen is now acidic



aldimine



restoring aromaticity



ketimine

Sources of vitamin B_6

- Animal:
  - Meat,
  - Fish eg salmon,
  - Poultry,
  - Liver
- Plants :
  - nuts, cereals
  - bananas, Potatoes,
  - legumes
  - Non-citrus fruits
  - Fortified cereal
  - Soy products

Chief functions of Vit B_6 in the body

- Energy metabolism:
  - Amino acid and fatty acid metabolism :
  - Part of coenzymes pyridoxal phosphate
  - Catalyzes transaminations & decarboxylations of amino acids
  - PLP is important in f.a and aa metabolism

- Convert tryptophan to niacin and to serotonin
- Helps to make red blood cells
- In plants, used in biosynthesis of phenylpropanoids from amino acids

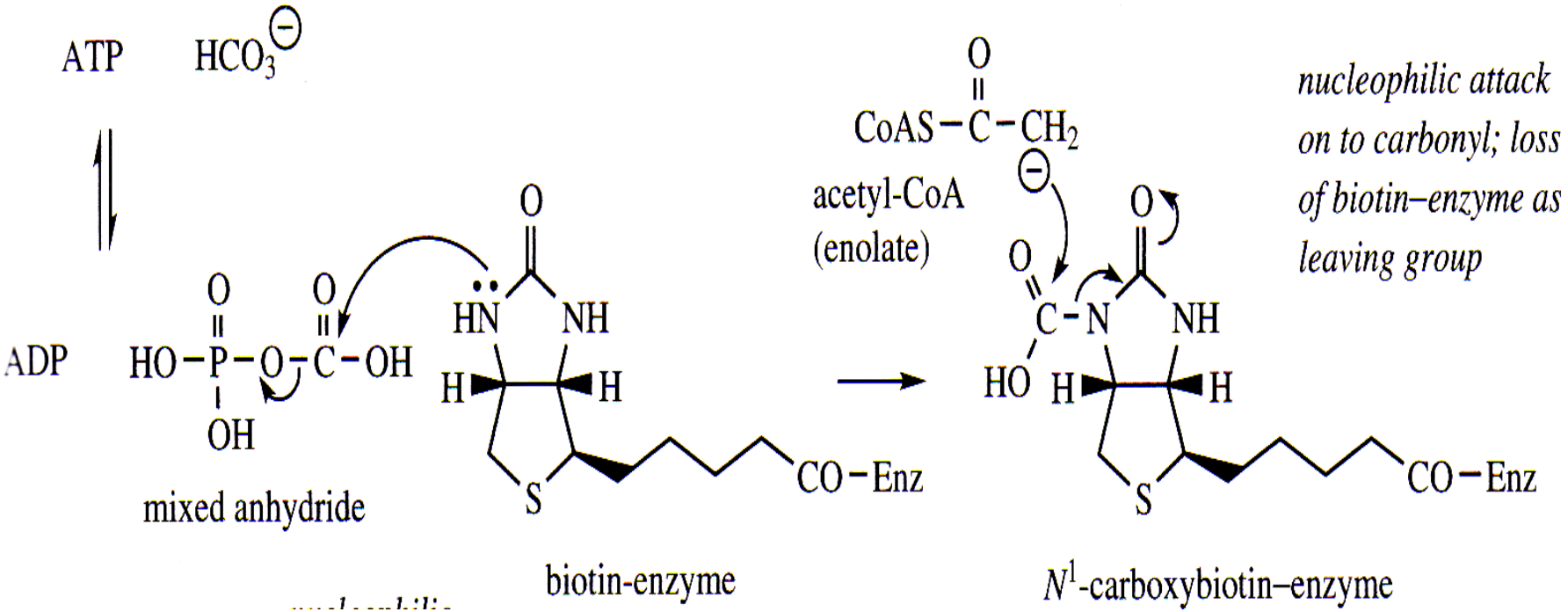
Deficiency symptoms of Vitamin B_6

- Scaly dermatitis
- Anemia (small-cell type)
- Depression, confusion, abnormal brain wave pattern, convulsions
- Nervous disorders, skin rash, muscle weakness,

- Vit B_6 can be lost through cooking, deficiency usually caused by poor absorption

Biotin (B_7)

Biotin (Vitamin H): functions as a carboxyl group carrier
Ex: transforms acetyl-CoA to malonyl-CoA (acetate pathway)
Deficiency is rare, but could lead to dermatitis and hair loss ☹



- 1998 adequate intake (AI)

  Adults: 30 μg/day

Biotin Sources

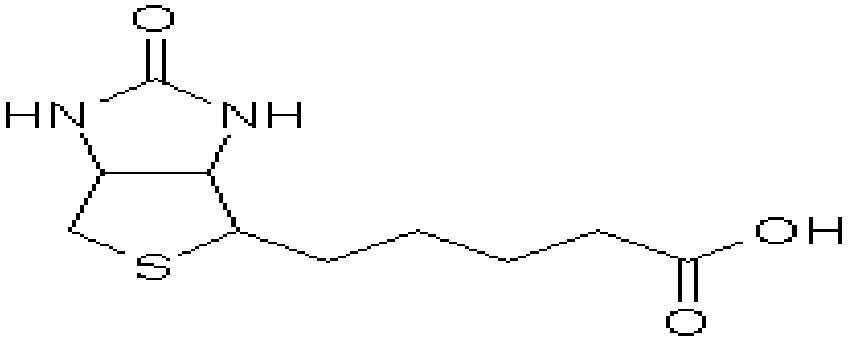
- Animal sources
  - Organ meats, fish
  - Egg yolks, liver, kidney, milk
- Plant sources- Soybeans, Whole grains, yeast, cereals
- Also produced by intestinal microflora

- **Chief functions in the body - part of a coenzyme used in energy metabolism, fat synthesis, amino acid metabolism, and glycogen synthesis**

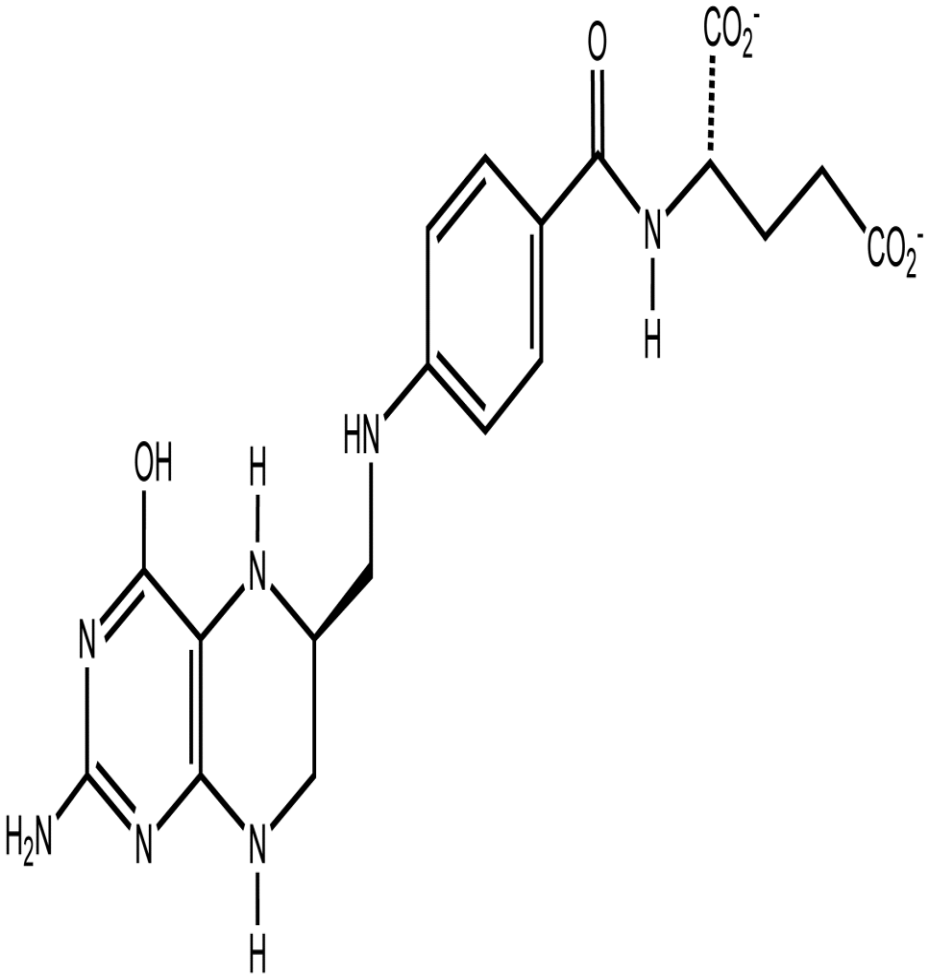
Biotin "chemistry on a tether"

- Mobile carboxyl group carrier
- Bound covalently to a lysine
- The biotin-lysine conjugate is called biocytin
- The biotin ring system is thus tethered to the protein by a long, flexible chain

- Whenever you see a carboxylation that requires ATP and CO2 or HCO3-, think biotin!
- Activation by ATP involves formation of carbonyl phosphate (aka carboxyl phosphate)
- Carboxyl group is transferred to biotin to form N-carboxy-biotin
- The "tether" allows the carboxyl group to be shuttled from the carboxylase subunit to the transcarboxylase subunit of ACC-carboxylase



Folate (B_9)



- Other names
  - Folic acid
  - Folacin
  - Pteroylglutamic acid (PGA)
- 1998 RDA
  - Adults: 400 μg/day
- Upper level for adults: 1000 μg/day

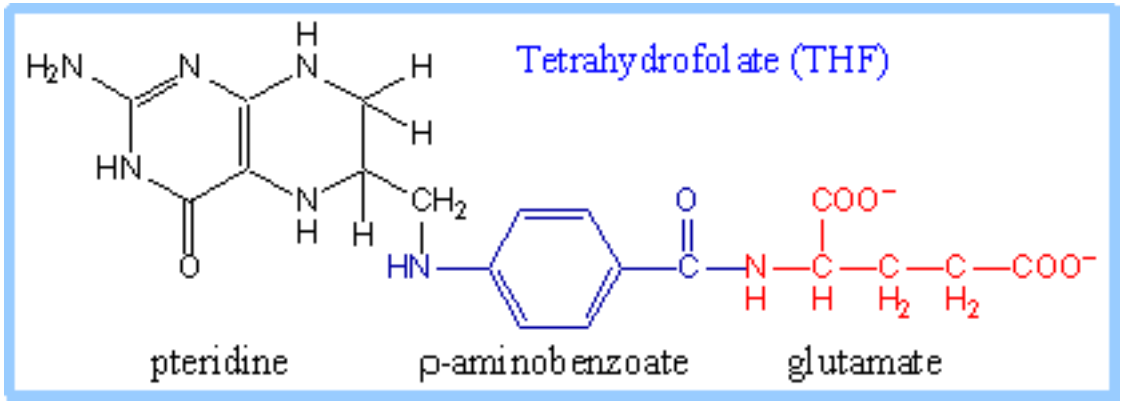
Folate Sources

- Plant sources
  - Whole & Fortified grains
  - Leafy green vegetables
  - Legumes
  - Seeds
  - Yeast
  - some fruits

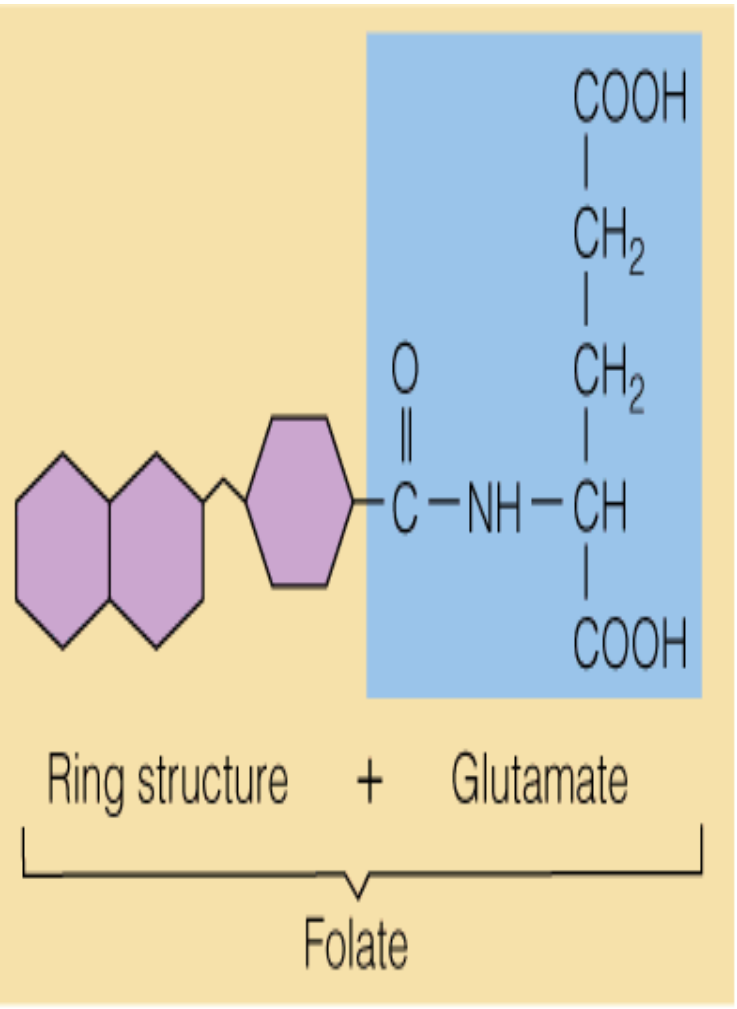
- Animal sources
  - Liver,

Folic Acid

- Folates are donors of 1-C units for all oxidation levels of carbon except that of CO_2
- Active form is tetrahydrofolate (THF)
- THF is formed by two successive reductions of folate by dihydrofolate reductase

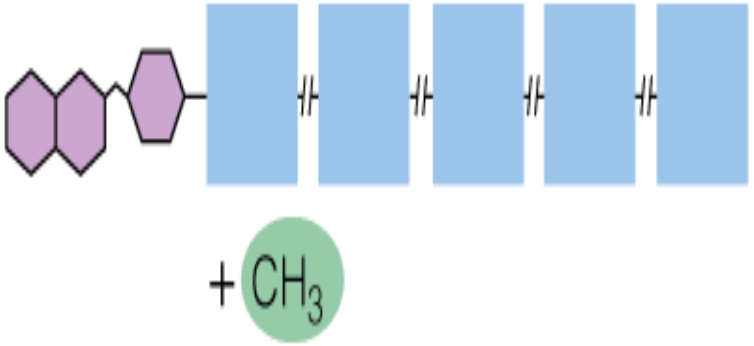


Folate

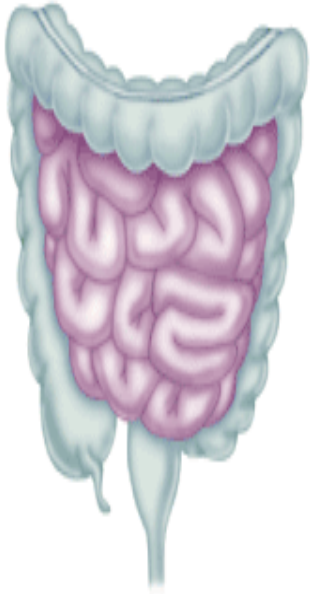


In foods, folate naturally occurs as polyglutamate. (Folate occurs as mono-glutamate in fortified foods and supplements.)

Spinach

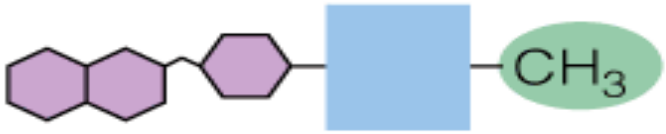


In the intestine, digestion breaks glutamates off . . . and adds a methyl group. Folate is absorbed and delivered to cells.

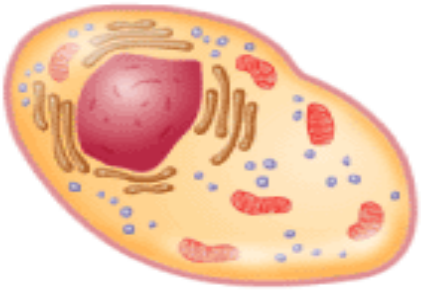


Intestine

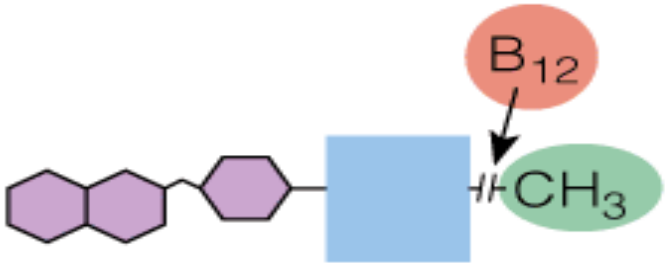
Folate



In the cells, folate is trapped in its inactive form.



Cell



To activate folate, vitamin B_{12} removes and keeps the methyl group, which activates vitamin B_{12}.

Both the folate coenzyme and the vitamin B_{12} coenzyme are now active and available for DNA synthesis.

DNA

Folate

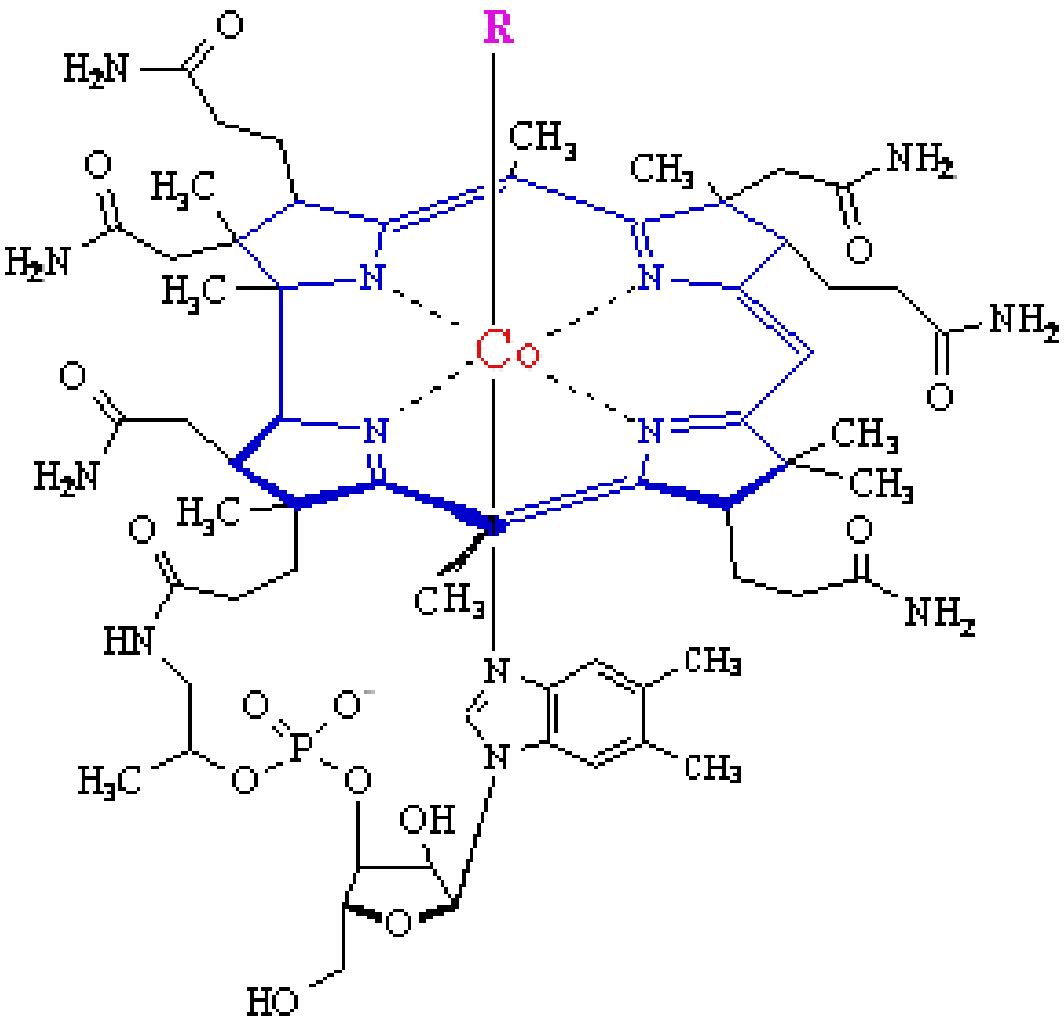
- Chief functions in the body
- Part of coenzymes
  - Tetrahydrofolate (THF)
  - Dihydrofolate (DHF)
  - used in DNA synthesis
  - DNA important in new cell formation
- THF important in one-C metabolism
  - Acts as a carrier of methyl, methylene or formyl groups
- Involved in amino acid &nucleotide metabolism,
- Involved in red blood cell formation

Folacin Deficiency

- Anemia,
- Neural tube defects in a fetus,
- Cardiovascular problems in adults
- **Neural Tube Defects**
  - Malformation of the central nervous system that forms very early in the pregnancy (often even before woman realizes she is pregnant
- Spina bifida- spine develops outside of the body
- Anencephaly- entire brain and skull above the ears is missing
- Folate intake linked to reduced CVD, colon cancer in women and depression in men

Vitamin B_{12}

R groups vary:
CN, OH, H_2O, NO_2, Me



Other names: cobalamin (and related forms)

- Contains Co(III) coordinated to a corrin ring
- (R = CN is cyanocobalamin, most common form)

1998 RDA

Adults: 2.4 μg/day

Vitamin B_{12} Sources

- Animal products
  - Meat, poultry fish, shellfish, Eggs
  - Milk, cheese ,
  - dairy products
- Fortified cereals
- Microbial in origin; intestinal flora contribute towards human dietary needs.
- Stored in the liver

Chief functions of B_{12} in the body

- New cell synthesis:
  - Part of coenzymes for new cell synthesis
  - methylcobalamin
  - deoxyadenosylcobalamin
- Methylations reactions
  - one-C metabolism (methylations) reactions
  - Conversion of of homocysteine to methionine
- Biosynthesisof DNA, amino acids, fatty acids,
  - Needed to maintain RBC, genes
  - Helps to maintain nerve cells
  - Reforms folate coenzyme
  - Helps to break down some f.a & amino acids
- Activates Folate

Vitamin B_{12}

- Absorption of Vitamin B_{12} requires
  - HCl
  - Pepsin
  - Intrinsic factor
- Poor absorption is thought to be a complication of aging
- Easily destroyed by microwave cooking

Vitamin B_{12} Deficiency

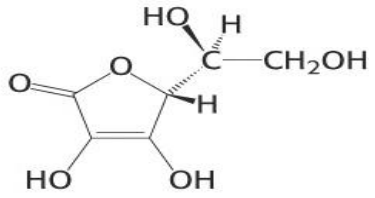
- Pernicious Anemia
  - Common in strict vegetarians – obtained only from animal sources

- "Intrinsic factor" needed for B_{12} absorption
- secreted by the parietal cells in lining of gastric mucosa
- Toxicity: none reported

Ascorbic Acid

Vitamin C

- A vitamin in some animals
  - Most plants and animals make ascorbic acid - for them it is not a vitamin
  - Only a few vertebrates - man, primates, guinea pigs, fruit-eating bats and some fish (rainbow trout, carp and Coho salmon) cannot make it!
- Vitamin C is a reasonably strong reducing agent
- It functions as an electron carrier (describe how)

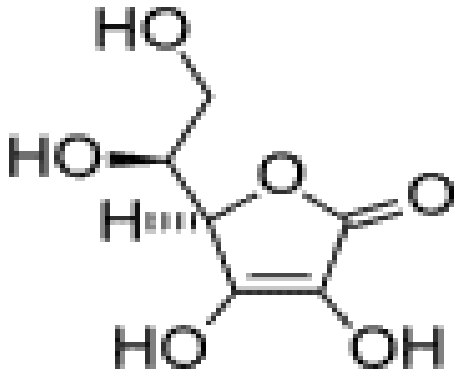


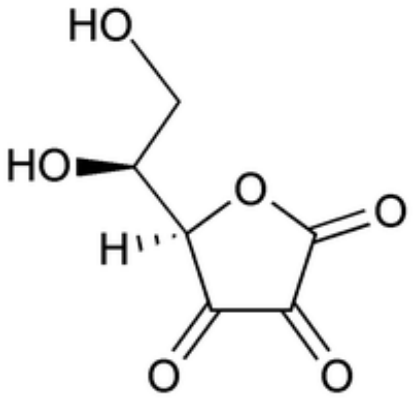
Vitamin C (Ascorbic acid)

- Hydroxylations of proline and lysine (collagen)
- Metabolism of Tyr in brain
- Fe mobilization from spleen
- May prevent the toxic effects of some metals
- Ameliorates allergic responses
- Can stimulate the immune system

Vitamin C (Ascorbic acid)

- Antioxidant, strong reducing agent
- Collagen synthesis, tissue repair, bones & teeth, immune system, iron absorption
- Cannot be made by human body though animals can biosynthesize from glucose
- Found in citrus fruits, cruciferous veggies, tomatoes, dark green leafy, berries, mangos, melons
- Degraded by cooking
- **Deficiency causes**
  - scurvy,
  - anemia,
  - depression,
  - infection,
  - tooth/gum problems,
  - muscle deterioration,
  - fragile bones,
  - poor wound healing





L-dehydroascorbic acid