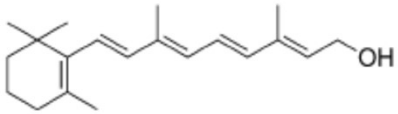
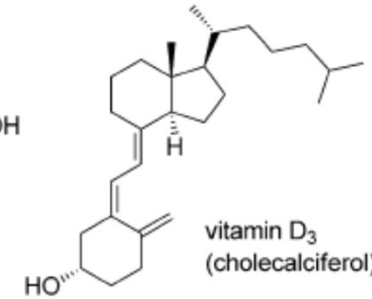
Vitamine

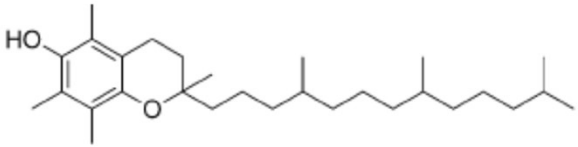
Vitamine



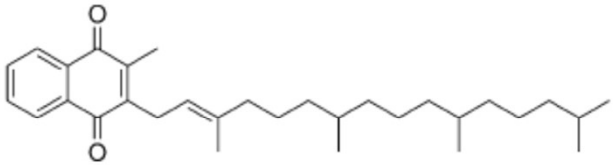
vitamin A (retinol)



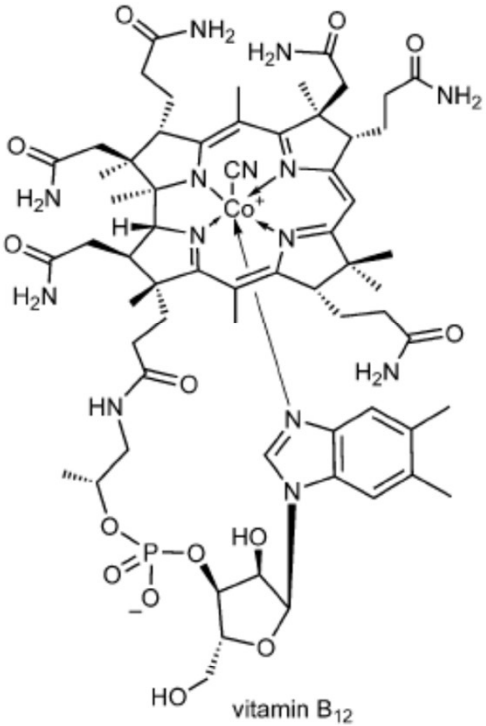
vitamin D_3 (cholecalciferol)



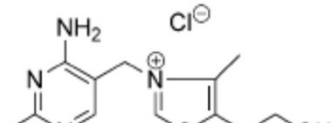
vitamin E ((all-*rac*)-α-tocopherol)



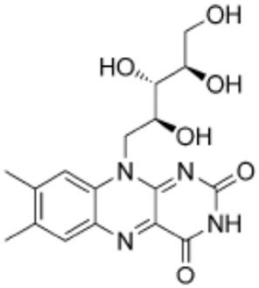
vitamin K_1 ((all-*rac*,*E*)-phylloquinone)



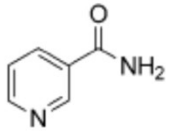
vitamin B_{12} (cyanocobalamine)



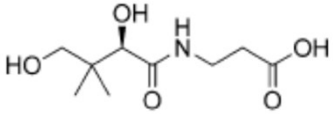
vitamin B_1 (thiamine)



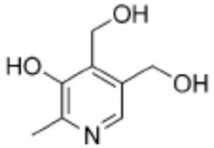
vitamin B_2 (riboflavin)



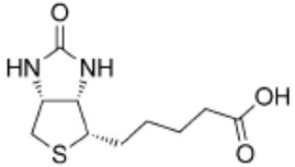
vitamin B_3 (niacin)



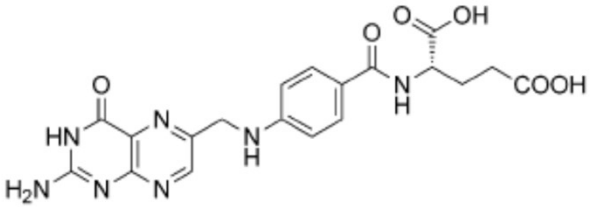
vitamin B_5 (pantothenic acid)



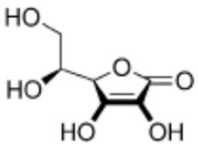
vitamin B_6 (pyridoxine)



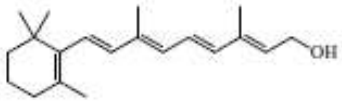
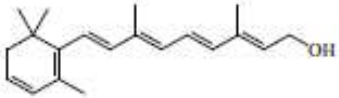
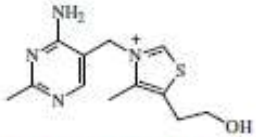
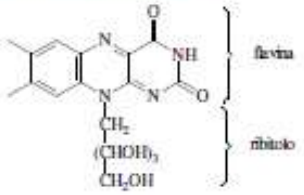
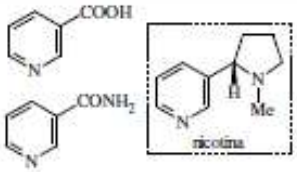
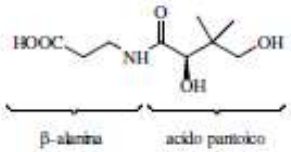
vitamin B_7 (vitamin H, biotin)

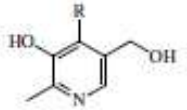
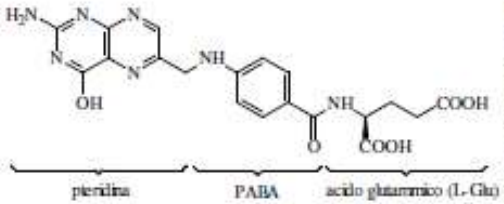
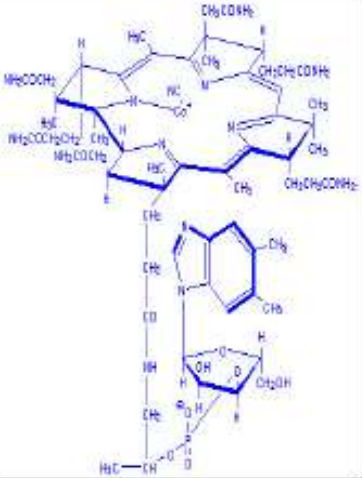
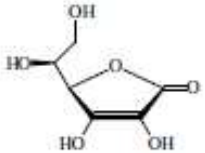


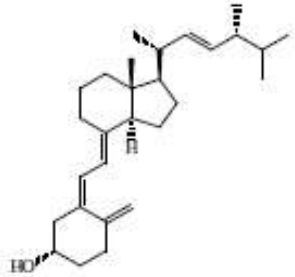
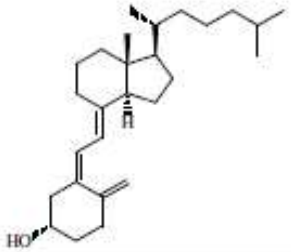
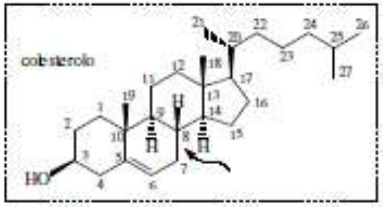
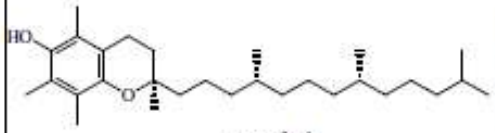
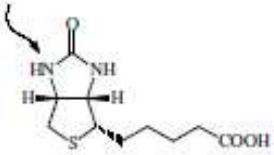
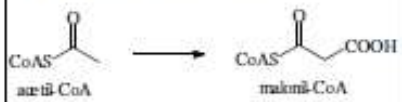
vitamin B_9 (folic acid)

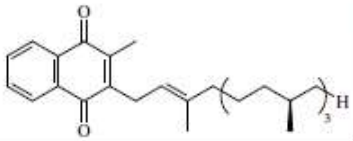
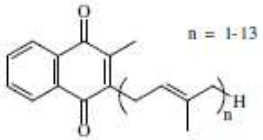
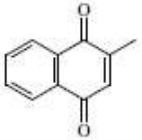
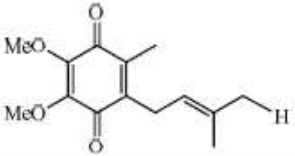


vitamin C (L-ascorbic acid)

Vitamina	Nome	Struttura	Azione	Effetti dovuti alla carenza	Fonti
A_1 (liposolubile)	Retinolo (axeroftolo)		- ciclo della visione - sviluppo embrionale - differenziazione cellulare - protegge dai tumori - antiossidante (contro i radicali liberi)	- cecità notturna - xeroftalmia ("occhi secchi"): essiccamento della cornea dovuto a mancata secrezione lacrimale (può provocare la cecità) - crescita insufficiente - sviluppo inadeguato di ossa e sistema nervoso - degenerazione di reni e ghiandole - sterilità	- *fonti di β-carotene*: lattuga, spinaci, carote, peperoncino piccante, patate dolci, albicocche, meloni, zucca, prezzemolo, germogli; - *fonti di retinolo*: olio di fegato di pesce, fegato (vitello, manzo), formaggio, burro.
A_2 (liposolubile)	Deidroretinolo		Stessa azione della vitamina A_1, ridotta al 30-40% circa		
B_1 (idrosolubile)	Tiamina (aneurina)	 Stabile al calore (<100°C) ma instabile in ambiente basico. Solfiti e bisolfiti scindono il legame CH_2-N	- è fondamentale nel metabolismo dei carboidrati e dei lipidi (produzione di energia) come ***coenzima*** della piruvato decarbossilasi - è necessaria per il buon funzionamento di cervello, muscoli, cuore, sistema nervoso (azione non coenzimataca): chiamata "aneurina" proprio perché scongiura disturbi neurologici	- **beri-beri**: disordini neurologici, perdita di appetito e di peso, affaticamento, debolezza muscolare, insufficienza cardiaca (colpisce soprattutto i popoli che si nutrono esclusivamente di riso brillato)	- cereali integrali: grano, riso (essenzialmente nella crusca) - lievito di birra - ortaggi, fagioli, legumi in genere - uova, latte - nocciole
B_2 (idrosolubile)	Riboflavina (lattoflavina, in quanto abbonda nel latte)		- è parte essenziale dei due ***coenzimi*** FAD e FMN - facilita l'assorbimento di proteine e carboidrati N.B.: essendo gialla viene anche usata come colorante alimentare	- dermatiti, anemia - diarrea, vomito - perdita di appetito - disturbi cerebrali Stabile al calore ma sensibile alla luce (è gialla!), che scinde il legame con il ribitolo	- lievito di birra - fegato - latte e latticini - cavoli, spinaci, verdure a foglia verde - fegato, pesce, uova
B_3 (PP: "pellagra preventing") (idrosolubile)	Niacina (acido nicotinico, trasformato nell'organismo in nicotinammide)		- è parte essenziale del ***coenzima*** NAD^+ (o $NADP^+$) ed è il più importante trasportatore di elettroni del metabolismo primario - aiuta la circolazione del sangue e la produzione di ormoni sessuali	- **pellagra**: diarrea, dermatiti, demenza - caduta di capelli	E' ampiamente diffusa negli alimenti (in particolare: carne, pesce, fegato, farina, lievito di birra, cereali)
B_5 [Coenzima A] (idrosolubile)	Acido pantotenico		- costituente del ***coenzima*** A - combatte lo stress - stimola gli anticorpi	Carenza sconosciuta nell'uomo, data la sua diffusione negli alimenti (da cui il nome: *pan*)	E' ampiamente diffusa negli alimenti (in particolare: lievito di birra, fegato, funghi, frutta a guscio, latte e derivati)

Vitamina	Nome	Struttura	Azione	Effetti dovuti alla carenza	Fonti
B_6 (idrosolubile)	Piridossina (in realtà: piridossina + piridossale + piridossamina)	 R = CH_2OH: piridossina (piridossolo) R = CHO: piridossale R = CH_2NH_2: piridossamina	Il piridossal 5-fosfato, in particolare, è ***coenzima*** di parecchi enzimi, quali quelli coinvolti nel metabolismo degli a.a. (transaminasi, decarbossilasi) Catalizza la trasformazione L-Trp -> vitamina PP	- lesioni ad occhi, bocca, naso - cambiamenti neurologici Sensibile al calore (cottura)	- carne - salmone - lievito di birra - uova, latte - cereali - nocciole - patate - banane
B_9 (idrosolubile)	Acido folico		Trasportatore intermedio (come ***coenzima*** FH_4, acido tetraidrofolico) di gruppi CH_2OH, CHO o CH_3 Fondam. per il sistema nervoso e indisp. in gravidanza	- alterazione della biosintesi delle basi puriniche e della timina Sensibile alla luce ed al calore	- lievito di birra - fagioli - fegato - lenticchie - spinaci, asparagi - peperoni, carote, pomodori - frutta (arance, banane) - uova
B_{12} (idrosolubile)	Cobalamina cianocobalamina (R = CN) idrossicobalamina (R = OH) aquocobalamina (R = H_2O) nitritocobalamina (R = NO_2) (metilcobalamina (R = Me) 5'-deossiadenosil-cobalamina		Nell'organismo le cobalamine vengono convertite nel ***coenzima*** B_{12}, cofattore di numerosi processi metabolici quale ad es. - la metilazione nella biosintesi della metionina - riarrangiamenti molecolari - riduzione di ribonucleotidi a desossiribonucleotidi per la sintesi del DNA in alcuni batteri anello corrinico	- anemia perniciosa: disturbi nervosi, bassa produzione di globuli rossi Sensibile alla luce	- flora intestinale N.B.: prodotto di semi-sintesi dagli estratti di cobalamine di culture batteriche
C (idrosolubile)	Acido L-ascorbico		Essenziale per la formazione del collagene, la più importante proteina strutturale di pelle, ossa, tendini e legamenti. Interviene come ***coenzima*** nella ossidrilazione di prolina e lisina Sensibile all'aria	- **scorbuto**: dolori muscolari, lesioni della pelle, fragilità dei vasi sanguigni, gengive sanguinanti, perdita di denti	- agrumi freschi (degrada rapidamente all'aria, in quanto facilmente ossidabile)

Vitamina	Nome	Struttura	Azione	Effetti dovuti alla carenza	Fonti
D_2 (liposolubile)	Ergocalciferolo (biogenesi: apertura dell'anello B dell'ergosterolo)		Determina l'assorbimentio di calcio e fosforo ed è quindi Importante per un normale processo di calcificazione delle ossa (se ne deduce un ruolo nel trasporto e deposizione di Ca^{++})	- **rachitismo** nei bambini - osteoporosi	- olio di fegato di pesce
D_3 (liposolubile)	Colecalciferolo (biogenesi: apertura dell'anello B del 7-deidrocolesterolo)	 		Cf. D_2	Cf. D_2
E (liposolubile)	Tocoferolo (*tokos* = nascita, *fero* = porto: sostanze capaci di ridare fertilità)	 α-tocoferolo α-, β-, γ- e δ-tocoferolo si differenziano per il numero di metili nelle posizioni 5, 7 e 8: 5/7/8 (α), 5/8 (β), 7/8 (γ), 8 (δ)	I tocoferoli possiedono attività antiossidante, prevenendo l'ossidazione degli acidi grassi insaturi per esposizione all'aria	- anemia - invecchiamento precoce - fibrosi cistica - epatopatia - danni neurologici nei bambini	- germe di grano - olii vegetali - asparagi, spinaci - cavolo - pomodori
H [Coenzima R] (idrosolubile)	Biotina		Trasportatore di carbossile in reazioni catalizzate da carbossilasi:, Es.:  [via dell'acetato (β-ossidazione)]	- dermatiti - perdita di capelli La carenza è rara perché è prodotta anche dalla flora intestinale. Eventuale carenza in caso di dieta ricca in bianco d'uovo crudo (avidina)	- cereali - lieviti - uova, latte - fegato - flora intestinale

Vitamina	Nome	Struttura	Azione	Effetti dovuti alla carenza	Fonti
K_1 (K: "koagulation") (liposolubile)	Fillochinone (fitomenadione)		La forma attiva è presumibilmente la vitamina K_2. Favoriscono la formazione della protrombina nel fegato: questa si trasforma nella trombina, la quale accelera la trasformazione del fibrinogeno in fibrina (componente fibrosa dei coaguli ematici), favorendo in definitiva la formazione del coagulo. In quanto chinoni, possono servire come trasportatori di elettroni.	- emorragie	- verza, cime di rape, spinaci - insalata, broccoli - ceci, lenticchie - kiwi - latticini, uova
K_2 (liposolubile)	Farnochinone (menachinone)				
K_3 (liposolubile)	Menadione				Vitamina di sintesi
Coenzima Q	Ubichinone-n		Trasportatore di elettroni nei mitocondri		

		Natural source	Best if taken with	Deficiency symptoms	Toxicity symptoms
Vitamin A 5,000-50,000 IU	Fat Soluble	Carrots-raw & juiced, pumpkins, yams, tuna, cantaloupe, mangos, turnip, beet greens, butternut squash, spinach, fish, eggs	Choline, vitamins C, D, E, essential fatty acids, zinc	Poor night vision, macular degeneration, increased risk of cataracts, dry skin. Hearing, taste, smell, nerve damage	Nausea & vomiting, headaches, insomnia, dry skin, joint pain, constipation
Vitamin B1 *Thiamine* 25-300 mg	Water Soluble	Rice bran, pork, beef, ham, fresh peas, beans, breads, wheat germ, oranges, enriched pastas, cereals	Manganese, vitamin C, E, vitamin B complex	Mild: appetite & weight loss, nausea, vomiting, fatigue, nervous system problems Severe: beri beri, muscle weakness, decreased DTR, edema, enlarged heart	Generally non-toxic.
Vitamin B2 *Riboflavin* 25-300 mg	Water Soluble	Poultry, fish, fortified grains & cereals. Broccoli, turnip greens, asparagus, spinach, yogurt, milk, cheese	Vitamin B complex, vitamin C	Mild: cracks & sores to corners of the mouth & tongue, red eyes, skin lesions, dizziness, hair loss, inability to sleep, sensitivity to light, and poor digestion. Severe (rare): anemia, nerve disease	Generally non-toxic.
Vitamin B3 *Niacin* 25-300 mg	Water Soluble	Chicken breast, tuna, veal, beef liver, fortified breads & cereals, brewer's yeast, broccoli, carrots, cheese, corn flour, dandelion greens, dates, eggs, fish, milk, peanuts, pork, potatoes, tomatoes	Vitamin B complex, vitamin C	Mild: canker sores, diarrhea, dizziness, fatigue, halitosis, headaches, indigestion, inability to sleep, loss of appetite, dermatitis Severe: pellagra	Nausea, vomiting, abdominal cramps, diarrhea, flushing. Severe: Liver damage, irregular heart rate, rash to large portions of the body, gouty arthritis
Vitamin B5 *Pantothenic Acid* 25-500 mg	Water Soluble	Whole grains, mushrooms, salmon, brewer's yeast, fresh vegetables, kidney, legumes, liver, pork, royal jelly, saltwater fish, torula yeast, whole rye & whole wheat flour	Vitamins A, C, E	Rare: Nausea, vomiting, fatigue, headache, tingling in the hands, sleep disturbances, abdominal pains & cramps	Generally considered non-toxic.
Vitamin B6 *Pyridoxine* 1.5-2 mg	Water Soluble	Bananas, avocados, chicken, beef, brewer's yeast, eggs, brown rice, soybeans, whole wheat, peanuts, walnuts, oats, carrots, sunflower seeds	Potassium, vitamin C, vitamin B complex	Anemia, seizures, headaches, nausea, dry & flaky skin, sore tongue, cracks on mouth, vomiting	Generally considered non-toxic. High doses (2000-6000 mg/day) can cause nerve disorders.
Vitamin B12 *Cyanocobalamin* 25-500 mcg	Water Soluble	Clams, ham, cooked oysters, king crab, herring, salmon, tuna, lean beef, liver, blue cheese, camembert & gorgonzola cheese	None required	Unsteady gait, chronic fatigue, constipation, depression, digestive disturbances, dizziness, drowsiness, liver enlargement, hallucinations, headaches, inflammation of the tongue, irritability, mood swings, nerve disorders, palpitations, pernicious anemia, tinnitus, spinal cord degeneration	Generally considered non-toxic.
Vitamin C 60-5,000 mg	Water Soluble	Broccoli, cantaloupe, kiwifruit, oranges, pineapple, peppers, pink grapefruit, strawberries, asparagus, avocados, collards, dandelion greens, kale, lemons, mangos, onions, radishes, watercress	Bioflavanoids, calcium, magnesium	Mild: poor wound healing, bleeding gums, easily bruised, nosebleeds, joint pain, lack of energy, susceptibility to infection. Severe: scurvy	Generally considered non-toxic. High doses (5,000 mg and up/day) can cause abdominal bloating and diarrhea.
Vitamin D 400-800 IU	Fat Soluble	Sun exposure, sardines, salmon, mushrooms, eggs, fortified milk, fortified cereals, herring, liver, tuna, cod liver oil, margarine	Calcium, choline, vitamins A & C, phosphorus, essential fatty acids	In infants, irreversible bone deformities. In children: rickets, delayed tooth development, weak muscles, softened skull In adults: osteomalcia, osteoporosis, hypocalcemia	Nausea & vomiting, headaches, constipation, diarrhea, fatigue, loss of appetite, excessive thirst & urination, protein in urine, liver & kidney damage
Vitamin E 30-1,200 IU	Fat Soluble	Vegetable & nut oils, including soybean, corn, safflower, spinach, whole grains, wheat germ, sunflower seeds	Essential fatty acids, vitamins A, B1, C, manganese, selenium	Rare symptoms may include anemia and edema.	Generally non-toxic; but stomach upset, dizziness and diarrhea can occur.
Vitamin K 80 mcg	Fat Soluble	Green leafy vegetables including spinach, kale, cauliflower, broccoli	None required	Rare, except in newborns, where bleeding tendencies are possible. Elevated levels of vitamin K can interfere with the effects of anti-coagulants.	Generally non-toxic; but a type of jaundice may occur in premature infants.

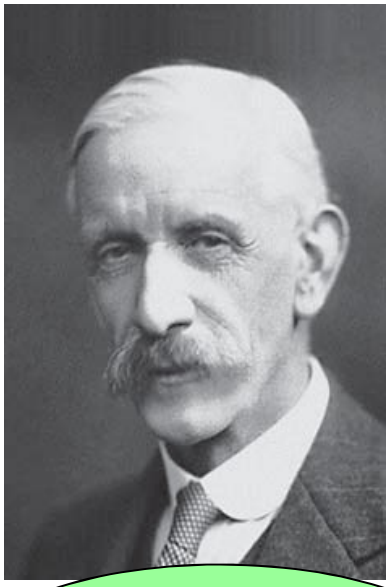
		Natural source	Best if taken with	Deficiency symptoms	Toxicity symptoms
Folic Acid	Water Soluble	Fortified cereals, pinto beans, navy beans, asparagus, spinach, broccoli, okra, brussels sprouts, barley, beef, bran, brown rice, brewer's yeast, cheese, chicken, dates, green leafy vegetables, lamb, legumes, lentils, liver, milk, mushrooms, oranges, split peas, pork, tuna, whole grains	Multivitamin	Anemia, irritability, weakness, sleep disturbances, pallor, sore & reddened tongue	Generally considered non-toxic.
400-1,200 mcg					

Minerali

		Natural source	Best if taken with	Deficiency symptoms	Toxicity symptoms
Calcium	Mineral	Skim milk, nonfat yogurt, kale, cheeses, collard greens, canned salmon & sardines with bones, mustard greens, broccoli, figs, calcium-fortified orange juice, carob, oats, prunes, asparagus, sesame seeds, soybeans, tofu, watercress, whey	Boron, essential fatty acids, lysine, magnesium, manganese, phosphorus, vitamins A, C, D, F, cobalt, folic acid, iron, zinc	Muscle spasms, rickets, osteomalacia, osteoporosis	Generally considered non-toxic. Calcium supplements are not recommended for those individuals with kidney disease or a history of kidney stones.
1,000-1,500 mg					
Chromium	Trace Mineral	Brewer's yeast, broccoli, ham, grape juice, brown rice, cheese, whole grains, dried beans, calves liver, chicken, corn, corn oil, dairy products, eggs, potatoes, mushrooms, wine, beer	None required	Rare: alterations in metabolism of fats, carbohydrates, proteins, amino acids	Generally considered non-toxic. Exposure to industrially inhaled chromium has been linked to lung cancer.
200-600 mcg					
Copper	Trace Mineral	Shellfish, nuts, seeds, cocoa powder, beans, whole grains, mushrooms, calves liver, avocados, barley, beets, broccoli, lentils, oats, oranges, radishes, raisins, salmon, green leafy vegetables	Cobalt, folic acid, iron, zinc	Osteoporosis, inability of body to manufacture collagen, fatigue, baldness, slow growth, slows nervous system development, retardation	Nausea, vomiting, abdominal pain, diarrhea, headaches, metallic taste, hemolytic anemia
0.5-2 mg					
Fluoride	Trace Mineral	Fluoridated water, tea, canned salmon, mackerel, kidney, liver	None required	Dental caries, brittle bones	Mottled teeth, osteomalacia, osteoporosis
1.5-4 mg					

		Natural source	Best if taken with	Deficiency symptoms	Toxicity symptoms
Iodine	Mineral 0-150 mcg (Most individuals) 150-300 mcg (For those living in low-iodine areas or for those with low iodine diets.)	Iodized salt, shellfish, saltwater fish, milk, seaweed	Iron, manganese, phosphorus	Growth and sexual development can be delayed in children; goiter	Generally considered non-toxic, if under 1,000 mcg/day. High doses can cause headaches, metallic taste in mouth and rash. Doses over 20,000 mcg/day have been associated with iodide goiter.
Iron	Mineral 15-25 mg (Men) 18-30 mg (Women)	Iron fortified cereals, beef, baked potatoes, clams, pumpkin seeds, soybeans, eggs, fish, liver, green leafy vegetables, whole grains, nuts, avocados, beets, brewer's yeast, dates, peaches, pears, lentils, dried prunes, raisins, sesame seeds	None required	Anemia, dry, coarse hair, dysphagia, dizziness, fatigue, hair loss, cracked lips or tongue, nervousness, slowed mental response, pallor	Generally considered non-toxic, if under 75mg/day. High doses can cause abdominal cramps, vomiting, and diarrhea. Severe overdoses of iron can be considered fatal if medical attention is not sought.
Magnesium	Mineral 500-750 mg	Brown rice, avocados, spinach, haddock, oatmeal, navy beans, lima beans, broccoli, yogurt, bananas, baked potatoes, apples, apricots, brewer's yeast, tofu, cantaloupes, grapefruit, green, leafy vegetables, lemons, nuts, salmon, sesame seeds, wheat	Calcium, phosphorus, potassium, vitamins B6 (pyridoxine), C, D	Sleep disturbances, irritability, rapid heartbeat, confusion, muscle spasms, GI upset	Rarely toxic. Symptoms may include diarrhea, fatigue, and arrhythmia..
Manganese	Trace Mineral 15-30 mg	Canned pineapple juice, wheat bran, wheat germ, whole grains seeds, nuts, cocoa, shellfish, tea, dairy products, apples, apricots, avocados, bananas, brewer's yeast, cantaloupe, grapefruit, green, leafy vegetables, peaches, figs, salmon, soybeans, tofu	Calcium, iron, vitamin B complex, vitamin E	Rare: atherosclerosis, confusion, tremors, elevated cholesterol levels, impaired vision & hearing, skin rash, irritability, increased blood pressure, pancreatic damage, sweating, increased heart rate, mental impairment, grinding of teeth	Generally considered non-toxic. Exposure to industrially inhaled manganese has been linked to psychiatric and nervous disorders.
Molybdenum	Trace Mineral 75 mcg	Beans, whole grains, cereals, milk, milk products, dark green, leafy vegetables, legumes, peas, meats	None required	Rare: increased heart rate, mouth & gum disorders, impotence in older males, increased respiratory rate, night blindness	Generally considered non-toxic.
Phosphorus	Mineral 1200 mg	Halibut, non-fat yogurt, salmon, skim milk, chicken breast, extra lean ground beef, oatmeal, lima beans, broccoli, asparagus, corn, dairy products, eggs, dried fruits, highly carbonated beverages, legumes, nuts, sesame, pumpkin, sunflower seeds	Calcium, iron, manganese, sodium, vitamin B6 (pyridoxine)	Fatigue, irritability, decreased appetite, bone pain, weakness, skin sensitivity	Rarely toxic. Symptoms may include brittle bones related to loss of calcium (osteoporosis).
Potassium	Trace Mineral 3,500 mg	Dried apricots, baked potatoes	None required	Dry skin, acne, chills, diarrhea, impaired cognitive function, muscle spasms, arrythmia, edema,decreased reflex response, thirst, glucose intolerance, growth retardation, insomnia, elevated cholesterol, decreased blood pressure	Rarely toxic. Symptoms may include arrythmia & heart failure (doses exceeding 18gm/day).
Selenium	Mineral 100-400 mcg (Those living in low-selenium areas, i.e.: coastal & glaciated regions.) 50-200 mcg (Those living in high-selenium areas.)	Lobster, brazilian nuts, shellfish, whole grains, organ meats, brown rice, poultry, broccoli, dairy products, onions, salmon, tuna, torula yeast, vegetables, wheat germ, wheat grains	None required	Muscle weakness, linked to cancer & heart disease, fatigue, growth retardation, elevated cholesterol levels, susceptibility to infection, sterility	Rarely toxic. Symptoms may include garlic breath, brittle hair & nails, irritability, liver & kidney impairment, metallic taste in mouth, dermatitis, and jaundice.
Sodium	Trace Mineral 2,400 mg	Cheese, most meats, especially ham & bacon, canned soups, canned vegetables, canned tuna, cereals, bread, cabbage, milk, sardines	Calcium, potassium, vitamin D, sulfur	Nausea, vomiting, fatigue, abdominal cramps, dehydration, confusion, depression, dizziness, palpitations, headaches, impaired taste, low blood pressure, seizures	Edema, elevated blood pressure, potassium deficiency, diseases of the liver & kidneys

Vitamin	Coenzyme	Reaction catalyzed	Human deficiency disease
Water-Soluble Vitamins			
Niacin (niacinate)	NAD^+, $NADP^+$	Oxidation	Pellagra
	NADH, NADPH	Reduction	
Riboflavin (vitamin B_2)	FAD, FMN	Oxidation	Skin inflammation
	$FADH_2$, $FMNH_2$	Reduction	
Thiamine (vitamin B_1)	Thiamine pyrophosphate (TPP)	Two-carbon transfer	Beriberi
Lipoic acid (lipoate)	Lipoate	Oxidation	—
	Dihydrolipoate	Reduction	
Pantothenic acid (pantothenate)	Coenzyme A (CoASH)	Acyl transfer	—
Biotin (vitamin H)	Biotin	Carboxylation	—
Pyridoxine (vitamin B_6)	Pyridoxal phosphate (PLP)	Decarboxylation	Anemia
		Transamination	
		Racemization	
		C_α—C_β bond cleavage	
		α,β-Elimination	
		β-Substitution	
Vitamin B_{12}	Coenzyme B_{12}	Isomerization	Pernicious anemia
Folic acid (folate)	Tetrahydrofolate (THF)	One-carbon transfer	Megaloblastic anemia
Ascorbic acid (vitamin C)	—	—	Scurvy
Water-Insoluble (lipid-soluble) Vitamins			
Vitamin A	—	—	—
Vitamin D	—	—	Rickets
Vitamin E	—	—	—
Vitamin K	Vitamin KH_2	Carboxylation	—



Frederick Hopkins
UK - 1861-1947
Chimico

1906 - "No animal can live on a mixture of pure protein, fat, carbohydrate, salts, and water".

This started the search for "growth factors" in food.

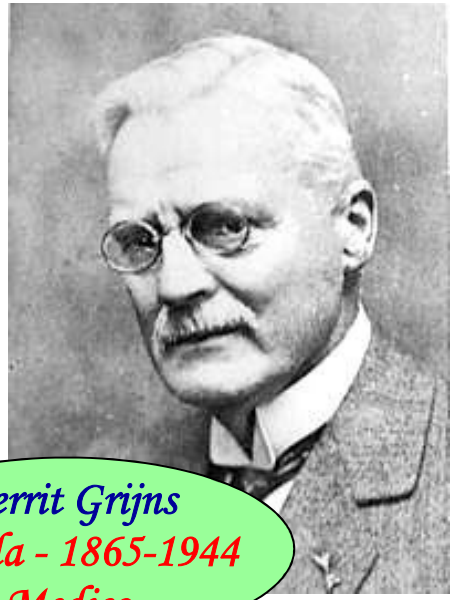
Christiaan Eijkman
Olanda – 1858-1930
Medico

It was the Dutch physician **Christiaan Eijkman** who found in ***1896*** that a constituent of rice bran can prevent a **beriberi-**like disease in chickens.

The credit for being the first scientist to adopt the **deficiency theory** for the etiology of this disease belongs to **Gerrit Grijns**. In ***1901*** he stated that the disease breaks out when a substance necessary for the metabolism is lacking in the food.

1912 – Funk isola una sostanza bioattiva dalla crusca del riso, chiamandola **vita-ammina** (più tardi rinominata **aneurina** ed infine **tiamina**)

Casimir Funk
Polonia – 1884-1967
Biochimico



Gerrit Grijns
Olanda - 1865-1944
Medico

Funk realized that this substance could cure chickens and humans of beriberi. He published a landmark paper "The etiology of the deficiency diseases" and stated that all such diseases can be prevented and cured by the addition of certain preventive substances, for which he proposed the name "vitamins".

Quasi contemporaneamente……

….two American chemists, Elmer Verner McCollum and Marguerite Davis (1887-1967), were working with rats in ***1913***. ***They found that on certain diets in which mixtures of sugar, proteins, and minerals were used the rats stopped growing. IF, however, a little bit of butter or egg-yolk was added to the diet, they grew and were healthy.***

Something was present in butter or egg-yolk that seemed to be necessary for normal growth. Whatever it was, however, did not soak out of the butter or egg-yolk into water. The substance was not water-soluble.

When butter or egg-yolk was soaked in ether, the substance needed for growth passed into the ether. McCollum and Davis could ascertain that rats grew and were healthy when this substance was added to the rats' diet.

Elmer McCollum
USA – 1879-1967
Chimico

At first, McCollum and Davis did not notice any special illness in rats that lacked the fat-soluble substance in their diet. The rats just stopped growing.

Later that same year, however, two other American chemists, Thomas Burr Osborne and Lafayette Benedict Mendel, continued to experiment and ***found that rats, which lacked this fat-soluble substance in their diet, had trouble with their eyes***. Their eyes grew dry and inflamed.

A similar disease was known to occur sometimes in human beings. Not only did the eyes become inflamed, but people who were ill in this way had trouble seeing in dim light, especially at night, so the disease was called "***nightblindness***".

It seemed then that there were two different vitamins:
a fat-soluble vitamin, which cured night- blindness,
a water-soluble vitamin, which cured beriberi.

Two different vitamins deserved two different names. There was no chance of knowing the chemical composition, in 1913. ***McCollum and Davis thus decided to avoid giving the vitamins real names. They would just use letters of the alphabet***.

They called the fat-soluble vitamin which they had discovered "Vitamin A".

They called the water-soluble antiberiberi substance, "Vitamin B".

It was in this way that letters began to be used for the names of vitamins. Later, vitamins C, D, E and K were added, and it was realized that vitamin B can contain more than one factor, so a further differentiation into vitamins B1, B2, and so on was made.

The discovery of vitamins as essential factors in the diet was a scientific breakthrough that changed the world. Diseases such as scurvy, rickets, beriberi, and pellagra were recognized to be curable with an adequate diet. These diseases had been prevalent for thousands of years and had a dramatic impact on societies as well as on economic development.

These scientific breakthroughs were honored with ***12 Nobel Prizes to 20 laureates***.

The first Nobel Prize in chemistry relating to vitamins was given to ***Adolf Windaus*** (1928) for his studies on the constitution of sterols and their connection with the vitamins.

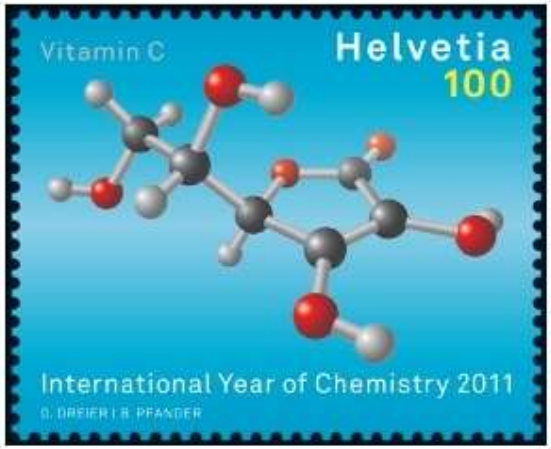
This was followed by the Nobel Prize in Medicine and Physiology in 1929 jointly to ***Christiaan Eijkman***, for the discovery of the anti-neuritic vitamin, and to ***Sir Frederick Gowland Hopkins***, for the discovery of the growth stimulating vitamins.

Vitamins are essential organic compounds which are either not synthesized in the human or animal organism, or are formed in insufficient amounts, and therefore must be taken up with the diet as such or as a precursor.

Vitamin	Discovery	Isolation	Structural elucidation	First Synthesis
vitamin A	1916	1931	1931	1947
vitamin D	1918	1932	1936	1959
vitamin E	1922	1936	1938	1938
vitamin K	1929	1939	1939	1939
vitamin B_1	1912	1926	1936	1936
vitamin B_2	1920	1933	1935	1935
niacin vitamin B_3	1936	1936	1937	1994
pantothenic acid vitamin B_5	1931	1938	1940	1940
vitamin B_6	1934	1938	1938	1939
biotin vitamin B_7 vitamin H	1931	1935	1942	1943
folic acid vitamin B_9	1941	1941	1946	1946
vitamin B_{12}	1926	1948	1956	1972
vitamin C	1912	1928	1933	1933

The first commercialized vitamin was ascorbic acid/vitamin C from Merck (Cebion), which was isolated from plant leaves, and became available in 1933.

The first industrial-scale chemical production was also of vitamin C and was achieved by F. Hoffmann–La Roche (Roche) in 1934, and was based on a combined fermentation and chemical process developed by Tadeus Reichstein.



Vitamina A

Apparato intestinale	Colite
	Diarrea
	Emorroidi
	Morbo Celiaco
	Stitichezza
	Vermi
Articolazioni	Artrite
	Gotta
Bocca	Alitosi
	Gusto
	Ulcere aftose della bocca
Cervello/sistema nervoso	Epilessia
	Etilismo
	Meningite
Cistifellea	Calcoli alla cistifellea
Capelli/cuoio capelluto	Problemi dei capelli
Cuore	Angina pectoris
	Arteriosclerosi
	Aterosclerosi
	Infarto del miocardio
	Insufficienza cardiaca congestizia
Denti e gengive	Disordini dei denti e delle gengive
	Piorrea
Fegato	Cirrosi epatica
	Epatite
	Itterizia
Gambe	Vene varicose
Ghiandole	Diabete
	Fibrosi cistica
	Gonfiore ghiandolare
	Gozzo
	Ipertiroidismo
	Prostatite
Muscoli	Distrofia muscolare

http://www.laleva.cc/almanacco/vitamina_A.html

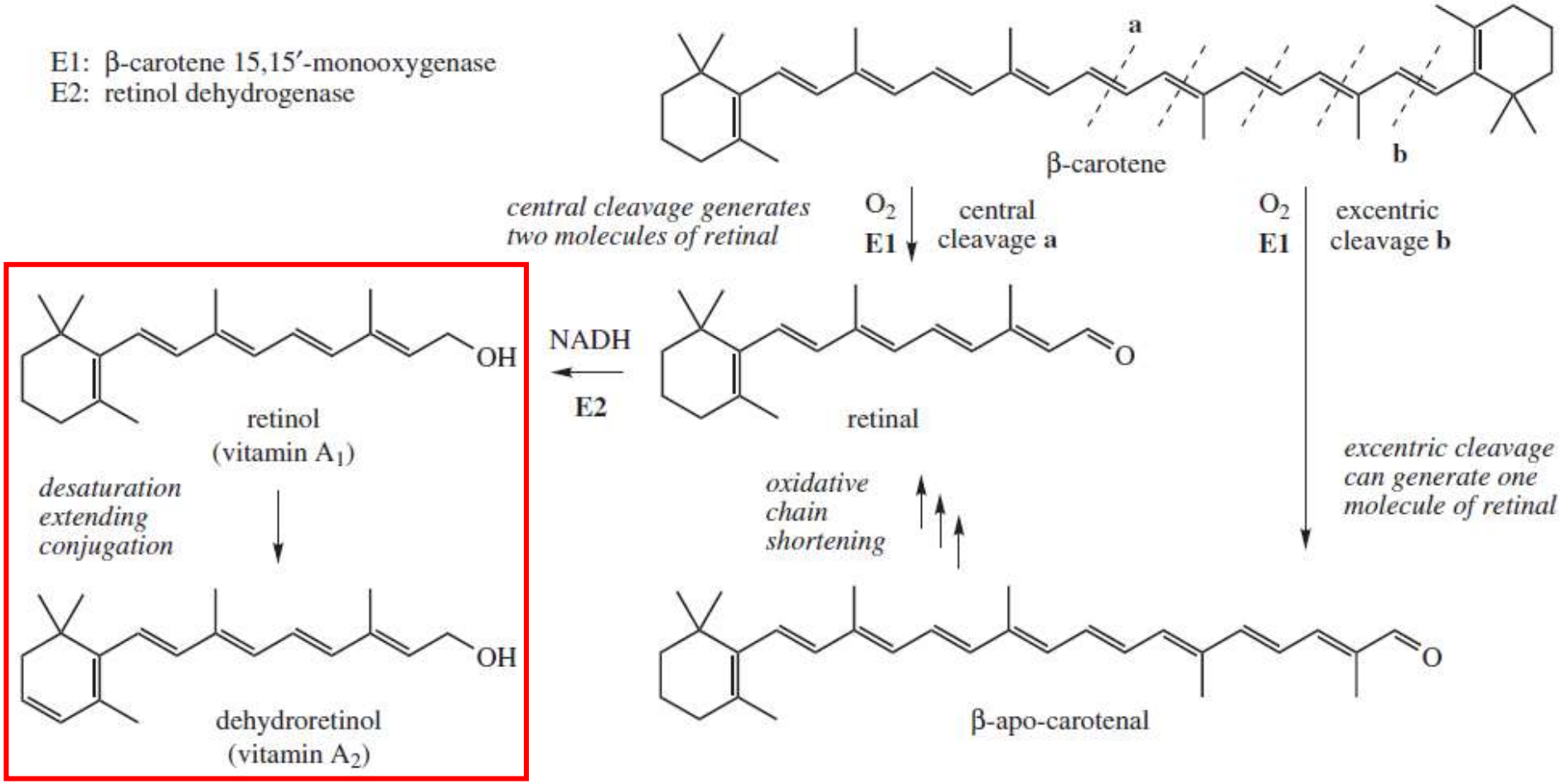
Occhio	Ambliopia
	Astenopia
	Cataratta
	Cecità notturna
	Congiuntivite
	Glaucoma
	Macchie di Bitot
	Miopia
	Strabismo
	Vista offuscata
	Xeroftalmia
Orecchio	Otite
	Otite media
	Tinnito
Ossa	Fratture
	Osteomalacia
	Rachitismo
Pelle	Acne
	Dermatite
	Eczema
	Forfora
	Foruncoli
	Herpes zoster
	Impetigine
	Pelle secca
	Piaghe da decubito
	Piede d'atleta
	Psoriasi
	Rughe
	Scottature
	Ulcere
	Verruche (plantari)

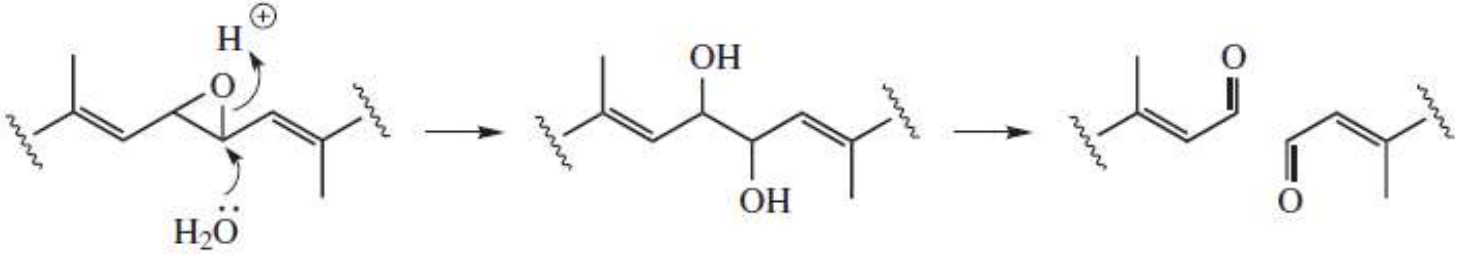
Vitamina A

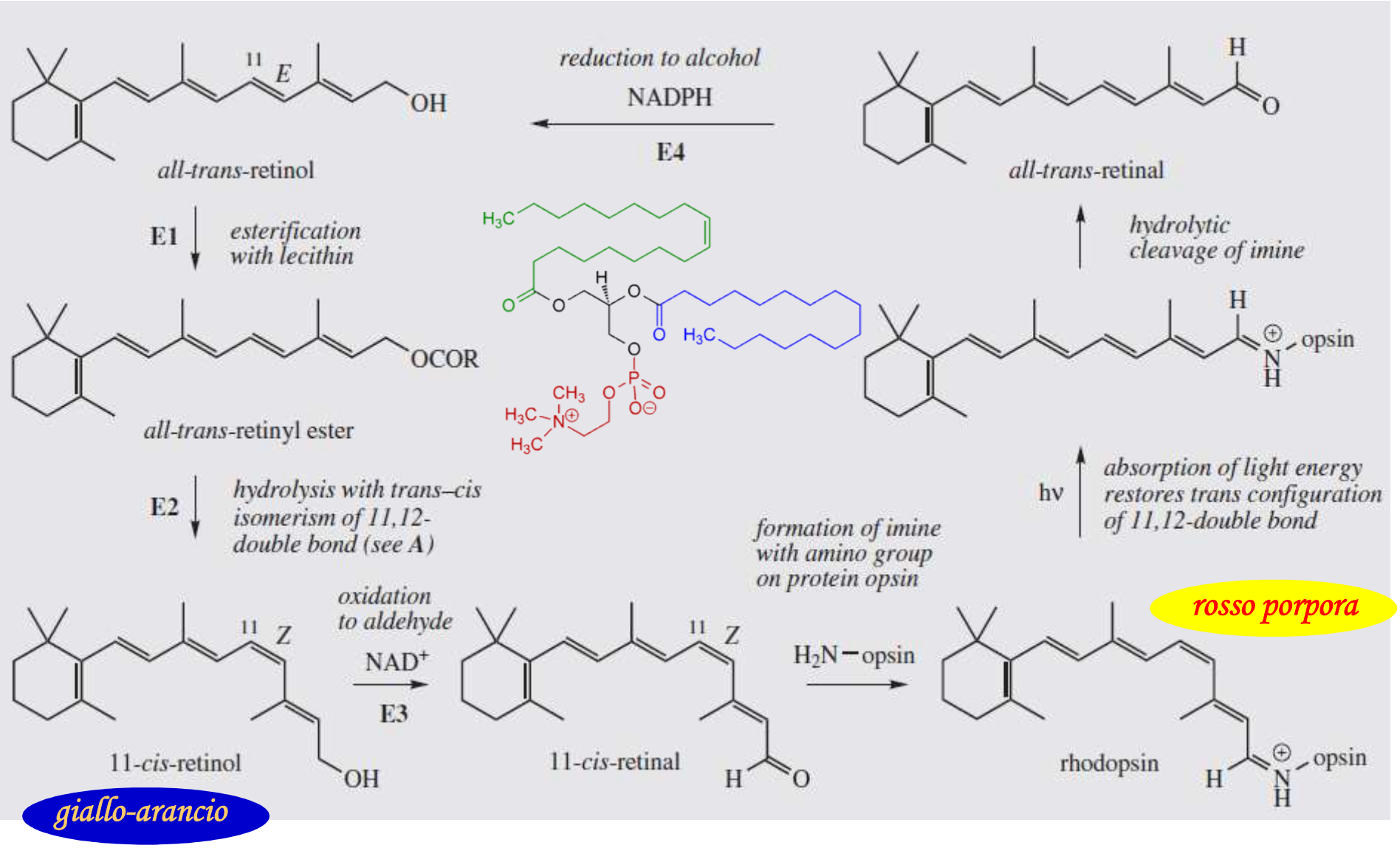
Polmoni/apparato respiratorio	Allergie
	Asma
	Bronchite
	Enfisema polmonare
	Infiammazione della laringe
	Influenza
	Olfatto
	Raffreddore comune
	Rinite allergica
	Sinusite
	Tubercolosi
Reni	Calcoli renali
	Nefrite
Sangue e apparato circolatorio	Angina pectoris
	Arteriosclerosi
	Aterosclerosi
	Diabete
	Emofilia
	Ictus cerebrale
	Itterizia
	Mononucleosi
Sistema riproduttivo	Impotenza
	Prostatite
	Sterilità
	Vaginite
Stomaco	Gastrite
	Gastroenterite
	Ulcera peptica
Testa	Cefalea
	Emicrania
	Febbre
	Sinusite
Unghie	Problemi delle unghie
Vescica	Cistite
Generale	Affaticamento
	Candida albicans
	Etilismo
	Febbre
	Febbre reumatica
	Gravidanza
	Infezioni
	Kwashiorkor
	Morbillo
	Raffreddore comune
	Rinite
	Scarlattina
	Scorbuto
	Stress
	Varicella

Vitamina A

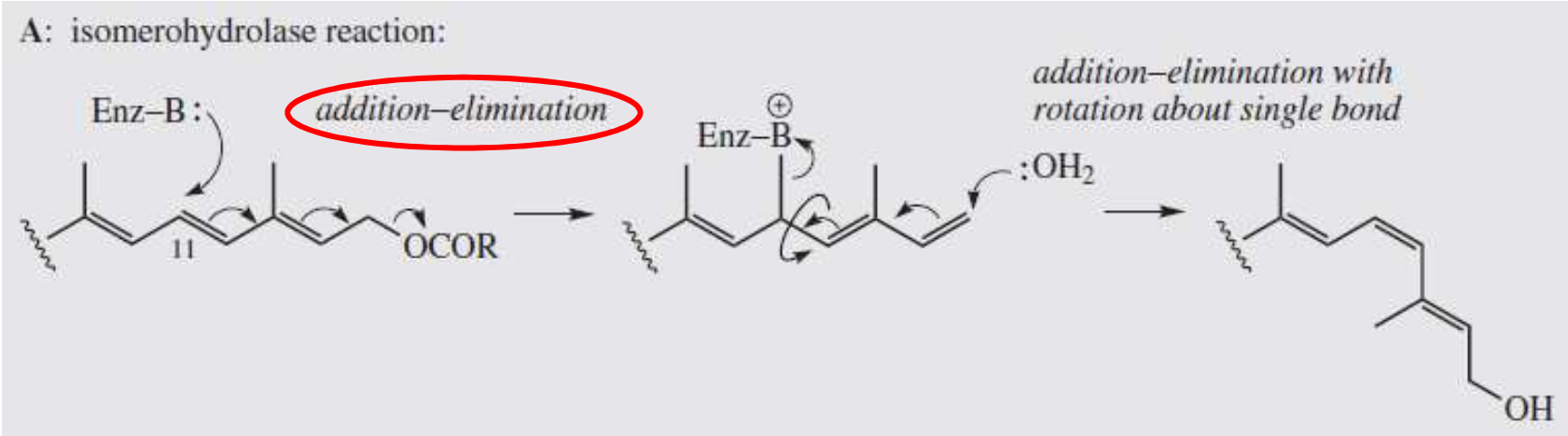
E1: β-carotene 15,15′-monooxygenase
E2: retinol dehydrogenase

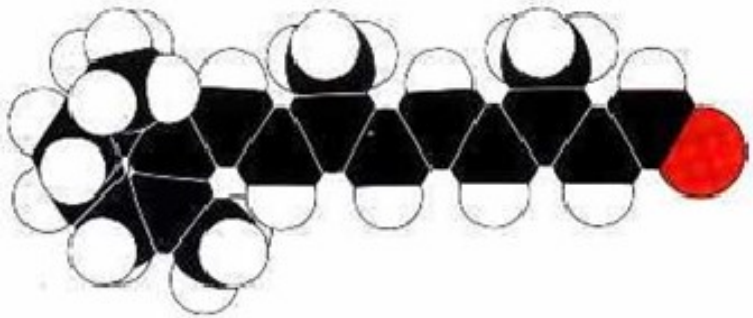


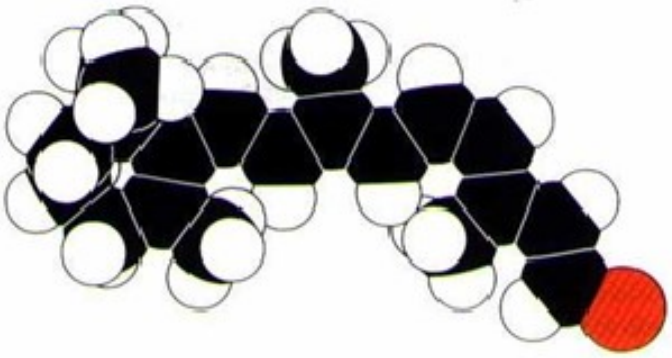


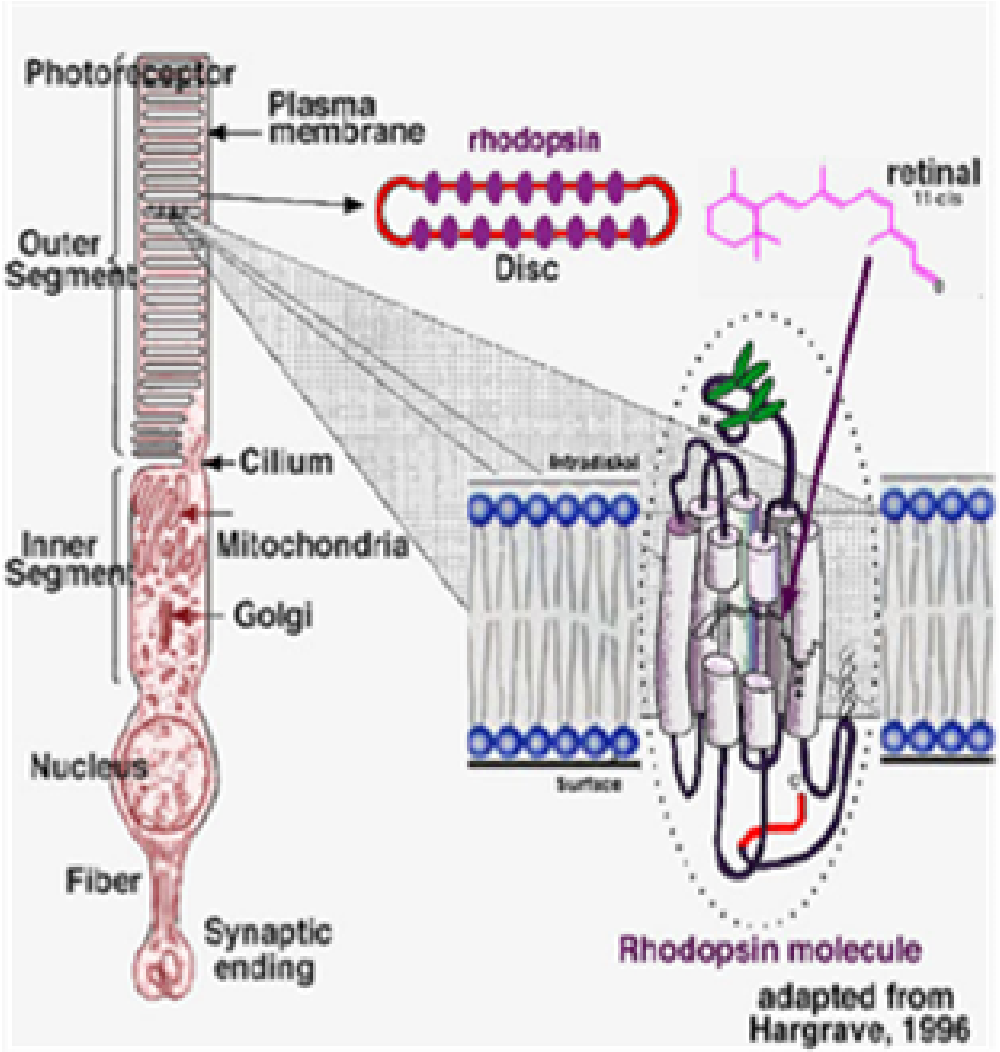


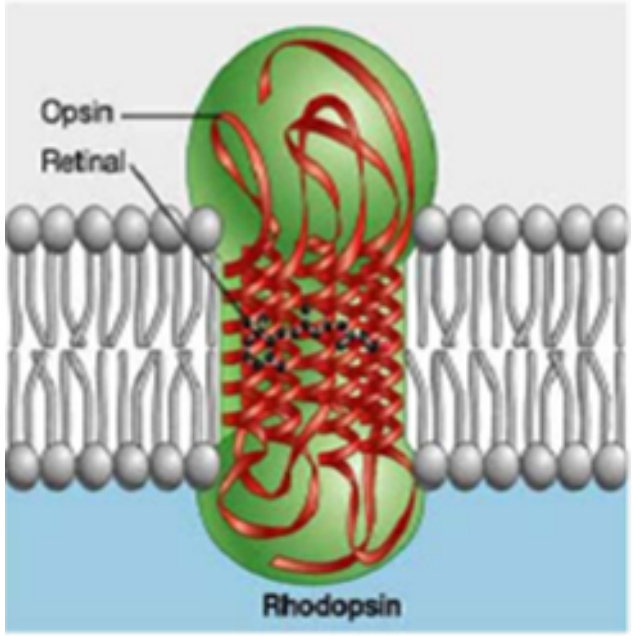
E1: lecithin retinol acyl transferase
E2: isomerohydrolase
E3: 11-*cis*-retinol dehydrogenase
E4: *all-trans*-retinol dehydrogenase


A: isomerohydrolase reaction:
Enz–B :
addition–elimination
11
OCOR
Enz–B
:OH2
addition–elimination with
rotation about single bond
OH

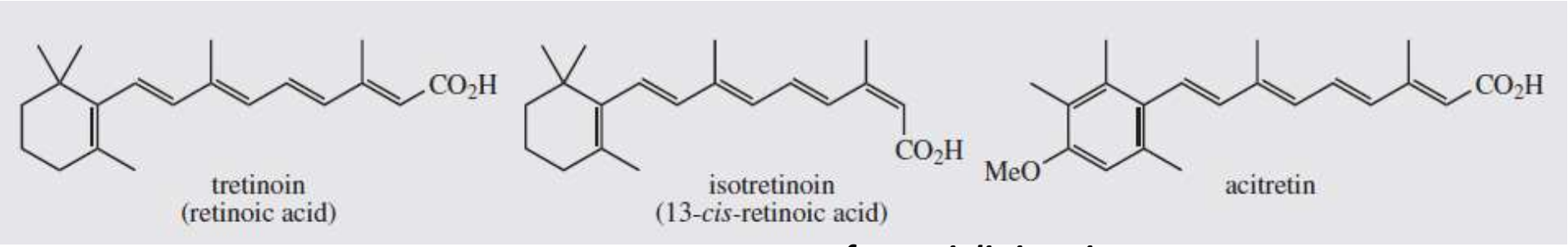





Photoreceptor
Plasma membrane
rhodopsin
retinal
Outer Segment
Disc
Cilium
Inner Segment
Mitochondria
Golgi
Nucleus
Fiber
Synaptic ending
Rhodopsin molecule
adapted from Hargrave, 1996


Opsin
Retinal
Rhodopsin

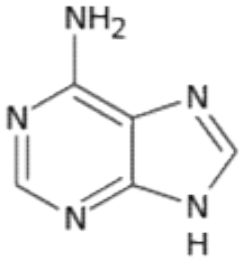
L'acido retinoico tutto-trans è il metabolita della vitamina A più attivo biologicamente; gioca un ruolo importante nella regolazione dell'espressione genica, nella differenziazione cellulare e nella proliferazione delle cellule epiteliali.

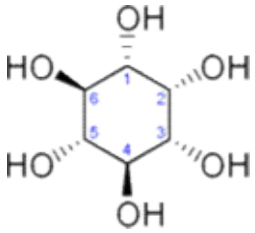


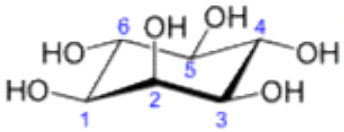
farmaci di sintesi

Acidi retinoici di sintesi sono utilizzati per il trattamento topico (o per via orale) contro acne, eczema e psorìasi (anche se non sono esenti da controindicazioni ed effetti negativi collaterali).

- B_1: Tiamina
- B_2: Riboflavina (è anche indicata come vitamina G)
- B_3: Niacina (è anche indicata come vitamina PP)
- B_4: Adenina (un tempo considerata una vitamina, oggi non viene più considerata tale)
- B_5: Acido pantotenico (è anche indicata come vitamina W)
- B_6: Piridossina
- B_7: Biotina (è anche indicata come vitamina H, vitamina I, o Coenzima R)
- B_8: Myo-inositolo (non e' piu' considerata una vitamina perche' viene sintetizzata dal metabolismo umano)
- B_9: Acido folico o folacina (è anche indicato come vitamina M)
- B_{10}: Acido paramminobenzoico o *PABA* (non piu' considerato essenziale; è anche indicata come vitamina R)
- B_{11}: Inositolo (non piu' considerato essenziale; è anche indicata come vitamina S)
- B_{12}: Cobalamina
- B_{17}: Amigdalina (laetrile)





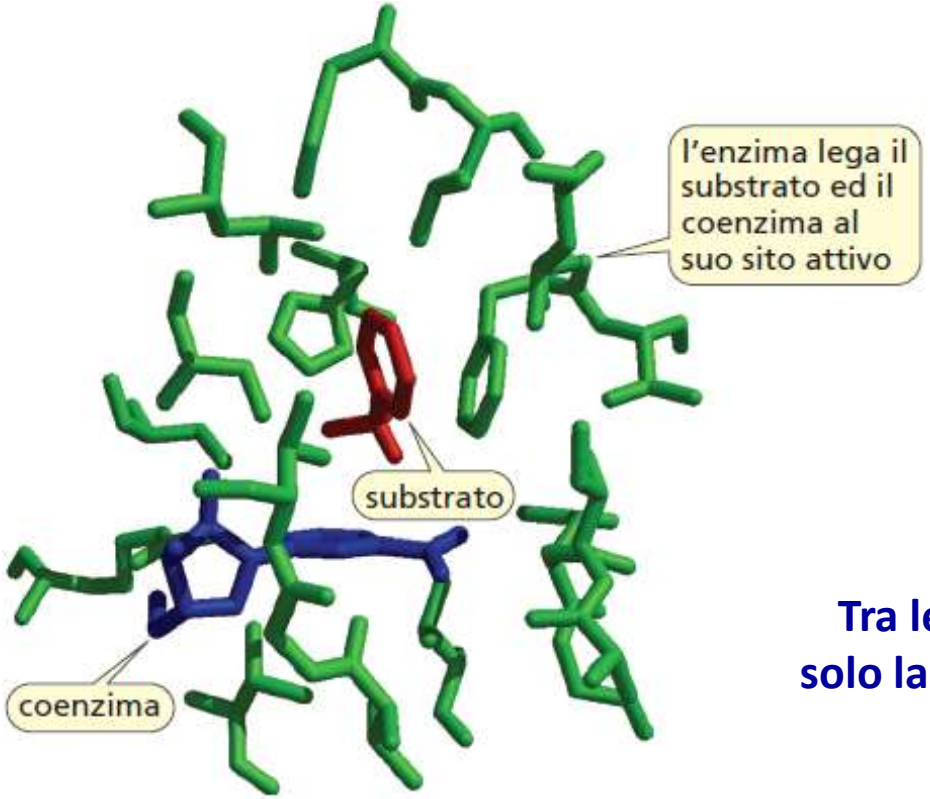


***cis*-1,2,3,5-*trans*-4,6-cicloesanesolo**

Complesso B

Complesso B

Tutte le vitamine idrosolubili, eccetto la vitamina C, sono precursori di coenzimi.

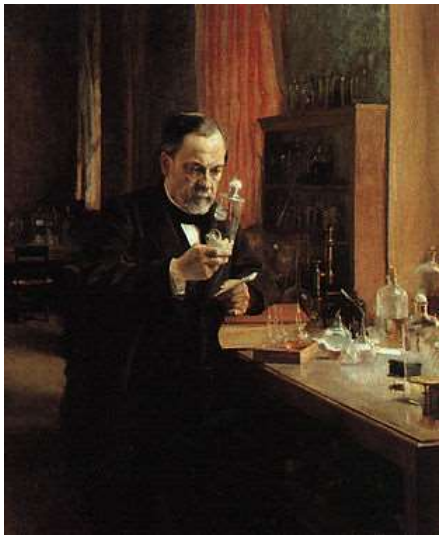


Tra le vitamine liposolubili, solo la vitamina K è precursore di un coenzima!

Poiché sarebbe estremamente inefficiente per l'organismo utilizzare un composto solo una volta e quindi scartarlo, i coenzimi vengono riciclati. Perciò, ogni volta che un coenzima subisce una modificazione strutturale durante una reazione, verrà successivamente riconvertito nella sua forma originale.

Vitamina B_1

Louis Pasteur, 1822-1895



Louis Pasteur nel suo laboratorio, dipinto di Albert Edelfelt (1885)

Colera dei polli (1880)

Annals of Nutrition and Metabolism Vol. 61(3), 2012

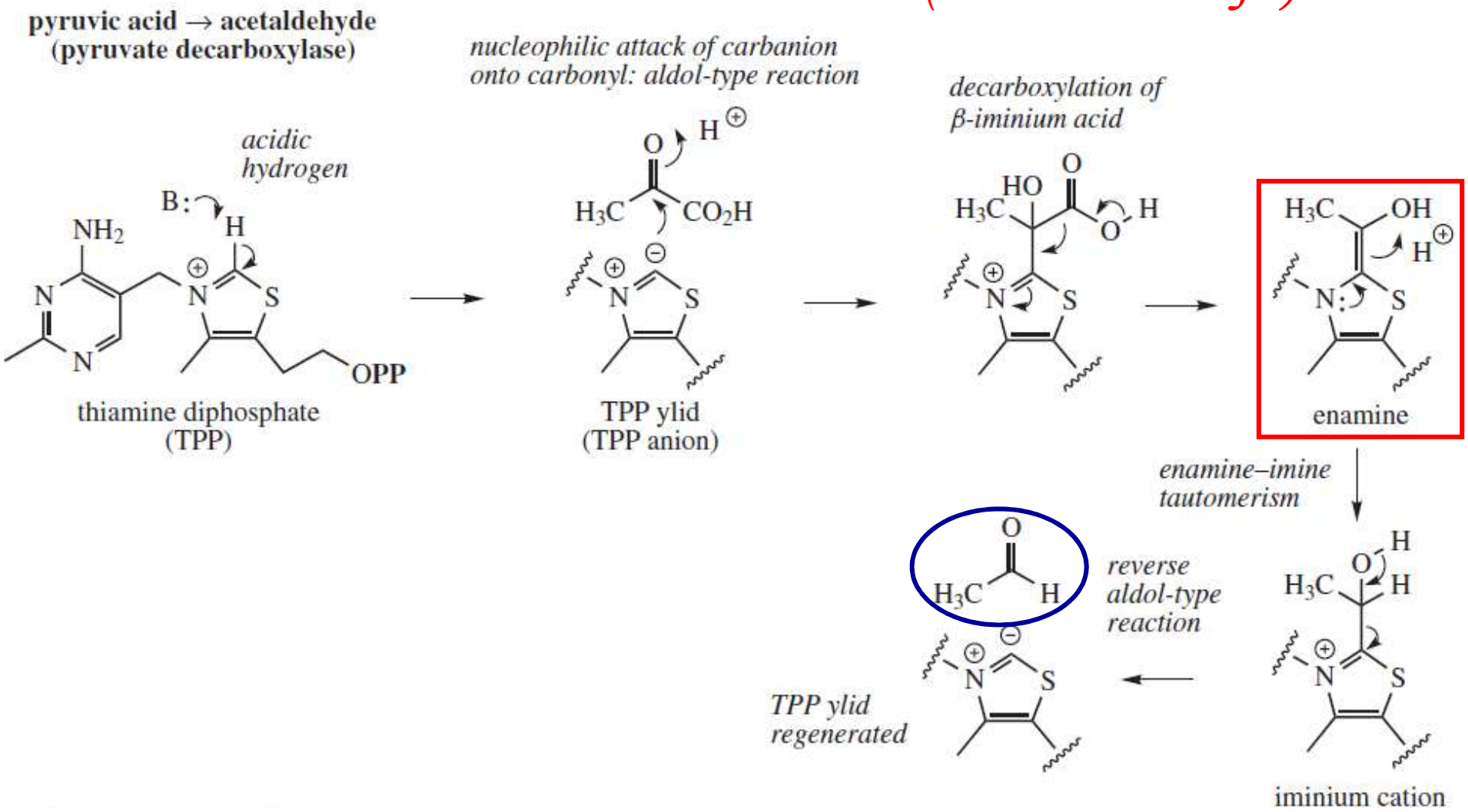
The Discovery of Vitamins: 100th Anniversary Special Issue

Thiamin deficiency was long known as 'beriberi' in English and 'kakké' in Japan and China. ***The cause of beriberi was attributed to miasmas rising from wet soil and later to an unknown infectious organism***. Systematic studies of beriberi began in the Dutch East Indies in the 1880s. Cornelis Pekelharing and Cornelis Winkler investigated beriberi in the Dutch East Indies ***and thought that they had isolated a micrococcus that was responsible for the disease***. Christiaan Eijkman observed that chickens fed white rice developed a leg paralysis or 'polyneuritis', whereas chickens fed brown (unpolished) rice did not. ***Gerrit Grijns succeeded Eijkman in the beriberi studies in Java and concluded correctly that there were unknown substances in foods that were needed for the peripheral nervous system***. In 1926, Barend Jansen and Willem Donath isolated and crystallized a substance that cured polyneuritis in pigeons. Robert Williams synthesized thiamin in 1936.

Trasferimento di acile

Vitamina B_1

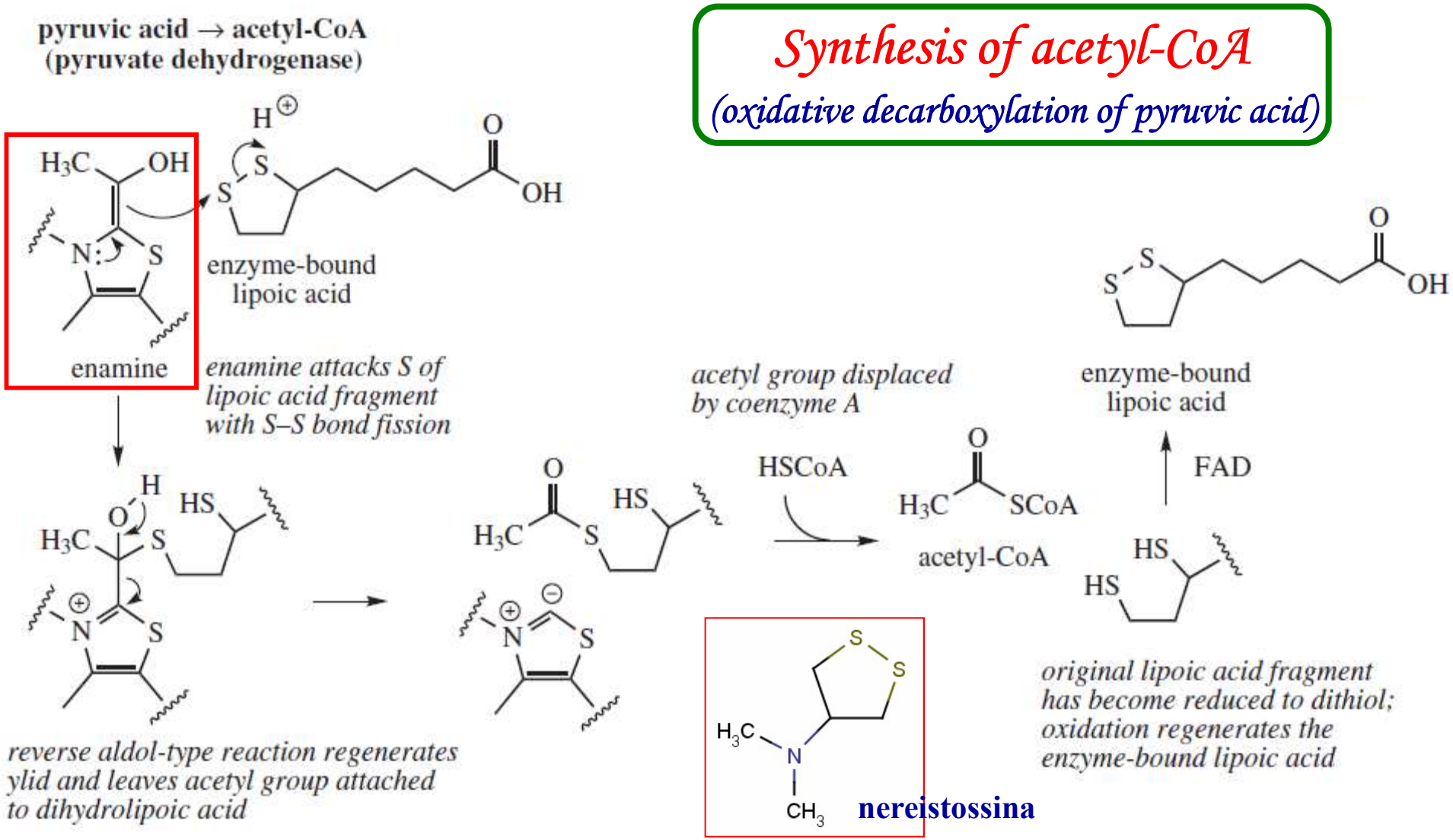
Decarboxylation of α-keto acids
(two-carbon transfer)



Vitamina B_1

Decarboxylation of α-keto acids
(two-carbon transfer)

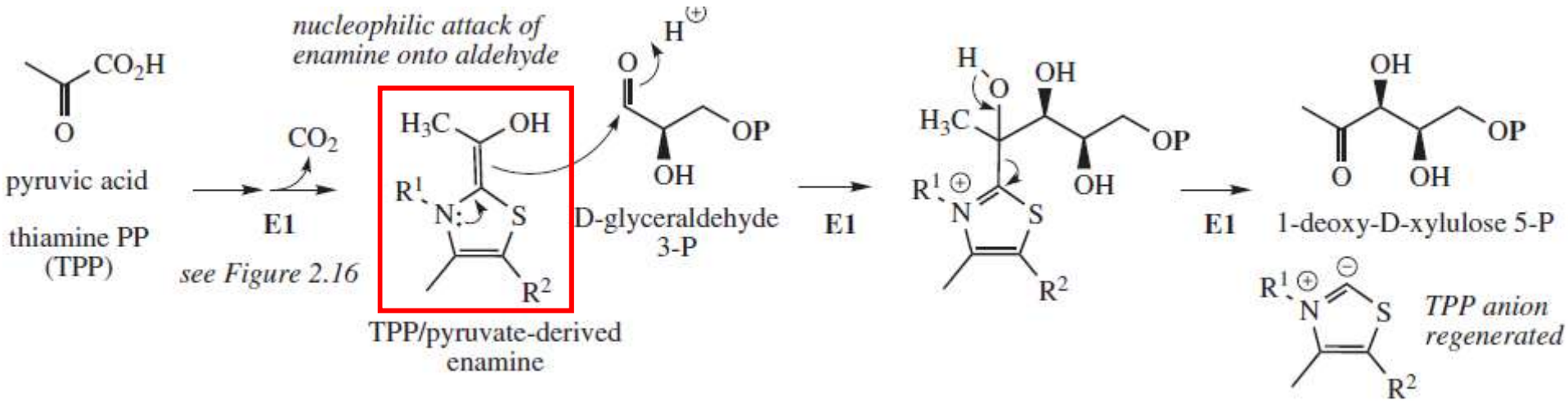
Synthesis of acetyl-CoA
(oxidative decarboxylation of pyruvic acid)



Vitamina B_1

Decarboxylation of α-keto acids
(two-carbon transfer)

Allungamento della catena di un carboidrato



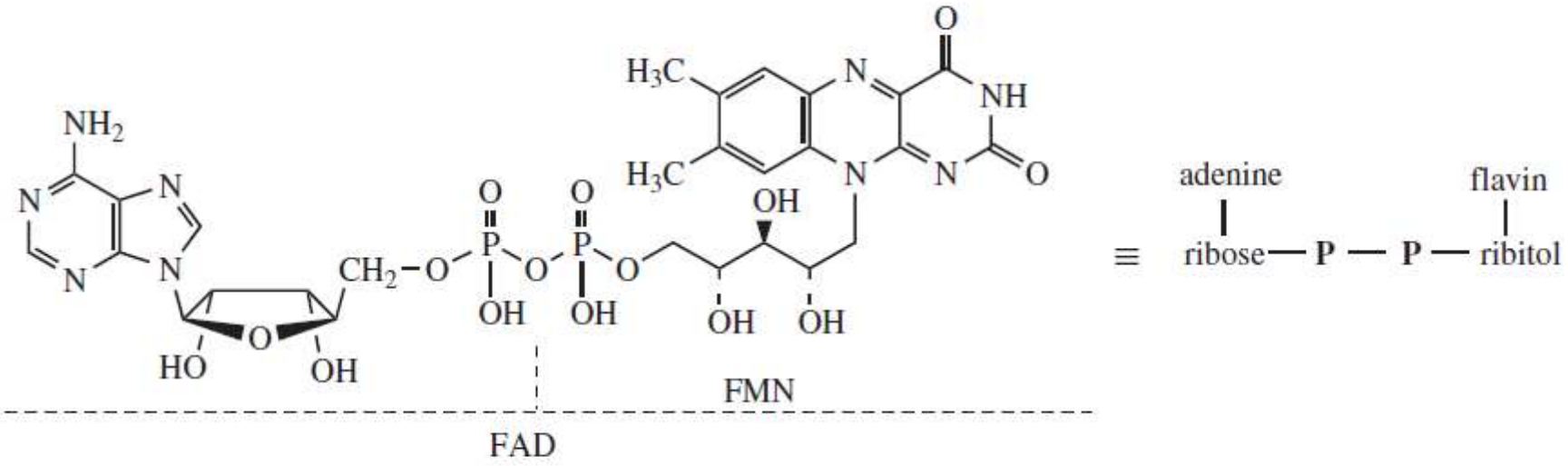
MEP

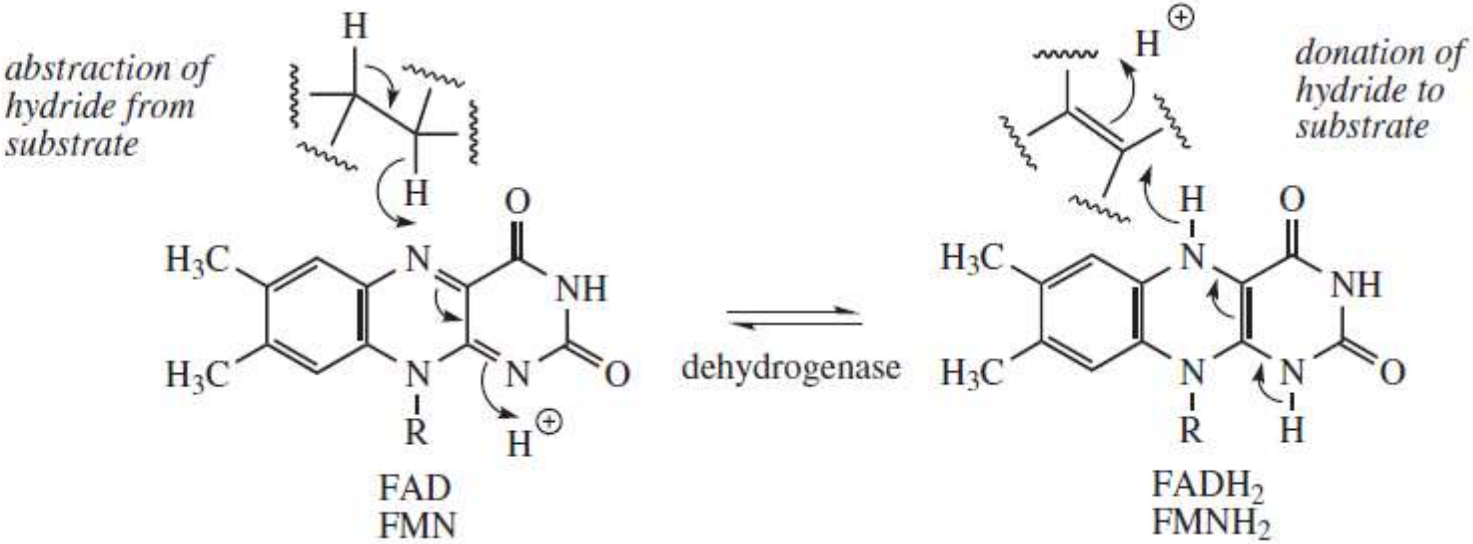
piante, alghe, batteri

Vitamina B_2

Redox couples of metabolism

Dehydrogenases: FAD and FMN





Vitamina B2

Axel Hugo Theodor Theorell

The Nobel Prize in Physiology or Medicine 1955 was awarded to Hugo Theorell
"for his discoveries concerning the nature and mode of action of oxidation enzymes"

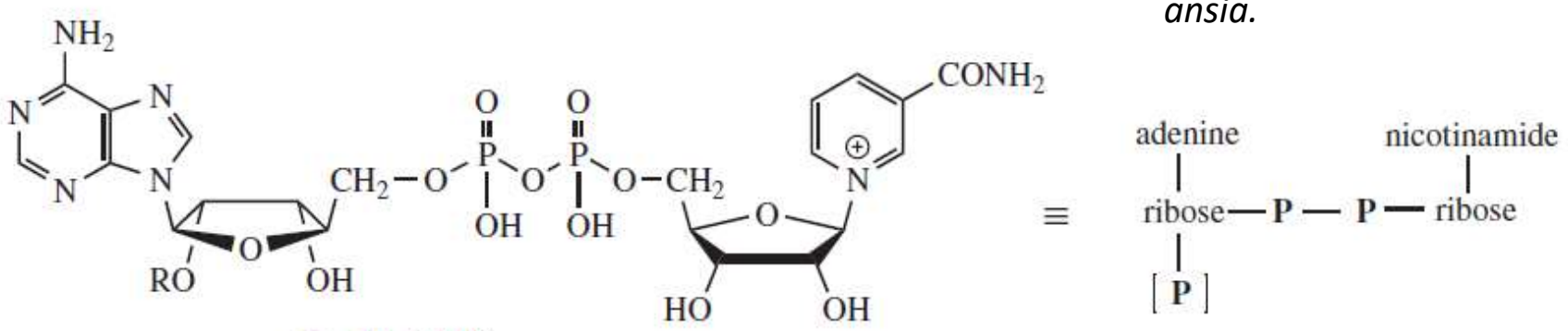
Vitamina B_3

La carenza di niacina provoca la pellagra, una malattia che si manifesta inizialmente con dermatite e che poi, se non curata, progredisce fino a causare pazzia ed infine la morte.

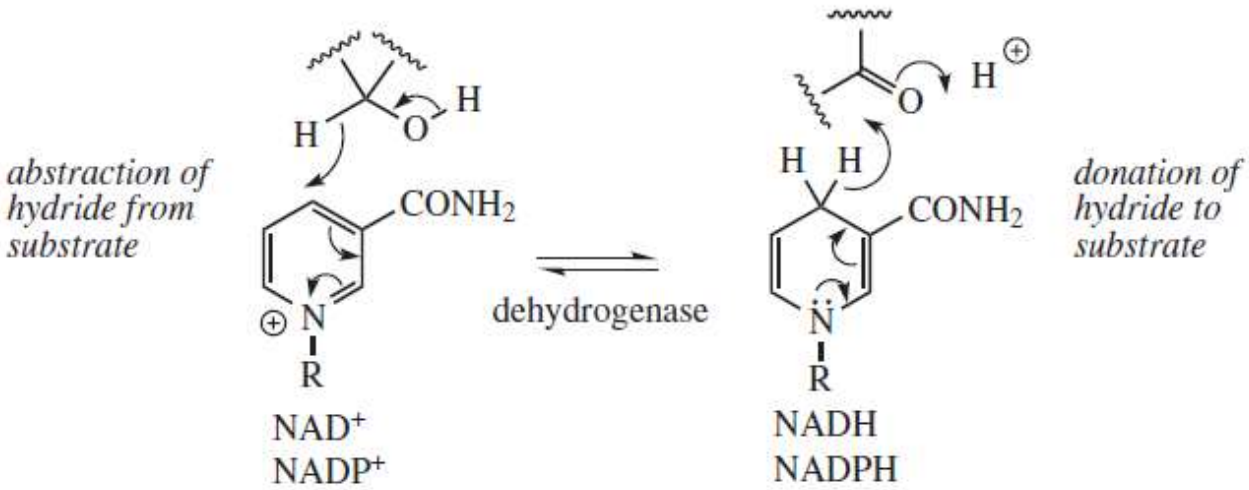
*E' detta «malattia delle "**quattro D**" (demenza, dermatite, diarrea e decesso). I sintomi della pellagra sono disepitelizzazione (desquamazione - perdita della pelle) delle mani e del collo, diarrea, perdita di appetito e di peso, stress, lingua arrossata e gonfia, depressione e ansia.*

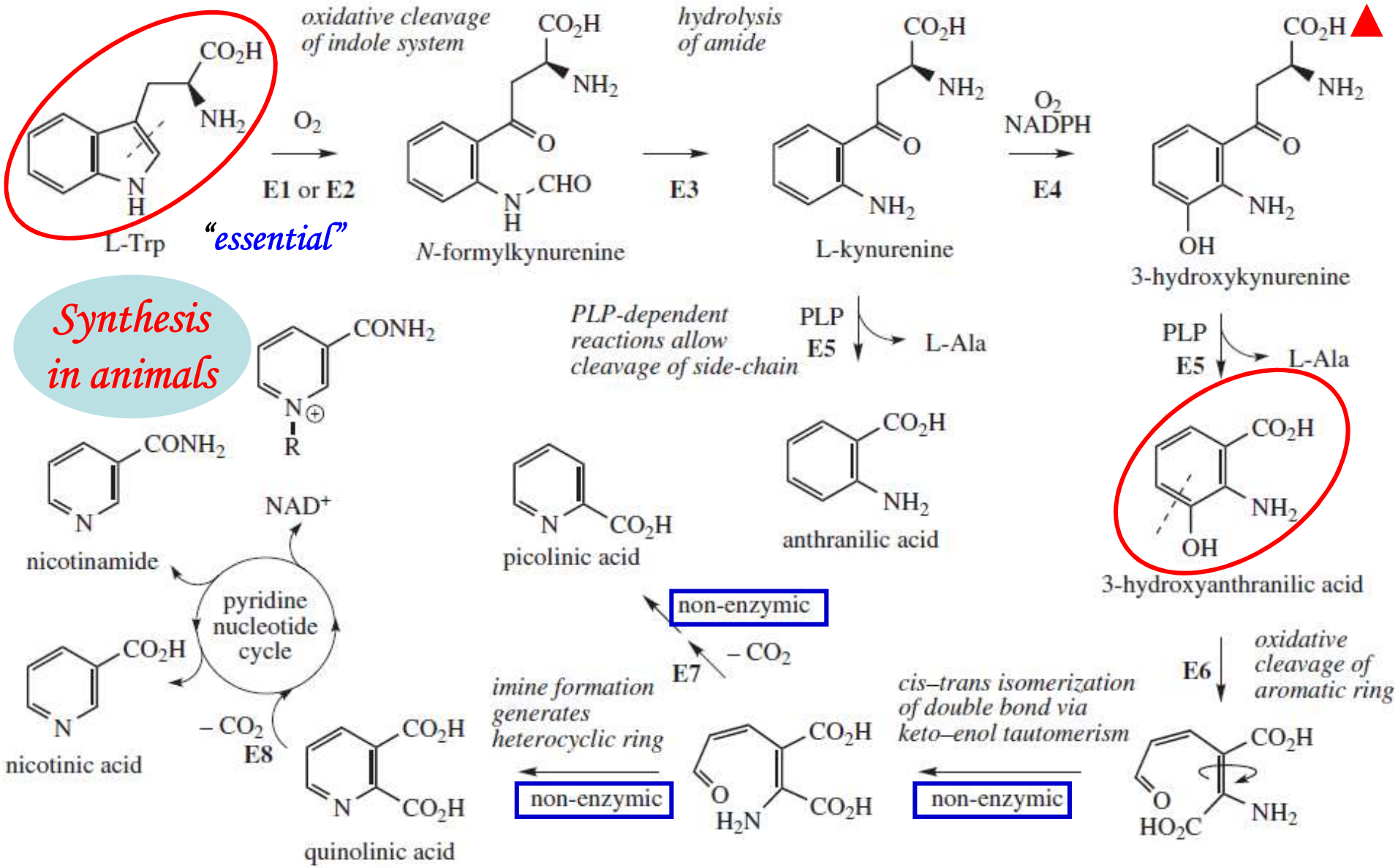
Redox couples of metabolism

Dehydrogenases: NAD⁺ and NADP⁺



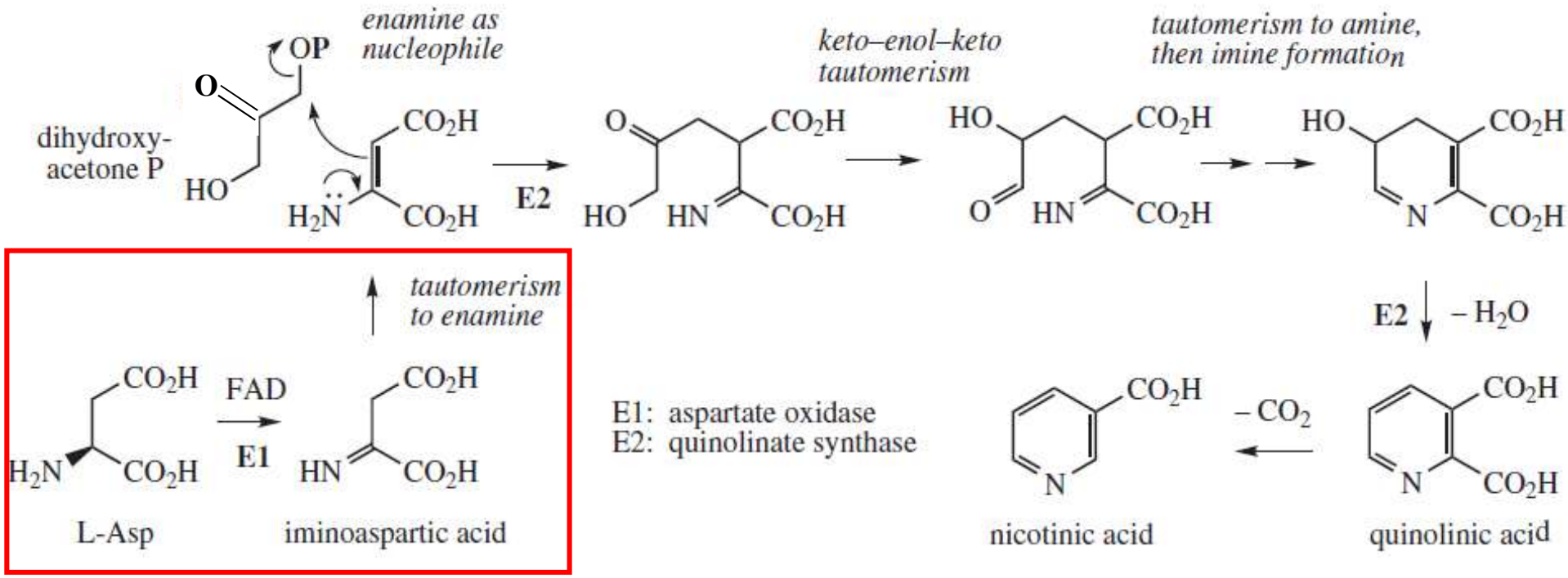
R = H, NAD⁺
R = P, NADP⁺



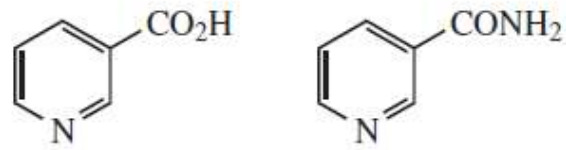


E1: L-tryptophan 2,3-dioxygenase (L-Trp-specific)
E2: indoleamine 2,3-dioxygenase (broad specificity)
E3: kynurenine formamidase
E4: kynurenine 3-monooxygenase
E5: kynureninase
E6: 3-hydroxyanthranilate 3,4-dioxygenase
E7: aminocarboxymuconate-semialdehyde decarboxylase
E8: quinolinic acid phosphoribosyltransferase

Synthesis in plants

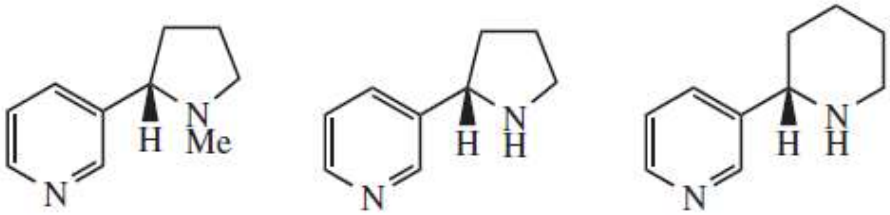


Nicotina

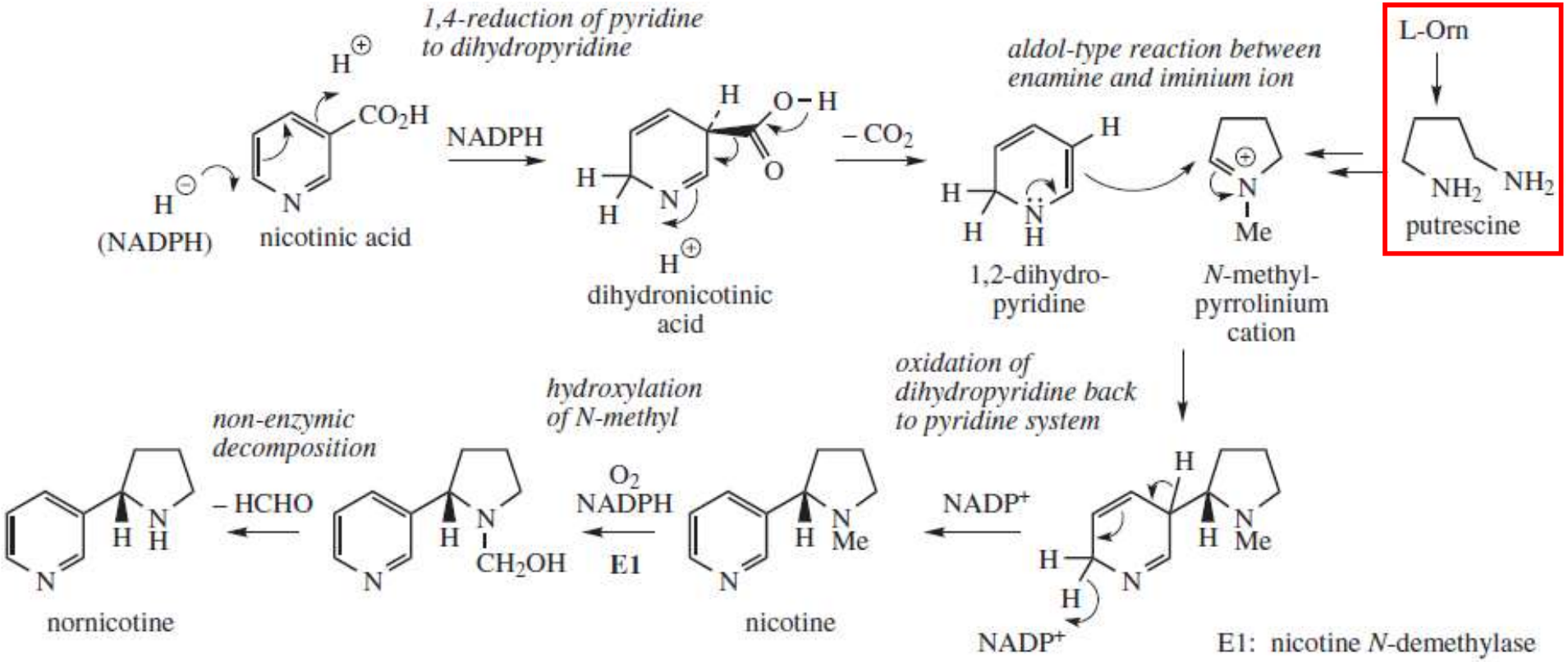


nicotinic acid (niacin/vitamin B_3) nicotinamide

Pyridine alkaloids



nicotine nornicotine anabasine

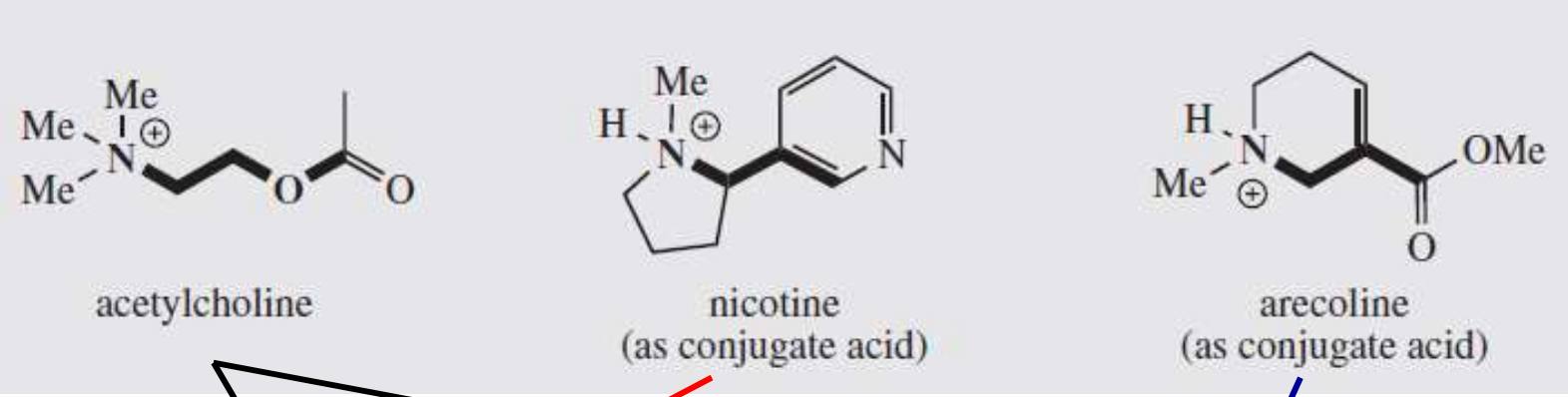


Nicotiana tabacum

Kingdom:	*Plantae*
Division:	*Magnoliophyta*
Class:	*Magnoliopsida*
Order:	*Solanales*
Family:	*Solanaceae*
Genus:	*Nicotiana*
Species:	*N. tabacum*

Effetti della nicotina

L'arecolina è un alcaloide naturale ottenuto dalle noci di Betel

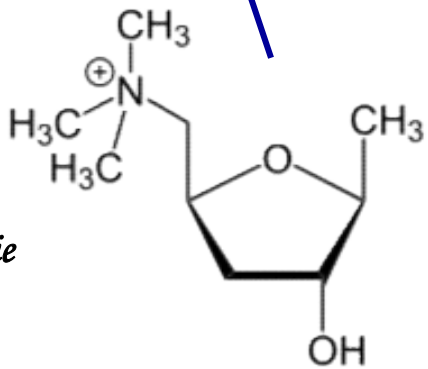


Recettori nicotinici

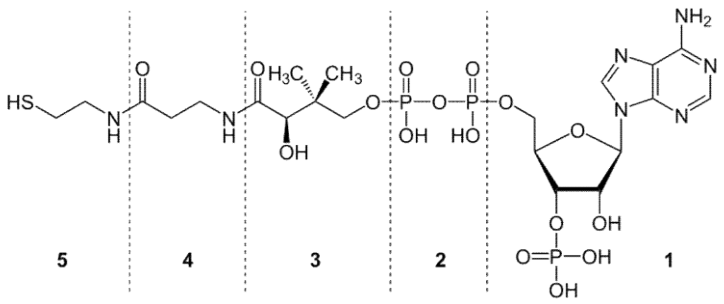
Recettori muscarinici

Effetti sull'SNC

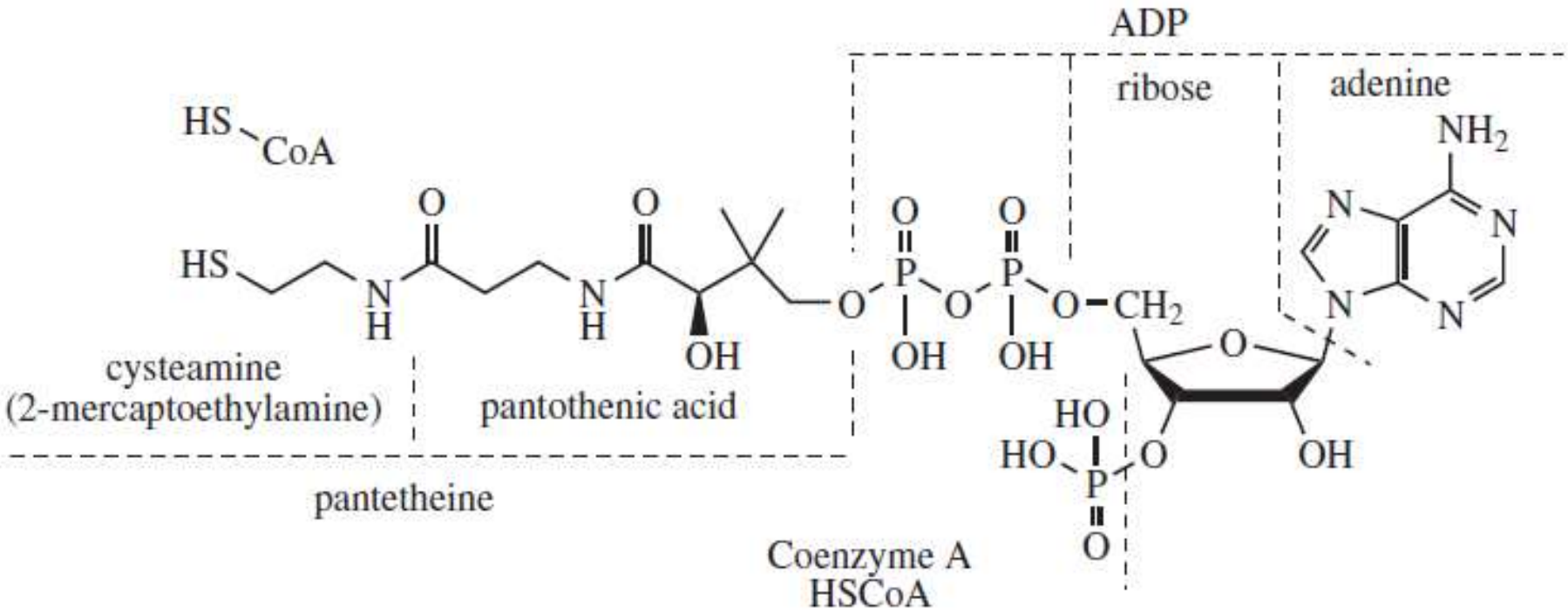
La muscarina è un alcaloide contenuto nell'Amanita muscaria e in alcune altre specie di funghi velenosi (in particolare specie appartenenti ai generi Inocybe e Clitocybe).



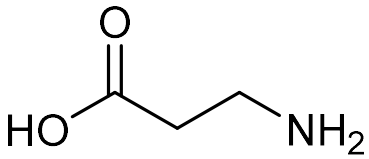
Vitamina B_5

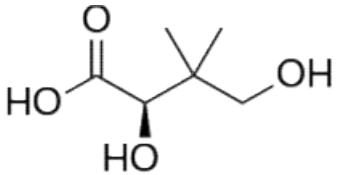


1: 3'-phosphoadenosine. 2: diphosphate, organophosphate anhydride.
3: pantoic acid. 4: β-alanine. 5: cysteamine.



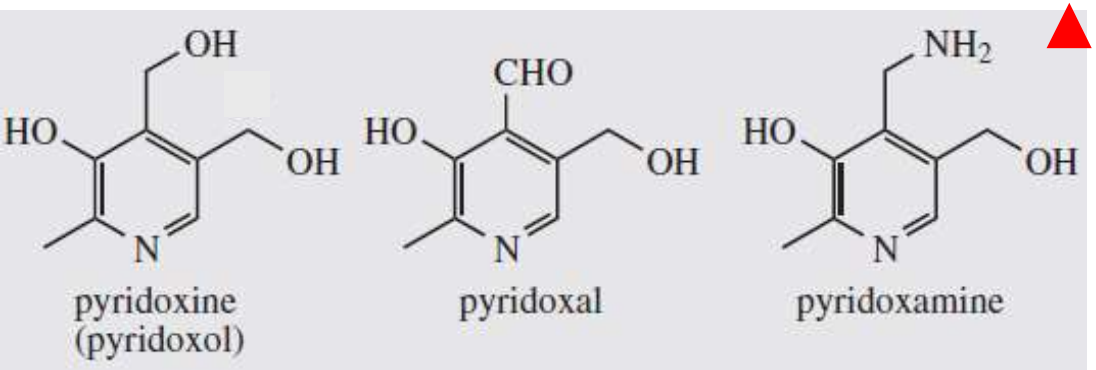
β-*alanina*





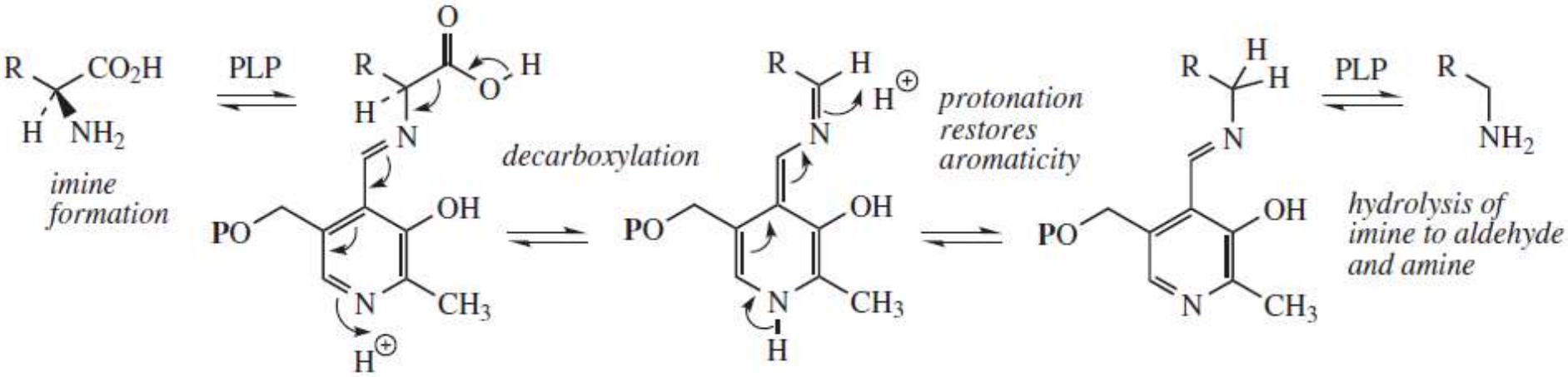
acido pantoico

Vitamina B_6



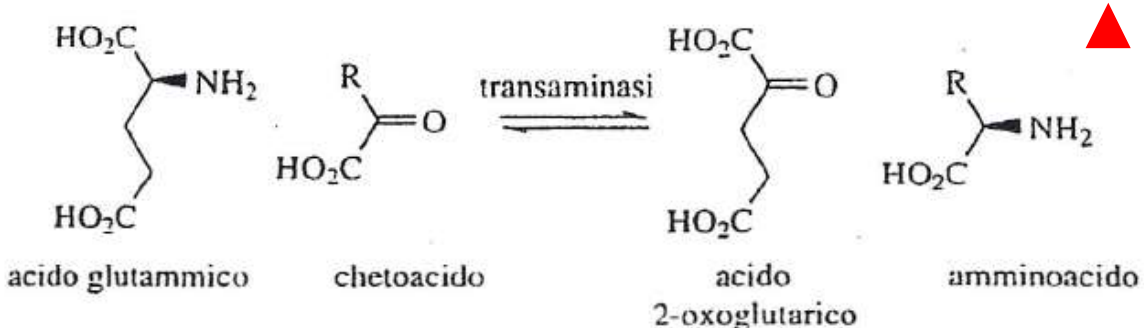
Decarboxylation reactions

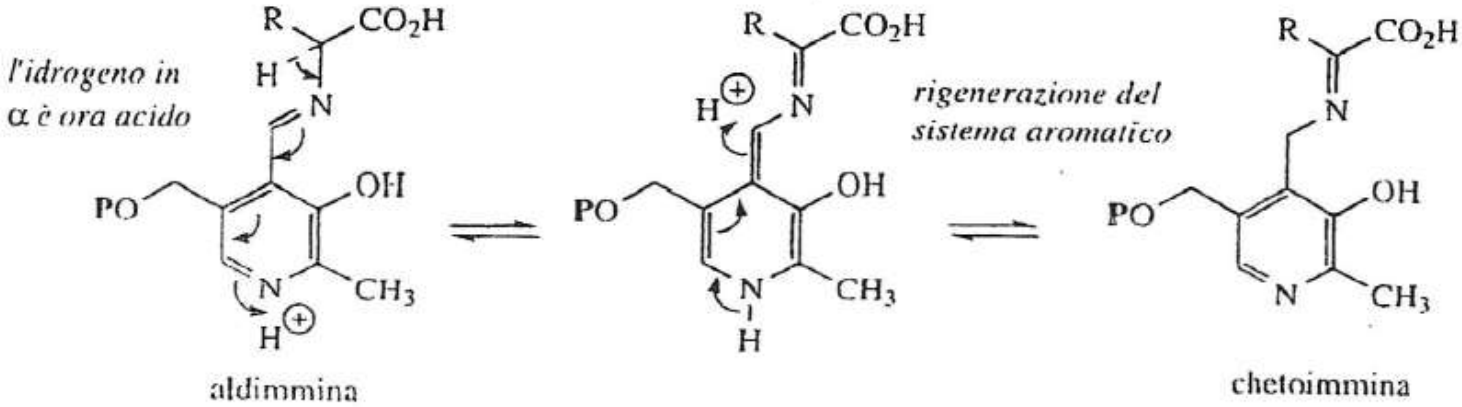
(a) α-amino acids

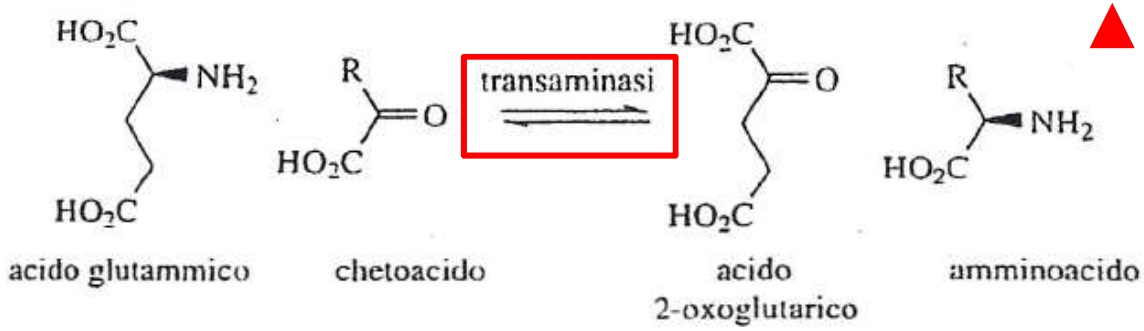


Vitamina B_6

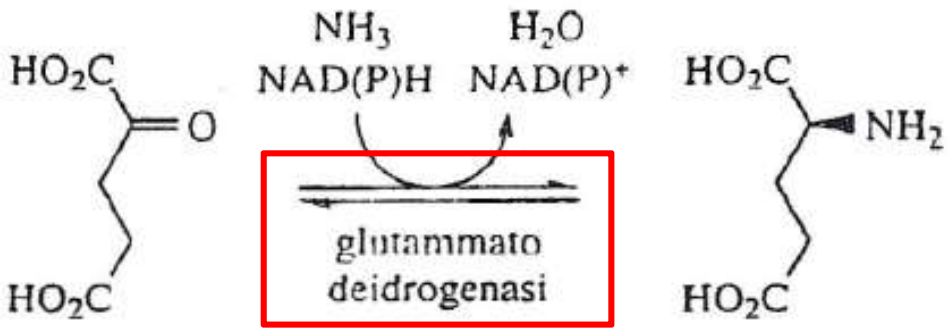
Transam(m)inazione

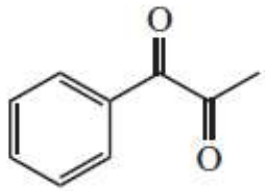


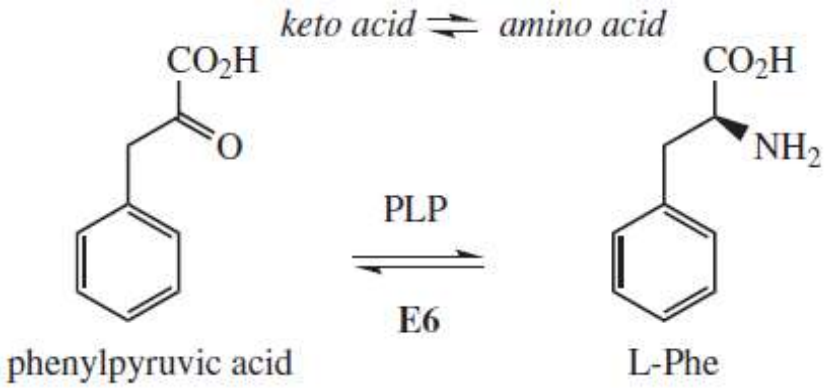


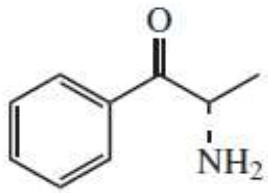


amminazione riduttiva





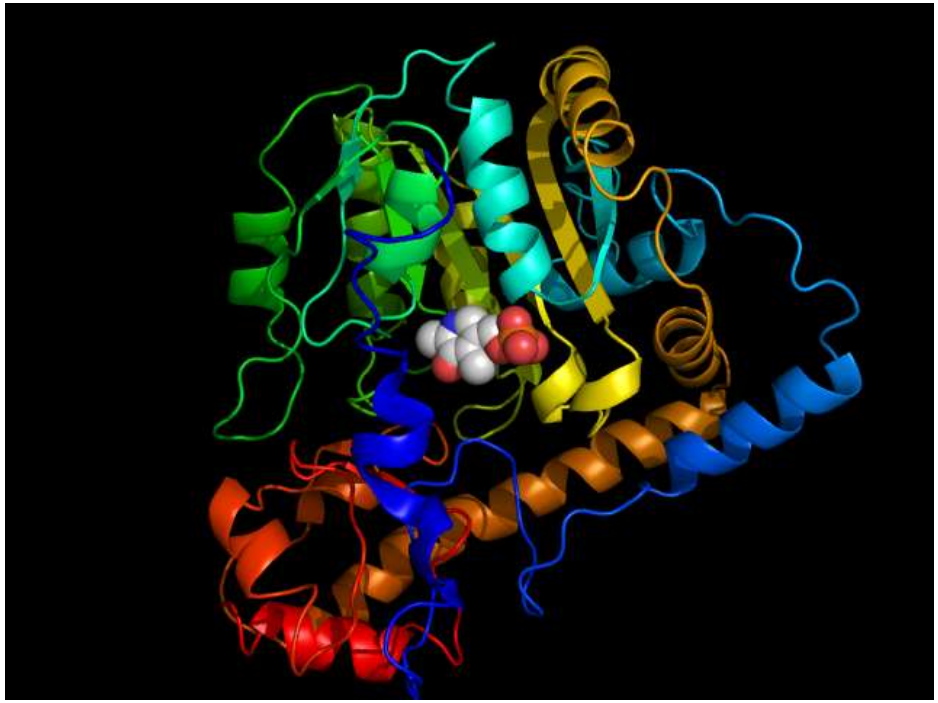




(–)-cathinone

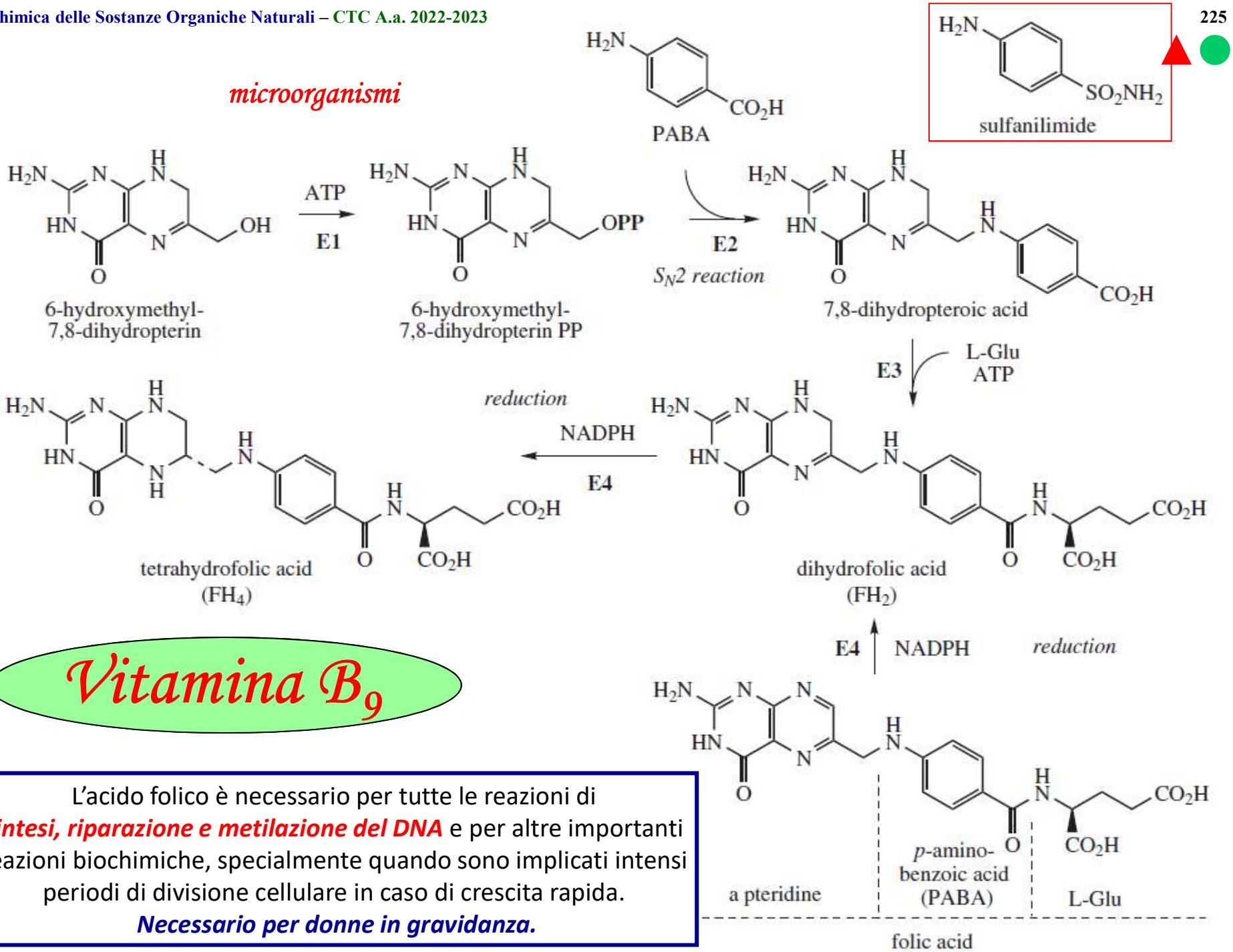
derivato anfetaminico

Le transaminasi (o aminotransferasi) sono una sottoclasse di enzimi (appartenenti alla classe delle transferasi) predisposti a catalizzare la reazione di trasferimento del gruppo amminico α da un amminoacido a un α-chetoacido.



Aspartato transaminasi di E. coli con PLP come cofattore

Le transaminasi sono usate in medicina soprattutto al fine di ***evidenziare la presenza o meno di un danno epatico***. Se la cellula epatica è integra, tali enzimi rimangono all'interno della stessa; un fenomeno infiammatorio causato da virus o altro, che determini alterazione della permeabilità della membrana e/o distruzione della cellula, fa sì che le transaminasi vengano liberate all'esterno della cellula e riversate nel sangue, con conseguente aumento della loro concentrazione plasmatica.



Vitamina B_9

L'acido folico è necessario per tutte le reazioni di ***sintesi, riparazione e metilazione del DNA*** e per altre importanti reazioni biochimiche, specialmente quando sono implicati intensi periodi di divisione cellulare in caso di crescita rapida.

Necessario per donne in gravidanza.

Contenuto di alcuni cibi ricchi di folati

Prodotto	Contenuto medio (µg/100g)
Lattuga a foglia larga	1700
Corn flakes, germe di grano, soia, lievito di birra	1500 - 1200
Fegato di pollo	800
Muesli	650
Fegato di manzo	560
Fiocchi di crusca, mais	550 - 400
Tuorlo d'uovo	320 - 200
Spinaci bolliti, zucchine	290 - 180
Cavoletti di Bruxelles	270
Barbabietole rosse	260
Funghi secchi	250
Asparagi, broccoli, carciofi	240 - 180
Patate bollite	90
Pomodoro in conserva	70
Arance	60
Fagioli	50
Cioccolato	40
Fave, lenticchie	50 - 40

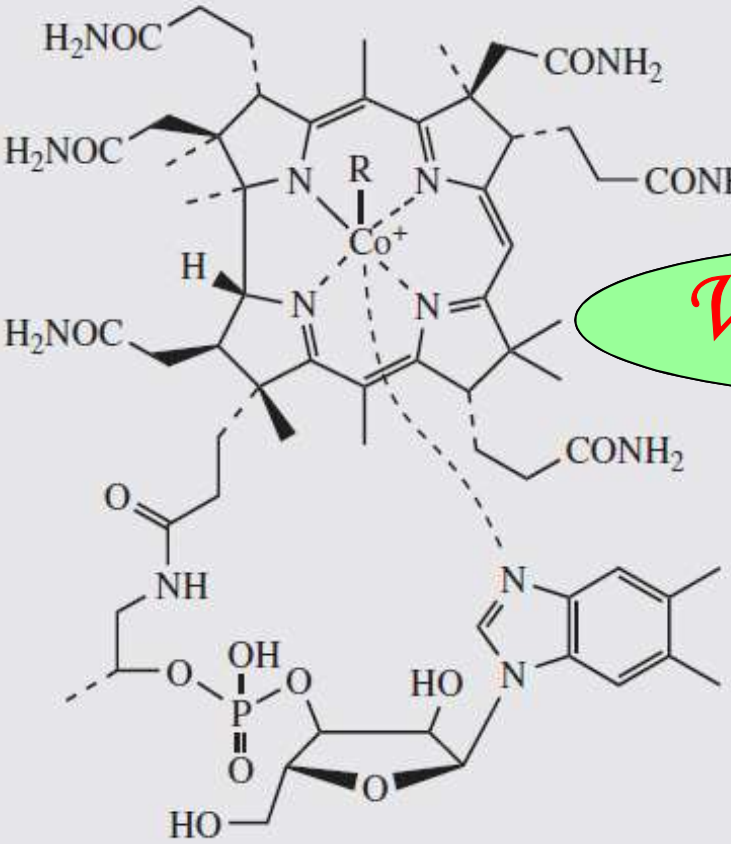
La carenza di acido folico è assai diffusa, soprattutto nei paesi sottosviluppati.

Le cause di ciò sono molteplici e vanno dalle malattie infettive, alle terapie farmacologiche, alla gravidanza, al malassorbimento.

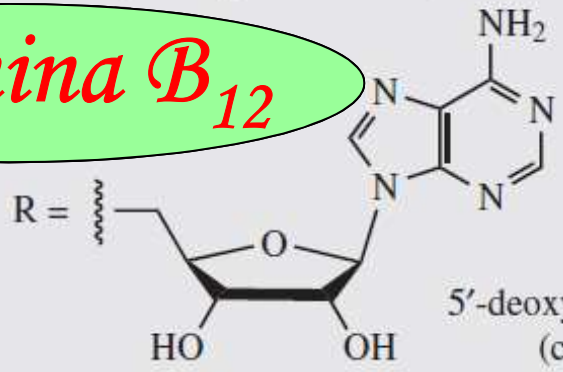
Tutto ciò si traduce in problemi nella sintesi di DNA ed RNA.

Gli elementi più coinvolti da questo problema sono le cellule a ricambio rapido, come quelle del midollo osseo.

Vitamina B_{12}

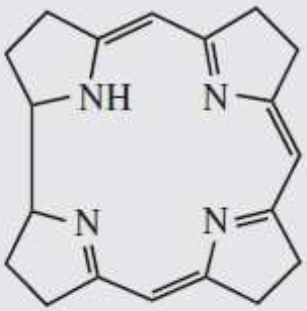


R = CN, cyanocobalamin (vitamin B_{12})
R = OH, hydroxocobalamin (vitamin B_{12a})
R = H_2O, aquocobalamin (vitamin B_{12b})
R = NO_2, nitritocobalamin (vitamin B_{12c})
R = Me, methylcobalamin (methyl vitamin B_{12})

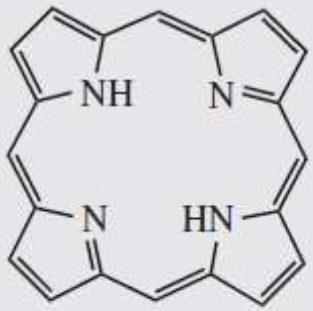


5′-deoxyadenosylcobalamin (coenzyme B_{12})

The vitamin plays a key role in the normal functioning of the brain and nervous system, and for the formation of blood.



corrin ring system

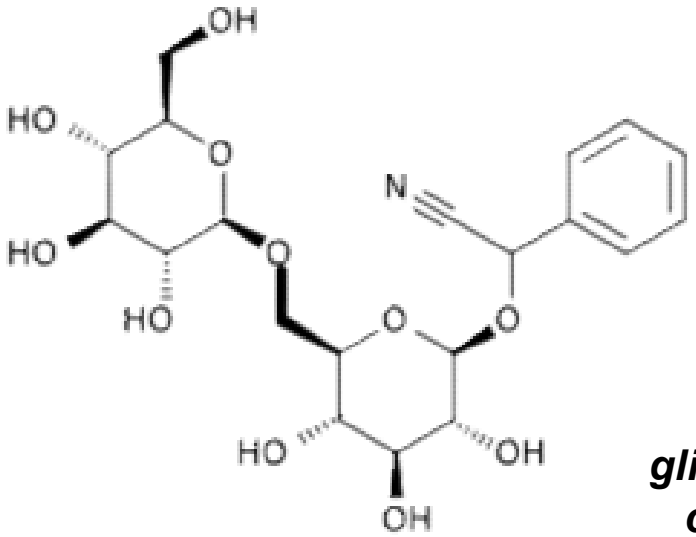


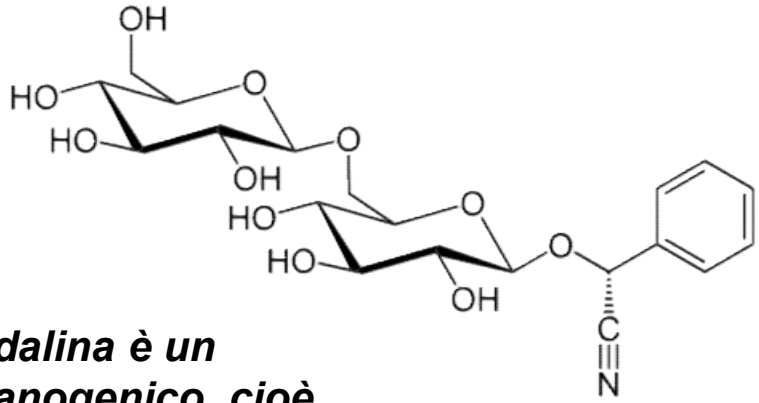
porphyrin ring system

Neither fungi, plants, nor animals are capable of producing vitamin B12. Only bacteria and archaea (archibacteria) have the enzymes required for its synthesis, although many foods are a natural source of B12 because of bacterial symbiosis.

Vitamina B_{17}

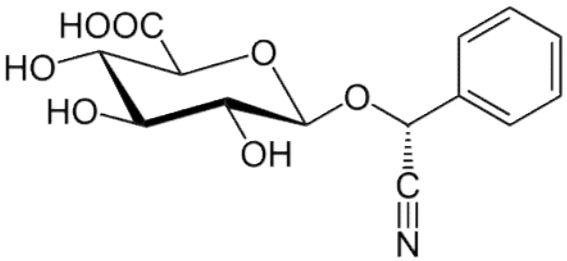
amigdalina





L'amigdalina è un glicoside cianogenico, cioè capace di liberare acido cianidrico

laetrile



Nel 1950 Ernest Krebs preparò il laetrile, una sostanza simile all'amigdalina, ma con una molecola di glucosio in meno.

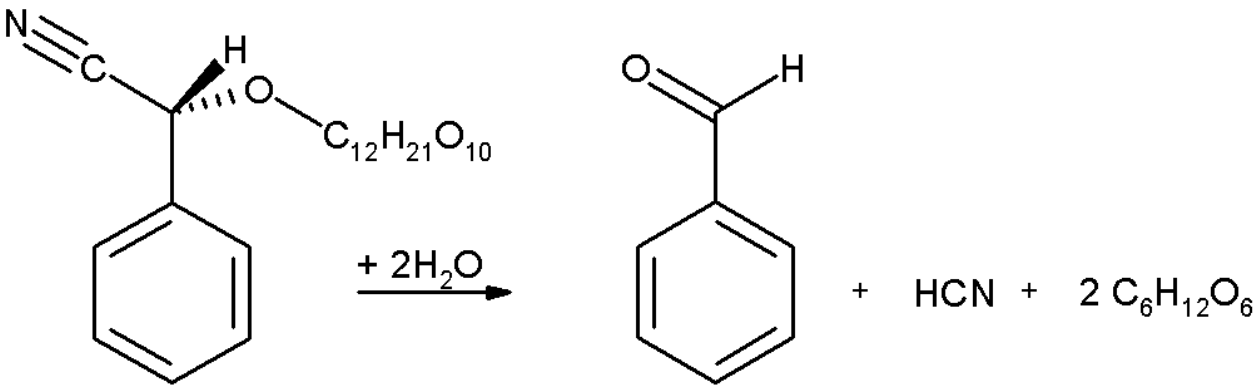
Krebs, senza apportare alcuna evidenza clinica o scientifica, sostenne di poter usare il laetrile come presunto agente antitumorale.

Soprannominò impropriamente la sostanza "**vitamina B17**".

amigdalina

Vitamina B_{17}

L'amigdalina di per sé è poco reattiva. Essa reagisce soltanto con l'enzima ***beta-glucosidasi***, e dalla degradazione si ottengono glucosio, benzaldeide e acido cianidrico.



L'***emulsina***, una beta-glucosidasi contenuta nei semi del mandorlo amaro ma presente in cellule separate da quelle contenenti amigdalina, se viene a contatto con questa la decompone, scindendola nelle stesse tre sostanze suddette. ***L'insieme di emulsina e amigdalina può provocare, in caso di ingestione corporea, sintomi da avvelenamento da acido cianidrico***, anche se assunte entrambe in piccole o piccolissime dosi.

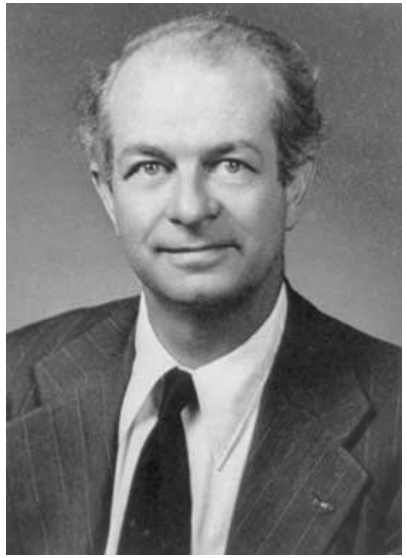
Vitamina C (acido ascorbico)

***"Come vivere più a lungo e sentirsi meglio"*, Linus Pauling**, 1989 Edizioni Frassinelli

*"La vitamina C - acido ascorbico, sodio ascorbato o calcio ascorbato - è coinvolta in un gran numero di reazioni biochimiche nel corpo umano. Due delle sue maggiori interazioni sono **il potenziamento del sistema immunitario** e **la sintesi del collagene**, una **sostanza proteica reticolata** molto importante che tiene unito il corpo umano. Il collagene rinforza i vasi sanguigni, la pelle, i muscoli e le ossa. L'uomo non può creare collagene senza la vitamina C.*

Quello che mi impressionò venti anni fa fu quando Irwine Stone indicò che la maggior parte degli animali, escluso l'uomo e le scimmie, producevano vitamina C.

*Non facendo affidamento al cibo o alle pasticche di vitamine, gli animali producono vitamina C nel fegato in proporzione al loro peso corporeo. Per un uomo adulto le proporzioni dovrebbero essere una media di **10-12 g.** al giorno".*



1901 - 1994

Come vivere più a lungo e sentirsi meglio"

è un classico della medicina moderna

Fortemente contrastato dalla comunità scientifica internazionale per la sua ostinata attenzione sul ruolo terapeutico di dosaggi elevatissimi di Vit. C, Pauling è stato uno dei primi scienziati a rivelare al grande pubblico l'importanza delle vitamine e dei cereali integrali. Ha capito con grande anticipo il rischio per la salute derivante dal consumo eccessivo di zuccheri raffinati e ha fornito suggerimenti che risultano ancora perfettamente validi per chi volesse intraprendere un serio percorso verso un buono stato di salute generale.

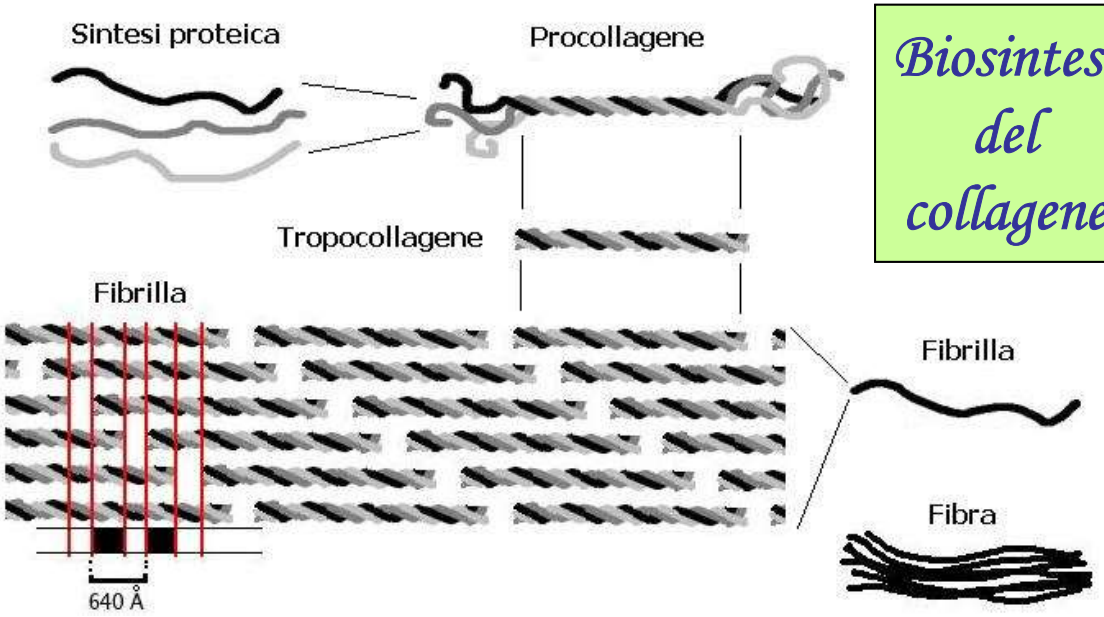
Presumibilmente 10-12 grammi/die di Vitamina C non sono raccomandabili, ma bisogna riconoscere a Pauling il merito di averci aiutato a comprendere i molteplici ruoli terapeutici e preventivi di questa importante vitamina.

Nel corso dei suoi studi sulle proteine e in particolare sull'emoglobina, Pauling si occupò anche di malattie molecolari, come l'anemia falciforme.

"L'instaurarsi dello scorbuto è caratterizzato da una perdita delle forze, da depressione, irrequietezza e da una rapida sensazione di spossatezza a seguito di ogni piccolo sforzo.
La pelle diventa giallastra e cinerea.
Il paziente si lamenta di dolori muscolari.
In seguito, il viso assume un aspetto macilento.
Le gengive si ulcerano, i denti cadono e l'alito diventa fetido. Emorragie di notevole portata interessano i muscoli e gli altri tessuti, cosicché il malato sembra coperto di lividi.
Gli ultimi stadi della malattia sono caratterizzati da una spossatezza profonda, diarrea, disturbi ai polmoni e ai reni, che portano alla morte".

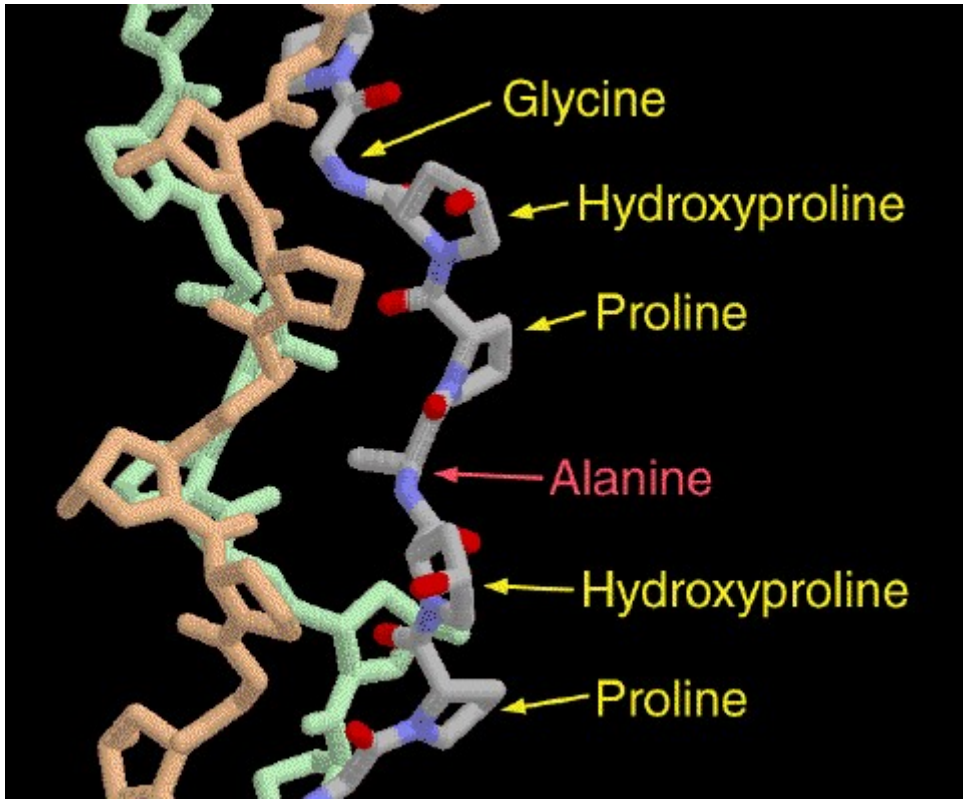
Biosintesi del collagene

La biosintesi del collagene avviene ad opera di diversi tipi cellulari a seconda del tessuto (ad esempio, fibroplasti nel tessuto connettivo, osteoplasti nell'osso). Solo una prima fase è intracellulare.



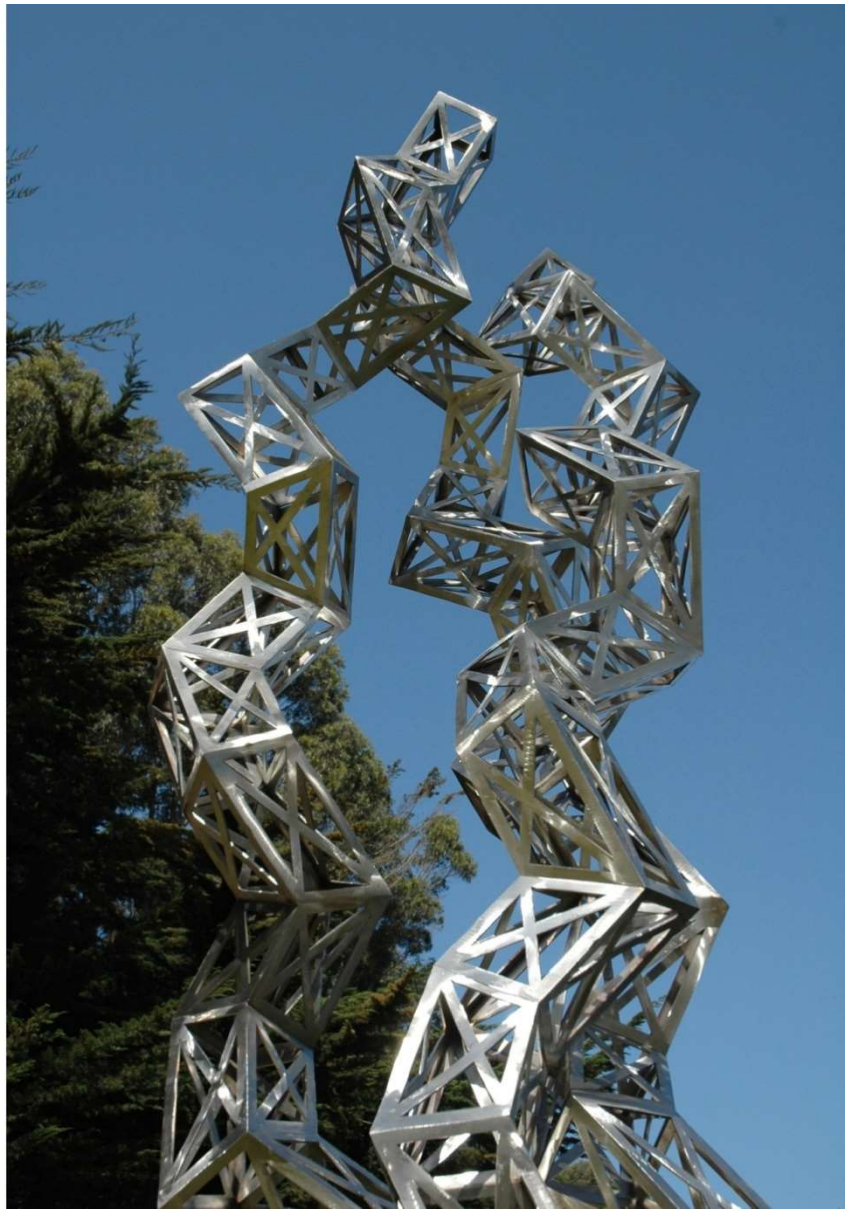
Il collagene nasce come procollagene, prodotto che possiede rispetto al collagene due telomeri, uno N-terminale e uno C-terminale, che hanno struttura globulare. La catena nascente di procollagene subisce idrossilazione di specifici residui di prolina e lisina ad idrossiprolina e idrossilisina (ad opera di idrossilasi, con cofattore essenziale la vitamina C), con la produzione di catene alfa di procollagene. Tre di queste catene si avvolgono a formare una tripla elica, stabilizzata da legami-H tra amminoacidi idrossilati (legami crociati). Questa elica passa nell'apparato del Golgi e da qui, attraverso vescicole di secrezione, viene secreta all'esterno della cellula; qui subisce l'azione di alcune procollagene peptidasi, che tagliano i telomeri trasformando il procollagene in tropocollagene.

Le molecole di tropocollagene si dispongono in file parallele a formare fibrille le quali, infine, possono disporsi in fasci ondulati o paralleli per formare fibre o fasci di fibre.



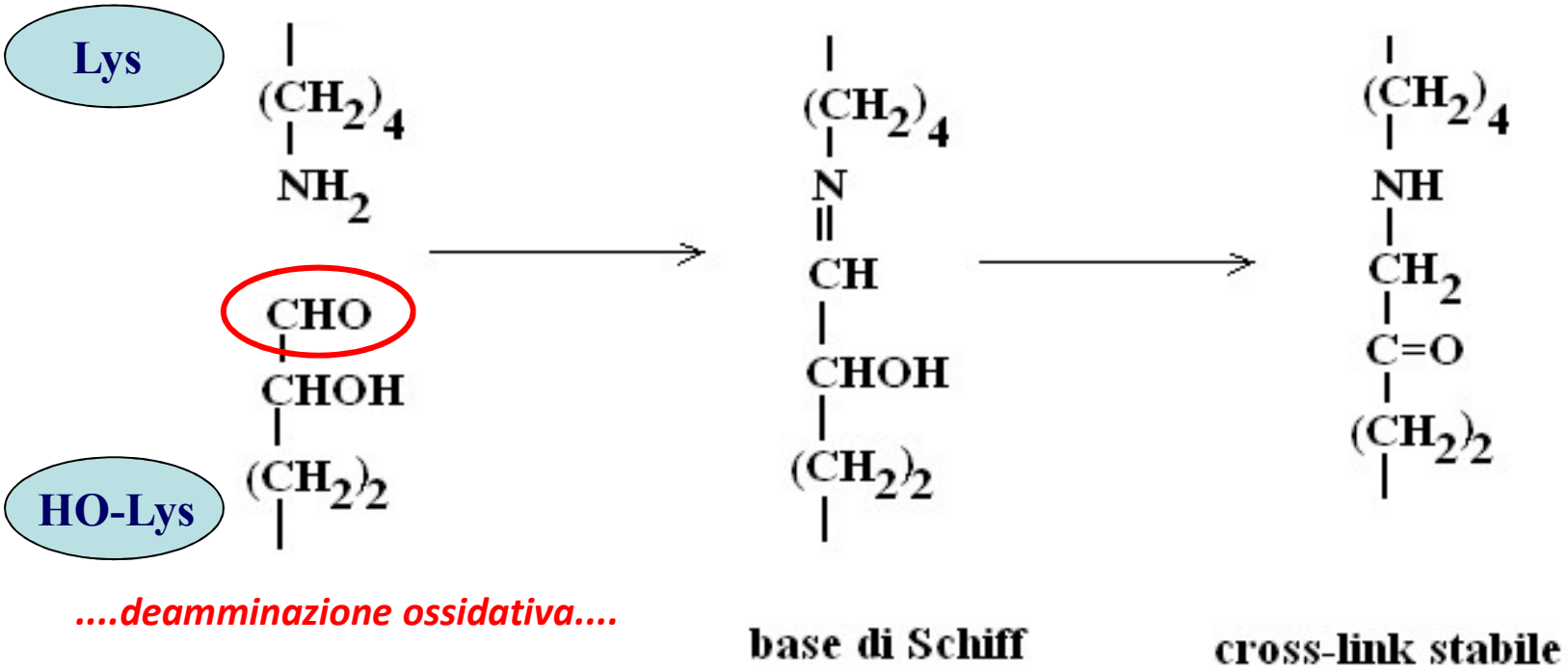
La tripla elica del collagene è resa compatta e stabile da una particolare sequenza di ammino acidi. Un ammino acido ogni tre è glicina e molti dei rimanenti ammino acidi sono prolina o idrossiprolina. Qui a fianco è mostrata una tipica tripla elica. Notare come la glicina formi un gomito sottile all'interno dell'elica, e come la prolina e l'idrossiprolina pieghino la catena proteica a forma di elica.

In questa struttura è stato inserito un ammino acido più grande, alanina, nella posizione normalmente occupata dalla glicina, per dimostrare che questa crea problemi di ingombro sterico con le catene vicine.

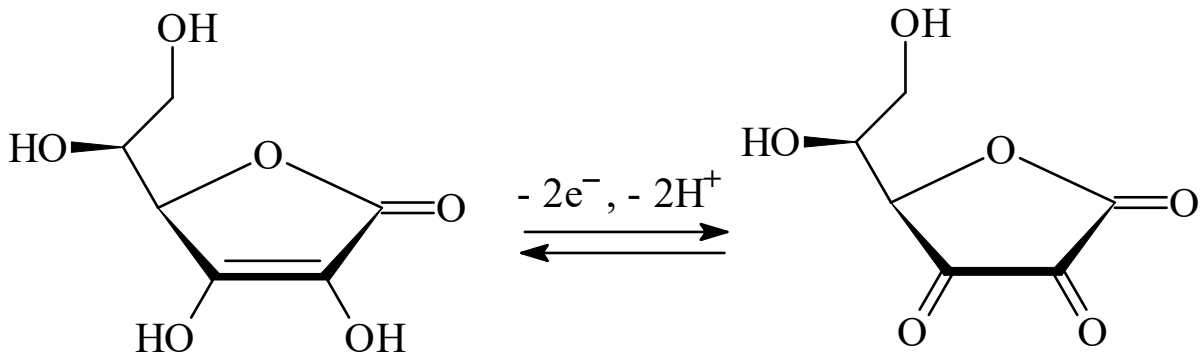


Districare il Collagene
(Unraveling Collagen)
(2005) di Julian Voss-Andreae, in acciaio inossidabile, alta 3,40 m. Usando le coordinate atomiche depositate nella Protein Data Bank, l'artista tedesco-americano ha realizzato questa scultura basata sulla struttura del collagene (Stamford, CT).

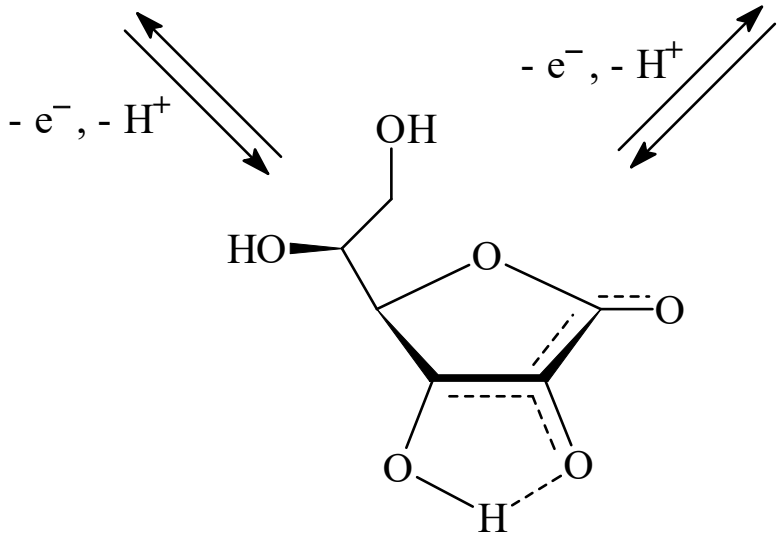
Formazione cross-links covalenti tra fibrille collagene



Le basi di Schiff tra residui di Lys e HO-Lys sono + stabili perché riarrangiano come mostrato sopra → importanza dell'idrossilazione (vit. C-dipendente)



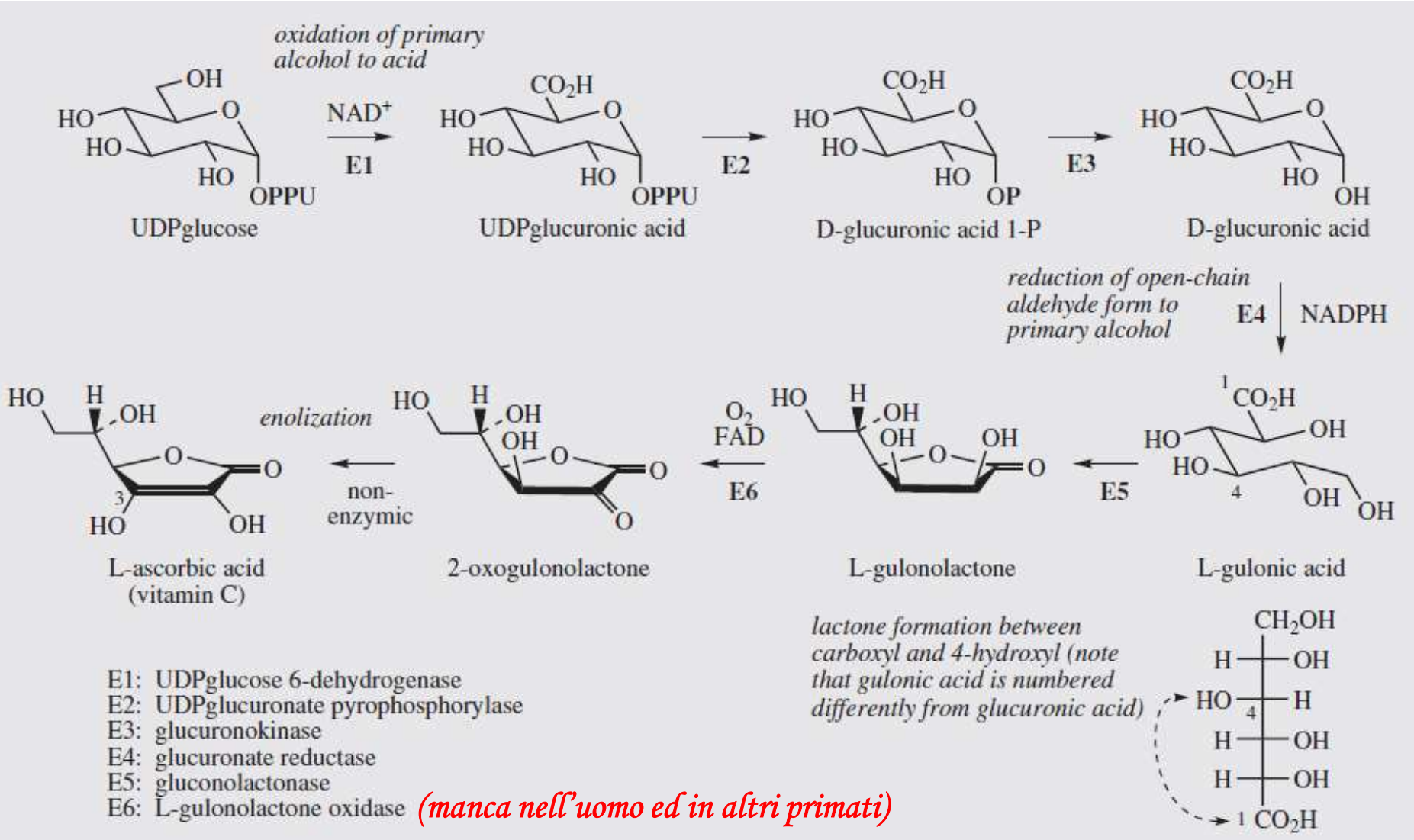
acido L-ascorbico acido L-deidroascorbico



L-semideidroascorbato

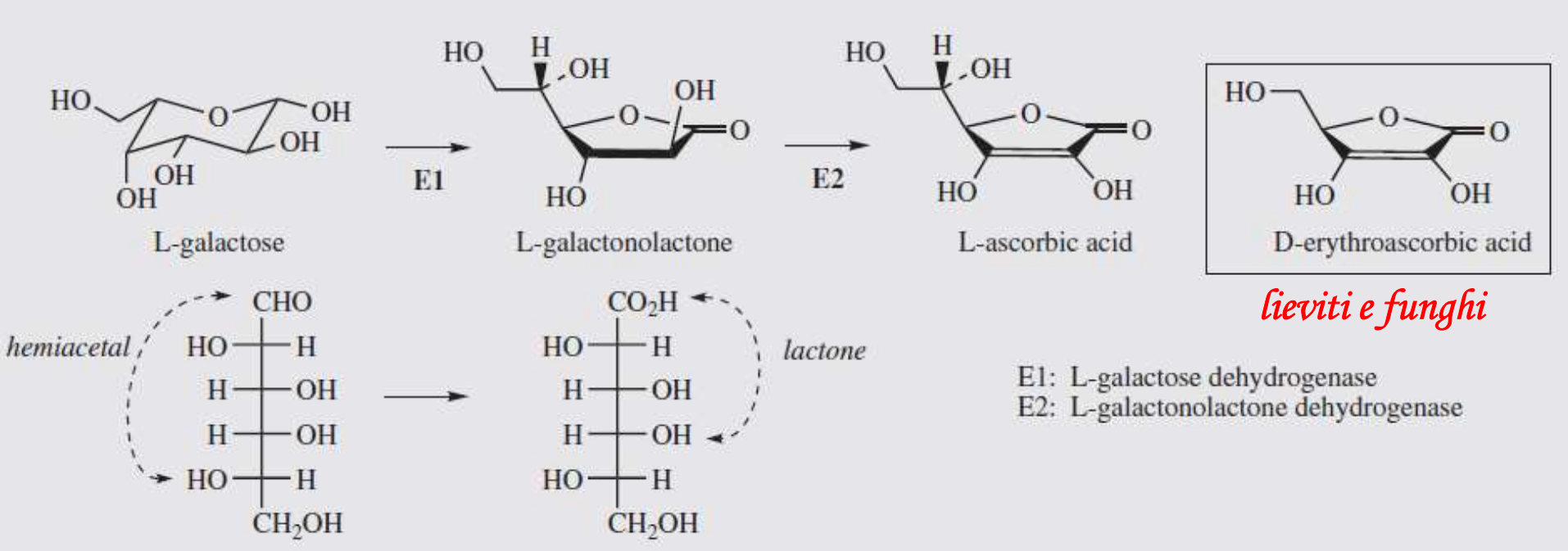
Sintesi biologica

animali (fegato)



Sintesi biologica

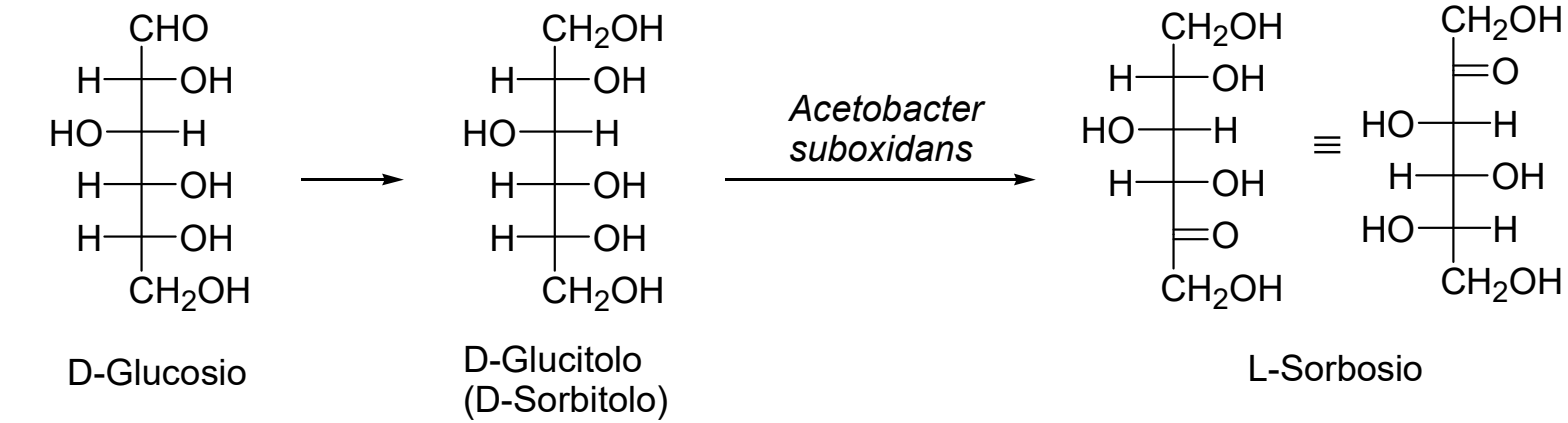
piante

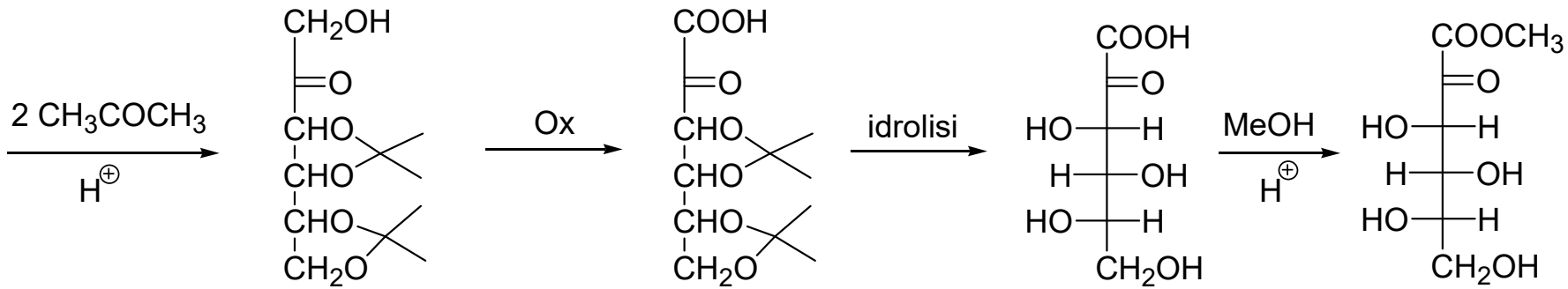


lieviti e funghi

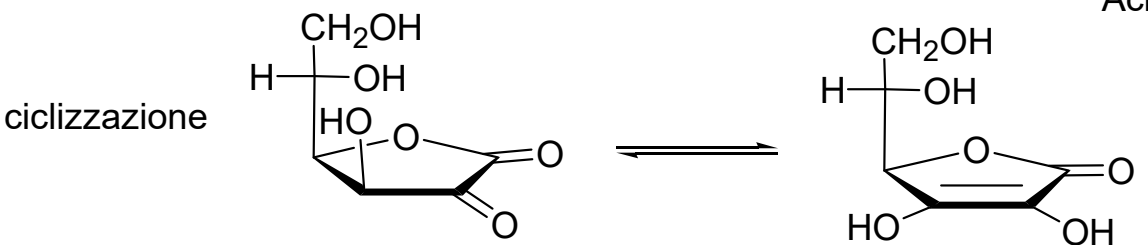
Sintesi industriale

Processo Reichstein (1933)

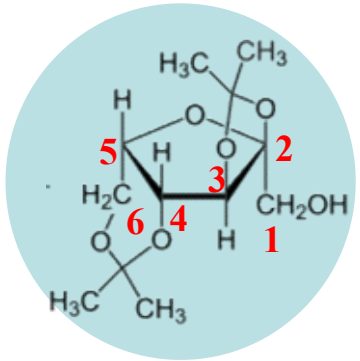




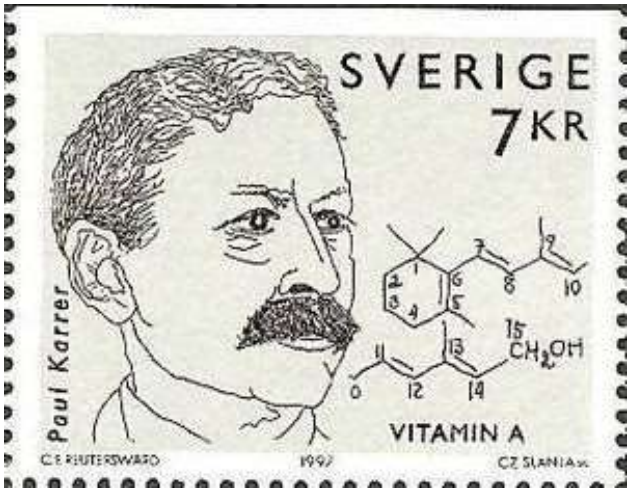
Acido L-2-chetogulonico

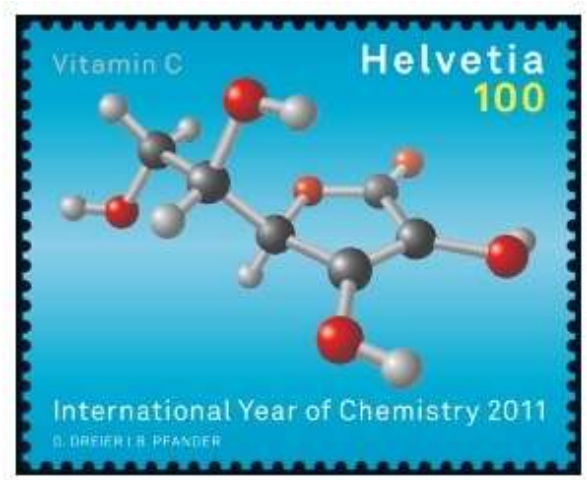


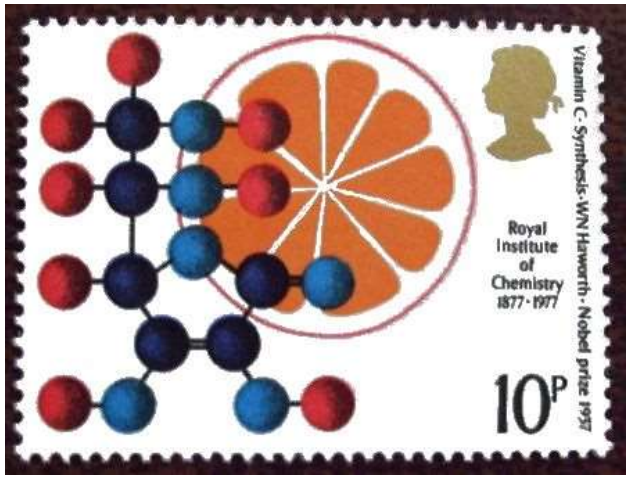
Acido L-ascorbico



In 1937, the Nobel Prize for Chemistry was awarded to Norman Haworth for his work in determining the structure of ascorbic acid (shared with Paul Karrer, who received his award for work on vitamins), while the prize for Physiology or Medicine went to Albert Szent-Gyorgyi for his studies of the biological functions of L-ascorbic acid.







Vitamina F - acidi grassi
(EFA: Essential Fatty Acids)

Saturated

butyric	4:0	CO_2H
caproic	6:0	CO_2H
caprylic	8:0	CO_2H
capric	10:0	CO_2H
lauric	12:0	CO_2H
myristic	14:0	CO_2H
palmitic	16:0	CO_2H
stearic	18:0	CO_2H
arachidic	20:0	CO_2H
behenic	22:0	CO_2H
lignoceric	24:0	CO_2H
cerotic	26:0	CO_2H
montanic	28:0	CO_2H
melissic	30:0	CO_2H

Abbreviations:

Number of carbon atoms

Position of double bonds

18:2 (9c,12c)

Stereochemistry of double bonds
(c = *cis/Z*; t = *trans/E*)

Number of double bonds

Acidi grassi saturi

n° atomi di C: n° doppi legami	nome comune	nome IUPAC	formula	p.f. (°C)	fonti
4:0	acido butirrico	acido butanoico	$CH_3(CH_2)_2COOH$	-8	grassi del latte
5:0	acido valerianico (acido valerico)	acido pentanoico	$CH_3(CH_2)_3COOH$	-	-
6:0	acido capronico (acido caproico)	acido esanoico	$CH_3(CH_2)_4COOH$	-3	grassi del latte
7:0	acido enantico	acido eptanoico	$CH_3(CH_2)_5COOH$	-	fiore di vite (dal greco oinanthe)
8:0	acido caprilico	acido ottanoico	$CH_3(CH_2)_6COOH$	16	grassi del latte, grassi del cocco
9:0	acido pelargonico	acido nonanoico	$CH_3(CH_2)_7COOH$	-	Pelargonium roseum
10:0	acido caprinico (acido caprico)	acido decanoico	$CH_3(CH_2)_8COOH$	31	grassi animali e vegetali
11:0	-	acido undecanoico	$CH_3(CH_2)_9COOH$	-	-
12:0	acido laurico	acido dodecanoico	$CH_3(CH_2)_{10}COOH$	43,2	grassi animali e vegetali
13:0	-	acido tridecanoico	$CH_3(CH_2)_{11}COOH$	-	-
14:0	acido miristico	acido tetradecanoico	$CH_3(CH_2)_{12}COOH$	53,9	grassi del latte, oli di pesce, grassi animali e vegetali
15:0	-	acido pentadecanoico	$CH_3(CH_2)_{13}COOH$	-	-
16:0	acido palmitico	acido esadecanoico	$CH_3(CH_2)_{14}COOH$	62,8	grassi animali e vegetali
17:0	acido margarico	acido eptadecanoico	$CH_3(CH_2)_{15}COOH$	-	grassi animali e vegetali
18:0	acido stearico	acido ottadecanoico	$CH_3(CH_2)_{16}COOH$	69,6	grassi animali e vegetali
19:0	-	acido nonadecanoico	$CH_3(CH_2)_{17}COOH$	-	-
20:0	acido arachidico	acido eicosanoico	$CH_3(CH_2)_{18}COOH$	75,4	semi vegetali e grassi animali
22:0	acido behenico	acido docosanoico	$CH_3(CH_2)_{20}COOH$	-	semi vegetali e grassi animali
24:0	acido lignocerico	acido tetracosanoico	$CH_3(CH_2)_{22}COOH$	-	alcuni grassi vegetali, componente della sfingomielina
26:0	acido cerotico	acido esacosanoico	$CH_3(CH_2)_{24}COOH$	-	cera d'api, cera carnauba, grasso della lana
28:0	acido montanico	acido ottacosanoico	$CH_3(CH_2)_{26}COOH$	-	cere animali e vegetali
30:0	acido melissico	acido triacontanoico	$CH_3(CH_2)_{28}COOH$	-	cere animali e vegetali
32:0	acido laceroico	acido dotriacontanoico	$CH_3(CH_2)_{30}COOH$	-	-

Acidi grassi monoinsaturi

n° atomi di C: n° doppi legami	posizione dei doppi legami	nome comune	nome IUPAC	formula	p.f. (°C)	fonti
16:1*	7*	acido palmitoleico	acido cis-9-esadecenoico	$C_{16}H_{30}O_2$ $CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	-0,5	grassi del latte, grassi di riserva degli animali, oli di pesce, grassi vegetali
18:1	*cis*-9	acido oleico	acido cis-9-ottadecenoico	$C_{18}H_{34}O_2$ $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	16	olio di oliva, in tutti i grassi naturali
18:1	*trans*-9	acido elaidico	acido trans-9-ottadecenoico	$C_{18}H_{34}O_2$ $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	45	nei grassi dei ruminanti
18:1	11	acido vaccenico	acido cis-11-ottadecenoico	$C_{18}H_{34}O_2$ $CH_3(CH_2)_5CH{=}CH(CH_2)_9COOH$	-	-
20:1	11	acido gadoleico	acido cis-9-eicosenoico	$C_{20}H_{38}O_2$ $CH_3(CH_2)_7CH{=}CH(CH_2)_9COOH$	-	olio di colza
22:1	11	acido cetoleico	acido cis-11-docosenoico	$C_{22}H_{42}O_2$ $CH_3(CH_2)_9CH{=}CH(CH_2)_9COOH$	-	oli vegetali
22:1	13	acido erucico	acido cis-13-docosenoico	$C_{22}H_{42}O_2$ $CH_3(CH_2)_7CH{=}CH(CH_2)_{11}COOH$	-	olio di colza
24:1	15	acido nervonico	acido cis-15-tetracosenoico	$C_{24}H_{46}O_2$ $CH_3(CH_2)_7CH{=}CH(CH_2)_{13}COOH$	-	-

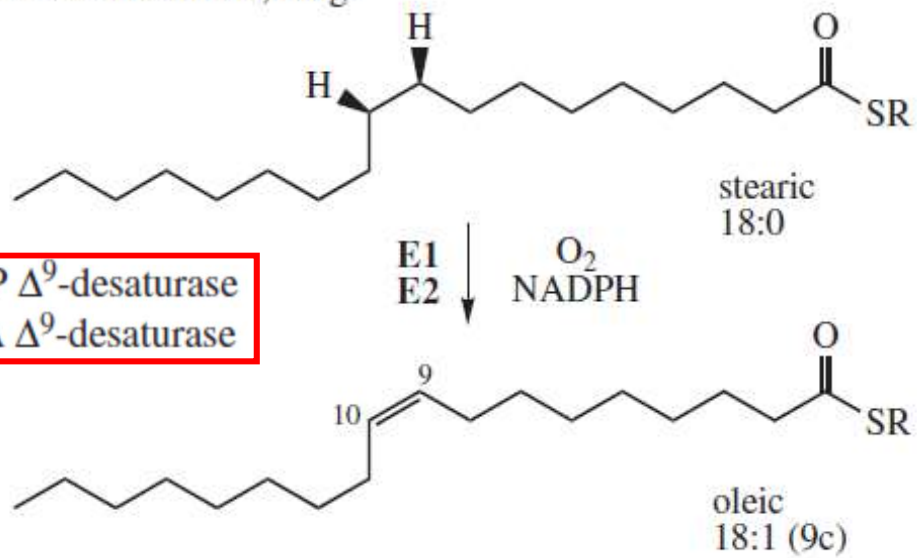
* $16{:}1^{\Delta 7}$

Acidi grassi poliinsaturi

n° atomi di C: n° doppi legami	posizione dei doppi legami	nome comune	nome IUPAC	formula	p.f. (°C)	fonti
18:2*	9,12*	acido linoleico	acido 9,12-ottadecadienoico	$C_{18}H_{32}O_2$	-5	olio di girasole
18:3	9,12,15	acido α–linolenico	acido 9,12,15-ottadecatrienoico (ALA)	$C_{18}H_{30}O_2$	-11	pesce ricco di grassi, oli vegetali
18:3	6,9,12	acido γ–linolenico	acido 6,9,12-ottadecatrienoico	$C_{18}H_{30}O_2$	-11	
18:4	6,9,12,15	acido stearidonico	acido 6,9,12,15-ottadecatetraenoico	$C_{18}H_{28}O_2$	-	semi di canapa, olio di semi di ribes nero
20:4	5,8,11,14	acido arachidonico	acido 5,8,11,14-eicosatetraenoico	$C_{20}H_{32}O_2$	-49,5	grassi animali, oli di pesce
20:5	5,8,11,14,17	acido timnodonico	acido 5,8,11,14,17-eicosapentaenoico (EPA)	$C_{20}H_{30}O_2$	-	oli di pesce
22:5	7,10,13,16,19	acido clupanodonico	acido 7,10,13,16,19-docosapentaenoico (DPA)	$C_{22}H_{34}O_2$	-	oli di pesce
22:5	4,7,10,13,16	acido di Osbond	acido 4,7,10,13,16-docosapentaenoico	$C_{22}H_{34}O_2$	-	oli di pesce
22:6	4,7,10,13,16,19	acido cervonico	acido 4,7,10,13,16,19-docosaesaenoico (DHA)	$C_{22}H_{32}O_2$	-	oli di pesce

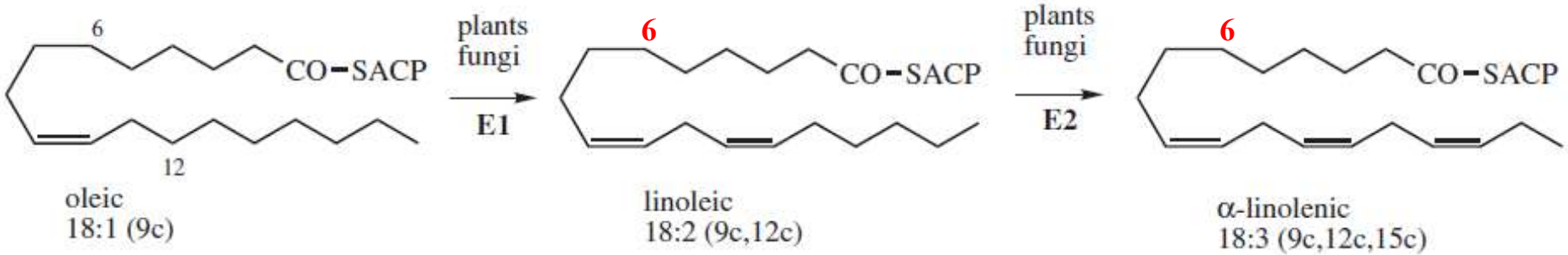
* $18{:}2^{\Delta 9,12}$

R = ACP in plants (ACP: Acyl Carrier Protein)
R = CoA in animals, fungi

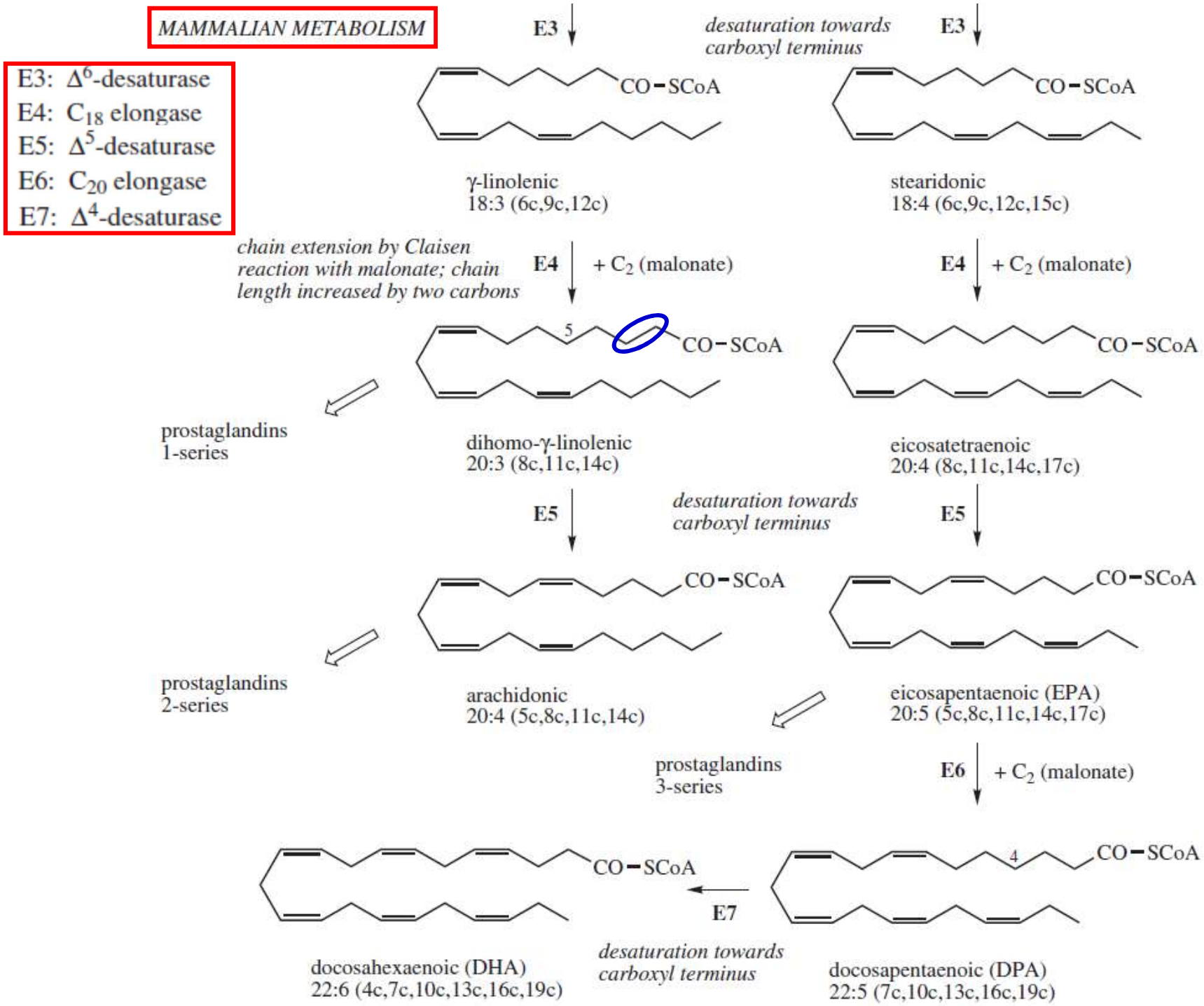


E1: stearoyl-ACP Δ^9-desaturase
E2: stearoyl-CoA Δ^9-desaturase

PLANT METABOLISM

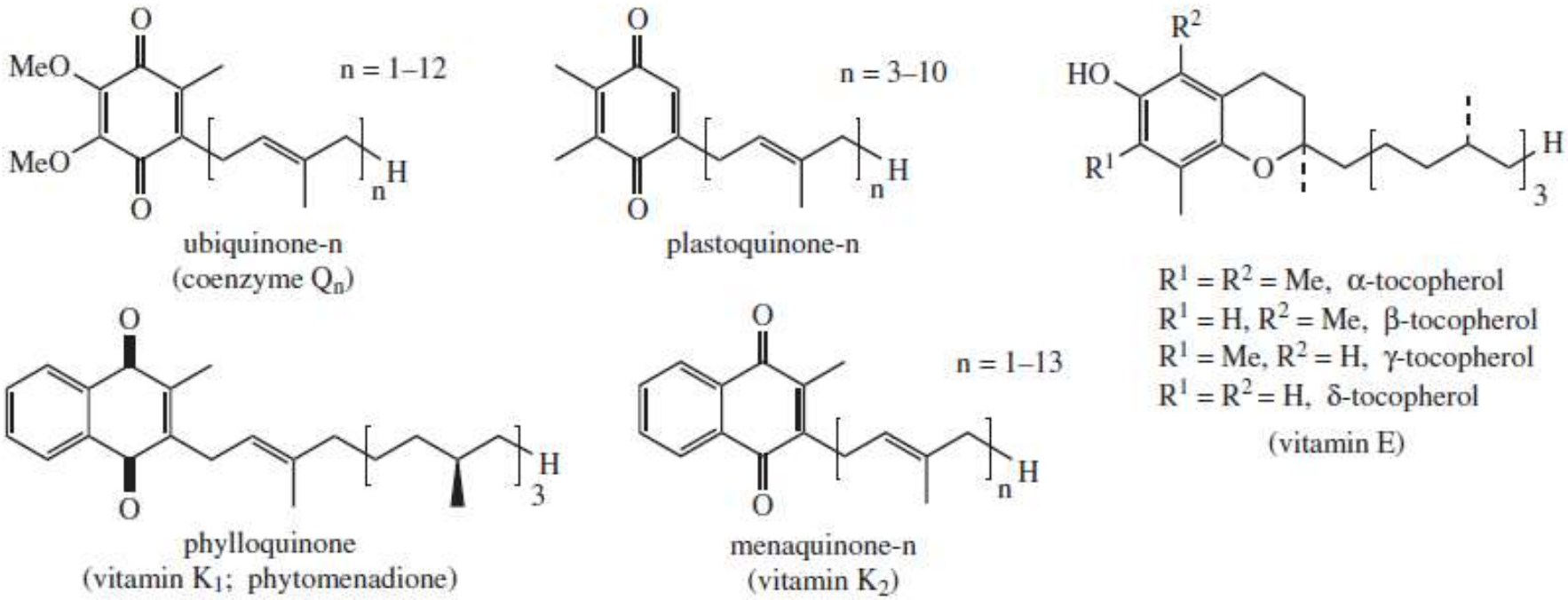


piante	*mammiferi*
E1: Δ^{12}-desaturase	E3: Δ^6-desaturase
E2: Δ^{15}-desaturase	

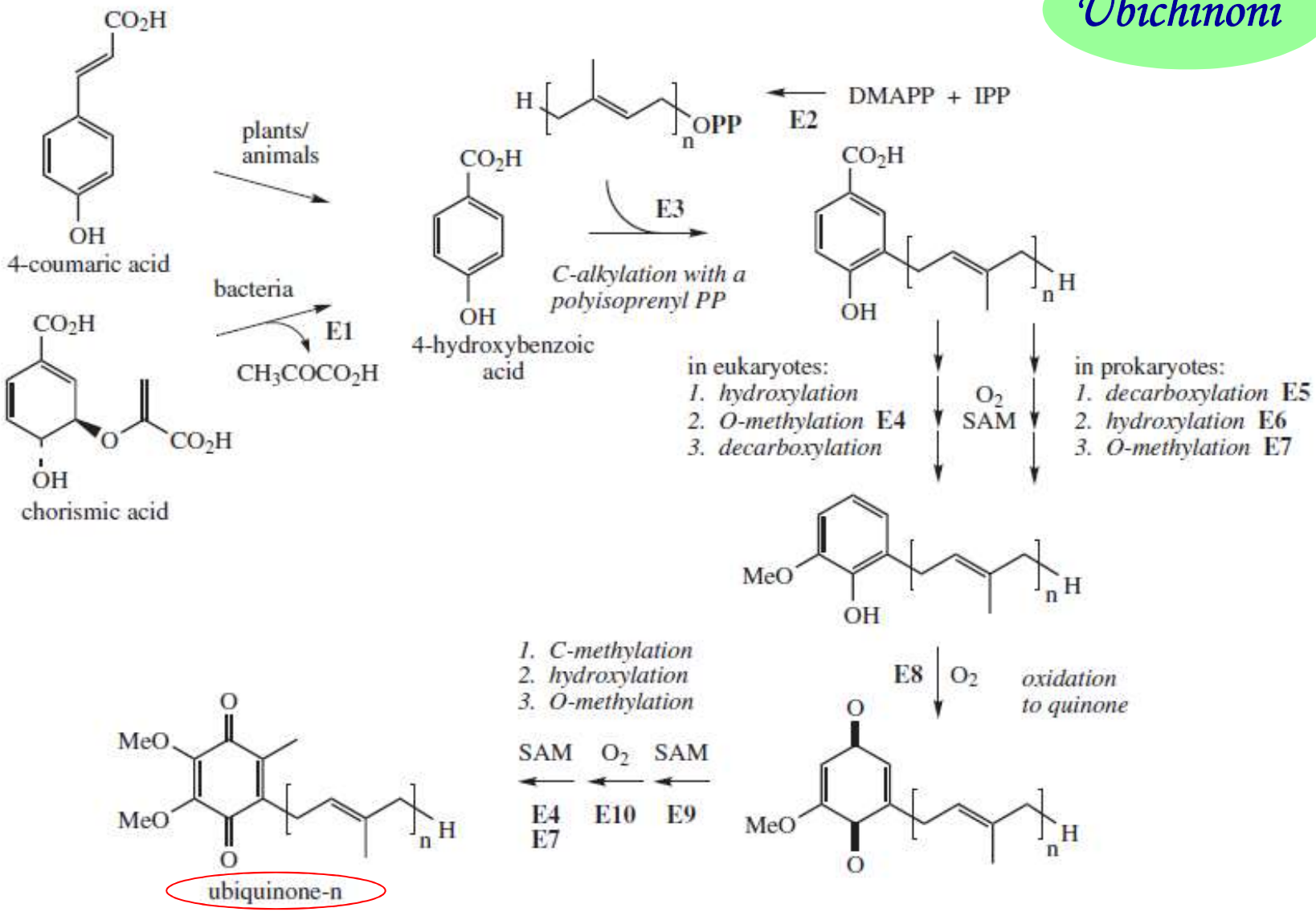

MAMMALIAN METABOLISM
E3: Δ6-desaturase
E4: C18 elongase
E5: Δ5-desaturase
E6: C20 elongase
E7: Δ4-desaturase
E3
desaturation towards carboxyl terminus
E3
CO−SCoA
CO−SCoA
γ-linolenic
18:3 (6c,9c,12c)
stearidonic
18:4 (6c,9c,12c,15c)
chain extension by Claisen reaction with malonate; chain length increased by two carbons
E4
+ C2 (malonate)
E4
+ C2 (malonate)
5
CO−SCoA
CO−SCoA
prostaglandins
1-series
dihomo-γ-linolenic
20:3 (8c,11c,14c)
eicosatetraenoic
20:4 (8c,11c,14c,17c)
E5
desaturation towards carboxyl terminus
E5
CO−SCoA
CO−SCoA
prostaglandins
2-series
arachidonic
20:4 (5c,8c,11c,14c)
eicosapentaenoic (EPA)
20:5 (5c,8c,11c,14c,17c)
prostaglandins
3-series
E6
+ C2 (malonate)
4
CO−SCoA
CO−SCoA
E7
docosahexaenoic (DHA)
22:6 (4c,7c,10c,13c,16c,19c)
desaturation towards carboxyl terminus
docosapentaenoic (DPA)
22:5 (7c,10c,13c,16c,19c)

Ubichinoni, Plastochinoni, Vitamine E e K,

Chinoni terpenoidici: convergenza di due vie metaboliche



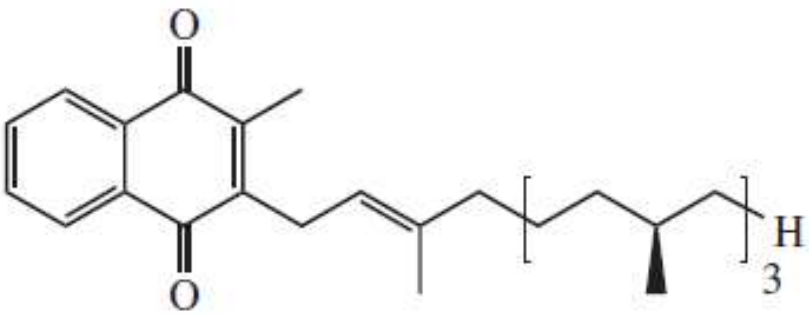
Ubichinoni



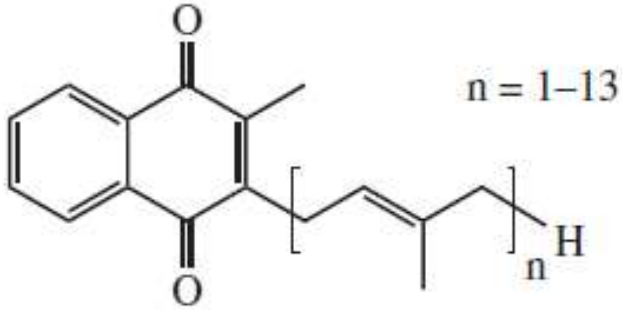
E1: chorismate lyase (UbiC)
E2: polyprenyl diphosphate synthase (Coq1, IspB)
E3: 4-hydroxybenzoate polyprenyltransferase (Coq2, UbiA)
E4: Coq3
E5: UbiD
E6: UbiB
E7: UbiG
E8: Coq6, UbiH
E9: Coq5, UbiE
E10: Coq7, UbiF

Coq: *Saccharomyces cerevisiae* (n = 6)
Ubi, Isp: *Escherichia coli* (n = 8)

Vitamina K (Koagulation factor)



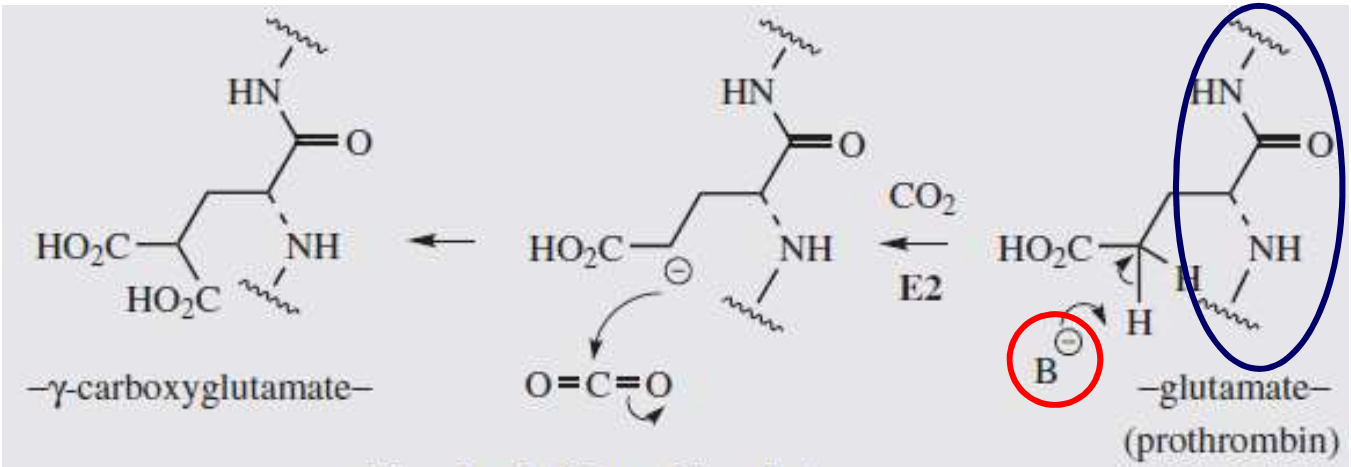
phylloquinone
(vitamin K_1; phytomenadione)



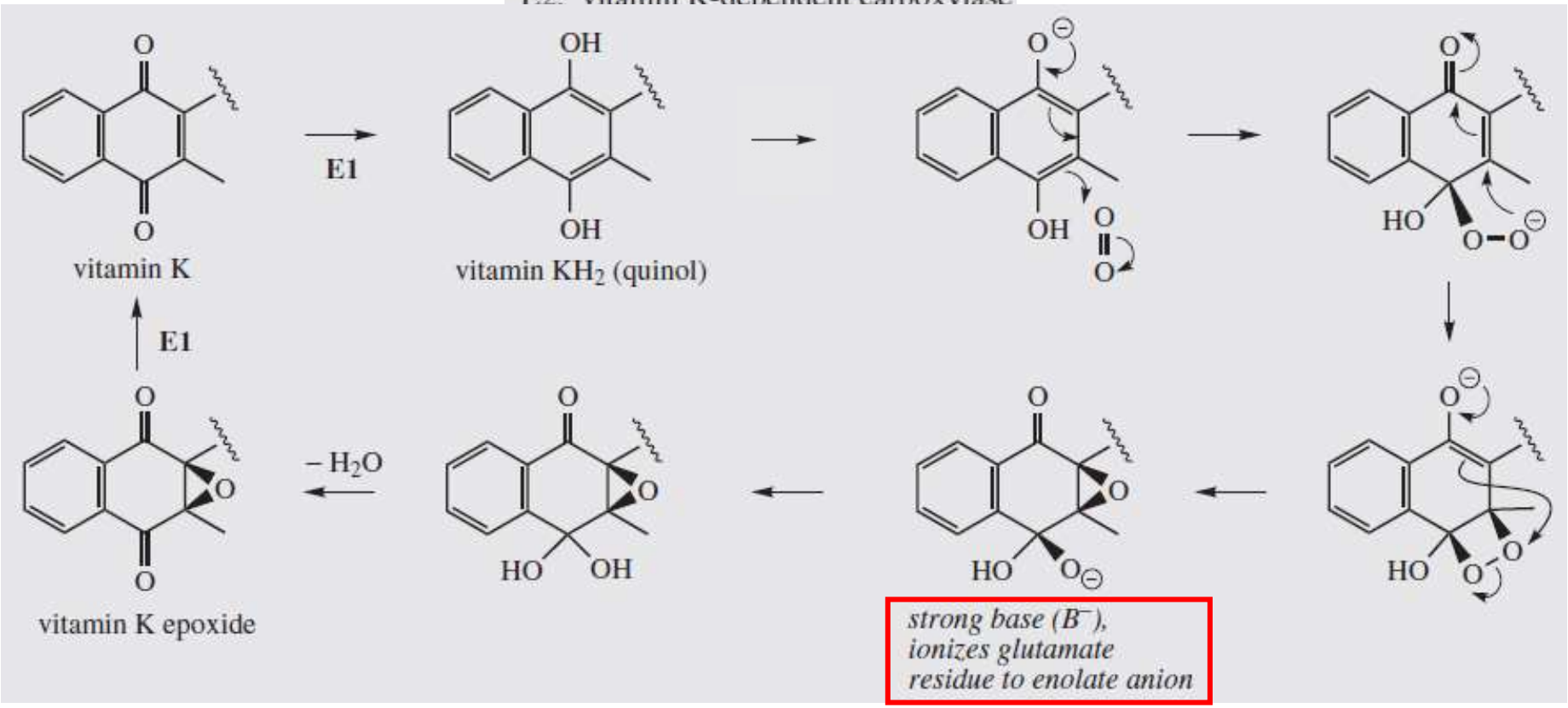
menaquinone-n
(vitamin K_2)

a significant amount of vitamin K_2 is produced by the intestinal microflora

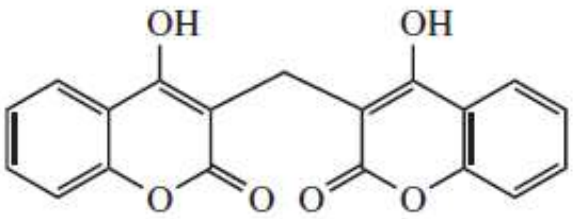
Vitamin K supplements are given routinely to newborn infants, since they initially lack the intestinal bacteria capable of producing the vitamin.



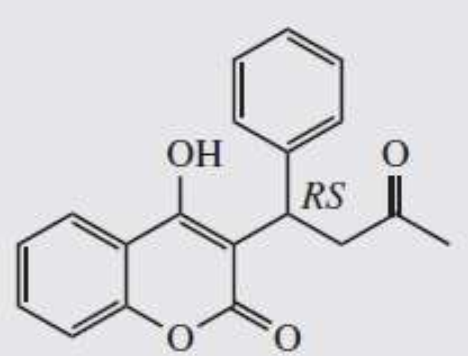
E1: vitamin K epoxide reductase
E2: vitamin K-dependent carboxylase



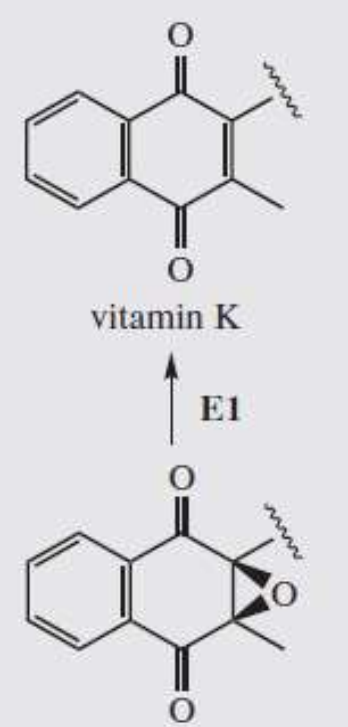
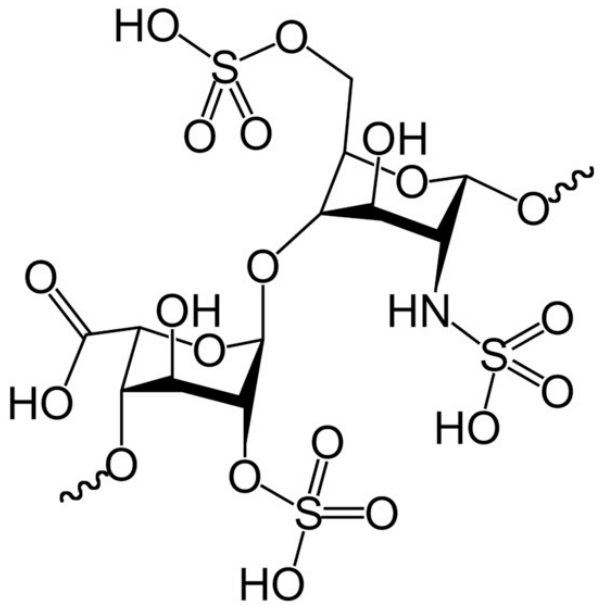
During the carboxylation, the reduced vitamin K is converted into an epoxide, and vitamin K is subsequently regenerated by reduction. The same protein is capable of reducing vitamin K to its quinol form. Anticoagulants such as dicoumarol and warfarin (see page 163) inhibit this reductase. In contrast, the polysaccharide anticoagulant heparin (see page 498) does not interfere with vitamin K metabolism, but acts by complexing with blood-clotting enzymes.



dicoumarol



warfarin



Heparin
(glycosaminoglycan)