I. THE ORIGIN OF NUTRIENTS

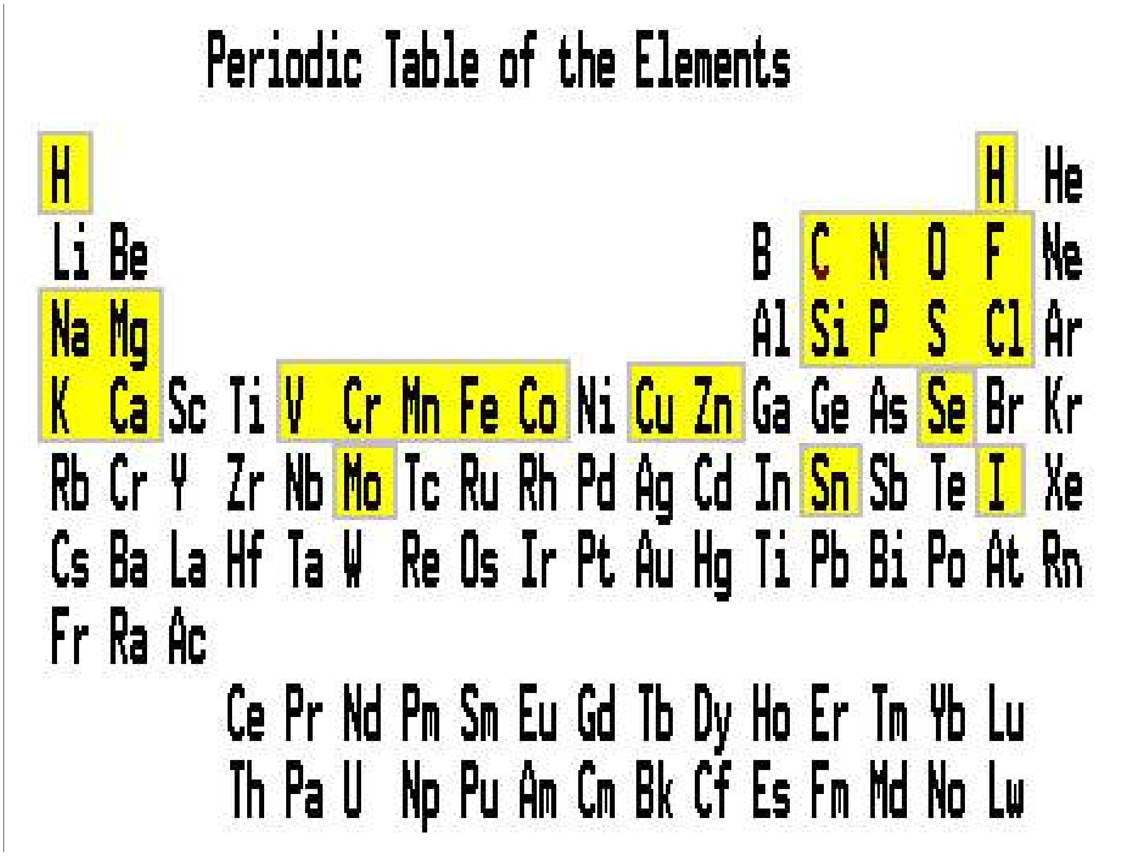
"If the Great Zuzu hadn't wanted people to eat people he wouldn't have made them out of meat!"

-Old Cannibal's Answer

A related *question*: Why do humans continue to eat animal source food? Is there some essential nutrient for humans synthesized only by animals?

The current list of nutrients for which human RDAs (Recommended Dietary Allowances) have been set includes essential amino acids, essential fatty acids, minerals and vitamins.

The minerals can be dismissed readily; they're all nuclear fusion products cooked in stars, and made neither by plants nor animals. In this abbreviated periodic table of the elements carbon (C), hydrogen (H), nitrogen (N), and oxygen (O) are the chief players in the game of life. On the next page are the other shaded players, their chemical symbols, chief metabolic functions and RDA ranges from infancy to adulthood, with most of the high numbers given for pregnancy[1].



[1] Leveille GA, Zabik ME, and Morgan KJ. *Nutrients in Foods*. The Nutrition Guild. Cambridge, 1983. ISBN 0-938550-00-4. pp I-11,14.

Twenty Essential Inorganic Nutrients[2]

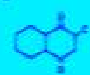
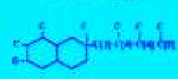
Name	Symbo	Function	RDA Range
Calcium	Ca	Bone, nerve regulation, cell membrane gates.	400-1200 mg
Chloride	Cl	Chief negative ion in blood, acid in stomach.	275-5100 mg
Chromium	Cr	Present in "Glucose tolerance factor."	.01-.2 mg
Cobalt	Co	Component of Vitamin B_{12}.	?
Copper	Cu	Constituent of oxidase enzymes.	.4-3 mg
Fluoride	F	Increases hardness of bones, teeth.	.1-4 mg
Iodine	I	Component of thyroid hormones.	40-200 µg
Iron	Fe	Component of hemoglobin, cytochromes.	6-15 mg
Magnesium	Mg	Bones. Enzyme co-factor.	40-400 mg
Manganese	Mn	Enzyme cofactor. Glycoprotein synthesis.	.3-5 mg
Molybdenum	Mo	Constituent of oxidase enzymes.	15-250 µg
Phosphorus	P	Bone, ATP, nucleic acids, phosphate in blood.	300-1200 mg
Potassium	K	Chief positive intracellular ion. Nerve function.	350-5625 mg
Selenium	Se	Acts with vitamin E as anti-oxidant.	10-75 µg
Silicon	Si	Bone development in some species.	?
Sodium	Na	Chief positive extracellular ion. Nerve function.	115-3300 mg
Sulfur	S	Component of sulfur amino acids. Cartilage.	?
Tin	Sn	Traces essential in rats. Function unknown.	?
Vanadium	V	Traces essential in lower plants, rats.	?
Zinc	Zn	Cofactor of many enzymes. Prostatic fluid.	5-19 mg

[2] Murray RK, Granner DK, Mayes PA, and Rodwell VW. *Harper's Biochemistry.* Appleton and Lange. Norwalk, CT 1990. ISBN 0-8385-3640-9.pp 576, 578.

The remaining nutrients are organically synthesized in chemical pathways which have developed during the 3-1/2 billion years of biological evolution on Earth[3].

Below are organic nutrients with functions, origins, RDA ranges, and abbreviated structural formulas which omit hydrogen atoms and bonding angles for clarity.

Essential Organic Nutrients

Name	Alternate	Structure*	Major Functions	Original Synthesis by:	RDA Range
Ascorbic Acid*	Vitamin C		Antioxidant, collagen	Plants, most animals	35-60 mg
Biotin			A carboxylase coenzyme	Intestinal Bacteria	.15-.5 mg
β- Carotene*	Vitamin A		Skin, vision	Chloroplasts (in leaves)	1500-8000 IU
Folic Acid			Nucleoprotein synthesis	Plants, bacteria	.1-.8 mg
Menadione	Vitamin K		Blood clotting	Plants, intestinal bacteria	5-65 μg
Niacin*	Vitamin B_3		Redox protein carrier	Plants, animals	5-20 mg
Pantothenic Acid			Forms coenzyme A	Yeast, bacteria, plants	3-10 mg
Pyridoxine	Vitamin B_6		Amino acid metabolism	Microorganisms, plants	.2-.7 mg
Riboflavin	Vitamin B_2		Redox coenzyme	Microorganisms, plants	.6-2 mg
Thiamine	Vitamin B_1		Carbohydrate coenzyme	Microorganisms, plants	.5-1.7 mg
α-Tocopherol	Vitamin E		Antioxidant (with Selenium)	Plants	5-30 IU

Unless so stated carbon atoms occupy the corners of the ring structures and the ends of lines. Most of the nutrients are coenzymes (the active part of an enzyme that the body cannot make) involved in energy transactions. The three with asterisks require exposition in light of the following definition:

"Vitamins are organic molecules in food that are required for normal metabolism but cannot be synthesized in adequate amounts by the human body."[4]

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[3] Scientific American. *Evolution.* ISSN 0036-8733 1978;239(3):54.

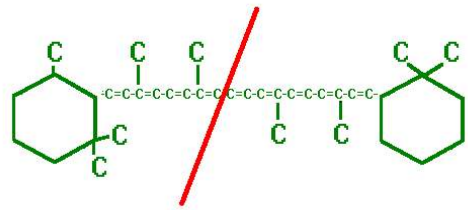
[4] Martin DW, Mayes PA, Rodwell VW, and Granner DK. *Harper's Review of Biochemistry.* Lange Medical Publications. Los Altos, CA 1985. ISBN 0-87041-038-5. p 673.

*Ascorbic Acid (Vitamin C) is an antioxidant also involved in amino acid metabolism, maintenance of blood vessel integrity, and the synthesis of collagen and adrenal hormones. Plants and most animals can synthesize vitamin C, but prehumans and other primates probably lost the ability 25 million years ago as a result of a mutation which was non-lethal and in fact adaptive since ascorbic acid was a plentiful component of the arboreal diet[5].

*β-Carotene is usually called pro-vitamin A and retinol is called "Vitamin A". I believe this is an error on the part of the nutritional establishment. Two molecules of retinol, an essential hormone-like metabolite required for skin, vision, and reproduction[6], are formed in the body by enzymatically splitting one molecule of β-Carotene, a photosynthetic[7] plant pigment [8] interacting with chlorophyll and found in green leafy vegetables.

This being so retinol fails the definition of vitamin. β-carotene should be called the true Vitamin A. It is synthesized only by plants. Retinol is synthesized only by animals[9], but there can be no retinol in the animal kingdom unless somewhere in the food chain there is an animal eating plant β-Carotene.

Analogously, consider riboflavin, vitamin B_2, metabolized after absorption to a flavoprotein, an important enzyme in oxidation-reduction reactions[10]. Correctly, riboflavin is identified as a vitamin, the flavoprotein made from it is not.



B-Carotene

Strangely, the US Hospital Formulary refers to β-carotene as a drug and retinol as a vitamin[11] an exact inversion of the reality. β-Carotene is also an anti-oxidant and protective against several forms of cancer. Except for yellowing of the skin it is non-toxic.

By contrast retinol is toxic when taken in excess and retinol supplements alone may increase the risk of esophageal cancer[12]. About 10 cases of "vitamin A" toxicity are reported yearly, usually in people who have taken an excess of retinol[13], in what they believe to be harmless vitamin pills.

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[5] Note 3. p 158.

[6] Note 2. p 563.

[7] Goodwin and Mercer. *Introduction to Plant Biochemistry.* Pergamon Press. Oxford, 1983. ISBN 0-08-024921-3. p 118.

[8] *ibid*. p 92.

[9] Van Nostrand Reinhold Co. *Van Nostrand's Scientific Encyclopedia.* New York, 1968. p 441.

[10] Note 2. p 548.

[11] American Society of Hospital Pharmacists. *American Hospital Formulary Service.* Bethesda, 1990. ISBN 0-930530-96-9. pp 2036-7.

[12] Graham S, Marshall J, Haughey B, et al. *Nutritional epidemiology of cancer of the esophagus.* Am J Epidemiol. ISSN 0002-9262. 1990;131(3):454-67.

[13] Bendich A, Langseth L. *Safety of vitamin A*. Am J Clin Nutr. ISSN 0002-9165. 1989;49(2):358-71.

*Niacin (formerly vitamin B_3) is a proton carrier in oxidation/reduction reactions[14]. Niacin is synthesized by both animals and plants. It also fails the definition of vitamin since in humans, 60 mg of left-over dietary tryptophan, an essential amino acid, can be used to synthesize 1 mg of niacin[15].

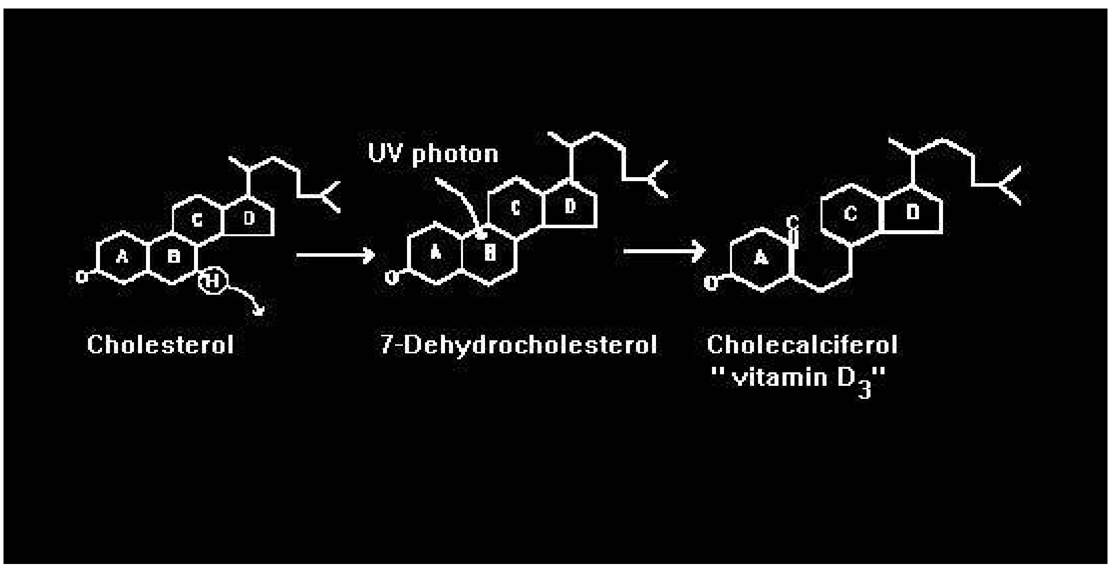
All the rest of the nutrients in the table are synthesized by microorganisms and plants, not animals[16].

Calciferol ("Vitamin D") was intentionally omitted from the table. It is now 35 years since W.F Loomis, writing in the *Scientific American*[17] explained the series of historical errors which led to the term "vitamin D". The substance in question does not look like a vitamin nor act like a vitamin, does look like a hormone and act like a hormone, and like a hormone is made in the body. Thus by definition it is *not* a vitamin and its continued misclassification as a vitamin is an indictment of the nutritional establishment's inertia and inability to correct its basic errors.

Loomis in brief: rickets, a deforming childhood bone disease reached epidemic proportions in 19th century England. It was found that a substance in cod liver oil could treat and prevent rickets and this was isolated and christened "vitamin D". Meanwhile the British Medical Association had mapped out the distribution of rickets and found it peaked in cities like Birmingham, London, and Manchester, all shrouded by a thick pall of coal smoke from the industrial revolution. When they put the kids out in the country sunlight they got over their rickets.

SYNTHESIS OF CALCIFEROL.

By enzymatic means a hydrogen atom is removed from the #7 position in the B ring of cholesterol which is thus destabilized. When it is moved to the skin and struck by a photon of ultra-violet light the B ring opens up to form cholecalciferol:



[14] Loomis, W.F. *Four Billion Years.* Sinauer Associates. Sunderland, Mass. 1988. ISBN 0-87893-476-6. p 35.

[15] Note 2. p 551.

[16] Lindner M. *Nutritional Biochemistry and Metabolism*. Elsevier Science Publishing Co. New York, 1985. ISBN 0-444-01241-9. pp 70-71.

[17] Loomis W. *Rickets*. Scientific American. *Human Nutrition*. W.H. Freeman. San Francisco, 1978. ISBN 0-7167-0183-9. p 193.

This is further modified enzymatically in the liver and kidney to become calcitriol, one of a triad of potent calcium regulating hormones (calcitonin and parathyroid hormone are the other two) synthesized in the body and expressly designed to "bypass the vagaries of dietary calcium."

Ergosterol, a molecule similar to cholecalciferol, is synthesized by yeast and used to be added to cow's milk, which in its fresh-from-the-teat condition contains only 5-45 IU calciferol/quart. (Human milk has about 60 IU/quart and colostrum 150 IU/quart[18]). Macrobiotic and Black vegan children living in northern climates, whose skin pigment protects them from *excess* ultra-violet radiation, are at risk for rickets[19] without calciferol supplements. Hence there are legitimate grounds for recommending this hormone to selected population groups.

However, 400 IU calciferol/quart is added to milk even in Hawaii, although a search of the Hawaii Medical Journal back to the inaugural issue in 1856 failed to disclose a single reported case of rickets. Under ordinary exposure to sunlight (estimated at 30 minutes per week during the month of June, longer in winter months) humans synthesize adequate calciferol.

The RDA for "vitamin D" (calciferol) is 400 IU/day. Toxicity in infants has been reported at 2000 IU/day and in adults at 50,000 IU/day[20]. Abnormal (ectopic) tissue calcifications form in rabbits fed 2 mg/day[21] (no other vitamin is toxic in a dosage of 2 mg) and in rats fed 10,000 IU/day[22]. Since the cause of ectopic calcification (phleboliths, Mönckeberg's medial sclerosis, calcific tendinitis) in humans is not known, it might be a good idea to stop giving calciferol to *everybody* until we find out.

An analogy here would be to cortisol, a necessary sterol hormone replacement for patients with Addison's disease who are unable to synthesize their own. We do not call cortisol "Vitamin C" because a small minority require it. Neither should we call calciferol a vitamin on the same grounds. Both are toxic when taken in excess or by people who don't need them.

There is no question that "Vitamin D" cow's milk put an end to rickets in the U.S. Irradiated ergosterol added to any common food would have done the same but the chief selling point of cow's milk is its calcium content so the addition of calciferol to milk was not only logical but financially rewarding to the dairy industry. I am old enough to recall the advertising blitz which hit my elementary school in St. Paul, Minnesota in the 1930's when "Vitamin D" milk came in.

About 10 cases of "vitamin D" toxicity are also reported yearly in the U.S. and the most recent investigators[23] traced their cases to a dairy which not only used the wrong form of "vitamin D" but used it in doses ranging from zero to 500 times too much. In case a vegan feels a need to take this substance, the second highest source in the USDA database is Shiitake mushrooms (D2) coming in at 1660 IU/100gm just below cod liver oil with 10,000 IU/100gm (D3).

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[18] Cantarow AC, and Schepartz BS. *Biochemistry.* W.B. Saunders. Philadelphia 1957. LOCCC 57-11267. p 152.

[19] Jacobs C, and Dwyer T. *Vegetarian children: appropriate and inappropriate diets.* First International Congress on Vegetarian Nutrition. Am J Clin Nutr. 1988;48(3):811.

[20] Encyclopedia Britannica, Inc. *Encyclopedia Britannica.* Chicago, 1974. ISBN 0-85229-290-2. Vol. X, p 470.

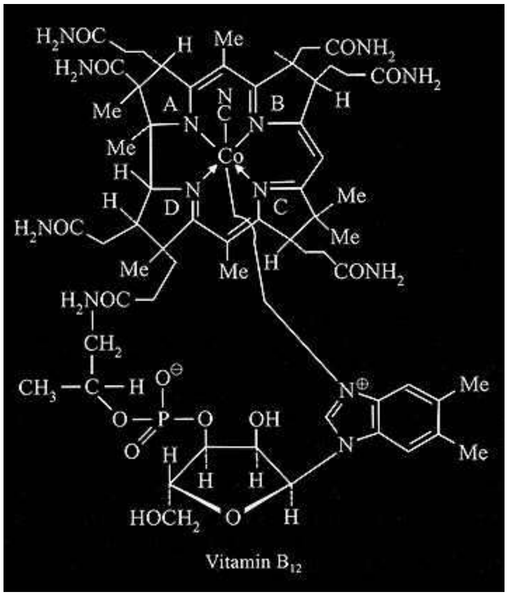
[21] Smith M, and Elvove E. *The Action of Irradiated Ergosterol in the Rabbit*. Public Health Reports. 1929;44(21):1248.

[22] Kingma J, Roy P. *Ultrastuctural Study of Hypervitaminosis D Induced Arterial Calcification in Wistar Rats.* Artery 1988;16(1):51-61.

[23] Jacobus C, Holick M, et al. *Hypervitaminosis D Associated with Drinking Milk.* NEJM. 1992;326(18):1173-77.

"Vitamin D" fails the definition of vitamin whether from plant or animal sources. And science fails when language is distorted by special interest.

Vitamin B_{12}:



Vitamin B_{12}

This large complex molecule acts with folic acid in the production of genetic nucleoproteins[24]. It is synthesized only by bacteria, including intestinal bacteria, The absorption and transport of vitamin B_{12} requires several binding proteins, including "intrinsic factor" secreted by the stomach.

Studies of unsupplemented British vegans in the 1960's showed that while they had lower mean B_{12} levels than omnivores only one out of seven had a true deficit (30 pg/ml)[25]. Were they eating dirt or had their bacteria recolonized high enough into their small intestines so the B_{12} could be absorbed? B_{12} analogues in tempeh and spirulina are thought to be inactive[26]. Some brands of yeast have B_{12} added but B_{12} ("cobalamin") supplementation, should be considered by all strict vegetarians (vegans), at least until the scientific dust settles.

ESSENTIAL FATTY ACIDS:

There are two essential fatty acids in the human diet:

Linoleic acid, found in plant cell membranes[27] and seeds:

C-C-C-C-C-C=C-C-C=C-C-C-C-C-C-C-C-COO-

And α-linolenic acid synthesized only in the chloroplasts of green plants and microorganisms[28]:

C-C-C=C-C-C=C-C-C=C-C-C-C-C-C-C-C-COO-

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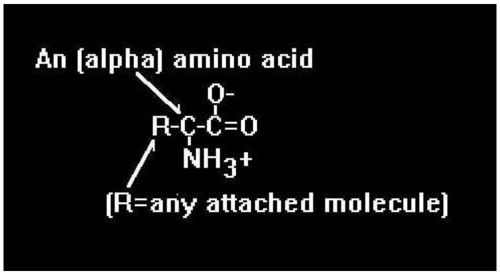
[24] Note 2. p 557.

[25] Ellis, F.R. and Montegriffo, V.M.E. *Veganism, Clinical Findings and Investigations.* Am J Clin Nut 1970;23(3):250.

[26] Herbert VL. *Vitamin B12:Plant Sources,Requirements, and Assay.* First International Congress on Vegetarian Nutrition. Am J Clin Nutr. ISSN 0002-9165. 1988;48(3):857.

[27] Salisbury F, Ross C. *Plant Physiology.* Wadsworth Publishing Co. Belmont 1985. ISBN 0-534-04482-4. p 269.

[28] Simopoulos A. *Omega-3 fatty acids in health and disease and in growth and development.* Am J Clin Nutr 1991;54:446. ISSN 0002 9165. p 446.

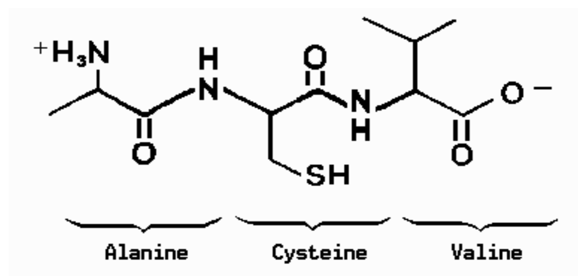


Amino acids were among the earliest organic molecules on earth. Given a primitive environment four billion years ago which included hydrogen, water vapor, ammonia, and methane, a random lightning bolt could assemble amino acids in a hurry[29]. Such high energy transactions aren't appreciated by biological systems however, so they synthesize amino acids in low energy reactions which are catalyzed by enzymes and which don't knock over the furniture.

Hundreds of amino acids exist in nature[30], more can be synthesized in the laboratory, but only about 36 are used in higher animals and only 20 of those are involved in protein metabolism[31] Way back in the beginning the amino isomers which rotated polarized light to the left rather than the right got the Darwinian nod and were permanently locked into evolution so they're called levorotatory (L)-aminos. They also have an amine group (NH2) and a carboxylic acid group (COOH) hooked to the same (alpha) carbon atom so they're called L-α-(alpha)-aminos. A polymer is a string of identical molecules daisy-chained together by chemical bonds. A copolymer is a string of similar but not identical molecules. Proteins are copolymers of the 20 L-α-amino acids.

A variety of side chains hang off the alpha carbon so protein is a long string of similar but not identical α-amino acids linked by NH2-COOH bonds. Proteins form a wide variety of enzymes and cellular structures, and act in the transfer of molecular information.

Shown below is a short length of protein, a tri-peptide copolymer composed of alanine, cysteine, and valine.



Some life forms (plants, many bacteria) can form all 20 protein amino acids from carbon, hydrogen, nitrogen, oxygen, and sulfur. Essential amino acids are those which can't be synthesized by animals and humans; their number ranges from eight to eleven, depending on the reference book. In spite of different structures the essential aminos require an average of 6 enzymes for synthesis while the non-essential aminos only require one or two. In the parsimony of nature, animals are plant predators. The plants have enough enzymes to make the essential aminos so those animals which continue to make their own are using up matter and energy to make something they can more easily eat. The survival value is negative rather than nil so these animals are selected out, leaving only animals that depend on the essential (plant synthesized) amino acids[32].

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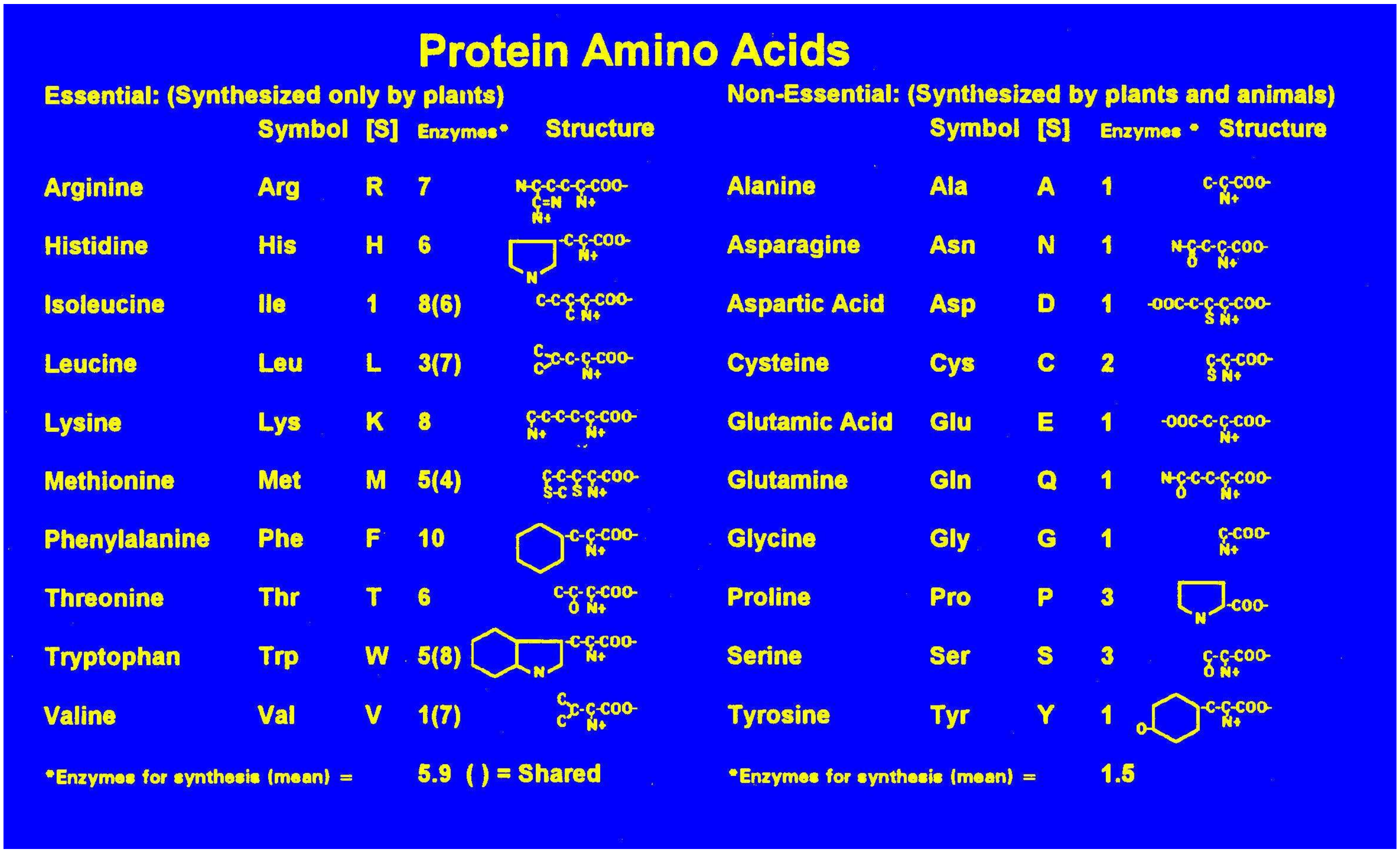
[29] Random House. *Random House Encyclopedia*. New York, 1977 ISBN 0-394-40730-X p 406

[30] Van Nostrand Reinhold Co. *Van Nostrand's Scientific Encyclopedia.* New York, 196 p 113

[31] Murray RK, Granner DK, Mayes PA, and Rodwell VW. *Harper's Biochemistry.* Appleton and Lange. Norwalk, CT 1990 ISBN 0-8385-3640-9 pp 25-27

[32] Note 6. p 276.

Below are the twenty protein amino acids with their abbreviated structural formulas and the number of enzymes needed for synthesis. The COO- of any one can be linked to the N+ of any other so the possible combinations are extensive.



Protein Amino Acids

Essential: (Synthesized only by plants)	Symbol	[S]	Enzymes*	Non-Essential: (Synthesized by plants and animals)	Symbol	[S]	Enzymes*
Arginine	Arg	R	7	Alanine	Ala	A	1
Histidine	His	H	6	Asparagine	Asn	N	1
Isoleucine	Ile	I	8(6)	Aspartic Acid	Asp	D	1
Leucine	Leu	L	3(7)	Cysteine	Cys	C	2
Lysine	Lys	K	8	Glutamic Acid	Glu	E	1
Methionine	Met	M	5(4)	Glutamine	Gln	Q	1
Phenylalanine	Phe	F	10	Glycine	Gly	G	1
Threonine	Thr	T	6	Proline	Pro	P	3
Tryptophan	Trp	W	5(8)	Serine	Ser	S	3
Valine	Val	V	1(7)	Tyrosine	Tyr	Y	1
*Enzymes for synthesis (mean) =			5.9 ( ) = Shared	*Enzymes for synthesis (mean) =			1.5

From the above it can be concluded that none of the nutrients essential to humans are synthesized by animals. Short cuts would have arrived at the same point: Essential amino and fatty acids are essential simply because animals cannot synthesize them hence must obtain them from the plants that do. Vitamins are organic molecules necessary in the diet of humans, but most of the same molecules are necessary in the diet of other animals too so those animals cannot synthesize them either and must also obtain them from plants. It thus follows that essential nutrients obtained from animal foods all originated in the plant kingdom. Hence animal source food amounts to second hand nutrition, and the only unique ingredients in animal source food are cholesterol and saturated fat, both harmful to human health.

If we were cats it would be different. Cats have been on a carnivorous track for as long as there have been cats so they've lost the ability to synthesize arachidonic acid, carnitine, niacin, retinol, and taurine, which they get by eating other animals. But we're not cats.

There is no teleology implied here; no benevolent nature is creating plant foods to suit the dietary requirements of man. Rather, early primates adapted their metabolism to the only game in town, the plants, and humans evolved from them. Animals are plant predators, appropriating nutrients the plants made for their own use. Animals thus free themselves of the need to maintain primordial biosynthetic pathways. That some humans prey on other animals as well reflects feeding strategy, not biochemistry.

All life depends on photosynthesis, the business of plant leaves, and plant leaves are still the best nutritional bargain for humans.