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I. Nutrition concepts

I.1. Nutrition

Nutrition is the set of metabolic reactions by which our body transforms and uses food to obtain everything it needs to function and maintain life properly.
According to the WHO/FAO (2003), nutrition is the food intake that meets the body's needs. *Good nutrition* is a suitable and balanced diet that guarantees good health.
Nutrition can also be defined as a science that studies the multiple relationships between human beings and food. It concerns many scientific disciplines and is particularly interested in the biological processes surrounding the use of nutrients, the nutritional needs of populations, the study of eating behaviors, and agri-food production.

I.2. Foods and nutrients:

Food is a complex natural substance that contains basic elements called **nutrients** (at least two nutrients). Humans consume these substances, which are necessary for the proper functioning of their bodies (staying alive, moving, working, building new cells and tissues for growth, resistance, and fighting infections).
It is ***digestion*** (mechanical and chemical transformation) which will transform these foods into assimilable nutrients (which can pass into the blood) in the small intestine, and provide the energy necessary for all cells of the body for their functioning.
For this purpose, ***nutrients*** are defined as chemical substances resulting from the transformation of food in the body.

I.3. Food composition

Food composition refers to the content of water, nutrients, and other compounds found in food. The essential nutrients for health are macronutrients and micronutrients.

I.3.1. Water

Water is present in varying quantities in foods. Green vegetables can contain up to 95%, and meat contains, on average, 50 to 70%. To this end, food covers a significant part of water intake.

I.3.2. Macronutrients

These are the essential nutrients required in large quantities for the proper functioning of the body. They make up approximately 98% of our foods, along with water. These nutrients include carbohydrates, proteins, and lipids

.I.3.2.1. Carbohydrates

These are carbohydrates, the main source of energy for our body. Foods high in carbohydrates include fruits, vegetables, grains, bread, pasta, and legumes.
There are two types of carbohydrates: simple (fast) carbohydrates and complex (slow) carbohydrates, including dietary fiber:

- *Simple carbohydrates* are mainly present in the diet in the form of glucose, fructose (in fruits), lactose (in milk), and sucrose (powdered sugar) and are assimilated very quickly by the body. When the body urgently needs fuel, it calls on these simple sugars;
- *Complex carbohydrates* are also preferred to enable a balanced diet. They are the primary source of energy for the body, providing a slow release of energy to build up reserves for the day, unlike

simple carbohydrates. In addition, ***dietary fibers*** are more or less long-chain polysaccharides that humans cannot digest. Foods of plant origin (fruits, vegetables, whole grains, legumes, etc.) contain dietary fiber while those of animal origin do not.

I.3.2.2. Lipids

Lipids are also an important source of energy for our body. Foods high in fat include oils, nuts, seeds, butter, and fatty meats.
Lipids are fats that are found in food in two forms:

- ***glycerides*** (mono, di, and triglycerides) which essentially have an energy role;
- ***Phospholipids*** which have a physiological role in cell membranes;
- There is another family of lipids, ***the sterols*** in which we find cholesterol. They are also the essential components of certain hormones (steroids).

Glycerides and phospholipids contain fatty acids. Depending on their chemical structure, we distinguish:

- ***saturated fatty acids*** which are mainly of animal origin;
- and ***unsaturated fatty acids*** (monounsaturated and polyunsaturated).

Among ***the unsaturated*** fatty acids, we find two essential fatty acids for humans: linoleic acid (C18:2n-6) and α-linolenic acid (C18:3n-3). They are considered essential because the body is unable to synthesize them, and they must be obtained through food..

<u>Family of ω6 with linoleic acid (C18 - 2 ω6):</u>

CH_3-$(CH_2)_4$-CH = CH-CH_2-CH = CH-$(CH_2)_7$-COOH is the precursor of long-chain fatty acids:

- γ-linolenic acid (C18:3ω6);
- Arachidonic acid (C20:4ω6);
- Docosapentaenoic acid (C22:5ω6).

<u>Family of ω3 with linolenic acid (C18:3ω3):</u>

CH_3-CH_2-CH = CH-CH_2-CH = CH-CH_2-CH = CH-$(CH_2)_7$-COOH is the precursor of lo
fatty acids:

- Eicosapentaenoic acid (EPA) (C20:5ω3);
- Docosahexaenoic acid (DHA) (C22:6ω3).

I.3.2.3. Proteins

Proteins are very large molecules formed by a succession of amino acids linked together by peptide bonds. They are the main components of all cells and molecules of the human body (organs, hormones, enzymes, neurotransmitters, antibodies, etc.) and are involved in many physiological processes such as the immune response, oxygen transport, or even digestion.
Protein-rich foods include meat, fish, eggs, dairy, legumes and nuts.
There are thousands of different proteins but only twenty amino acids in the entire living world. Among these twenty amino acids, eight cannot be synthesized by the body (***essential amino acids***) and must be provided through food: ***methionine, lysine, tryptophan, threonine, phenylalanine, isoleucine, valine and leucine***. Histidine and arginine are conditionally indispensable. Cysteine and tyrosine can decrease the need for methionine and phenylalanine.

I.3.3. Micronutrients

These are the substances which are necessary in small quantities for the proper functioning of the body (they only represent 2% of our foods): vitamins, mineral salts and trace elements. These micronutrients do not provide energy but are essential for the proper assimilation, proper transformation and proper use of macronutrients. Micronutrients cannot be produced by the body and must be provided through a varied, balanced and good quality diet.

I.3.3.1. Vitamins

Vitamins are organic substances necessary for the body, present in very small quantities. Foods rich in vitamins include fruits, vegetables, dairy products, meats and grains.

Vitamins are divided into 2 families:

- *Lipid-soluble vitamins* which are soluble in fats and which the body can store: A, D, E, K;

- *Water-soluble vitamins* which are soluble in water (Vit. C and group B vitamins) and are not stored in the body (with the exception of B_{12}). Their intake must therefore be ensured daily through our diet (Table 1).

Table 1: Food sources of different vitamins

Name		Food sources
Water soluble		
B_1	Thiamine	Cereals, yeasts, meats, offal
B2	Riboflavin	yeasts, meats, offal, cheese
B_3/PP	Niacin	Yeast, liver, peanuts
B5	Ac. Panthotenic	eggs, meats, yeast
B_6	Pyridoxyne	Yeasts, liver, eggs, milk
B_8/H	Biotin	Offal, eggs, yeast
B9	Ac. Folic	Miscellaneous foods (vegetables, offal)
B_{12}	Cobalamin	Meats, liver, fermented products
VS	Ac. Ascorbic	Fruits and vegetables
Fat-soluble		
HAS	Retinol	Butter, liver, fish, carrots
D	Calciferol	Fish oils, milk
E	Tocopherol	Vegetal oils
K	Phytomenadione	Green vegetables (cabbage, spinach)
	Phylloquinone	Synthesis by bacteria in the digestive tract

I.3.3.2. Minerals

Minerals are inorganic substances that are also essential for life but do not constitute an energy source. Mineral-rich foods include fruits, vegetables, dairy products, meats and grains (Table 2 and 3).

Depending on the order of magnitude of their concentration in the human body, mineral elements are divided into two large families:

- macroelements (or major mineral elements):

They are present in the body with a concentration of at least 0.1 g/kg of body weight and require a daily intake of around 1 mg/kg/day.

These are mainly: calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), phosphorus (P) and sulfur (S).

Table 2: Food sources of the main mineral elements

Mineral elements	Food sources
Calcium (Ca)	Milk and dairy products, egg yolk, dried vegetables
Sodium (Na)	Cooking salt, eggs, meats, canned goods, mineral water, milk, fish
Potassium (K)	Fruits (banana), vegetables, dried fruits, fish, meat, chocolate
Magnesium (Mg)	Chocolate, pulses, seafood, fruits
Phosphorus (P)	Virtually present in all foods, including milk, dairy products, egg yolk, bread and pulses.

- Trace elements:

They are present in the body with a concentration less than or equal to 1 mg/kg of body weight. According to the WHO, 14 trace elements are essential for life: Iron (Fe), Zinc (Zn), Copper (Cu), Selenium (Se), Iodine (I), Silicon (Si), Tin (Sn), Nickel (Ni), Fluorine (F), Manganese (Mn), Vanadium (V), Molybdenum (Mo), Chromium (Cr), Cobalt (Co).

Table 3: Food sources of the main trace elements

Name	Food sources
Iron (Fe)	Heme iron (Offal, liver, red meat, egg yolk), shellfish, well absorbed Non-heme iron (fruits, dried vegetables, chocolate): bioavailability 5x lower (Absorption inhibited by fibers, phytates, tannins, etc.).
Chromium (Cr)	Watercress, mushrooms, seafood, offal, whole eggs, brewer's yeast.
Cobalt (Co)	Veal, offal, tomatoes, cabbage, lentils, oilseeds, dried fruits, seafood, carrots, wheat, plums.
Fluorine (F)	Mineral water, tea, carrots, grapes, wheat, fish, cabbage, spinach.
Iodine (I)	All seafood products, green vegetables, prunes, garlic, pineapples, bananas.
Selenium (Se)	Brewer's yeast, wheat germ, herring, offal, onions, garlic.

Besides water and oxygen, our foods must provide eight amino acids, two fatty acids, nine water-soluble vitamins, four fat-soluble vitamins, and ten mineral elements. Our body cannot produce them, we must find them in our diet.

I.4. Energetic value:

The energy value of a food corresponds to its caloric intake, that is, the quantity of energy that can be extracted from it and supplied to the body. It is expressed in kilocalories (kcal) or kilojoules (kJ).
To measure the energy value of glucose, we place it in **a calorimeter** (Figure 1) and then burn it to measure the heat released during the following reaction:

$$C_6H_{12}O_6 + 6O_2 \dashrightarrow 6CO_2 + 6H_2O + \text{heat.}$$

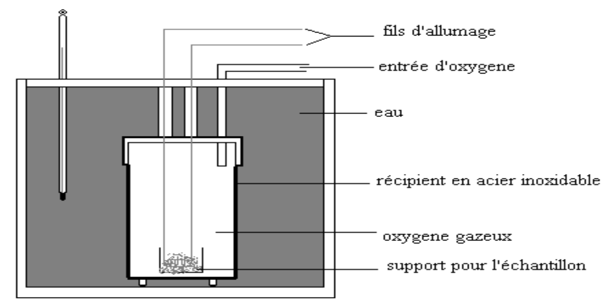


Figure 1: Calorimeter for measuring the energy value of foods

This oxidation reaction completely releases the energy contained in the glucose molecule; the reaction products (H_2O and CO_2) have zero energy.
In this equation, a molecule of glucose with a molar mass (180 g/mol) releases 2860 Kj.
Therefore: 1 gram of glucose gives 2860/180 = ~ 17 kJ.

By doing the same with proteins and lipids, we arrive at the following values:

1 g of carbohydrates 17 kJ 4 kcal.

1 g of proteins 17 kJ 4 kcal.

1 g of lipids 38 kJ 9 kcal

The international unit of mechanical energy is the Joule (1 kc al = 4.18 k J).

I.5. Calories:

The Calorie is the unit of measurement of the energy value of foods. It is defined as the quantity of heat (energy) necessary to raise the temperature of 1 gram of liquid water by 1° Celsius from 14.5°C to 15.5°C under one atmosphere pressure.

II. The major food groups and their constituents

Foods typically originate from natural sources, including plants, animals, and minerals, and can be consumed raw or after undergoing various culinary or industrial processing. No single food contains all the nutrients our body needs except breast milk for babies up to 6 months of age. Each food group provides specific nutrients, so eating a balanced and varied diet is essential for good health.

Foods are divided into three groups:

- Energy foods;
- Protein foods;
- Hydromineral and vitamin foods.

II.1. Energy foods

Foods containing complex carbohydrates or lipids are energetically rich and provide proteins, vitamins, and minerals.

Energy-rich foods are:

- Cereals and derivatives;
- Sweet products;
- tuberous roots (carrots, beets);
- dried vegetables (peas, beans, lentils);
- certain fruits rich in starch (Banana);
- fatty substances (oils and fats).

II.1.1. Cereals and derivatives

Cereals are species generally cultivated for their grain, whose starchy endosperm, reduced to flour, is edible by humans or domestic animals. Most cereals belong to the *Gramineae* (or *Poaceae*) family. These are wheat, barley, oats, rye, corn, rice, millet, and sorghum:

Generally, four diverse groups of foods prepared from cereal grains are:

- Bakery products, made from flour or semolina (breads, pastries, pancakes, biscuits, and cakes);
- Cereals reduced to flour or semolina;
- Drinks made from fermented grain products and from boiled and roasted grains;
- Whole grain products (oatmeal, brown rice, popcorn, shredded grains, and breakfast puffs.

All cereal grains have high energy values (starch, lipid, and protein). Whole grains are a source of dietary fiber, vitamins, minerals, and antioxidant compounds.

Compared to refined products, whole products contain more complex carbohydrates and fewer simple carbohydrates. Other constituents of interest in cereals are magnesium and antioxidants (vitamin E, phytic acid, and selenium), which can help reduce the risk of cardiovascular disease. Furthermore, the bran of whole grains is rich in fiber. There are two types of fibers. Insoluble fibers which, by water absorption, will increase the food bolus and accelerate transit, thus fighting against constipation. And soluble fibers which reduce cholesterol, particularly LDL cholesterol.

II.1.2. Sweet products

Sugars are found naturally in many foods, such as fruit (fructose) and milk (lactose). Added sugars are those that are incorporated into foods and drinks during their manufacturing or preparation. These added sugars include sucrose (table sugar), high fructose corn syrup, honey, maple syrup, and other sweeteners. It is a quickly usable source of energy.

Sweet products include a variety of foods and beverages, such as soft drinks, sweetened fruit juices, pastries, candies, sweetened breakfast cereals, cakes, and cookies. These products can be high in calories and added sugars while providing a few essential nutrients.

II.1.2. Fat body

In food, we distinguish between visible fatty substances (oils, margarine, butter, fats), and invisible fatty substances (meat, fish, cheese).
They are subdivided according to their origins into fatty substances of vegetable origin (oils), of animal origin (butter and fat), and processed fatty substances (margarine).

II.2. Protein foods

(Building and restorative foods)

The nutritional qualities of these foods are important because they also provide vitamins and mineral elements (iron, calcium, phosphorus, zinc, copper, vitamin B_{12}, etc.).
Foods rich in protein are:

- Foods of animal origin (meat, fish, eggs, milk, cheese, etc.);
- Foods of plant origin (legumes, cereals, etc.).

II.2.1. Meats and fish

Meat is generally defined as all the muscle tissues of animals, mainly from farms intended for human food. There are different types of meats, including:

- *Red meat:* The source of this product is generally mammals such as beef, sheep, and pork. These meats tend to be higher in fat than white meats.
- *White meat:* It comes from poultry, such as chicken and turkey. White meats tend to be leaner than red meats.
- *Game meat:* It comes from hunted wild animals, such as deer, wild boar, or wild duck.
- *Processed meat:* These are meats that have undergone processing (cold meats, sausages, etc.).

Meat is an excellent source of animal protein, which has a balanced amino acid composition. They represent on average 20% of the total product weight. The lipid content varies with the types of meat (from 3 to 23%). White meats are low in fat while pork and beef are richer.

However, in the same animal, lipid intake varies with the piece chosen. There are as many monounsaturated fatty acids (MUFA) as saturated fatty acids (SFA) and very few polyunsaturated fatty acids (except in the heart, liver, or kidneys). Meat also contains Trans fatty acids (TFA), which are of natural origin, and produced in the rumen of beef or lamb. In addition to its high iron levels, meat provides heme iron. It represents 50 to 80% of the iron in meat depending on the species and is better absorbed than non-heme iron. On the other hand, meat improves the absorption of non-heme iron by two to three times, from other foods that accompany it during the meal. Meat constitutes one of the best dietary sources of zinc with both high levels (2 to 7 mg/100g) and high bioavailability. It is also one of the foods that contain the most selenium, i.e. 6 to 14 µg/100g for meats on average and up to 90 for liver or 116 for kidneys. Meat also represents a major source of vitamins B_3, B_6, and particularly vitamin B_{12} which is exclusively present in products of animal origin.

Fish have always occupied an important place in the diet, both from a taste and nutritional point of view. Their flesh is tender, does not require long cooking, generally contains little fat, is easily digested, and can be an important source of omega-3 fatty acids. Fish is a great option for a healthy and balanced diet due to its richness in high-quality protein, beneficial omega-3 fatty acids, essential B vitamins, important minerals (selenium, zinc, magnesium, and phosphorus), and vitamin D. Additionally, fish is generally low in saturated fat, making it a healthier option compared to high-fat red meats and dairy products. Regular fish consumption can help reduce the risk of obesity and metabolic diseases. Oily fish like salmon and sardines are also a good source of vitamin A and vitamin D, which can benefit vision, skin, and overall health.

However, it is important to note that the nutritional quality of fish can vary depending on its origin and cooking method. To maximize health benefits, it is recommended to choose sustainably sourced fish, cook them healthily (grilled or steamed), and incorporate them as part of a balanced and varied diet.

II.2.2. Milk and cheese

Milk is a nutrient-rich liquid produced by the mammary glands of certain female mammals. It represents an excellent source of complete protein, which contains all the essential amino acids necessary for our body. It is also a source of many essential nutrients such as vitamin A, vitamin B_{12} , phosphorus, potassium, and magnesium.

The different types of milk commonly consumed are:

- *Cow's milk:* It is rich in protein, calcium, vitamin D and vitamin B_{12}. However, some people are intolerant to lactose, a sugar found in cow's milk, which can lead to digestive problems;
- *Goat's milk:* It is similar to cow's milk in terms of nutritional composition. It is also high in protein and calcium, but it contains less lactose than cow's milk, which may be beneficial for some people with lactose intolerance;
- ***Sheep's milk:*** Sheep's milk is also similar to cow's milk in terms of nutritional composition. It generally contains more fat and protein than cow's milk, and it is often recommended for people with lactose intolerance;

- ***Soy milk:*** Soy milk is a popular alternative to animal-based milk for vegans and people with lactose intolerance. It is naturally lactose-free and generally contains less fat than cow's milk. In addition, it is rich in protein and unsaturated fatty acids, while being a source of calcium and vitamin D if fortified;
- ***Almond, coconut, rice milk, etc. :*** These plant-based milks are also used as alternatives to milk of animal origin. They are generally lactose-free and suitable for vegans. However, they may be lower in protein than animal-based milks unless they are specifically fortified.

Cheeses are dairy products obtained from the coagulation of milk. They can be made from the milk of different animal species, including cow, goat, sheep or buffalo milk. Each type of cheese has its own flavor, texture and nutritional value. They represent an excellent source of high-quality proteins, essential for building and repairing body tissues. Additionally, cheeses are an important source of calcium and phosphorus. Some cheeses, especially hard cheeses, are rich in fat-soluble vitamins (Vit. A, D, E and K). Additionally, cheese is an important source of vitamin B_{12}. It is recommended to limit the daily consumption of cheese due to its fat (especially saturated fat) and sodium content.

II.2.3. Legumes

Legumes are a family of plants that produce pod-shaped fruits (beans, broad beans, lentils, chickpeas, etc.). They are rich in high quality plant proteins. They contain a full range of amino acids, making them a healthy alternative to animal proteins. They are rich in fiber, minerals and vitamins, making them an excellent source of nutrients in the diet. They also represent an excellent source of complex carbohydrates and are rich in vitamins (group B) and minerals (iron, zinc, magnesium, potassium). Additionally, they are naturally low in fat and contain no cholesterol, making them beneficial for cardiovascular health.

Legumes can be combined with whole grains (brown rice, quinoa) to form a complete protein. This provides all the necessary essential amino acids.

II.3. Hydromineral and vitamin foods

(Protective and regulatory (functional) foods)

II.3.1. Fruits and vegetables

Fruits are delicious and nutritious natural foods that usually come from flowering plants. They are often eaten raw, although they can also be used in culinary preparations (fruit juices, smoothies, desserts, jams). They offer a wide variety of health-promoting nutrients. The different categories of fruits are:

Red fruits or berries: Strawberry, raspberry, blackcurrant, blackberry, blueberry.... ;

Stone fruits: peach, apricot, cherry, plum, olive...;

Pome fruit: Apple, pear, grape, kiwi.... ;

Nuts: Walnuts, almonds, hazelnuts.... ;

Mediterranean and tropical fruits: Lemon, citrus fruits, avocado, banana, pineapple, mango….
Fruits are an excellent source of vitamin C which strengthens the immune system and promotes healthy skin. They also contain vitamins A, B, E and K, each of which plays a specific role in maintaining the overall health of the body. In addition, fruits are rich in minerals (potassium, magnesium and calcium) which are essential for bone health, the proper functioning of muscles and the nervous system. The antioxidants found in fruits (flavonoids, carotenoids and vitamin C) help neutralize free radicals in the body, thereby reducing oxidative stress and the risk of chronic diseases. Fruits are also rich in dietary fiber, which contributes to healthy and regular digestion.

Vegetables are edible parts of plants, whether cultivated or wild, that are eaten for their nutritional qualities and health benefits. The different categories of vegetables are:
Leafy vegetables: Cabbage, chives, watercress, spinach, lettuce, parsley, leek, celery, fennel…. ;
Stem vegetables: Asparagus, kohlrabi….;
Root vegetables: Beetroot, carrot, turnip, sweet potato, radish….;
Bulb vegetables: Garlic, shallot, onion….;
Fruit vegetables: Eggplant, cucumber, squash, zucchini, chili pepper, green beans, etc.;
Whole seedlings: Soybean sprouts, radish shoots, etc.;
Buds: Brussels sprouts, bamboo shoot….;
Inflorescences: Artichoke, broccoli, cauliflower….;
Seeds: Bean, lentil, pea, etc.;
Tubers: Potato, Jerusalem artichoke….;
Rhizomes: Ginger, lotus….;
Carpophores: Mushroom….
Vegetables are rich in fiber, thus promoting efficient digestion and helping to maintain a balanced body weight by providing a feeling of satiety. Their vitamins (Vit. A, C, K and B_6) help strengthen the immune system, maintain radiant skin and support blood clotting. In addition, vegetables are full of minerals (potassium, magnesium and calcium) essential for the proper functioning of muscles, the nervous system and bone health. Thanks to their powerful antioxidants (lycopene, lutein), these plant wonders help neutralize free radicals, thus reducing the risk of chronic diseases. Finally, their alkalizing effect helps maintain pH balance in the body, thus promoting better overall health.
It is recommended to consume at least 5 servings of fruits and vegetables per day. One serving is usually around 80 to 100 grams.

II.3.2. Drinks

Beverages are an integral part of our daily diet and can play a vital role in our hydration and nutritional intake. There are different categories of drinks:

- <u>Non-alcoholic drinks, carbonated or not (</u> tap water and bottled water (from springs and minerals), fruit and vegetable juices, sweetened drinks, exciting drinks, milk drinks, infusions);
- <u>Alcoholic beverages (wine, beer, liquor, etc.)</u>

II.3.2.1. Waters

The different waters consumed on a daily basis (tap water or bottled water (from springs and minerals)) each have their own particularities. They differ by their origin, their stability or even their treatment.

Mineral water is natural, of underground origin, pure (no disinfection treatment which could modify its mineral and microbial composition) and has a stable mineral composition. It undergoes very strict controls.

Spring water is of underground origin and has a mineral composition that can vary over time. A brand of spring water can use several resources with different compositions.

Tap water has different origins: lakes, rivers, groundwater. It undergoes a disinfection treatment and its composition may vary. Furthermore, ***water filtered*** by a carbon filter would eliminate the chlorine taste, lead and limescale from tap water.

II.3.2.2. Fruit and vegetable juices

Fruit and vegetable juices can be consumed as fresh juice, juices prepared from concentrates, or pasteurized juices sold in bottles or cartons. They contain various vitamins (Vit. C, A, K) and minerals (potassium and magnesium). They are rich in antioxidants (polyphenols and carotenoids), which can help neutralize free radicals and protect the body's cells from oxidative damage. However, much of the dietary fiber is lost when fruits and vegetables are processed into juice. They may also contain significant amounts of natural sugar, which increases their caloric intake.

II.3.2.3. Sugary drinks

These are drinks that contain significant amounts of added sugars (sucrose or high fructose corn syrup). They include, among others, sodas, sweetened fruit drinks, sweetened soft drinks, sports drinks, and sweetened iced teas.

II.3.2.4. Exciting drinks

Exciting drinks are drinks that contain stimulating ingredients (caffeine, taurine, guarana, ginseng, various vitamins, and minerals) designed to temporarily increase alertness, attention and energy:

- *Coffee,* is appreciated for its distinctive flavor, its intoxicating aroma, and its stimulating effects due to the presence of caffeine (increases attention, concentration and alertness, nervousness, insomnia);
- *Tea (Camellia sinensis)* contains caffeine in lower quantities than coffee (less pronounced stimulating effect than coffee). There are several types of tea, the most common of which are black tea, green tea, and white tea.. Tea, especially green tea, is rich in antioxidants (polyphenols and catechins) that can help neutralize free radicals and protect the body's cells from oxidative damage.

II.3.2.5. Infusions

Infusions are hot drinks prepared by soaking plant parts (leaves, flowers, roots, bark or seeds) in hot water for a period of time. This process allows the active compounds and flavors to diffuse into the water, creating an aromatic and fragrant drink.

III. Nutritional needs

A balanced diet is a set of measures concerning the quantity of food, their distribution throughout the day, the type of food, and the way of eating to respect a balanced diet. It is composed of all the substances necessary for the proper functioning of our body. This healthy and balanced diet provides children, adolescents, and young adults with what they need to grow, develop, learn, and be active. To this end, improving the food supply is a question of nutritional balance, and variety of foods, flavors, textures, colors, taste, and the pleasure of eating well.

On the other hand, **nutritional status** is an individual's physiological state that results from the relationship between food consumption (in macro and micronutrients) and needs and the body's capacity to absorb and use nutrients. In this sense, **malnutrition** is a pathological state resulting from an inadequacy by excess or default between food intake and the body's needs. Malnutrition takes three different forms:

- Undernutrition or undernutrition (eating insufficiently);
- Dietary deficiencies (eating poorly or unbalanced);
- Overeating or over-nutrition (eating too much).

III.1. Definitions

III.1.1. Nutritional needs and specific needs

Nutrient or energy requirements are defined as the amount of that nutrient or energy required by organs and tissues to provide energy, maintenance, growth, metabolic and physiological functioning, repair, protection, basic thermoregulation, hydration, and a notion of pleasure linked to food, in a healthy individual.

In addition to these basic needs, there are additional needs (***specific needs***) necessary during certain periods of life characterized by particular physiological circumstances (growth, pregnancy, breastfeeding, aging) or even during stress or certain pathologies.

Several factors vary nutritional needs:

The physiological variation factors concern sex, age, body mass of individuals, the absorbed portion of the ingested nutrient, physical activity, the fight against cold or excessive heat, temporary additional physiological needs (growth, gestation, and lactation), and possible interactions between different nutrients.

Factors of pathological variations are linked to exceptional thermoregulation (fever), the fight against infections, tissue repairs of wounds, fractures, surgical interventions, and possible interactions between nutrients and drugs.

III.1.2. Average Nutritional Need (BNM)

According to Anses (National Agency for Food, Environmental, and Occupational Health Safety-France), ***the BNM*** is the average nutritional need within the population, as estimated from data on individual intake to a criterion of nutritional adequacy during experimental studies.

The nutritional adequacy criteria used are often parameters for nutrient balance or metabolic renewal, modification of the state of reserves, or markers of functions associated with the nutrient during depletion-repletion studies. In certain physiological situations such as growth or pregnancy, the need can be deducted by the factorial method based on the criteria previously described criteria and taking into account additional components linked to these situations.

III.1.3. Nutritional Reference for the Population (RNP)

The **nutritional reference for the population (**RNP) is the intake, which theoretically covers the needs of almost the entire population (97.5% in most cases), as estimated from experimental data. The RNP is obtained by estimating the parameters of the need distribution. We often consider that the population's need distribution follows a Gaussian law (the mean and the median being equal in this statistical distribution).

The RNP is estimated from the BNM to which two standard deviations are added, to thus determine the intake that covers the needs of 97.5% of the population. The standard deviation is most often estimated at 15% (safety margin to take into account inter-individual variability and cover the needs of the majority of the population) of the BNM (**Figure 2**), the RNP is then equivalent at 1.3 times the BNM (as the coefficient of variation of nutritional needs is 15%, 2 X 15% = 30%, then the RNP is 130% of the BNM).

This definition corresponds to that of the term ***"advised nutritional intake (ANC) or recommended nutritional intake (ANR)"***, which is no longer in use today and which was also used by extension for satisfactory intake (AS).

These recommendations should not be taken as standards to be imposed individually. Instead, they are references for achieving a good state of nutrition, which could limit deficiencies, imbalances, or overloads within a given population.

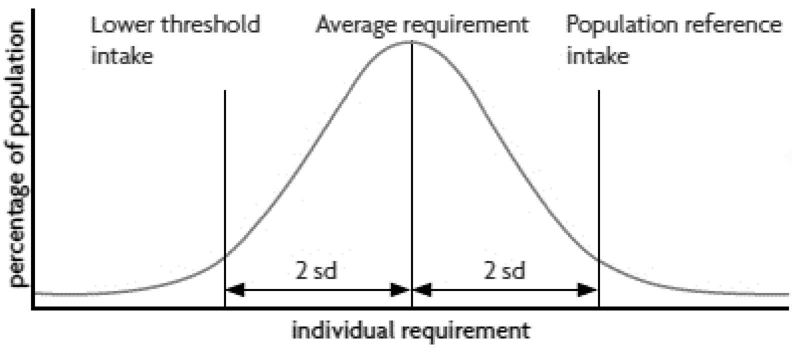


Figure 2. Distribution of nutritional needs of a population group, for a normal distribution of needs and a known variation in needs between individuals. The population's reference intakes are two standard deviations above the average requirement and the minimum intake threshold is two standard deviations below the average requirement.

At the population level:

- If all subjects have nutritional intakes higher than the RNP, there is no significant risk of a problem in covering nutritional needs at the level of this population;
- Conversely, if a large fraction of the population has intakes lower than the RNP, there is a significant risk of non-coverage of needs.

At the level of an individual:

- A subject whose contributions are greater than the RNP necessarily covers his needs;
- A subject whose intakes are lower than the RNP will, depending on their level of need, cover it or not => Even if the nutritional intakes are lower than the recommended intakes, we cannot conclude that there is a deficiency (signs of deficiency), because it There is great variability in individual nutritional needs, for the same sex and in the same age group.

For this purpose, Nutritional Requirements are not equal to **nutritional references for the population**: nutritional requirements depend on the individual, the experimental measurement, and the medical objective. On the other hand, the RNPs depend on the population and the public health objective and are more significant than the average needs of the group.

III.1.4. Satisfactory intake (AS)

AI is defined as the average intake of a population or subgroup for which the nutritional status is considered satisfactory. The AS is the nutritional reference used when:

- the BNM and therefore the RNP cannot be estimated due to a lack of sufficient data;
- the RNP value can be estimated but is not considered satisfactory. When long-term population observational studies show health effects, such as disease prevention, they can be considered to define an AS.

Data used to estimate nutritional status are often obtained through observational studies but sometimes generated from experimental studies.

III.1.5. Upper Safety Limit (LSS)

LSS is defined as the maximum chronic daily intake of a vitamin or mineral considered unlikely to pose a risk of adverse health effects to the entire population.

III.1.6. Recommended Daily Allowances (RDA)

These are unique values for each nutrient, which do not consider differences related to age or sex. They are harmonized at the European level and are regulatory values. An individual whose intake is equivalent to the RDA has little risk of not meeting his or her needs.
These values are used for the labeling of certain products.

The nutritional needs and recommended intake concerns:

- energy (quantitative needs);
- the different nutrients and their distribution (qualitative needs);
- as well as water, mineral salts, and vitamins.

III.2. Energy needs

The human body uses energy continuously, even if the amounts vary. The energy used is replenished discontinuously through the power supply. Energy from food is transformed through a series of metabolic processes into different forms of energy: chemical, thermal, mechanical, etc.

For this purpose, the energy needs or expenditures for 24 hours are the sum of four major items:

- Basal (resting) metabolism;
- energy spent on physical activity;
- thermoregulation;
- the thermal effect of food (postprandial thermogenesis).

Furthermore, the energy balance represents the difference between energy intake and expenditure. When contributions are equal to expenses, we speak of a balanced balance sheet and therefore of weight stability:

$$\text{energy intake (AE)} - \text{energy expenditure (DE)} = \Delta(\text{energy reserve})\ (\Delta E)$$

When the expenses are greater than the contributions, we will speak about a negative balance which will consequently lead to weight loss conversely when the balance is positive, that is to say, that the contributions will be greater than the expenses, we will be faced to weight gain, mainly in fat mass.

This balance, or imbalance, can depend on several factors including eating habits, cultural habits, physical activity, sedentary lifestyle, one or more associated pathologies, lifestyle, working style, family and social situation, etc.

The balance between expenditure and energy intake ensures stability of body weight, which is essential for maintaining a good health balance.

III.2.1. Establishment of energy needs

To establish energy needs (expenditures), it is necessary to establish its components: basic metabolism, physical activity, thermoregulation, and thermal effect of food:

$$\text{Energy expenditure} = \text{Basic metabolism} + \text{thermoregulation} + \text{specific dynamic action} + \text{muscular work}$$

- **Basic metabolism (MB): This** is the energy expenditure measured in a naked individual, at intellectual rest (thinking of nothing) and physical rest (lying down), placed in conditions of thermoneutrality (neither too hot nor too cold (around 25°C) and fasting for 12 hours. It will therefore represent the energy spent by the body to ensure its vital functions (respiratory, digestive, cardiovascular, etc.). It varies from one individual to another depending on age, weight, and height. Basal metabolism represents approximately 60% of 24-hour energy expenditure.

- **Physical activity level (PAL):** According to the WHO: "Physical activity means any movement produced by the skeletal muscles, responsible for an increase in energy expenditure". It should be noted that the "active" level of physical activity was used to establish estimated energy needs. This activity level is recommended for a healthy diet and physically active lifestyle, which will recommend a minimum of 60 minutes of moderate physical activity per day for young people aged 18 or younger. Adults should accumulate at least 30 minutes of moderate physical activity each day in addition to their typical daily activities (housework, walking to the bus stop, etc.). This expenditure increases with the increase in muscle mass, the intensity and duration of physical efforts, and the muscles' quality and training. The energy spent on physical activity represents between 20% and 40% of total energy expenditure.

- Thermoregulation: Body temperature must be maintained at around 37/37.5°C. When the temperature drops or increases considerably, metabolic, physiological, or behavioral processes (sweating, shivering, etc.) control it to remain approximately constant. Nowadays, we are protected from these temperature variations by clothing, heating, or air conditioning in our homes; the expenses linked to thermoregulation are generally negligible.

- Postprandial thermogenesis: This energy expenditure is associated with chewing, digestion, absorption, and food storage in response to a single meal. The foods we ingest must be transformed to be used or stored by the body. These different metabolisms will cost energy. This is what we call postprandial or dietary thermogenesis. This cost is estimated at 5 to 10% of the caloric value of carbohydrates, 20 to 30% of proteins, and 5% of lipids. The energy intake must be distributed over at least three meals of the day. Snacks can then supplement this intake.

Generally, meals served in school food services will not meet the high energy requirements established for certain age groups, such as adolescents. The consumption of healthy snacks is then recommended.

III.2.2. Assessment of energy needs

III.2.2.1. Assessment of basal metabolism

There are many equations to estimate the MB, each having its limits, none prevails over another:

- <u>Equations from Black *et al.* (1996):</u>

Black *et al*. proposed, in 1996, equations which depend on the gender, weight, height and age of the person, in order to evaluate the basic metabolism:

- Man: $MB = 1.083 \times P^{0.48} \times T^{0.50} \times A^{-0.13}$
- Woman: $MB = 0.963 \times P^{0.48} \times T^{0.50} \times A^{-0.13}$

With: P: weight in kg; T: size in meters; A: age in years.

The results will be expressed in megajoules per day (MJ/Jr=10^3 KJ/Jr).

Example: Man, 37 years old, 1.80, 79 kg.

Franck's metabolism according to Black et al will be:

$MB = 1.083 \times 79^{0.48} \times 1.80^{0.50} \times 37^{-0.13}$ = **7.40 MJ/Day = 1770.3 kcal/day**

1kcal = 4.18 kJ, to express the results in kcal, you will therefore have to divide the result in kJ by 4.18.

- <u>Harris and Benedict equations:</u>

Harris and Benedict proposed other equations to evaluate the basal metabolism:

- Man: $MB = 0.276 + 0.0573 \times P + 2.073 \times T - 0.0285 \times A$
- Woman: $MB = 2.741 + 0.042 \times P + 0.711 \times T - 0.0197 \times A$

With: P: weight in kg; T: size in meters; A: age in years.

The results will be expressed in megajoules per day (MJ/Dr).

Example: Man, 37 years old, 1.80, 79 kg.

MB = 0.276 + 0.0573 x 79 + 2.073 x 1.80 – 0.0285 x 37 = **7.23 MJ/Day = 1729.7 kcal/Day**

➢ <u>Henry's equations:</u>

Henry's equations (Table 4) can also be used to assess basal metabolism.

Table 4: Henry's equations

Gender	Age (year)	MB (MJ)	MB (KCAL)
Man	0-3	0.255 x P - 0.141	61.0 x P -33.7
	3 -10	0.0973 x P + 2.15	23.3 x P + 514
	10 - 18	0.0769 x P + 2.43	18.4 x P + 581
	18 - 30	0.0669 x P + 2.28	16.0 x P + 545
	30 - 60	0.0592 x P + 2.48	14.2 x P + 593
	>60	0.0563 x P + 2.15	13.5 x P + 514
Women	0-3	0.246 x P - 0.0965	58.9 x D – 23.1
	3 -10	0.0842 x P + 2.12	20.1 x P + 507
	10 - 18	0.0465 x P + 3.18	11.1 x P + 761
	18 - 30	0.0546 x P + 2.33	13.1 x P + 558
	30 - 60	0.0407 x P + 2.90	9.74 x P + 694
	>60	0.0424 x P + 2.38	10.1 x P + 569

P = weight in kg

Example: Man, 37 years old, 1.80, 79 kg.

MB = 0.0592 x 79 + 2.48 = **7.16 MJ/Day**

MB = 14.2 x 79 + 593 = **1714.8 Kcal/Day**

➢ <u>Simplified method:</u>

The MB can also be estimated as follows:

• Man: MB (kJ) = 110 x Ideal weight

• Woman: MB (kJ) = 100 x Ideal weight

Calculation of ideal weight:

It is possible to calculate the ideal weight using the Lorentz formula:

• Man: Ideal weight (kg) = Height (cm) - 100 - $\frac{(Height - 150)}{4}$

• Woman: Ideal weight (kg) = Height (cm) - 100 - $\frac{(Height - 150)}{2.5}$

Example 1: A woman aged 27 and measuring 1.68 m.

Ideal weight = 168 - 100 - ((168-150) /2.5) = 60.8 kg.

Example 2: Man, 37 years old, 1.80, 79 kg.

Ideal weight = 180 – 100 – (180-150) / 4 = 72.5 kg.

Its basic metabolism with the simplified method: MB = 110 x 72.5 **= 7975 kJ/Day = 1907.9 kcal/Day.**

We note that this formula gives us a higher metabolism, which is why it should only be used for a quick calculation, in fact it does not take into account the different parameters. It will be useful to check that the MB that you calculated with one of the formulas seen above does not present any errors.

- **Relationship between BMR and body composition:**

Body composition includes fat mass and lean mass. Fat mass is virtually anhydrous, it constitutes the sector of energy reserves. Lean mass is rich in water (5%) and consumes a lot of energy.
Basal metabolism is correlated with lean mass: biologically active mass (it therefore decreases during malnutrition, with age, and is lower in women than in men).

The evaluation of the body composition (weight level) of an individual uses **the body mass index (BMI)** or body mass index (BMI).
Also called the Quételet index after its inventor, it is a value that allows you to estimate a person's corpulence. It was initially used for adult subjects but diagrams have been created in recent years in order to be able to follow the weight evolution of children. It is calculated by dividing the weight in kg by the height (in meters) squared. The result is expressed in kg/ ^{m2}:

$$BMI\ (Kg/m^2) = \frac{\underline{Weight}}{(Size)^2}$$

The BMI makes it possible to estimate whether a person is overweight or obese (Table 5), it can also be a diagnostic criterion in cases of malnutrition.
We consider an ideal weight with a BMI between 18.5 and 25 kg/m2 (average index of 22).

Table 5: Interpretation of BMI according to WHO

BMI in kg/ ^{m2}	Interpretation according to WHO
<18.5	Underweight (weight loss due to malnutrition)
<16.5	Severe underweight
16 – 17	Moderately underweight
17 – 18.5	Mild underweight
18.5 – 25	Normal build
25 to 30	Overweight (Pre-obesity)
>30	Obesity
30 to 35	Grade 1 obesity
35 to 40	Grade 2 obesity
40	Grade 3 obesity

Example 1: Woman: 63 kg and 1.69 m
BMI = 63 /1.69² = 22.05 Kg/m ^{2}
Example 2: A man is 1.82 m tall. What will be his ideal weight?
Ideal weight = 22 x 1.82² = 72.87 kg. (22 being the ideal BMI)

III.2.2.2. Assessment of physical activity level

The level of physical activity (NAP) will be calculated over a day, by averaging the intensity level of the different activities carried out (Table 6 and 7).

Table 6: Level of intensity of different physical activities carried out over a day

Activity	NAP coefficient
Sleep and nap, rest while lying down	1
In a seated position: rest, TV, computer, video games, board games, reading, writing, office work, transport, meals, etc.	1.5
In a standing position: short trips around the house, cooking, washing, housework, shopping, laboratory work, sales, driving machinery.	2.2
Women: walking, gardening or equivalent, gymnastics, yoga. Men: manual, standing, professional activities of medium intensity (chemical industry, machine tool industry, carpentry, etc.).	3
Men: walking, gardening, high-intensity professional activities (masonry, plastering, car repair, etc.).	3.5
Sport, intense professional activities (earthworks, forestry work, etc.).	5

Table 7: Example of a day for an office worker

Activity	NAP coefficient	Duration (H)	Total
Sleep	1	7.5	7.5
Standing (preparing breakfast, washing, etc.)	2.2	2	4.4
Walk (to get to work)	3	0.5	1.5
Sitting (working behind a computer)	1.5	4	6
Standing (outdoor lunch break)	2.2	1	2.2
Sitting (work)	1.5	3	4.5
Sport (fairly intense)	5	1	5
Standing (cleaning, eating, showering, etc.)	2.2	3	6.6
Sitting (television)	1.5	2	3
	Total	24	40.7

A total of 40.7 is therefore obtained over 24 hours. To calculate an average, simply divide this average by 24:

Average NAP for this person = 40.7 / 24 = 1.7.

III.2.2.3. Assessment of total daily energy requirement

The FAO/WHO recommends to calculate the daily energy expenditure (Need) (DEJ), the official method which applies for the basic metabolism, a multiplier coefficient correlated to the level of physical activity (NAP):

$$DEJ\ (kJ) = MB\ (kJ) \times NAP$$

Example: Man, 37 years old, 1.80, 79 kg, average NAP of 1.6.
Basal metabolism estimated according to the formula of Black et al. at 7.40 MJ/Day or 7400 kJ/Day.
DEJ = 7400 x 1.6 = 11,840 kJ/Dr = 2832.54 kcal/Jr.

- Average energy requirement for the population

In clinical practice, it is of little use to seek to precisely quantify the energy needs of a given individual, and it is simply necessary to situate their needs according to the population to which they belong (Tables 8 and 9). The precise determination of the energy balance by calorimetry is the responsibility of the specialist.

Table 8: Recommended average energy needs/day depending on gender

Age	20 to 40 years old	41 to 60 years old
Men (kcal)	2400 to 2700	2500
Women (kcal)	2200	2000

Table 9: Recommended average energy needs/day depending on the level of physical activity

Physical activity level	Men (kcal)	Women (kcal)
Sedentary	2100	1800-2000
Average activity level	2500	2200
High activity level	3000 to 3500	2700
Protein (%)	10 – 15	10 - 15
Lipids (%)	30 – 35	30 - 35
Carbohydrates (%)	50 – 55	50 - 55
		Pregnancy: + 350 kcal Breastfeeding: + 500 kcal

III.3. Protein needs

III.3.1. Assessment of qualitative needs

Ingested proteins have two origins:

Animal proteins (meat, poultry, fish, dairy products) are complete proteins, that is to say, they contain all the essential amino acids (Leu, Thr, Lys, Trp, Phe, Val, Met, Isl, (His)) to the growth and maintenance of the integrity of the organism.

Plant proteins, except for soy protein, do not contain all the amino acids in sufficient quantities to be complete proteins. However, complete proteins can be obtained by making the following combinations:

- combine a plant protein with an animal protein;
- combine a legume with cereals (rice, bread, etc.);
- combine a legume with nuts or seeds.

These associations do not need to be made during the same meal. If complementary foods are consumed within 24 hours, you can still benefit from the benefits of complete proteins.

There are 4 essential criteria for evaluating the nutritional quality of proteins: Chemical Index (CI), Biological Value (BV), Digestibility (CUD), and Bioavailability Rate.

- **The chemical index (CI) or the chemical score (SC):**

The Chemical Index expresses the limit of use of each of the 8 Essential Amino Acids (EAA) once they are in circulation in the body (therefore post-intestinal crossing).

According to the Food and Agriculture Organization of the United Nations: "the level of each essential amino acid contained in a food protein is expressed as a percentage of the level of this same amino acid in an equal quantity of a protein reference (PR). The essential amino acid for which the percentage is lowest is said to be "limiting"; it is this percentage that constitutes the chemical index".

$$\textbf{Chemical index (\%)} = 100 \times \frac{\textbf{Content of essential amino acids in dietary protein (mg/g)}}{\textbf{Content of the same amino acid in the reference protein (mg/g)}}$$

It is said to be limiting because the proportion of use of the 7 other AAEs will be limited to the % of its presence.

The reference protein has long been that of egg white (it contains in sufficient quantity all the essential amino acids that the body needs, and in sufficient quantity, its chemical index is equal to 100), to finally become a protein established by the WHO (World Health Organization), totally virtual and resulting from scientific recommendations.

Example: if Valine happens to be the limiting AAE with a quantity in mg equal to 84% of what the PR recommends, then the 7 other AAEs will only have a usefulness of 84% compared to their recommended rate. in PR. The IC of this protein will therefore be 84.

To best limit the inhibitory action of limiting AAEs, it is, therefore, advisable to have meals containing a variety of foods. In fact, from one food to another, the aminogram will be different, and therefore the limiting amino acid will not be the same. Very often Methionine is found to be the limiting AAE for proteins of animal origin, while it is Lysine for proteins of plant origin. Thus, consuming foods with distinct protein properties in the same meal will allow the AAEs to complement each other; this is called "protein complementation". It is easy to understand that this eating habit must be followed rigorously by an athlete because it will allow his body to optimize recovery and muscle building.

- Biological value (BV):

The Biological Value expresses the % of amino acids/gr of dietary protein (after ingestion) which will be used for protein synthesis in the body. The Biological Value is calculated by subtracting the % of nitrogen found in stools and urine from the quantity of nitrogen absorbed.

- Protein digestibility (CUD):

This involves identifying the ability of the digestive system to break down a food protein into amino acids, and then reject the latter into the blood. The task of the protease enzymes will be more or less complicated depending on the origin of the protein (animal or vegetable), but also depending on the cooking process, and depending on the composition of the other nutrients ingested. Proteins of animal origin are more digestible than those of plant origin, their loss of amino acids (non-passage of the intestinal wall) is on average 10%, compared to 25% for plant proteins. This demonstrates in particular the inhibiting effect that fiber has on the digestibility of food proteins. To define the digestive value, a Digestive Utilization Coefficient (DUC) was therefore developed.

$$\text{Digestive Utilization Coefficient (CUD)} = 100 \times \frac{\text{Quantity of protein assimilated}}{\text{Amount of protein provided}}$$

It depends on various factors: preparation of the food source (cooking, etc.), presence of polyphenols, fibers, and non-nutritional compounds in the food.

- The speed of bioavailability:

This is the time it takes to break down a nutrient to make its elements available for passage into the blood, following the digestive stage. In the case of proteins, it is the protease enzymes that have the function of separating the amino acids from each other, so that they become free and can thus pass through the intestinal wall. The proteases will work more or less quickly depending on the origin of the protein, but also depending on the nutrients that accompany it.

It turns out that some proteins are perfectly digestible (very little loss to the stools) but take a long time to be gastrically empty and then broken down by proteases. Thus, a food ration of certain proteins with slow digestibility may take up to 7-8 hours to be completely broken down in the digestive system, without suffering significant losses in the stools.
The speed of bioavailability of a protein is information for strategic purposes: a rapidly assimilable protein is not necessarily better than a slowly decomposing protein; what we must rather understand is that one will simply be more advantageous than the other depending on the time circumstances.

Calculations have been implemented to correct the biological value, or the chemical index of a protein by its digestibility (CDU). These corrected indices are the PDCAAS (Protein Digestibility Corrected Amino Acid Score: IC x CUD), the Di-Sco Index (Digestibility Score: IC x CUD), or the NPU (net protein utilization: VB x CUD).

As none of the 4 criteria alone can define the nutritional quality of a food protein, it is therefore appropriate to take them all into account when making your food choices (Table 10).

Table 10: Criteria for evaluating the nutritional quality of proteins in some foods

Source of Protein	Value biological (VB)	Limiting Essential Amino Acid/IC	Digestibility (CUD)	Bioavailability time
Hydrolyzed whey	100	-	100%	15-20 gr/hour
Isolated whey	100	-	100%	12-15 gr/hour
Concentrated whey	100	-	100%	10-12 gr/hour
Whole egg	94	-	96% (raw = 75%)	3 gr/hour
Egg white	88	-	100% (raw = 50%)	8 gr/hour
Cow milk	86	Methionine	95%	5 gr/hour
Chicken breast	80	Methionine	94%	7 gr/hour
Fish	77	Leu-Try-Phe	94%	7 gr/hour
Concentrated casein	77	-	99%	5-6 gr/hour
Beef	76	Methionine	96%	6 gr/hour
Complete rice	74	Lysine	96%	7 gr/hour
Soy concentrate	73	Met-Try	95%	4 gr/hour
Soy isolated	73	Try	98%	6 gr/hour
White rice	67	Lys-Met-Try	95%	7 gr/hour

III.3.2. Assessment of quantitative needs

The human body cannot store protein and constantly needs to obtain it from food.
The recommendations regarding protein intake are of the order of 10 to 15% of energy intake. The minimum safe nutritional protein intake is 0.8 to 1 g/kg of body mass/day for a healthy adult weighing 70 kg (56 to 70 grams of protein per day).

- Consequences of a deficiency in essential proteins: The body draws proteins from the muscles, weakening and dysfunctioning. Protein deficiency results from insufficient intake of either protein or essential amino acids. The deficiency of a single essential amino acid, over a long time, has the same effects as a protein deficiency.

Ultimately, the consequences of the deficiency, apart from the muscles, are fatigue, brittle nails, hair loss (lack of keratin), visual problems, weakened ligaments, weakened bones (osteoporosis), susceptibility to infections (decrease in the immune system)...
In protein deficiency called "kwashiorkor", the lack of protein mainly affects young children aged 6 months to three years in poor countries (no nutrients of animal origin even though they are no longer breastfed). The first symptoms are fatigue or even anemia. In the absence of dietary correction, the deficiency leads to a delay or cessation of growth, weight loss and reduction of muscle mass, swelling of the stomach, or even digestive and mental disorders. To correct this lack of protein, consuming meat, milk or fish helps correct this deficiency.

- Consequences of an excess of essential proteins: Increase in urea and uric acid (with consequences, among other things, attacks of gout), attack on bones and joints due to increased acidity in the organism.

- Vegetarian diet: Vegetarianism is a diet that excludes foods that have required the death of an animal: red and white meat, offal, fish and seafood, gelatin, and rennet. In vegetarian women and children, a lack of meat and fish can lead to iron deficiencies causing anemia and significant fatigue. You should then opt for vegetables rich in iron, such as pulses. It is also advisable to eat cooked eggs to limit protein deficiencies.

- Vegan diet: Veganism excludes all products of animal origin. A correct diet is very complicated in this case. You have to find a balance between vegetables and cereals. It can be difficult to continue such diets for a long time because there is a risk of multiple deficiencies (vitamins, minerals, and proteins).

III.4. Carbohydrate needs

III.4.1. Assessment of qualitative needs

The breakdown of carbohydrates results in the formation of glucose (80%, the main fuel of our body), fructose, and galactose which represents the final stage of carbohydrate digestion. These simple sugars will subsequently be absorbed and passed into the blood.
The concentration of glucose in the blood, glycemia, is constantly regulated.

Furthermore, the classic separation between fast sugars and slow sugars is no longer relevant: certain foods containing large molecules are digested very quickly (white bread for example).
Today, nutritionists classify carbohydrate foods according *to the glycemic index* (Figure 3, Table 11) which expresses the speed with which they raise blood sugar levels.

$$GI = 100 \times \frac{\text{area "of the food to be tested"}}{\text{"reference food" area}}$$

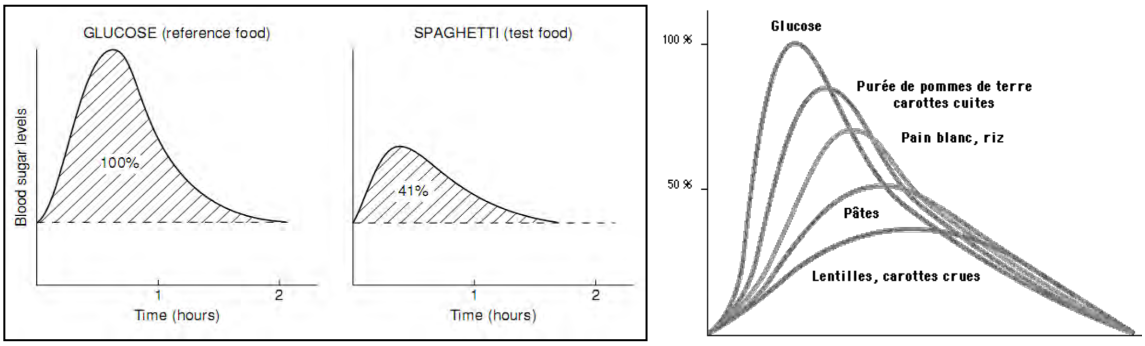


Figure 3: Glycemic index of certain foods

Table 11: Glycemic index of certain foods.

Food: Quantity equivalent to 20 g of glucose	Glycemic index (%)
20 g of glucose	100
200 g steamed carrots	90
100 g of mashed potatoes (flakes)	80
40 g of white bread	65
100 g of rice	60
100g pasta	50
40 g wholemeal bread (whole grain)	50
400 g of milk	30
100g lentils	25
200 g raw carrots	25

On the other hand, dietary fiber plays several important roles in the human body due to its specific properties:

- *Regulation of intestinal transit:* by increasing the volume and consistency of stools, and preventing constipation, which reduces the risk of developing hemorrhoids;
- *Weight control*: they tend to be more satiating, in the stomach, the fibers swell with water, gain volume, and thus provide a feeling of satiety;
- *Reduction of cholesterol levels*: by binding to cholesterol in the gastrointestinal tract, which reduces the risk of cardiovascular diseases;
- *Promoting healthy intestinal flora*: they serve as food for beneficial bacteria.

III.4.2. Assessment of quantitative needs

Carbohydrates are present in large quantities in our diet and provide approximately 50-55% of the energy we need. This contribution must be distributed as follows:

- 40% in the form of complex carbohydrates
- 10% simple carbohydrates

The minimum carbohydrate requirement is around 150 g/day: too high an intake promotes an increase in triglycerides and a decrease in HDL cholesterol.

A daily fiber intake (2 kcal/g) of 25 to 38 g, depending on age and sex, is recommended. Legumes that are rich in dietary fiber can help achieve this goal.

III.5. Lipid needs

III.5.1. Assessment of qualitative needs

Lipid requirements are distributed across the different fatty acids:

➢ Saturated fatty acids (SFA):

- *Excess atherogenic SFA:* palmitic acid, myristic acid, and lauric acid;
- *SFA with no known deleterious effect:* stearic acid and short-chain fatty acids (SCFA). These SCFAs are currently the subject of numerous scientific studies (They have effects on the gastrointestinal (GI) tract which influence the health of the intestine, they have an impact on the immune system (butyric acid: anti-inflammatory) and could play a role in protection against colorectal cancer).

➢ Monounsaturated fatty acids (MUFA): Oleic acid, the main representative of MUFA and the main component of olive oil, seems to have a favorable effect on the lipid profile.

➢ Polyunsaturated fatty acids (PUFA): are mainly represented by Omega-3 and Omega-6 which have a role in preventing cardiovascular risk. The omega-6 / omega-3 ratio should ideally be 5.

➢ Cis fatty acids and trans fatty acids:

  - Cis monounsaturated fatty acids would exert a preventive action on cardiovascular diseases, especially if the oils are first cold pressed.
  - "Trans" fatty acids have harmful effects on human health. Not only do they increase LDL cholesterol, but they reduce HDL cholesterol. They increase triglycerides in the blood (risk of cardiovascular disease).

Lipids provide a greater amount of energy than carbohydrates and proteins. They are easily stored by the body and constitute reserves (a 65 kg person has 8 to 10 kg of lipids).

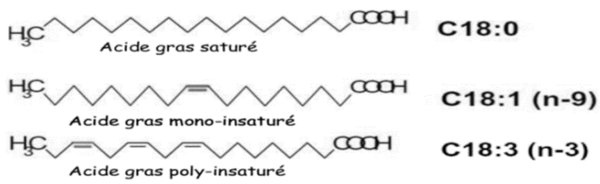
Lipids are provided by food, but the body can make them from excess carbohydrates. In industrialized countries where food is generally abundant, excess fat has become a real health problem.

The good and bad fatty acids:

Apart from their energetic quality, certain fatty acids have an essential structural role because they are incorporated into the phospholipids of cell membranes. They ensure membrane fluidity and maintain the balance between external and internal exchanges of the cell.

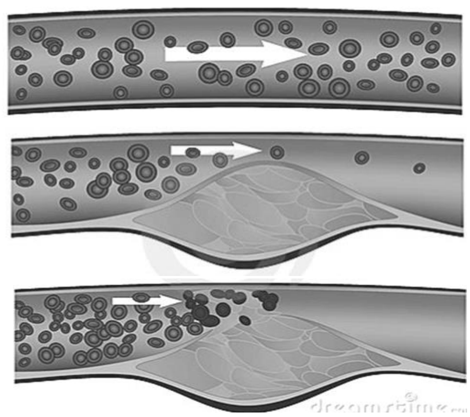
Saturated fatty acids have a linear form. They are generally solid at normal temperatures. The main sources are foods of animal origin: meat, poultry, and dairy products. These molecules form compact structures that tend to stiffen cell membranes and limit exchanges. Saturated fats circulating in the blood also increase cholesterol levels.

Unsaturated fatty acids promote membrane fluidity because the stack of phospholipids is less compact. Polyunsaturated fatty acids are generally liquid at room temperature and are mainly found in vegetable oils (corn, soy, sunflower, walnut, flax). They help regulate cholesterol levels in the blood and are essential for the growth of the child and the regeneration of skin tissues.



Cholesterol is characteristic of the animal kingdom. It does not provide any energy but it is a lipid compound essential for life. It is found in the brain, spinal cord, and in certain hormones. It plays an essential role in the functioning of the nervous system, is involved in the formation of cell membranes, and is involved in the production of digestive juices. Most of the cholesterol in our body is made by the liver. The cholesterol present in foods such as eggs, offal, butter, and whole milk is therefore an element that the body can do without because it produces it. If dietary cholesterol intake is high, some are not digested and are rejected directly.

We cannot speak of good or bad dietary cholesterol, this distinction only applies to cholesterol produced by the human body, endogenous cholesterol. Cholesterol circulates in the blood but it is a lipid substance, which cannot move without help in an aqueous environment. It is transported by specialized proteins: lipoproteins. The nature of these determines what we call “good” and “bad” cholesterol:



High-density lipoproteins or HDL represent "good" cholesterol because they pick up excess cholesterol present in the blood and cells, and can even attack cholesterol stuck to the arteries. They bring it back to the liver which is then responsible for eliminating it through the bile. The higher the blood level of HDL cholesterol, the lower the risk of arteriosclerosis.

Low-density lipoproteins or LDL constitute “bad” cholesterol. They collect cholesterol from the liver to transport it to the cells. When the amount of cholesterol carried by LDL is excessive, the excess sticks to the wall of the arteries. These deposits can therefore cause cardiovascular problems.

Foods rich in lipids are:

- foods of animal origin: they contain saturated fatty acids (sheep and cattle fat) and unsaturated fatty acids (fatty fish: mackerel, herring, salmon, sardines, tuna, trout);
- foods of plant origin: they are richer in unsaturated fatty acids (olive, soy, rapeseed, peanut oils, as well as in dried fruits: nuts, hazelnuts, peanuts, etc.), they contain also saturated fatty acids obtained after saturation by hydrogenation (butter, margarine);
- Fruits and vegetables (except avocado, olive, and dried fruits) do not contain lipids.

III.5.2. Assessment of quantitative needs

The daily requirement for lipids varies depending on the individual but should not exceed 30 to 35% of energy needs.

The recommendations regarding total lipid intake are of the order of 30 to 35% of energy intake. These contributions are distributed across the different fatty acids (recommended daily intake):

- 50% of omega 9 type monounsaturated fatty acids;
- 25% polyunsaturated fatty acids such as omega3 and omega 6;
- 25% saturated fatty acids.

III.6. Vitamin requirements

III.6.1. General characteristics of vitamins

Vitamins are involved in biological functions such as construction, functioning, and maintenance of the body. Vitamin deficiency causes pathologies, however, conversely, prolonged overconsumption produces destabilizing effects. Not being synthesized by the body, except for vitamins K and D, vitamin intake is achieved through balanced nutrition. Vitamins are classified according to their solubility into water-soluble vitamins not stored in the body and stored fat-soluble vitamins.

III.6.2. Water-soluble vitamins

The water-soluble vitamins are the B vitamins and vitamin C. Table 12 groups together the roles, daily requirements, and consequences of deficiency of these vitamins.

III.6.3. Fat-soluble vitamins

The fat-soluble vitamins are vitamins A, D, E, and K. Table 13 brings together the roles, daily requirements, and consequences of deficiency of these vitamins.

Table 12: Roles, daily requirements, and consequences of water-soluble vitamin deficiency.

Vitamins	Roles	Daily needs	Consequences of impairment
Vitamin C (Ascorbic acid)	- It is an anti-oxidant, thus suppressing excess free radicals which contribute to cellular aging; - It contributes to the protection of blood vessels and the prevention of cardiovascular diseases; - It allows the assimilation of iron present in plants; - It eliminates toxins from products that can cause cancer. - It promotes healing (production of collagen) and participates in the synthesis of dopamine and norepinephrine (neuromediators).	60 to 100 mg/day for adults.	Scurvy: abnormalities of the teeth and appendages, edema, and hemorrhages especially from the mouth.
Vitamin B_1 (thiamine)	- It acts in the body in its active form resulting from its transformation in the liver, thiamine pyrophosphate (TPP); - TPP is involved in the activity of enzymes, in particular, those that produce cell energy from carbohydrates (or sugars); - The TPP also contributes to the production of the neurotransmitter; - TPP promotes the breakdown of alcohol in the body.	1 to 1.5 mg/day for adults.	- *Asthenia:* weakening of the body, physical fatigue; - *Anorexia:* symptom which corresponds to a loss of appetite; - *Beriberi (husked rice):* Central and peripheral neurological signs (balance and walking disorders), heart failure.
Vitamin B_2 (riboflavin)	- It is active in the form of two coenzymes: flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD); through these coenzymes, vitamin B_2 is therefore involved in the metabolism of proteins, carbohydrates, and lipids, as well as in the production of keratin essential for the skin, hair, and nails; - These coenzymes are involved in the activity of numerous enzymes (respiration of mitochondria, degradation of fatty acids).	1.3 mg/day for an adult.	Mucosal and skin lesions
Vitamin B_3	- It is activated in the liver into two coenzymes: NAD and NADP: - NAD (nicotinamide adenine dinucleotide) has an important role in redox reactions of metabolism and cellular respiration. It also participates in calcium metabolism; - NADP (nicotinamide adenine dinucleotide phosphate) is mainly involved in certain enzymes (oxidoreductases) that act as catalysts in redox reactions.	They are around 14 to 17 mg/day for adults.	- Neurological *abnormalities;* - *Paresthesias:* abnormality of sensations, the patient feels tingling or tingling in an area of the body without apparent cause; - *Pellagra*: photosensitive, neurological dermatitis.

Vitamin B_5	- It acts as a precursor of coenzyme A (CoA) in the metabolism of fats, carbohydrates, and proteins.	10 mg/day for adults.	As pantothenic acid is very widespread, deficiency states are exceptional.

Vitamin B_6	- It is activated into pyridoxal phosphate (PLP);
	- PLP is involved in the metabolism of amino acids:
	  - in the conversion of glycogen to glucose;
	  - in lipid metabolism;
	  - in the synthesis of the hormones serotonin, dopamine, adrenaline, and norepinephrine.
		2.0 to 2.2 mg/day for adults.	- Skin abnormalities;
			- Convulsive seizures.

Vitamin B_8	Vitamin B_8 contributes to cell life, the production of fatty acids, and the metabolism of lipids and amino acids. Vitamin B_8 contributes to the strengthening of hair (prevention of hair loss) and nails.	- 50 mcg/day for adults.	- Dermatitis; - Alopecia: acceleration of hair loss and/or body hair.
Vitamin B_9	- Produce red blood cells and thus prevent anemia; - Prevent certain birth defects; - Promote the normal growth and development of the fetal spine, brain, and skull during the first trimester of pregnancy.	330 mcg /day for adults.	- Macrocytic anemia; - Neural tube defect: spina bifida (Latin meaning "split spine") is a malformation congenital linked to a defect in the closure of the neural tube during embryonic life.
Vitamin B_{12}	- It contributes to the formation of neurotransmitters; - It also participates in the metabolism of the body's cells, in the synthesis of DNA, and in the production of energy due to the synthesis of fatty acids; - it has a role in hematopoiesis (*Hematopoiesis* is the physiological process allowing the creation and renewal of blood cells or hematocytes).	2.4 µg /day for an adult.	*Macrocytic anemia:* this is a form of anemia with increased Mean Cellular Volume caused by the presence of anti-intrinsic factor antibodies, gastrectomies following Crohn's disease, or a strict vegetarian diet.

Table 13: Roles, daily requirements, and consequences of fat-soluble vitamin deficiency.

Vitamins	Roles	Daily needs	Consequences of impairment
Vitamin A	It is necessary for vision, the immune system, cell growth, and cell differentiation, it has anti-oxidant effects which protect the body from the effects of aging.	750 µg/day for an adult	- Eye signs: night vision; - Hyperkeratosis; - Viral infections; - Overdose: nausea, vomiting, intracranial hypertension causing dizziness.
Vitamin D	- It is vital for bone and dental health because it plays an essential role in the metabolism of calcium and phosphorus in the body; - Vitamin D increases the intestine's ability to absorb calcium and phosphorus; - it also participates in the balance of calcium in the body, in the immune system, and hematopoiesis. It also promotes the regeneration of muscle fibers and muscle contraction; - It also participates in the deposition and removal of calcium from bones according to the body's needs.	10 mcg/day for adults.	- *Rickets* in children; - *Osteomalacia in adults:* bone decalcification; - *Overdose:* hypercalcemia (excess calcium in the blood), hypercalciuria (excess calcium in the urine), kidney stones.
Vitamin E	Through its anti-oxidant effect, role in preventing the harmful effects of free radicals.	12 to 15 mg/day for adults.	- Hemolytic anemia of premature babies; - Ataxia: neurodegenerative pathology which results in disorders of the coordination of voluntary movements without muscular weakness.
Vitamin K	It is essential in the blood coagulation process, as well as for the bones where it promotes the fixation of calcium on the protein matrix of the bones.	From 70 to 140 µg/day for an adult.	Hemorrhagic disease of the newborn.

III.7. Hydromineral needs

III.7.1. Water needs

Water is essential to life; the body contains more than 60% of it. It plays a role as a transporter, participates in maintaining homeostasis, and is responsible for lubricating the mucous membranes. Daily water requirements correspond to 1 mL/kcal/day or 30-35 mL/kg body weight. For an adult living in a temperate climate and having average physical activity, the recommended intake is 2500mL/24h. It includes endogenous water inlets (200 to 300mL/24h, produced by oxidations of lipids, carbohydrates, and proteins) and exogenous inputs between foods and drinks (it is recommended to drink between 1000 and 1500 mL of water/24 hours for a sedentary adult).

Water is the only drink essential to life: certain spring and mineral waters are rich in calcium and magnesium and it is advisable to vary the sources (Table 14).

However, these fluids are eliminated mainly by the kidneys (urine: 1000 to 1500 mL) and perspiration (300 mL); small quantities are also eliminated through the lungs (evaporation: 400 to 500 mL) as well as through the stools (40 to 200 mL).

Table 14: Composition in mg/L of spring water

Components	Aris	Besbassa	Ain bouglez	Youkus	Ifri	Nestle	Guedila	Mileza
Calcium	65.6	54.16	**4.6**	77.40	**90**	55	78	111
Magnesium	6.8	**2.04**	3.75	14.50	24	17	**37**	34
Potassium	1.9	2.00	1	**4.65**	2.1	**0.5**	2	1
Sodium	28.5	**5.00**	29	13.40	15.8	>12	29	**29**
Sulfates	75	4.00	10	35.80	68	33	95	190
Chlorides	37	10.0	30	25.70	72	>15	40	10
Bicarbonates	234.2	164.70	48.8	218.00	265	210	-	311
Nitrates	**2.7**	9.00	9	2.00	**15**	4.6	4.5	3.2
Nitrites	0.01	0.01	0.06	00.00	0.02	0	<0.01	<0.01
Silicas	-	-	-	2.33	-	12	-	
Dry residue at	276 180°	206 180°	140 105°	285.00 180°	380 180°	372 180°	564 180°	680 110°
pH	7.78	7.29	6.87	7.4	7.2	7.8	7.35	7.33

III.7.2. Mineral requirements:

About 20 minerals are essential for humans. They are classified into 2 categories:

- *Major minerals:* Calcium (Ca), Chlorine (Cl), Magnesium (Mg), Phosphorus (P), Potassium (K), Sodium (Na);

- And *trace elements:* Iron (Fe), Zinc (Zn), Copper (Cu), Selenium (Se), Iodine (I), Silicon (Si), Tin (Sn), Nickel (Ni), Fluorine (F), Manganese (Mn), Vanadium (V), Molybdenum (Mo), Chromium (Cr), Cobalt (Co).

Minerals are part of the composition of tissues, they participate in the conduction of nerve impulses and muscle functioning, and they participate in enzymatic reactions. These elements cannot be synthesized by the body and must be provided through food. They are eliminated regularly by the kidneys and our diet must provide sufficient quantities of them every day (Tables 15 and 16).

Table 15: Roles, daily needs, and consequences of deficiency in major mineral elements.

Mineral elements	Roles	Daily needs	Consequences of impairment
Calcium (Ca)	Bone strength: 90% of calcium is stored in bones; Regulator of nervous excitability; Normalize heartbeat; Ensure muscle contraction and relaxation.	1-year-old baby: 0.5 g of calcium/day; Young person aged 18, pregnant woman or elderly person: 1.3 g to 1.5 g/day; Average for an adult: 1 g/day.	Prolonged deficiency: insufficient bone mass, seizures, heart rhythm problems, and weakening of bones (osteoporosis).
Sodium (Na)	Main extracellular mineral element; Responsible for the body's water balance; Transmission of nerve impulses to neurons in the brain; It allows the muscle contraction mechanism; It is involved in the regulation of blood pressure.	Current recommendations: limit consumption. Men / no more than 8 g of salt/day; Women and children: no more than 6.5 g of salt/day.	Very rare deficiency; Deficiency in case of repeated vomiting, prolonged diarrhea, excessive sweating: muscle cramps, loss of appetite, dehydration, drop in pressure, and confusion.
Potassium (K)	Main intracellular mineral element; Necessary for muscular activity and the heart muscle.	4,700 mg/day.	Relative resistance to insulin action (need to administer much higher doses of insulin in diabetics suffering from potassium deficiency).
Magnesium (Mg)	Essential for cellular metabolism and the electrical potential of muscle and nerve cells.	Men: 420 mg/day; Women: 360 mg/day.	Muscle weakness, cramps, or digestive problems.
Phosphorus (P)	Along with calcium, it is essential for the constitution of bone tissue. It is also involved in energy metabolism for the transformation of nutrients.	300 mg/day.	Exceptional deficiency.

Table 16: Roles, daily needs, and consequences of deficiency in certain trace elements

Mineral elements	Roles	Daily needs	Consequences of impairment
Iron (Fe)	One of the fundamental constituents of red blood cells (hemoglobin): is essential for treating and preventing anemia; It is important for cellular respiration; It is essential for the production of energy; Tea and coffee reduce their intestinal absorption.	10 mg of iron/day; Women during menstruation: 15 to 20 mg/day.	Iron deficiency anemia (pale, smaller, fewer red blood cells); Severe fatigue; Lower performance at work and school; A slowdown in cognitive and social development in children; Difficulty controlling body temperature; Weakening of the immune system.
Chromium (Cr)	Involved in the action of insulin; Blood pressure regulator.	Given the paucity of data on the essential nature of chromium and its metabolism, requirements are not yet specified.	
Cobalt (Co)	Improves circulatory disorders; Part of the composition of vitamin B_{12} (fights anemia).		
Fluorine (F)	Balances the growth of bones and teeth.	There does not appear to be a physiological need for fluoride and no specific recommendations have been made.	
Iodine (I)	Essential for basic metabolism (thyroid functioning), and psychomotor development.	Adults: 150 mcg/day.	Growth disorders and thyroid hypofunction; Endemic goiters, cretinism, mental retardation, decreased fertility, increased stillbirth and infant mortality.
Selenium (Se)	Defense and stimulation reaction of the body; Antioxidants fight against aging and cellular degeneration.	7 0 mcg/day.	Skeletal myopathies.

copper (Cu)	It is involved in cellular enzymes and hematopoiesis (formation of blood cells); It is involved in the quality of cartilage, bone mineralization, regulation of neurotransmitters, immunity, iron metabolism, and oxidative metabolism of glucose (cytochrome oxidase).	Adult: 0.8 to 1 mg/day.	Immunodeficiencies.
Manganese (Mn)	Activator of many enzymes.	Adult: 2 – 5 mg/day.	Manganese deficiencies are rare and are accompanied by disturbances in the synthesis of steroids (cholesterol) and the hydrolysis of certain peptides, thus reducing the release of certain hormones such as insulin and angiotensin.
Molybdenum (Mo)	Sulfite oxidase, xanthine oxidase, and aldehyde dehydrogenase are three tissue metalloenzymes or molybdoenzymes. Other dehydrogenases also require molybdenum.	Adult: 75 – 250 mcg/day.	A total lack of intake can, in patients on total parenteral nutrition, cause intolerance to sulfur-containing amino acids and disrupt the metabolism of purine bases with consequent xanthinemia.

IV. Assessment of nutritional needs

IV.1. Cellular and animal models:

In this model, we study the impact of different nutrients on health, but when we have to transpose it to humans, it is not very easy.

IV.2. Physiological approaches in humans:

IV.2.1. Factorial method:

It evaluates the various needs of the body separately and takes into account the real absorption coefficient.

$$\text{Nutritional requirements} = \sum \text{of requirements/absorption coefficient}$$

The factors involved are as follows:

- Net maintenance requirement: obligatory physiological expenditure for normal functioning of the body. It includes the minimum unavoidable losses (endogenous, fecal, urinary, and cutaneous routes). These losses depend on the intake of the nutrient considered but also on the interaction with other nutrients.
- Net growth requirement: normal average retention in weight gain. It is derived from the estimation of variations in body composition with age.
- Net gestation requirement: average retention in the fetus and its envelopes, the placenta, the uterus, and the mother's blood mass.
- Net lactation requirement: quantity exported in milk.
- Actual absorption coefficient: average coefficient determined under common power conditions.

IV.2.2. Balance sheet method:

It studies the balance between inputs and outputs using assessments carried out at different and controlled intake levels to measure the net retention of a nutrient by the body.

The elements that influence the net retention of a nutrient are:

- previous level of intake of this nutrient: if there is excess, there will be saturation of reserves;
- variation in intestinal absorption and elimination rates;
- speed of use, storage, destruction, and elimination by the body;
- state of body reserves;

There are unavoidable minimal losses of a nutrient: these losses are measured for low or even zero intakes of this nutrient.

IV.2.3. Depletion – repletion method:

If a lack of a vitamin appears, we see how to overcome this deficiency. This method is therefore widely used for vitamins.

IV.2.4. Isotopic method:

We will mark a nutrient and we study its participation in different mechanisms, its reserves,... we follow it in the body. This method is expensive.

IV.3. Nutritional surveys:

It is a probabilistic approach.

IV.3.1. Dietary indicators:

The approach consisting of measuring food intake only makes it possible to assess in a probabilistic manner a risk of non-coverage of needs and not the non-coverage of these needs, much less the deficiency.

This method tends to overestimate the recommended intakes.

Defining what should be (needs and intakes) is different from defining what is (observed intake level).

IV.3.2. Biological markers:

Study of the activity linked to the presence of the nutrient: we look at what an individual eats and we look at their state of health (Suvimax = Supplementation with vitamins and minerals and antioxidants): these are studies to long term. This activity stops increasing in parallel with an increase in the intake of this nutrient (saturation phenomenon).

IV.4. Clinical approaches (methods):

Patient studies to identify the main essential nutrients. Currently, the contributions of these methods are limited, except for the study of enteral and parenteral nutrition.

IV.5. Epidemiological approach:

These are medium and long-term studies. There are several types of studies in nutritional epidemiology:

IV.5.1. Descriptive data:

Classic epidemiological studies are adapted to nutrition: These are descriptive, observational data that seek to highlight a potential relationship between a nutrient and a pathology.

IV.5.1.1. Ecological studies:

It is a statistical relationship; we look at what people eat to illness, to mortality.

Examples of ecological studies:

1. Correlation between colon cancer and meat consumption: There is a significant relationship but there are many constituents in meat.

2. Study of breast cancer and its relationship with fat consumption: The greater the fat consumption, the higher the risk of breast cancer.

3. Study of cancer and vegetable consumption: We see that breast cancer decreases as vegetable consumption increases.

IV.5.1.2. Cross-sectional studies:

At a given moment, we take a “photograph” of the population. This study can be reproduced at given times. Ex: Monica study: every 5 years, we do a cross-sectional study.

IV.5.1.3. Case-control study:

We take a **group of sick people** and a matched group of **non-diseased people**.

The people are comparable in age, sex, etc. and we compare their lifestyles depending on the presence of illness or not. So, we are looking for a **relationship between pathology and nutrition.**

IV.5.1.4. Longitudinal study:

We follow a population group that initially is healthy. These are very long studies. However, the study can change the behavior of individuals.

IV.5.2. Causal data:

Intervention study: = double-blind approach - Suvimax study which focuses on an antioxidant mixture. It is proven that the presence of a mixture of nutrients affects health

There are 3 groups: one which receives minerals + vitamins, one which receives another mixture, and a group which receives nothing.

Epidemiological studies seek causality; It takes a long time to demonstrate the effect of nutrition. Additionally, representative samples are required.

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