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* Coenzyme Definition

A coenzyme is an organic non-protein compound that binds with an enzyme to catalyze a reaction. Coenzymes are often broadly called cofactors, but they are chemically different. A coenzyme cannot function alone, but can be reused several times when paired with an enzyme.

Functions of Coenzymes

An enzyme without a coenzyme is called an *apoenzyme*. Without coenzymes or cofactors, enzymes cannot catalyze reactions effectively. In fact, the enzyme may not function at all. If reactions cannot occur at the normal catalyzed rate, then an [organism](https://biologydictionary.net/organism/) will have difficulty sustaining life.

When an enzyme gains a coenzyme, it then becomes a *holoenzyme*, or active enzyme. Active enzymes change substrates into the products an organism needs to carry out essential functions, whether chemical or physiological. Coenzymes, like enzymes, can be reused and recycled without changing reaction rate or effectiveness. They attach to a portion of the [active site](https://biologydictionary.net/active-site/) on an enzyme, which enables the catalyzed reaction to occur. When an enzyme is denatured by extreme temperature or pH, the coenzyme can no longer attach to the [active site](https://biologydictionary.net/active-site/).

Types of Enzymes

Cofactors are molecules that attach to an enzyme during chemical reactions. In general, all compounds that help enzymes are called cofactors. However, cofactors can be broken down into three subgroups based on chemical makeup and function:

Coenzymes

These are reusable non-protein molecules that contain carbon (organic). They bind loosely to an enzyme at the active site to help catalyze reactions. Most are vitamins, vitamin derivatives, or form from nucleotides.

Cofactors

Unlike coenzymes, true cofactors are reusable non-protein molecules that do not contain carbon (inorganic). Usually, cofactors are metal ions such as iron, zinc, cobalt, and copper that loosely bind to an enzyme’s active site. They must also be supplemented in the diet as most organisms do not naturally synthesize metal ions.

Prosthetic groups

These can be organic vitamins, sugars, lipids, or inorganic metal ions. However, unlike coenzymes or cofactors, these groups bind very tightly or covalently to an enzyme to aid in catalyzing reactions. These groups are often used in [cellular respiration and photosynthesis](https://biologydictionary.net/cellular-respiration-and-photosynthesis/).

Examples of Coenzymes

Most organisms cannot produce coenzymes naturally in large enough quantities to be effective. Instead, they are introduced to an organism in two ways:

Vitamins

Many coenzymes, though not all, are vitamins or derived from vitamins. If vitamin intake is too low, then an organism will not have the coenzymes needed to catalyze reactions. Water-soluble vitamins, which include all B complex vitamins and vitamin C, lead to the production of coenzymes. Two of the most important and widespread vitamin-derived coenzymes are nicotinamide adenine dinucleotide (NAD) and coenzyme A.

NAD is derived from vitamin B3 and functions as one of the most important coenzymes in a [cell](https://biologydictionary.net/cell/) when turned into its two alternate forms. When NAD loses an electron, the low energy coenzyme called NAD+ is formed. When NAD gains an electron, a high-energy coenzyme called NADH is formed.

NAD+ primarily transfers electrons needed for redox reactions, especially those involved in parts of the citric acid cycle (TAC). TAC results in other coenzymes, such as ATP. If an organism has a NAD+ deficiency, then [mitochondria](https://biologydictionary.net/mitochondria/) become less functional and provide less energy for cell functions.

When NAD+ gains electrons through a redox reaction, NADH is formed. NADH, often called coenzyme 1, has numerous functions. In fact, it is considered the number one coenzyme in the human body because it is necessary for so many different things. This coenzyme primarily carries electrons for reactions and produces energy from food. For example, the [electron transport chain](https://biologydictionary.net/electron-transport-chain/) can only begin with the delivery of electrons from NADH. A lack of NADH causes energy deficits in cells, resulting in widespread fatigue. Additionally, this coenzyme is recognized as the most powerful biological [antioxidant](https://biologydictionary.net/antioxidant/) for protecting cells against harmful or damaging substances.

Coenzyme A, also known as acetyl-CoA, naturally derives from vitamin B5. This coenzyme has several different functions. First, it is responsible for initiating fatty acid production within cells. [Fatty acids](https://biologydictionary.net/fatty-acids/) form the [phospholipid](https://biologydictionary.net/phospholipid/) bilayer that comprises the [cell membrane](https://biologydictionary.net/cell-membrane/), a feature necessary for life. Coenzyme A also initiates the citric acid cycle, resulting in the production of ATP.

Non-Vitamins

Non-vitamin coenzymes typically aid in chemical transfer for enzymes. They ensure physiological functions, like [blood](https://biologydictionary.net/blood/) clotting and metabolism, occur in an organism. These coenzymes can be produced from nucleotides such as adenosine, uracil, guanine, or inosine.

Adenosine triphosphate (ATP) is an example of an essential non-vitamin coenzyme. In fact, it is the most widely distributed coenzyme in the human body. It transports substances and supplies energy needed for necessary chemical reactions and [muscle](https://biologydictionary.net/muscle/) contraction. To do this, ATP carries both a phosphate and energy to various locations within a cell. When the phosphate is removed, the energy is also released. This process is result of the electron transport chain. Without the coenzyme ATP, there would be little energy available at the cellular level and normal life functions could not occur.

* Differentiate between fat and water soluble vitamins

Water-Soluble Vitamins

Water-soluble vitamins are those that are dissolved in water and readily absorbed into tissues for immediate use. Because they are not stored in the body, they need to be replenished regularly in our diet. Any excess of water-soluble vitamins is quickly excreted in urine and will rarely accumulate to toxic levels. With that being said, certain types of water-soluble vitamin, such as [vitamin C](https://www.verywellhealth.com/the-benefits-of-vitamin-c-supplements-89083), can cause diarrhea if taken in excess.

The water-soluble vitamins include the B-complex group and vitamin C, each of which offers the following health benefits:

* **Vitamin B1** (thiamine) helps to release energy from foods and is important in maintaining nervous system function.
* **Vitamin B2** (riboflavin) helps promotes good vision and healthy skin and is also important in converting the amino acid tryptophan into niacin.
* **Vitamin B3** (niacin) aids in digestion, metabolism, and normal enzyme function as well as promoting healthy skin and nerves.
* **Vitamin B6**(pyridoxine) aids in protein metabolism and the production of red blood cell, insulin, and hemoglobin.
* **Folate** (folic acid) also aids in protein metabolism and red blood cell formation and may reduce the risk of neural tube birth defects.
* Vitamin B12 (cobalamin) aids in the production of normal red blood cells as well as the maintenance of the nervous system.
* **Biotin** helps release energy from carbohydrates and aids in the metabolism of fats, proteins, and carbohydrates from food.
* **Pantothenic acid** aids in metabolism and the formation of hormones.
* **Vitamin C**(ascorbic acid) is central to iron absorption and [collagen synthesis](https://www.verywellhealth.com/collagen-supplements-for-skin-89940). It aids in wound healing and bone formation while improving overall immune function.1﻿

Fat-Soluble Vitamins

Fat-soluble vitamins are dissolved in fats. They are absorbed by fat globules that travel through the small intestines and distributed through the body in the bloodstream. Unlike water-soluble vitamins, excess fat-soluble vitamins are stored in the liver and fatty (adipose) tissues for future use They are found most abundantly in high-fat foods and are better absorbed if eaten with fat.2﻿

Because fat-soluble vitamins are not readily excreted, they can accumulate to toxic levels if taken in excess. Where a well-balanced diet can't cause toxicity, overdosing on fat-soluble vitamin supplements can.

There are four types of fat-soluble vitamin, each of which offers different benefits:

* **Vitamin A**is integral to bone formation, tooth formation, and vision. It contributes to immune and cellular function while keeping the intestines working properly.
* **Vitamin D** aids in the development of teeth and bone by encouraging the absorption and metabolism of phosphorous and calcium.
* **Vitamin E** is an antioxidant that helps fight infection and keeps red blood cells healthy.
* **Vitamin K** is central to blood clotting and also keeps bones healthy.
* Describe niacin in relation to its coenzymic function

***Niacin*** is a coenzyme, like [thiamine](https://www.sciencedirect.com/topics/food-science/vitamin-b1) and [riboflavin](https://www.sciencedirect.com/topics/food-science/riboflavin), that is responsible for energy release from carbohydrates. A niacin deficiency can lead to ***pellagra***, a disabling disease with symptoms that may be characterized by four “Ds”: depression, diarrhea, delirium and dementia.

Niacin is found in fortified breads and cereals. Protein foods, such as eggs, fish, meat, dairy milk and poultry, are naturally rich in niacin. They are also plentiful in the amino acid [*tryptophan*](https://www.sciencedirect.com/topics/food-science/tryptophan), which can be synthesized into niacin by the liver. Chicken breast, ground beef, halibut, tuna and turkey are particularly good sources of tryptophan. In the vegetable kingdom, asparagus, baked potatoes and cantaloupe have significant amounts of tryptophan.

Niacin has been used to lower LDL cholesterol and raise HDL cholesterol when administered as a drug under medical guidance. In heavy doses, niacin has been known to cause a ***“niacin flush”*** due to the capillaries increasing in size. This condition can lead to fatigue and even liver damage. Caution should be used if one is taking niacin or B-complex supplements.

**Sources of niacin:** eggs, fish, legumes, meats nuts, peanuts, poultry, pork

**Roles in body:** coenzyme, digestive and nervous system functions, healthy skin

**Deficiency:** appetite loss, confusion, fatigue, flaky skin, indigestion, pellagra

**Toxicity:** cramping, flushing, headaches, irregular heartbeat, irritated ulcers, liver dysfunction

Cooking Foods with Niacin

Niacin is one of the more stable water-soluble vitamins and is minimally at risk for destruction by air, heat or light.

The adult RDA for niacin is 14 to 16 milligrams of niacin equivalents (NE) daily [4, 12].