NovaQ10

Coenzyme Q10 Facts or Fabrications

William V. Judy, Ph.D., Willis W. Stogsdill, M.D., Daniel S. Judy, M.D. and Janet S. Judy, R.N. CRC

CoEnzymeQ10 has been researched for years by scientists around the world, and its importance to the human body and its reported health benefits are widely known. For more than 30 years, people have been taking CoQ10 supplements in its oxidized form, *ubquinone*. When *ubiquinol* — the reduced form of CoQ10 — entered the US commercial market, manufacturers claimed that they had discovered a way to make the product stable so it could be used as a food or nutritional supplement in various delivery forms including softgels and free CoQ10 molecules in water and/or lipid based solutions such as liposomes, micelles, or nanoparticles. Several marketers also claimed that ubiquinol was the most bioactive and preferred form of CoQ10 in that 90–95% of the total body CoQ10 was in the form of ubiquinol. The absorption and bioavailability was claimed to be 300% better than of the oxidixed (ubiquinone) forms of CoQ10. The information provided to the consumers led to a general feeling or understanding that the oxidized form that had been in the market for three decades was an inferior compound and not the product form the body preferred — and thus consumers should consider switching to the new reduced and "bioactive" product form.

Obviously, this marketing approach, and the claims made, created controversies among and between CoQ10 scientists around the world and the marketing groups. These controversies led to editorials written by a scientist to explain the differences between Ubiquinone and Ubiquinol, and resulted in rebuttals from marketing groups regarding their opinions in the accuracy of the editorials. The opinions in the editorials were from the scientist who discovered CoQ10 in 1957 and from the President of the International Coenzyme Q10 Association. Those opinions in the rebuttal referenced one study on the absorption of Ubiquinone and several papers on the antioxidant capacity of Ubiquinol along with the conversion of one form to the other in response to oxidative or metabolic stress. In evaluating the claims made relative to Ubiquinol, we have judged many to be factual yet not functional. Other claims appear to be mere fabrications to meet marketing needs and confusing many consumers.

The following is a list of claims made by various CoQ10 marketing groups relative to CoQ10, in the oxidized Ubiquinone and the reduced Ubiquinol forms. We have evaluated many of these claims based on scientific FACT or marketing group FABRICATIONS. The areas to be discussed are:

1. The CoQ10 molecule
2. CoQ10 absorption
3. CoQ10 transport
4. Conversion of Ubiquinone to Ubiquinol and vice versa
5. CoQ10 bioavailability
6. Functions of Ubiquinone and Ubiquinol

1. The CoQ10 Molecule

The characteristics of the CoQ10 molecule in many ways control its absorption and thus its bioavailability to the body cells. Ubiquinone (oxidized form) has a molecular weight of 864 Dalton's whereas Ubiquinol (reduced form) has two more hydrogen molecules and forms with the oxygen, a hydroxyl unit on the head of the molecule, thus having an 866 molecular weight. Both forms are highly lipid soluble due to the predominance of the 10 unit isoprene tail. Ubiquinone is bright yellow in color and Ubiquinol is milky white in color. Ubiquinone and Ubiquinol form a redox (Oxidation – Reduction) pair and can be readily converted from one form to the other in the cells, lymph or blood when their respective functions are in demand.

In the cell, CoQ10 is predominantly found in the outside of the mitochondria inner membrane in the Ubiquinol form (90–95%). CoQ10 in man and large animals has 10 isoprene units in its tail (CoQ10), while smaller vertebrates have 9 isoprene units (CoQ9). The body synthesizes Ubiquinone in all living cells. Commercial CoQ10 is manufactured by two different processes: 1) partial synthesis of CoQ9 to CoQ10 and 2) a yeast fermentation extraction process from which CoQ10 is made by a friendly bacterium. CoQ10 has two isomers (Trans and Cis). The trans isomer makes up 99.95 to 100 percent of the CoQ10 in both commercial product types.

The following is a list of claims made about the CoQ10 molecules or crystals.

- CoQ10 is a vitamin like substance produced in all living human body cells. FACT
- CoQ10 is commercially made from sugar beets. FABRICATION

  CoQ10 is made by a partial synthesis from CoQ9 or by a yeast fermentation extraction process. The microorganisms which make the CoQ10 in the fermentation process could be fed sugar beets.
- Dr Karl Folkers discovered CoQ10 in beef heart Mitochondria in 1957. FABRICATION

  Dr. Fred Crane discovered CoQ10 and Dr. Folkers determined its chemical structure.
- CoQ10 is a lipid-soluble molecule. FACT
- Converting or placing lipid-soluble CoQ10 molecules into liposomes, micelles or nanoparticles make CoQ10 molecules soluble in water. FABRICATION

  The particles formed are dispersible in water due to the hydrophilic heads of the CoQ10 molecules forming the outer shell of the particles, and usually with the help of some surfactants. The CoQ10 molecule is still lipid-soluble and is absorbed in the body as such.
- Reducing the size of the CoQ10 molecule makes it more water soluble. FACT

  Reducing CoQ10 to CoQ 9, 8, 7 by cutting off its lipophilic tail will make it more water-soluble, however it then is no longer CoQ10.
- Making the CoQ10 molecule smaller and thus more water-soluble will allow it to be rapidly absorbed through water filled pores in the absorption cell membrane. FABRICATION

  Small lipid soluble molecules with 5–12 carbon atoms can be absorbed passively through water filled pores; however CoQ10 with 54 carbon atoms can not be absorbed through these hydrophilic pores.
- Ubiquinol, the reduced form of CoQ10, is synthesized in the body cells. FABRICATION

  The oxidized Ubiquinone form of CoQ10 is synthesized in the body's cells.
- Ubiquinone is yellow in color while Ubiquinol is a milky white color. FACT
- The term hydrophilic means readily dissolved in water, water-soluble, or absorbable. FABRICATION

  In fact, water-soluble molecules can be rapidly dissolved in water, however, if they are very large in size, their absorption may be poor. Water-soluble does not always equate or mean high absorption. Some molecules are simply too large to be absorbed well. CoQ10 cannot be converted into a water-soluble molecule.

- All CoQ10 product types must be placed in colored capsules or dark containers because CoQ10 is sensitive to light. FABRICATION

  Independent laboratory testing has clearly shown that crystal free CoQ10 in clear gelatin softgel capsules or crystalline CoQ10 have less than 1% by weight loss and no significant sensitivity to light. The primary reason for colored softgel capsules is to prevent the consumer from seeing crystals being formed inside the product.

2. CoQ10 Absorption

CoQ10, being a rather large molecule, is absorbed through the absorption cells in the small intestines by a *"simple passive facilitated diffusion"* process. *Passive* means that the process does not require energy. *Facilitated* means that the process requires a lipid molecule to act as a carrier for the CoQ10 molecules. Passive diffusion is down-hill transport and requires a greater CoQ10 concentration in the water phase adjacent to the side of the absorption cell membrane compared to that inside the cell membrane. To a point, the greater this gradient is, the faster and greater the absorption.

CoQ10 crystals cannot be absorbed. Thus, crystalline compounds must be dissolved to single molecules before absorption. Intestinal absorption occurs on a molecular level; meaning only single molecules can be absorbed. CoQ10 in its crystallized form has poor dissolution within the chyme of the intestines, because its melting point is 10 degrees centigrade above body temperature. Without the addition of a lipid carrier molecule to facillate the absorption of CoQ10, even single molecules are poorly absorbed. This is evidenced by the poor absorption of CoQ10 plain powder: less than 1%.

The following is a list of claims about CoQ10 absorption:

- For crystals of CoQ10 to be absorbed, they have to be dissolved to single molecules. FACT

  The body's intestinal absorption cells can not absorb crystals of any type.

- CoQ10 is absorbed through an active transport mechanism like that of sugar. FABRICATION

  CoQ10 being a large lipid-soluble molecule, is absorbed by a process called *"simple passive facilitated diffusion"* through the phospholipid cell membranes, not the active transport process.

- Combining CoQ10 with a sugar will allow the CoQ10 to be absorbed with sugar directly into the blood. FABRICATION

  Membrane proteins are involved in the absorption of sugar and sodium via an active transport mechanism. If CoQ10 was absorbed while being bound to sugar, its Cmax (maximum concentration in blood) would peak with sugar in about two hours instead of 5–8 hours as for most lipids.

- CoQ10 is absorbed across the intestinal cells directly into the venous blood. FABRICATION

  CoQ10 is absorbed across the intestinal cell membranes into the lymph vessels in the intestinal microvillus, not into the bloodstream.

- The poor dissolution of powder based CoQ10 tablets and lipid filled softgels in simulated gastric juice is a good indicator of poor absorption. FACT

  However, since CoQ10 is not soluble in water but is soluble in a lipid, shouldn't the solubility test for lipid soluble molecules be done in a lipid solution?

- Ubiquinol has far greater water solubility and much better absorption into the blood stream than does Ubiquinone. FABRICATION

  The addition of two hydrogen ions on the polar head of the Ubuquinol molecule will not make the molecule highly water-soluble or absorbed as a water-soluble molecule.

- Ubiquinol is more water-soluble than Ubiquinone. FACT

  When two hydrogen's atoms are added to the polar (water-soluble) head of the CoQ10 molecule, the increased mass will make Ubiquinol slightly more water-soluble than Ubiquinone. However, due to the larger total mass of the nonpolar tail of the molecule, it is still more lipid-soluble than water-soluble.

- Liposomes, micelles and nanoparticle CoQ10 products are absorbed, transported in lymph, blood and to the target body cells as liposomes, micelles or nanoparticles. FABRICATION

  The microspheres can not be absorbed. They are simply transport vehicles for ingested CoQ10, to be delivered to the intestinal absorption cells.

- Reduced CoQ10, an antioxidant, remains in the reduced form when ingested and absorbed. FABRICATION

  Reduced CoQ10 is highly unstable in the contents of the stomach and is converted to oxidized CoQ10 before absorption.

- The rapid dissolution of a liposome, micelle or nanoparticle CoQ10 products in water is a good indicator of high CoQ10 absorption. FABRICATION

  The rapid dissolution of these CoQ10 products types tells that these polar particles (water-soluble microspheres) will disperse rapidly in water. This does not mean that they are better absorbed. Only the CoQ10 molecules are absorbed, not the liposomes, micelles or nanoparticles.

3. CoQ10 Transport

Absorbed nutrients are transported from the intestines by two routes.

Small water-soluble and some small lipid-soluble nutrients, after absorption, enter the capillary blood in the intestinal microvillus and are transported by the blood to the liver. From the liver these small molecules are transported through the hepatic vein to the inferior vena cava, then to the heart and then into systemic circulation.

Large lipid-soluble nutrients such as CoQ10, after absorption, diffuse into the lymph capillary in the intestinal microvillus, and are transported in the lymph through the abdominal and thoracic lymph duct to the subclavian vein and then into the systemic circulation. In the lymph and blood, CoQ10 molecules are predominately in the reduced form and are bound to the low density lipoproteins (LDL). The delayed peak concentration of CoQ10 in the blood is due to the very slow lymph flow compared to that of blood. The portal venous blood is a delivery system to the liver, but the lymph is not.

The following is a list of claims about CoQ10 transport:

- After CoQ10 absorption, it is transported by the lymph to the liver where it is reduced and bound to phospholipids. FABRICATION

  The lymph is not a delivery system to the liver.

- CoQ10 is transported from the absorption cells to the venous blood by the lymphatic system. FACT

  The lymph is the delivery system for absorbed CoQ10 molecules to the systemic blood. Large animal studies show that CoQ10 peaks in the abdominal lymph duct in 2–3 hours after ingestion where as it peaks in venous blood in 6–8 hours. The reason for the delayed appearance in the venous blood is due to slow lymph flow.

- In the absorption cell, the lymph or the blood oxidized CoQ10 is converted to the reduced form of CoQ10. FACT

  Circulating CoQ10 in the blood is 90–95% in the reduced (Ubiquinol) form.

- CoQ10 is rapidly absorbed in the small intestines and is slowly transported by the lymph to the venous blood. FACT

  Total lymph flow is about 100 ml/minute whereas blood flow is 5,000 ml/minute.

4. Conversion of Ubiquinol to Ubiquinone and Vice-Versa

Ubiquinone and Ubiquinol, being redox pairs, are easily converted from one form to the other in the body. For example, when exogenous Ubiquinone is absorbed in the intestines it is converted to Ubiquinol in the absorption cells, the lymph, or the blood. Since CoQ10 is not used to produce energy in the lymph system or blood, it is understandable why this conversion takes place to fulfill the need for antioxidant protection in the circulation. On the other hand, in the inner membrane of the mitochondria where energy is made, the oxidized form of CoQ10 (Ubiquinone) is in great demand. Here the reduced Ubiquinol form is rapidly converted to the oxidized Ubiquinone form. In the mitochondria this conversion creates a Q-Cycle. It was once felt by the late Sir Peter Mitchell (Nobel prize, 1978) that the Q-Cycle would maintain the proportion of Ubiquione and Ubiquinol required for energy synthesis available forever. Little did he know at the time of his discovery that with age and disease the body's ability to produce Ubiquinone and to convert it to Ubiquinol would diminish and true CoQ10 deficiencies would be prevalent in an aging society.

The following is a list of claims about CoQ10 conversion:

- CQ10 can be converted from the reduced to oxidized form and vise versa in the body as needed. FACT

This is a unique characteristic of redox pairs.

- CoQ10 in the foods we eat is in the reduced form. FACT & FABRICATION

  The CoQ10 in fresh uncooked animal protein in is the reduced form. However, when cooked, it is converted to the oxidized form. Even when ingested uncooked (such as sushi or steak tartar), CoQ10 will be converted in the stomach to the oxidized form.

- CoQ10's ability to cycle back and forth between Ubiquinone and Ubiquinol accounts for many of its unique properties. FACT

5. CoQ10 Bioavailability

After absorption, CoQ10 accumulates in the blood and becomes bioavailable to all body cells. Bioavailability reflects absorption but it is not the actual absorption and should not be used as an accurate measure of such. It does, however, give a good estimate of the amount of CoQ10 available as an antioxidant in the blood and that available to the body cells. CoQ10 is accumulated and is stored in the cell membranes and in the membranes of the organelles in the cell.

It has been known for two decades that the bioavailability of the pure crystalline CoQ10 is less than that of liposome, micelle, and dissolved CoQ10 products. The current commercial and scientific issue is the bioavailability of the Ubiquinol form compared to that of the Ubiquinone form of CoQ10.

The following is a list of claims about CoQ10 bioavailability:

- Ubiquinol has a much higher bioavailability then the Ubiquinone used in other commercial CoQ10 supplements. FABRICATION

  In fact, the data on ubiquinol state that its bioavailability is 300 percent more than that of the oxidized dry powder products. Most dissolved, liposome, micelle and nanoparticle CoQ10 products claim to have a 260 to 350 percent greater bioavailability than oxidized dry powder CoQ10.

- The two hydroxyl groups on the Ubiquinol compound results in its stronger bonding with water and helps explain why it is so much more bioavailable than Ubiquinone. FACT

  This bonding does make Ubiquinol slightly more water soluble than Ubiquinone. However, the molecule is still lipophilic and is absorbed as a lipid.

6. Functions of Ubiquinone and Ubiquinol

Currently CoQ10 has two main functions in the body: it is used for energy production and functions as an antioxidant in the body.

Ubiquinone is a cofactor in the inner membrane of the mitochondria for the synthesis of energy (ATP). Since the body does not store energy (ATP), it must be rapidly produced through an oxidative phosphorlation process. CoQ10 is positioned between NADH and Cyto-Chrome C in the inner membrane and acts as cofactor stimulation to all three mediators to give up electrons to run the electron transport through complexes I-IV in this system. This function is specific to Ubiquinone in that no other molecule can replace Ubiquinone in this process. However, Ubiquinone and Ubiquinol as a redox pair form the Q Cycle in which they act to conserve each other in this process.

Ubiquinol is an antioxidant throughout the body. This is especially true in the cell membranes and those of the cell organelles. In these membranes CoQ10 may well be the primary lipophilic molecule essential for the prevention of lipid peroxidation resulting in cell damage and eventually cell death. Outside the cell and organelle membrane and in the presence of other lipophilic and hydrophilic antioxidants, Ubiquinol may recycle other antioxidants such as vitamin E and C.

The following is a list of claims about the functions of CoQ10

- Ubiquinol protects the body against toxic oxidative reactions. FACT

  Yes, but equally beneficial it also recycles Ubiquinone in the synthesis of energy.

- The functions of Ubiquinol in the body are more diverse than those of Ubiquinone. FABRICATION

  Ubiquinol functions in the body as an antioxidant and in the recycling of Ubiquinone, Vitamin E and Vitamin C. Ubiquinone, through its synthesis of energy, is involved in all body processes requiring energy: energy synthesis, active transport, membrane and nucleotide stability, synthesis of enzymes, coenzymes, hormones, neuro-transmitter synthesis and reuptake, cillary activity in the upper respiratory systems, all muscle contractile functions, sperm production and motility, deactivation of muscle contraction, pumping action of sweat and other cutaneous glands, etc. ***In fact, Ubiquinone is possibly the hub around which life processes revolve in the human body.***

- Clinical studies with Ubiquinol show it is superior to Ubiquinone. FABRICATION

  In fact, Ubiquinol became available in 2006 and to date, no clinical studies in human beings using Ubiquinol have been published in the peer-reviewed scientific literature. An anti-aging study in genetic mutated mice has been described, but the role of the genetic mutations in these mice as they pertain to CoQ10 conversion are not understood. This is a concern since mice use CoQ9 as an energizer and antioxidant whereas human beings use CoQ10.

- Ubiquinol supplements make Ubiquinone supplements obsolete. FABRICATION

  In fact, hundreds of clinical studies show that Ubiquinone is effective and is still the choice of practicing cardiologists. Ubiquinone and Ubiquinol are rapidly inter-converted back and forth as needed, regardless of which form is ingested.

The existence of CoQ10 in two forms and structures, having two separate but essential functions, and its ability to act as a redox pair to recycle each other as needed is the beauty of this molecule. Although Ubiquinone was discovered first and found to be essential for life, the discovery of Ubiquinol broadened the overall scope of this molecule relative to the health characteristics and benefits to man. Without Ubiquinone life is not possible in that the body can not survive without energy. On the other hand, the life sustaining feature of energy has to be maintained and protected. Since Ubiquinol recycles Ubiquinone, the life cycle is maintained for about 8 decades in man. This would not be possible if it was not for Ubiquinol and other antioxidants. The antioxidants act as part of the host defense system and thus, prevent the toxic by-products (free radicals and super oxides) from the synthesis of energy and all substances produced by the body from rapidly aging all cells and shortening and reducing the quality of life.

CoQ10 as a scientific entity is 50 years old. As a commercial food supplement it has been around for about 37 years. The basic and clinical science is still growing. It is now presented in basic and graduate level text books of the biomedical sciences. Its entry into clinical text and its acceptance in the clinical societies will eventually occur with more well controlled clinical trials. These clinical trials are currently a world wide effort. CoQ10 as a supplemental nutrient to standard clinical therapy is here now. Its use as a stand alone nutrient to insure and maintain normal health characteristics of man is rapidly growing throughout the world. This will continue to grow with continued and more advanced research.

In summary, many aggressive marketing campaigns introducing Ubiquinol have created false and misleading claims that have only generated more confusion about CoQ10.

The apparent lack of superior absorption, instability in the stomach, no clinical efficacy studies and the high cost of Ubiquinol have to be considered when making a decision as to which CoQ10 form should be sourced. Millions of consumers experience its many benefits each day. Ubiquinone and Ubiquinol are redox pairs in that one can be rapidly converted to the other and vice versa in areas where their specific functions are required. Thus, does it really matter which form is taken as a supplement? Yes, it does matter.

First, there is a cost comparison in that consumers still look for the lowest cost and effective products. Since the forms of CoQ10 can be easily converted from one form to another, it makes sense to choose a form that is more affordable. It was previously mentioned that Ubiquinol molecule becomes oxidized in the stomach. Consequently, taking Ubiquinol as a nutrient is essentially the same as taking the more stable and less expensive oxidized form.

Second, regardless of *the* product type, the most critical aspect of CoQ10 supplementation is absorption. Due to the high cost of CoQ10, an understanding of the best delivery system to maximumize absorption becomes the critical component in an effective and successful CoQ10 supplement. Based on the current CoQ10 research, the consumer's best bet is a CoQ10 product with superior absorption properties because dosage levels can be reduced to attain the same effective blood levels and health benefits.

References available upon request.

About the Author:

Dr. William Judy is a retired Professor of Physiology and Biophysics at the Indiana University School of Medicine and the Founder and President SIBR Research, Inc. SIBR Research, Inc. is a contract research center that conducts clinical trials on natural products for the international community. Dr. Judy has researched Ubiquinone (CoQ10) and used it with patients for over 35 years. His initial work was in collaboration with Dr. Karl Folkers, University of Texas. He was one of the first researchers to run long-term clinical trials, spanning 10 years or longer, on hundreds of cardiac patients, many of whom had been "left to die" by the medical establishment. Dr. Judy's articles, reports and reviews have appeared in multiple publications, and he has traveled the world, lecturing to physicians, health care professionals and scientists about the benefits of CoQ10 in health maintenance and disease prevention. Dr. Judy can be reached at sibrinc@cs.com.