J. Condensed Matter Nucl. Sci. 7 (2012) 11–25

Review Article

Biological Transmutations: Historical Perspective

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Abstract

In this review paper, it is shown that in biological systems, chemical elements can be transmuted into other elements. These facts have been established since the early 19th century, but they have been ignored by established science ever since. The purpose of this work is to show how during the past two centuries, a number of experimentalists have questioned the mass conservation law established by Antoine Lavoisier [1] for chemical reactions. They have proved experimentally in plants, bacteria and other living organisms, some elements are transmuted into other elements.

Keywords: Biological transmutations, Cold fusion, History, LENR

1. Introduction

The discovery of Cold Fusion in 1989 by Stan Pons and Martin Fleischmann [2] has triggered new attention in the field of biological transmutations. Even though experiments have shown that transmutations of elements occur in living cells, this field has been totally ignored by the scientific community. The situation is not different now, but recently new experiments, in particular, by Vysotskii and Kornilova [3] have brought new results using modern analytical techniques.

It is interesting to recall the situation of chemistry before Lavoisier, which was the time of alchemy, when the modern scientific method had not yet been developed. Also the nature of the elements had not been clearly identified.

Most of the works come directly from Herzelee's experiments. They triggered the experiments made by Baranger, Kervran, Goldfein, Holleman and then Vysotskii. Many experimental results described in this paper are not of a good quality because they have been performed in the 19th century or in the early 20th century, and the full data are not easily available. Some are coming from a secondary source, and therefore are less reliable. However, if we consider the totality of these data, including the most modern ones, there is compelling evidence that biological transmutations are a real scientific fact.

Very few theoreticians have tried to understand the possible mechanisms involved in these kinds of reactions, and it is more likely to take a long time before a reliable theory can be developed. One of the reasons is the lack of useful data where all elements before and after are well known to the scientists.

In this review, I also recall some of the works that I have performed myself [4] with germinating seeds and bacteria.

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2. Before Lavoisier

2.1. Jan Baptist von Helmont (1579–1644)

The work by von Helmont [5] in the 17th century is probably the first experiment that tried to study the workings of plants. He wanted to prove that the alchemical theory of the four elements was incorrect. He grew a willow tree in a clay vessel with 90 kg of dried soil. He covered the vessel with an iron cover having small holes. In his report, he explained that he did not take into account either falling leaves or dust. For 5 years, he watered the plant with filtered rainwater or if necessary with distilled water. He observed that the tree had gained 76 kg, whereas after drying the soil had only lost 57 g. He concluded: "Water alone had, therefore, been sufficient to produce 76 kg of wood, bark and roots". Von Helmont proved that the elements of water and earth were not elementary, since water had changed into wood, bark and roots. This experiment proved that the elements of water could change into elements of soil.

3. Antoine Lavoisier (1743–1794)

In 1789, the famous French scientist Antoine Lavoisier [1] performed very accurate experiments showing conservation of mass during chemical reactions. He wrote:

> *" We can state as an indisputable axiom that under all conditions, artificial or natural, nothing is created; an equal quantity of matter exists before and after the experiment and nothing occurs outside the changes and modifications in the combinations of the elements".*

Unfortunately, for him and science, he was beheaded because of his function as "fermier général", i.e. an unpopular tax collector of the old regime. It is also interesting to note his inventions of an accurate ice calorimeter to measure the heat of respiration of a guinea pig, proving that breathing is actually a combustion process.

Landolt [6] has confirmed the mass conservation during chemical reactions with better accuracy in 1908 with an accuracy of one part in 10^6, and later in 1913 by Manly [7] with one part in 10^8.

4. During the 19th Century

4.1. Johann Christian Carl Schrader (1762–1826)

From 1795 to1797, the Berlin Academy of Science announced a competition with the following aim:

> *" Of which types of the earthly materials, which are encountered by means of chemical analysis, of native grain species? Do they either come into the grains as they are found or come into being by means of the life force and brought into growth by the workings of the plant?"*

In 1799, the German scientist Schrader [8] won the competition for his experiments on the formation of minerals in grains. He used the seeds of wheat, barley and rye, amongst others, to germinate in an artificial medium of flowers of sulphur (amorphous sulfur in fine powder) (that was shown to be completely ash free) and watered with distilled water. The dust contamination was prevented during the experiments. From the analyses of the developed seedlings, he compared with the seeds which are planted, he concluded that the mineral matter had indeed been created.

4.2. Henri Braconnot (1780–1855)

In 1807, the highly reputable French scientist Henri Braconnot [9] reproduced Schrader's experiments. He allowed plants from seed to grow on different artificial media (flowers of sulphur, red lead oxide, granulated lead, pure river sand and even an organic product; decomposed wood that was extracted using hot water). He concluded that considerable formation of the mineral components, especially potassium in experiments with mustard seed and radish, had taken place.

4.3. Louis Nicolas Vauquelin (1763–1814)

In 1799, the French chemist Louis Vauquelin [10] became intrigued by the quantity of lime which hens excrete every day. He isolated a hen and feed it a pound of oats, which were analyzed for lime (CaO). Vauquelin analyzed the eggs and faeces and found that five times more calcium was excreted than was consumed. He observed, not only the increase of calcium but also a subsequent decrease of silicon. He is certainly the first scientist to have demonstrated the biological transmutation of silicon into calcium.

In his conclusion he remarked that a loss of only 1.274 g of silica cannot account for an increase of 14.118 g of limestone. He concluded that lime had been formed, but could not figure out how it happened. Further more, he encouraged other scientists to replicate his experiment.

4.4. Albrecht Thaer (1752–1828)

In the 18th century organic reactions are attributed to a "life force". Thaer [11] showed that under some circumstances, calcium transforms into silicon. According to him, silicon could come from potassium. Under certain circumstances calcium in the plant became changed into silicon, whilst this substance may itself be formed from potassium

4.5. William Prout (1785–1850)

In 1822, the English physiologist, Prout [12] studied chicken eggs in incubation. He found that hatched chicks had more lime (calcium) in their bodies than originally present in the egg, and it was not contributed from the shell.

4.6. Wilhelm Augustus Lampadius (1772–1842)

In 1832, Lampadius [13] thought that plants themselves create silicon in plants.

4.7. Vogel

In 1844, a German researcher named Vogel planted watercress seeds (Lepidum satirum) in a bell jar in crushed glass in a controlled air environment. They were fed nothing but distilled water, yet when grown they contained more sulphur than had been in the seeds originally. J.J. Berzelius reported the experiment in his book [14]. Vogel's answer was that sulphur was not a simple element or that sulphur was introduced from sources unknown.

4.8. Choubard

In 1831, Choubard [15] germinated watercress seeds in clean glass vessels and showed that the sprouts contained minerals, which did not previously exist in the seeds.

4.9. John Bennet Lawes (1814–1900) and Joseph Henry Gilbert (1817–1901)

In 1856–1873, two British researchers, Lawes and Gilbert observed an inexplicable variation in the amount of magnesium in the ashes of plants. They could "extract" more elements from the soil than the soil actually contained in the first place, in particular the formation of magnesium in grass.

4.10. Albrecht Von Herzeele(1821–?)

In 1876 Herzeele [16], a German pharmacist published a series of books in which he showed research proving that plants continuously create material elements. From 1875 to 1883, in Berlin, he conducted 500 analyses with different types of seeds. He worked with: clover, crimson, vetch, rapeseed, barley, watercress, bean, white beans, kidney beans, turnips, rye, peas lupine, coltsfoot and angelica. A typical experiment showed the variation of calcium, potassium and phosphorus in Vicia sativa during germination with or without addition of mineral salts in distilled water.Also he showed that the addition of various calcium salts to the medium increased the formation of potassium. The addition of K_2CO_3, increased the formation of calcium.

He concluded that "Plants are capable of affecting the transmutation of elements". His publications outraged so much the scientific community of the time that they were removed from libraries. His writings were lost for more than 50 years until about ca.1930 when a collection was found by accident in Berlin by Dr. Hauschka, who subsequently published Von Herzeele's findings (the philosopher W.H. Preuss had dedicated an article to him; Preuss defended the idea that inorganic nature was a product of the organic; Herzeele was in agreement, apparently inspired by Goethe).

5. During the 20th Century

5.1. Freudler

Freudler was a Professor at the famous French University, La Sorbonne. In 1928, he published a book based on his 10 years of research on the production of iodine by algae. He noticed a connection between tin and granite in which the algae produced and iodine in the plants.

5.2. Earle Augustus Spessard

In 1940, Spessard [17] performed an experiment in which an organic process was studied in a hermetically sealed container. The bottles were weighed after some years. At the end, living protozoa were still seen through the glass walls. Presumably plant assimilation and animal respiration followed each other more or less in balance. There was a weight *increase* of a few tenths of a milligram (with a balance accuracy of 0.02 mg). Sources of errors, so far as they were known, were carefully eliminated. The predicted continuation of this work did not appear. The increase in weight that was found was far too big to be considered as a "materialization" of the received light rays.

5.3. Rudolph Steiner (1861–1925)

Rudolph Steiner [18] in 1924 gave a series of lectures giving indications for the development of a new approach to agriculture that later became known as biodynamics. In the 5th series of his lectures, he referred to composting, he stated "even according to the purely external standards of analytical chemistry, this ought to betray the fact that there is a kinship between the way in which oxygen and nitrogen are connected in the air and that in which lime and hydrogen are connected in organic processes. Under the influence of hydrogen, lime and potash are constantly being changed into nitrogenous matter, and finally into actual nitrogen. And the nitrogen, which has come into being in this way, has a tremendous value for plant growth. Silicic acid, as we know, contains silicon and this in turn undergoes transmutation in the living organism. It is changed into a substance which is of exceptional importance but which is not reckoned by present-day science to be among the elements."

5.4. Henri Spindler

In 1946–1947, the French Scientist and Director of the Laboratoire Maritime de Dinard, Spindler [19] discovered Herzeele's work on the decrease of phosphorus and increase of calcium. In 1959, he measured an increase of iodine by 30% in algae, Laminaria flexicaulis and 80–100% in Laminaria sacharina.

5.5. Rudolf Hauschka (1891–1969)

An Austrian chemist, Hauschka [20] during the years 1934–1940, in sealed glass containers, weighed cress seeds, and found an increase in weight of 0.54% during the full moon, and a decrease of 0.58% during the new moon. He published several books in which he re-evaluated Herzelee's work, which he included as appendix in his books, *Substanzlehre* (though it has not been included in the English translation, *The Nature of Substances*).

5.6. Perrault

French scientist Perrault [21], from the Paris University, found that the hormone aldosterone provoked a transmutation of Na to K, which could be fatal to a patient.

5.7. Julien

Julien [22] was a French Scientist, from the Besançon University. In 1959, he proved that if tench are put in water containing 14% NaCl, their production of KCl increased by 36% within 4 h.

5.8. George 0shawa (1893–1966)

Oshawa [23] was a Japanese scientist, and an inventor of macrobiotics. He collaborated with Louis Kervran. His opinion was that transmutation occurs during mastication.

5.9. Pierre Baranger (1900–1970)

Pierre Baranger was a French Scientist, a professor of organic chemistry at the famous Ecole Polytechnique, and head of the Laboratory of Chemical Biology. He became intrigued with Herzeele's experiments, but he thought that the number of trials had been too limited and the precautions against error were insufficient. Baranger decided to repeat the experiments with all possible precautions and a very large number of cases, which would allow a statistical study. His research project from 1950 to 1970 involved thousands of analyses. Baranger verified the content of phosphorus, potassium, calcium and iron of vetch seeds before and after germination in twice-distilled water to which pure calcium chloride was not added. Hundreds of samples of 7–10 g each were selected, weighed to 1/100th milligram, and graded, then germinated in a controlled environment.

Baranger found an increase of 4.2% in calcium, and 8.3% of iron, and subsequently a decrease in phosphorus of 1.9%, and of potassium of 1.1%. Interestingly, an addition of $MnCl_2$ increases the amount of iron produced.

None of the specialists who examined Baranger's work were able to find any experimental errors. Baranger concluded:

> *"These results, obtained by taking all possible precautions, confirm the general conclusions proposed by Von Herzeele and lead one to think that under certain conditions the plants are capable of forming elements, which did not exist before in the external environment".*

In May 1959, he submitted an article for publication in the French Academy of Sciences, but was not accepted. Later in 1972, his family tried another submission without success. He had difficulties in publishing his findings, and died without being able to do so. Later, in 1977, his family asked Jean Marie Gatheron, a close friend of Baranger to publish Baranger's work [24]. In 1976, his family submitted the final report of Baranger to the Academic Commission of the French Academy of Agriculture. It was decided that the work would be presented to the full assembly in a secret meeting. The proposal of publication in a public meeting was rejected without any reason.

Baranger failed to provide relevant theory to explain his findings.

5.10. Leendert Willem Jacob Holleman (1906–1994)

From 1975 to 1989 Holleman [25], a Deutch scientist, performed experiments with alga Chlorella. He observed a decrease, then subsequent increase, of potassium. However, in spite of several attempts, he could not reproduce his own first positive experiments.

5.11. Correntin Louis Kervran (1901–1983)

Kervran is certainly the most well-known scientist having worked in the field of biological transmutations. He had a broad knowledge of plants, geology and nuclear science. His findings have been published in French in ten books [26], some of them have been translated into English [27]. He was also nominated for the Nobel Prize.

Observations

From 1935 Kervran [28] collected facts and performed experiments, which showed that transmutations of chemical elements do indeed occur in living organisms. It started when he investigated fatal accidents from carbon monoxide poisoning when none was detectable in the air. Next he analysed why Sahara oilfield workers excreted a daily average of 320 mg more calcium than they ingested without decalcification occurring.

Kervran pointed out that the ground in Brittany contained no calcium; however, every day a hen would lay a perfectly normal egg, with a perfectly normal shell containing calcium. The hens eagerly pecked mica from the soil, and mica contains potassium. It appears that the hens may transmute some of the potassium into calcium.

Experiments with seeds

From 1960 to 1980, Kervran reported the astounding results of his research showing that living plants were able to accomplish limited transmutation of elements. Then Kervran was the Conferences Director of the University of Paris, and his first paper was published in La Revue Générale Des Sciences, July 1960.

Kervran found that in nuclido-biological reactions, oxygen is always in the form of O, never O_2; reactions with nitrogen occur only with N_2, insofar as is known. The following reactions have been proposed:

$Na^{23} + H^{1} \rightarrow Mg^{24}$	$Na^{23} + O^{16} \rightarrow K^{39}$	$Na^{23} - O^{16} \rightarrow Li^{7}$
$Na^{23} \rightarrow Li^{7} + O^{16}$	$K^{39} + H^{1} \rightarrow Ca^{40}$	$Mg^{24} + Li^{7} \rightarrow P^{31}$
$Mg^{24} + O^{16} \rightarrow Ca^{40}$	$F^{19} + O^{16} \rightarrow Cl^{35}$	$C^{12} + Li^{7} \rightarrow F^{19}$
$Cl^{35} \rightarrow C^{12} + Na^{23}$	$Fe^{56} - H^{1} \rightarrow Mn^{55}$	$2\,O^{16} - H^{1} \rightarrow P^{31}$
$O^{16} + O^{16} \rightarrow S^{32}$	$2\,N^{14} \rightarrow C^{12} + O^{16}$	$N^{14} + Mg^{12} \rightarrow K^{19}$
$Si^{28} + C^{12} \rightarrow Ca^{40}$	$Si^{28} + C^{12} \rightarrow Ca^{40}$	$P^{31} + H^{1} \rightarrow S^{32}$

In 1980, Kevran [29] performed an experiment with oat seeds analysed using mass spectroscopy. They looked at phosphorus and calcium variations. They observed the following:

	Phosphorus (mg)	Calcium (mg)
Seeds	485	76
Plants	310	115.5
Difference (mg)	–175	+39.5

It is clear that the calcium increased with germination, whereas phosphorus decreased. There are certainly other elements that played a role, but they were not analysed in this experiment.

The French Society of Agriculture

In 1971, the laboratory of the French Society of Agriculture sprouted rye seeds under controlled conditions.

	Seeds	Sprouts	Difference (mg)	Difference (%)
Mg (mg)	13.34	3.20	–10.14	–335%
K (mg)	7.36	16.67	+9.31	+133%

These results are in good agreement with Kervran's previous findings.

Kervran was very active in promoting his work through books, conferences and mass medias. However, the Academy of Agriculture strongly opposed his efforts. In October 7, 1970, Stéphane Henin on one side and Léon Guéguen and Allez on the other side sent reports to the Academy by criticizing Kervran's results [30].

5.12. J.E. Zündel

Zündel [31] was a Swiss scientist, head of a paper company, and a chemical engineer at the Polytechnic School of Zurich (ETH Zurich) in Switzerland. Following Kervran's observations from 1970, he studied germinating seeds and observed a 54–616% increase of calcium. In another experiment, he grew 150 oats seeds (flämingkrone) in a controlled environment for 6 weeks. 1243 sprouts were analysed using atomic absorption spectroscopy for the presence of magnesium and calcium. The potassium decreased by 0.033%, the calcium increased by 0.032%, and magnesium decreased by 0.007%. The variation of magnesium was not significant, but the decrease in potassium balanced the increase of calcium. In 1972 with oat seeds, he observed an increase of calcium of 118%, a decrease of magnesium of 23%, and potassium 29%.

In 1971, he gave a lecture at the French Academy of Agriculture (Bull No. 4, 1972). In his lecture, he announced the following variations between seeds and sprouts:

	SiO_2	Ca	Mg	K
Seeds	111 mg	28 mg	27 mg	108 mg
Sprouts	123 mg	116 mg	27 mg	70 mg
	+10%	+314%	0%	–35%

In spite of the excellent quality of his works, the audience criticized him, including S. Henin, the head of the Department of Agronomy.

Later in 1979, Zündel, using a mass spectrometer at the the Microanalysis Laboratory of the French National Scientific Research Center, and neutron activation analysis at the Swiss Institute for Nuclear Research in Villigen (Aargau), confirmed the increase of calcium by 61%. There was also an increase of 29% in phosphorus and 36% in sulphur) [32].

However, the French Atomic Energy Commission has analysed Zündel's experiments in 1975 by neutron activation analysis of oat seeds. They found no change in calcium, sodium and manganese, but only a small decrease of potassium, also no isotopic variation in Ca^{48} and K^{41}.

5.13. Hisatoki Komaki

Following Kervran's work in 1970–1980, Komaki [33] from the Biological and Agricultural Research Institute studied the development of bacteria, mould and yeast. Among those: *Aspergillus niger*, *Penicillum chrysogenum*, *Rhizopus nigricans*, *Mucor rouxii*, *Saccharomyces cerevisiae*, *Torulopsis utilis*, *Saccharomyces ellipsoideus* and *Hansenula anomala*. Komaki reported that eight strains of microorganisms grown in potassium deficient culture media increased the total of potassium by transmutation of calcium to potassium. He also showed that phosphorus can be formed by the fusion of nitrogen and oxygen: $N + O \rightarrow P$. He even marketed a brewer's yeast product that, when applied to composts, increases their potassium content.

6. Present Times

6.1. Panos *T. Pappas*

In 1998, Pappas [34] published an article suggesting that biological transmutation occurs as a form of cold fusion in the cellular membrane sodium–potassium pump. According to Pappas, the ions are not pumped back and forth through the membrane, but instead transmute back and forth between Na and K.

6.2. Jean-Paul Biberian

Experiments were performed with seeds: wheat and oats as well as bacteria: Marine bacteria (Marinobacter sp strain CAB) and Lactobacilius [4]. In most of the experiments, variations in the concentration of minerals have been observed. In particular, it is interesting to note that when the seeds grew, heavy metals decrease in large amounts. Even though these results are only preliminary, they confirm the observations made by others, in particular Kervran.

6.3. Vladimir Vysotskii

Vysotskii is a scientist from Ukraine. He started working on biological transmutations in the 1990s. He is well known for using modern analytical techniques. In particular, he used Mossbauer spectroscopy, very sensitive to Fe^{57}, to measure its production. In natural iron, Fe^{57} represents only 2.2% of the total. The main isotope of iron is Fe^{56}, which represents 91.7%. Measuring Fe^{57} is also very easy by mass spectroscopy, since there is no possible interference with another element. The proposed transmutation is

$$Mn^{55} + D^2 \rightarrow Fe^{57}.$$

The experiments conducted by Vysotskii and Kornilova [3] were performed with bacteria capable of developing in heavy water. They chose *Bacillus subtilis*, *Escherichia coli* and *Deinococcus radiodurans*, as well as a yeast culture *Saccharomyces cerevisiae*. When manganese was introduced with $MnSO_4$, a clear spectrum was measured, indicating that manganese had been transmuted into iron. The authors analysed the material by time-of-flight mass spectroscopy showing that the mass 57 peak was as large as that of mass 56. This is another confirmation of the production of Fe^{57}. Vysotskii and Kornilova have also analysed another reaction

$$Na^{23} + P^{31} \rightarrow Fe^{54}.$$

In natural iron, Fe^{54} represents only 5.8%. The bacteria developed in a medium without iron, and after development they measured Fe^{54} as large as Fe^{56}.

In similar experiments they observed the following reaction

$$Cs^{133} + H^1 \rightarrow Ba^{134}.$$

In experiments destined to reducing radioactivity, they conducted experiments with synthetic microbiological cultures, which were up to 20 times more effective than the standard microbiological cultures. It was shown that Ba^{140}, which is radioactive with a half-life of 12 days, transforms into Sm^{152}, which is stable with the possible following reaction:

$$Ba^{140} + C^{12} \rightarrow Sm^{152}.$$

Interestingly, Cs^{137}, which is radioactive with a half-lifetime of 30 years, transmutes into Ba^{138}, which has a much shorter lifetime of 310 days.

$$Cs^{137} + H^1 \rightarrow Ba^{138}.$$

This work is certainly the best proof of biological transmutations.

6.4. Edwin Engel, Rudolf Gruber

In 2006, Engel and Gruber [35] from Germany wished to confirm Kervran and Baranger's works. They showed that during germination, manganese transmutes into iron. They used mung beans sprouted in $MnCl_2$. They showed an increase of iron. They assumed the following reaction

$$Mn^{55} + H^1 \rightarrow Fe^{56}.$$

7. Negative Experiments

Even though many positive experiments have been performed by indicating the reality of the phenomenon of biological transmutations, several experiments contradict these findings.

7.1. Nicolas Théodore de Saussure (1767–1845)

In 1804, de Saussure published his work: "Recherches chimiques sur la végétation", Nyon, Paris (Chemical Researches on Végétation). As a follower of Lavoisier, Saussure stood strongly with the standpoint of the conservation of matter and referred all transmutations and creation to the realm of fables. He puts special emphasis on the necessity of this field to be absolutely certain, with experiments, that the so-called created matter was not already present in the environment. So he demonstrated, for example, that the presence of silicates in plants, which were attributed to the life-force by Lampadius, was in reality determined by the amount of silicon present in the soil.

7.2. Jean-Louis Lassaigne (1800–1859)

Lassaigne initially worked in the laboratory of Louis-Nicolas Vauquelin. He was a professeur at Ecole Vétérinaire d'Alfort. His works were published in 1821 with the germination of grains supported the findings of de Saussure. His later works on the development of chicks contradicted the results of Vauquelin.

7.3. P.E. Jablonski

In 1836, Jablonski found no increase in the amount of ashes in the plants above the one in the seed. Therefore, criticizing Schrader and Braconnot.

7.4. Arend Joachim Friedrich Wiegmann (1770–1853) and A.L. Polstorff

Wiegmann and Polstorff made the following experiment: They followed the techniques of their predecessors, but with a soil that consisted of the most inert material known to them at that time. They let 28 seeds of garden cress (Lepidium sativum) germinate in distilled water in a platinum crucible that was filled with fine platinum wires. The crucible was placed under a glass bell jar through which circulated a mixture of 1% carbon dioxide. The seeds germinated and grew into small plants until, after 26 days, they began to die. After drying the crucible and its contents, ashing and weighing obtained 0.0025 g of ash. The weight of the ash obtained from 28 seeds was likewise 0.0025 g. Therefore, there was neither weight change nor new elements formed. However, this conclusion does not contradict previous experiments, since only the weights were compared. No attempt was made to check for the transmutation of one element into another.

7.5. M. Emile Rinck

In 1947, Rink checked Hauschka's work and found only 0.02% weight change.

7.6. Léon Guéguin

In 1970, Guéguin from the INRA (The French Institut of Agronomical Research) has shown that there was no transmutation in Kervran's type experiments.

7.7. D.B. Long

Long was a British scientist, from the Michaelis Nutricional Research laboratory, Harpenden, UK. In 1971, he published a report [36] indicating that he did not observe differences in K, Mg, Ca, Mn, Fe, Zn and Cu when looking at rye and oat seeds germinated. The table shown below shows his experimental results.

Elements	Seeds		Plants		Change (%)
	Average value	Standard deviation	Average value	Standard deviation	
Potassium (mg)	1.582	0.009	1.506	0.016	–4.8
Magnesium (mg)	1.270	0.006	1.273	0.006	+0.2
Calcium (μg)	2.122	0.016	2.157	0.019	+1.6
Manganese (μg)	28.8	0.1	24.9	0.2	–13.5
Iron (μg)	49.7	0.2	48.6	0.5	–2.2
Zinc (μg)	20.9	0.2	21.7	0.05	+3.8
Copper (μg)	6.22	0.2	6.57	0.1	+5.6

7.8. L. Soubiès and R. Gadet

Following Baranger's work, and his attempts to get his findings accepted by the scientific community, Soubiès and Gadet performed similar experiments with the Baranger's protocol and a more rigorous one. They presented their results in 1972 in the bulletin of the French Chamber of Agriculture. They demonstrated that using their better protocol no transmutation is detected, whereas with the original one there is less sodium produced. They proposed that the anomalies were due to diffusion of minerals from the glass used in the experiments.

7.9. Horber

In 1976, Horber, a Swiss scientist from Zurich, looked at calcium variations by neutron activation analysis. He found a 2% variation, but with a precision of $\pm$5%.

7.10. J.A. Jungerman and Murphy

In February 1977, Professor Jungerman and Murphy from the University of California, Davis reported the results of an experiment: the growth of oat seeds under carefully controlled conditions. Analysis was made by atomic absorption and X-ray fluorescence for Ca and K. They found no evidence of transmutation.

7.11. Carolyn E. Damon

In 1978, Damon from the U.S. Customs Technical Service Division conducted tests for biological transmutation with *Aspergillus terreus* and *Rhizopus nigricans*, he obtained negative results.

7.12. Bernd Franke

In 1978, Franke defended his thesis for States Exam at the Botanical Institute of the University of Heidelberg in Germany, the title of which was: "Critical examination of tests on the transformation of biological elements". He analysed calcium, magnesium and potassium during the growth of oats seeds (*Avena sativa*) and yeast (*Sacharomycus cervisiae*). He did not find any significant changes in the composition of the seeds and yeast during their analyses.

7.13. Enrico Di Vito, Carla Candian, Luigi Garlaschelli and Antonio Triassi

In 2002, these scientists from Italy failed to replicate Kervran's work. They looked at the growth of oat seeds (cultivar *Nave*). They analysed their products using ICP emission, but found no variation in Ca, Mg and K in sprouting oat seeds.

8. Theory

8.1. Kervran

Kervran thought that the nuclear reactions that occur in biology were connected to the structure of the nucleus. He developed a unique model of the nucleus with a design that explains the potential transmutations.

8.2. Costa de Beauregard(1911–2007)

Costa de Beauregard [37] was the Research Director at the Centre National de la Recherche Scientifique, Paris, and Professor of Theoretical Physics at the Institut de Physique Théorique Henri Poincaré. He studied Kervran's works in 1962 and began to correspond and met with him. He suggested that such transmutations neither take place through strong interactions nor through electromagnetic forces, but through the weak interaction. This takes place through the neutral current of the intermediate vector boson, the so-called Zo, particle. Kervran's reaction for a biological transmutation from potassium to calcium in germinating oats is thus explained as being initiated by neutrino capture (from cosmic rays) and the weak interaction follows mediated by the Z, neutral current.

$$\vartheta + {}^{1}_{1}\mathrm{H}^{+} + {}^{29}_{14}\mathrm{K}^{+} \underset{+\text{enzyme}}{\xrightarrow{+Z^{0}}} {}^{40}_{20}\mathrm{Ca}^{++} + \bar{\vartheta}\,.$$

In 2006, I called Costa de Beauregard at his home in Paris, and asked him if he continued his research. He replied that he did not.

8.3. Goldfein

In 1978, an officially funded effort from the U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, Virginia positively confirmed that mechanisms for elemental transmutations could occur in biological systems. The work was performed under the direction of Emil J. York, Chief of the Material Technology Laboratory. Solomon Goldfein was the principal investigator for the effort. Robert C. McMillan, Chief of the Radiation Research Group of the laboratory, provided guidance on matters of physics and nuclear physics. The abstract of the final report [38] reads as follows:

"The purpose of the study was to determine whether recent disclosures of elemental transmutations occurring in biological entities have revealed new possible sources of energy. The works of Kervran, Komaki and others were surveyed, and it was concluded that, granted the existence of such transmutations (Na to Mg, K to Ca and Mn to Fe), a net surplus of energy was also produced. The proposed mechanism was described in which Mg adenosine triphosphate, located in the mitochondrion of the cell, played a double role as an energy producer. In addition to the widely accepted biochemical role of Mg-ATP in which it produces energy as it disintegrates part by part, Mg-ATP can also be considered to be a cyclotron on a molecular scale. The Mg-ATP when placed in layers one atop the other has all the attributes of a cyclotron in accordance with the requirements set forth by E.O. Lawrence, inventor of the cyclotron." "It was concluded that elemental transmutations were indeed occurring in life organisms [sic] and were probably accompanied by a net energy gain."

Goldfein postulated a conformational structure of a stack of Mg-ATP molecules forming a helical chain. The Mg-ATP chelate produces oscillating electrical currents, which act as a micromini-cyclotron that accelerates hydrogen ions to relativistic speeds with sufficient potential to transmute an element to the next higher number. It was concluded that the elemental transmutations occurring in living organisms are accompanied by losses in mass representing conversion to thermal energy and that such energy probably is a net gain when compared to the amount required to effect the transmutation.

8.4. Conclusion

Lavoisier has established a mass conservation law which is valid in chemistry. Now we know that it is not true when nuclear reactions are involved. The review of more than two centuries of research demonstrates that this is not true in biology. It appears that all living organisms can under some circumstances produce nuclear reactions. However, there is an important need of finding an adequate theory to explain these results. It is highly probable that such a theory should also be capable of explaining Cold Fusion, or more generally, nuclear reactions in condensed matter. Another point is the irreproducibility of some experiments. Probably, in order to produce significant transmutation of an element, it is necessary that another element be missing. It seems that nature has a tendency to find ways to transmute an element into another to provide the necessary ingredients for the healthy growth of the four kingdoms of bacteria, fungi, plants and animals, including human beings.

Historically, the sequence of discoveries in biological transmutation is the following: Vauquelin was the initiator in 1799. Later Herzelee in 1876–1883 did a lot of research, but his work was removed. Later Hauschka rediscovered Von Herzelee's work. Baranger and Kervran discovered this work. As a consequence of their contribution to the field Zündel continued the work as well as Goldfein. Finally Vysotskii knowing the work of Kervran brought an important contribution.

This review shows that biological transmutations deserve a lot of attention from the scientific community. The consequences of this are important for science, medicine, agriculture and diet. The cost of research in this field is so low compare with other fields that it is unacceptable not to do it.

Studies of the process called cold fusion or Low Energy Nuclear Reactions (LENR) over the past 22 years show that nuclear reactions of various kinds can be initiated in inorganic solid materials under conditions similar to those present during the claimed biological transmutations. These reactions all have the basic characteristic of producing energy as would be required of a spontaneous reaction. In contrast, many of the proposed nuclear reactions in biological systems cannot result in energy production because mass is not lost in the process. Instead, the mass gain would require the concentration of significant energy from the environment. This violates the basic laws of thermodynamics and makes the suggested reactions impossible. In addition, the elements involved in the proposed nuclear reaction must have a way to find each other in the same biological structure and experience a reduction in their Coulomb barrier before interaction can occur. These several limitations severely limit possible explanations. However, these limitations do not make the nuclear reactions impossible, just more of a challenge to explain. The basic question to be answered is do such reactions actually occur in Nature? The evidence strongly indicates that some of the observed reactions actually occur, requiring an explanation to be found.

Acknowledgements

I wish to thank various people who have helped me in the realization of the biological transmutation experiments: The Holleman Stichting, David Cuthbertson, Valérie Michotey, Jean-Jacques Allegraud and Pascal Gos.

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