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Research Article

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The Use of Tools for Automatic Proof of Mathematical Logic Theorems for Modeling the Dynamic Balance of Minerals in the Human Body

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Abstract

Computer scientists build a logical framework for a particular subject or phenomenon. This methodology involves the use of axioms, which are self-evident statements that serve as the basis for a logical system. Axiomatic modelling begins by identifying the relevant concepts and objects that will be studied and then defining these concepts using axioms. These axioms are chosen based on their simplicity, consistency, and logical power, and are used to build a series of logical statements or theorems that describe the behaviour of the system being studied. This method allows researchers to build a clear and logical foundation for their work and allows them to prove the validity of their results through logical deduction. It is often used in mathematics and computer science, but can also be applied to other fields such as economics, physics, social science, biology and medicine. We proposed an extension of the method by incorporating knowledge about physiological processes in the human body by introducing biomedical parameters and logic and developed the novel method of Logical Dialectical Modelling (LDM). This original methodology uses, as tools, the logic of predicates of the 1st order and the Robinson method of automatic theorem proving. It prevents errors and simplifies the process of proving statements. The first time we applied LDM for the problem of providing the human body with the necessary dynamic balance of minerals. We analysed data [1,44,45] on the dependence of disease symptoms on the values of quantitative indicators of the concentration of minerals in the hair of children in the Chornobyl zone,LDM can provide a structured, logical approach to diagnostics that can help identify the root causes of problems and guide more effective treatment planning. LDM can be used together with artificial intelligence (AI) systems to improve the accuracy and efficiency of diagnostic processes. LDM is based on logical statements, they can be tested and refined using a rigorous, mathematical approach, which can help to increase the reliability and accuracy of the models. This can be useful for doctors in evaluating patients and making accurate diagnoses promptly. The purpose of the article is to demonstrate the use of LDM through in medicine too.

Keywords: Axiomatic Logical Modelling, Automatic Proof, Diagnostics

1. Introduction

In science, it is important to use mathematics to represent and describe natural laws and phenomena because mathematics is a precise and logical language that can provide a clear and unambiguous way to express ideas. Using logical-mathematical models allows scientists to make predictions and test hypotheses systematically and objectively. Additionally, expressing scientific ideas in a mathematical logical format can make them more rigorous and easier to communicate and understand [1-4].

Axiomatic logical modelling involves the use of mathematical principles and logical reasoning to understand complex systems, such as human metabolism. This approach involves the identification and definition of a set of axioms or assumptions that describe the underlying principles of the system being studied. These axioms are then used to derive mathematical models that represent the relationships between different variables within the system.

In the context of human metabolism, axiomatic modelling might be used to understand how different minerals are metabolized and how they impact various physiological processes.

To develop an axiomatic model, researchers must first identify a set of key variables that are relevant to the system being studied. These variables might include factors such as the concentration of different minerals in the bloodstream, the activity of specific enzymes or hormones, or the rate of metabolism.

Next, researchers must define a set of axioms or assumptions that describe the relationships between these variables. These axioms might include statements about the way that minerals are absorbed and metabolized by the body or the way that hormones regulate metabolism.

Using these axioms and mathematical techniques, researchers can then develop a mathematical model that represents the relationships between different variables within the system. This model can then be tested and refined through experimentation and observation, allowing researchers to better understand the underlying principles of human metabolism and how it can be influenced by different factors.

Here, we present our novell approach Logical Dialectical Modelling (LDM) as original not only in form but also in content, we present it here in more detail [5-9].

Under LDM the process of functioning of the investigated phenomenon (system) of living nature means:

- A set of physical variables that functionally fully characterizes each dynamic state of this system (phenomenon)allowed by nature.
- All identified in the course of full-scale experimentation, logical relations in the phenomenon, i.e. causal interdependencies and interactions between state variables, expressed exclusively with the help of logical operations, and uniquely defining each of the observed states of the dynamical system (phenomena);
- The logical relationships between state variables in a particular phenomenon are reflected in a *formula form*;
- All identified in the course of full-scale experimentation dialectical systems relationships between state variables, reflective elements:
- Nature driving forces in the phenomenon that ensure the current vital activity of the observed phenomenon, in the conditions of as each elementary object involved in the phenomenon (considered in the LDM as an operand), i.e., a state variable loaded with the meaning of the identifier of a certain physical quantity, accompanied by the properties and characteristics of this quantity),
- Nature driving forces in the phenomenon that ensure the unity and inconsistency of the behavioral essence of each elementary object during its functioning in a particular phenomenon, in a particular time and space;
- Nature driving forces in the phenomenon that ensure the unity and inconsistency of the essence of relations between pairwise interacting elementary objects in the phenomenon;
- Nature the main driving forces in the phenomenon that ensure the progressive evolution of the observed phenomenon, in conditions of unity and inconsistency, both in the behavioral essence of each elementary object in this phenomenon and in the essence of relations between pairwise interacting elementary objects in this phenomenon;
- Nature driving forces in the phenomenon that ensure the progressive evolution of the observed phenomenon in all its variety of forms and all its inconsistency;
- Dialectical systems the relationships between state variables in the phenomenon under study are also reflected in a formula form.

The concept of "nature of driving forces" provides, first of all, an answer to the question: why is the observed natural phenomenon carried out in this way, and not in another way?

We have decided to apply LDM to the role of minerals in health and disease. The dynamic balance of minerals is important for human health. **The complex knowledge about human physiology reflects the role of minerals in the human body and the process of their metabolism.**

The human body consists of 60% water, 34% organic substances, and 6% non-organic substances. The main chemical elements that form organic substances are carbon, hydrogen and oxygen. In addition, organic substances include nitrogen, phosphorus and sulfur [10].

The composition of inorganic substances of the human body includes 22 mandatory chemical elements, called minerals: calcium, phosphorus, oxygen, sodium, magnesium, sulfur, boron, chlorine, potassium, vanadium, manganese, iron, cobalt, nickel, copper, zinc, molybdenum, chrome, silicon, iodine, fluoride, selenium [11]. Minerals are divided into microminerals (the mass fraction of the element in the body exceeds 10^{-2}%), trace elements (10^{-3}—10^{-5}%) and microelements (below 10^{-5}%) [12]. Trace elements are present in the body of humans and animals in low concentrations, expressed in micrograms per 1 g of tissue mass. These concentrations are tens and hundreds of times lower than the concentrations of macrominerals (calcium, phosphorus, potassium, sodium, magnesium, chlorine, and sulfur) [13]. Trace elements have a pronounced mutual effect associated with their interaction at the level of absorption in the gastrointestinal tract, transport and participation in various metabolic reactions. In particular, an excess of one trace element can cause a deficiency of another. In this regard, careful balancing of food rations according to their microelement composition is of particular importance, and any deviation from the optimal ratios between individual components of the diet should be considered. Microelements can lead to the development of serious pathological changes in the body [14]. Macro and microelements, unlike various organic compounds, are not synthesized in the body, their balance is maintained solely by the products consumed in food. Under ideal conditions, the daily diet should cover the needs of the body. But, as studies show, the amount of elements in food products is progressively falling every year. We get macro and microelements from three primary sources: soil, air, and water [15]. Soil composition affects the selection, distribution of plants, and their variability under the influence of certain chemical compounds or chemical elements found in soils. A sharp insufficiency or excess of the content of any chemical element in the medium causes biogeochemical endemics in plants, animals, and humans [16]. For example, if there is insufficient iodine in food, a simple goiter occurs in animals and humans, if there is an excess of selenium in soils, the appearance of toxic selenium flora and many other endemics. Thus, the final composition of trace elements in the human body depends on the environmental conditions and, if necessary, on the level of microelements [17]. The composition can be adjusted either with food additives or with medical preparations. Taking into account the rapid technological process that has a gross impact on the environment, the depletion of soils and the introduction of genetic engineering in the food industry, it is possible to explain such a progressive development of the lack of elements in food products as their main source for the human body [18].

In case of the insufficient intake of minerals, the body can make up for the created deficit for some time by mobilizing them from tissue depots, and in case of excessive intake by increasing excretion. The body's tissue depots have powerful reserves of macro minerals (calcium, magnesium in bone tissue, potassium in muscle, and sodium in the skin and subcutaneous tissues. The reserves of trace elements in tissues are insignificant [19]. This explains the low adaptive capacity of the body to a lack of trace elements in food. The exchange of essential trace elements is intensified in some cases.

Athletes, for example, require significantly higher amounts of minerals due to physical activities compared to other groups. The most studied trace element is iron. 10 mg per day for men and 18 mg for women [20]. Minerals are essential for the vital functions of the body and take part in many processes:

- give strength to the skeleton;
- connect organic structures (proteins and lipids);
- activate enzymes;
- control the water balance (osmosis and excretion);
- regulate the acid-base balance;
- enhance the effect of neuromuscular transmission;
- interact with hormones, vitamins, and other metabolic regulators.

There is a well know citation of Dr Linus Pauling, a two-time Nobel Prize winner, who states "*You can trace every sickness, every disease, and every ailment to a mineral deficiency.*.". His biographers are not confident about this statement, but Pauling and his co-workers have stressed the importance of minerals anyway [21]. For example, traces of vanadium play a role in glucose metabolism. From the soil, minerals are absorbed by plants. Plants that enter the body with food are digested and absorbed along with minerals. Currently, scientists note the depletion of soil all over the world [22]. Farmland has 20% fewer minerals than it did a hundred years ago. As a result, the number of minerals in plants decreased. White flour loses 60% of calcium, 67.9% copper, 75.6 % iron, 48% molybdenum, 15.9% selenium, and 85.8% magnesium. Due to the depletion of the soil, our food is poor in minerals.

The lack of minerals in plants and food determines the lack of minerals in the human body. Therefore, we can only cover mineral deficiency with dietary supplements.

Among the many trace elements in the body, only 9 are essential, i.e. their imbalance leads to the appearance of clinical symptoms. All the others are nonessential. They are characterized by certain biological functions, but the deficiency syndromes are unknown. Some of them are components of cells and tissues as a result of adaptation to the environment. Essential trace elements are: zinc (Zn), iodine (I), chromium (Cr), cobalt (Co) (as a component of vitamin B12), manganese (Mn), molybdenum (Mo), magnesium (Mg), copper (Cu), selenium (Se) and iron (Fe). From the point of view of biological function, the elements can be divided into 2 groups:

1. Cofactors of enzymes (with activating, regulatory, and structural-stabilizing functions). Essential elements of this group: zinc, magnesium, manganese, molybdenum, copper and iron.
2. Components of biomolecules (can be found in skeletal bones, the metabolic system, etc.). The essential elements of this group are iodine, chromium, cobalt, and selenium [23].

Trace elements are involved in the regulation of most vital processes and biochemical reactions in the human body. In this sense, their role can be compared with the regulatory role of hormones, and the consequences of chronic deficiency - with severe hormonal disorders. However, if a healthy body itself can synthesize the necessary amount of hormones, then most of the trace elements it can get exclusively with food or in the form of supplements. Any lack of them is considered a general pre-disease condition, from which a variety of pathologies can develop in the future. For the activation of enzymes, activators are needed — cofactors, and coenzymes (>300). Some enzymes contain trace elements as an integral component of their structure. Schematically, the body's reactions can be represented as follows: substrate + enzyme + microelement-activator (coenzyme) = reaction. That is, in the absence of a trace element, the reaction is either impossible, or it will proceed, but with a huge expenditure of energy and time. The lack of trace elements can be caused mainly by three factors: insufficient absorption, increased consumption in physiological and pathological reactions and increased losses. Insufficient intake is most often caused by a decrease in the concentration of trace elements in food and reduced absorption in the gastrointestinal tract (various diseases and age-related changes in the gastrointestinal tract). Increased value consumption of trace elements is typical for athletes during intense physical exertion, children during intensive growth and puberty, the elderly, and pregnant women, with any diseases due to the activation of immunological reactions and reactions aimed at maintaining homeostasis. Increased losses of trace elements occur in athletes (with sweat), in diseases accompanied by exsiccosis fever (with sweat), etc. Since most processes of the immune system are also enzymatically dependent (synthesis of immunoglobulins, cytokines, phagocytosis processes), the absence or lack of macro-and microelements can lead to the fact that pathological processes will proceed faster than normal. reactions of the immune system, i.e., it will not be able to respond quickly to the penetration of the antigen into the body. In addition, detoxification and free radical scavenging processes are also impossible without sufficient levels of trace elements.

Below we briefly summarise the importance of minerals for human health.

1.1 Sodium (Na)

The recommended daily sodium intake for adults is less than 2.5 g per day [24]. Sodium supports the osmotic pressure of the blood, with increased intake promotes the elimination of potassium from the body, and participates in water metabolism and many biochemical reactions. Increased sodium intake causes fluid buildup in the body, swelling, and increased blood pressure. In the diet of people living in industrialized countries, the sodium content is usually high. At the same time, about 7 g of sodium is supplied with food, and as a food additive in cooking from 6 to 18 g. To prevent the development of hypertension, additional sodium intake in the daily diet is not recommended.

1.2 Potassium (K)

The daily requirement of an adult healthy person for potassium is 3.5 g [25]. It is a sodium antagonist, the main intracellular element. It promotes the elimination of fluids from the body. It is necessary for muscle contractions, participates in the processes that ensure the conduction of nerve impulses, corrects the alkaline balance of blood and tissue fluid, and participates in metabolic reactions, for example, the conversion of glucose into glycogen. It is also involved in regulating the heart rate. In clinical practice, potassium is used for cardiovascular insufficiency, and cardiac arrhythmias, when taking diuretic drugs.

1.3 Magnesium (Mg)

The recommended daily amount of magnesium to be consumed varies according to age and gender. On average, it is about 300–400 mg for men and 270–310 mg for women, always depending on which guidelines are used as a basis [26]. Magnesium is involved in the exchange of phosphorus, which helps to reduce blood pressure. During menopause in women, magnesium helps minimize the negative effects of this condition. It must enter the body in a certain ratio with calcium. It should be 1: 0.7 (Ca: Mg).

1.4 Phosphorus (P)

The daily requirement of a healthy adult is 550 mg [25]. It is one of the main components of bone tissue. Phosphorus is also necessary for the reaction of energy metabolism, it has a positive effect on libido, and participates in most metabolic reactions, including such as the formation of nucleoproteins, which are responsible for cell division and reproduction of offspring. This element must enter the body in a certain ratio with calcium. The optimal ratio of these elements is considered to be 1: 1.5 (Ca: P).

1.5 Calcium (Ca)

The daily requirement of an adult healthy person is about 700 mg [25]. Calcium is the main element of bone tissue. It is also involved in the regulation of cell membrane permeability and has the opposite effect of sodium. Calcium is involved in the mechanisms of blood clotting, and has an anti-stress effect. It promotes the elimination of heavy metal salts from the body and radionuclides, shows an antioxidant effect, has an anti-allergic effect, is a probiotic, and performs antioxidant functions. Calcium deficiency can provoke the development of hypertensive crises, toxicosis during pregnancy, an increase in blood cholesterol, the development of osteoporosis, and reduces the mechanical strength of bones. The body must be supplied in a certain ratio with phosphorus.

1.6 Zinc (Zn)

The daily requirement values vary from country to country. The US Food and Nutrition Board recommends an intake of 11 mg/day and 8 mg/day for adult men and women, respectively [27]. The German Nutrition Society recommends 1.5 mg of Zn per day for infants aged between 0 and 4 months. The recommended intake for adolescents between 15 and 19 years old is 11 mg of Zn per day for females and 14 mg of Zn per day for males. The recommended intakes for females aged 19 years and older with low, medium, and high phytate intakes, respectively, are 7 mg, 8 mg, and 10 mg of Zn per day; for males the values are 11 mg, 14 mg, and 16 mg of Zn per day, respectively [28]. Currently, the role of zinc in the formation of immunity and maintaining the function of the male sex glands (it is a component of the male sex hormone dihydrotestosterone) has been established. This is probably why it is found in the greatest amount in the tissues of the testicles and pineal gland, which is also directly related to the realization of the sexual function of men and women. Zinc is also a part of a large number of enzymes that provide metabolism, for example, catalyzing the metabolism of nucleic acids. Acids that ensure the implementation of the biological action of vitamins A and folic acid (hematopoiesis). Given the great importance of zinc in the metabolism, its long-term deficiency in the diet can lead to the development of many diseases: infertility, loss of sexual activity (sexual infantilism), decreased immunity, skin diseases, the development of anaemia; zinc deficiency increases the growth of tumours, disrupts the growth of hair and nails. It is established, for example, that the appearance of white spots on the nails in most cases occurs due to a deficiency of this mineral element. Supports the thymus function glands (synthesis of T-lymphocytes) [29].

1.7 Iron (Fe)

The daily requirement of an adult for iron is: 8.7 mg a day for men aged 19 and over. 14.8 mg a day for women aged 19 to 49. 8.7 mg a day for women aged 50 and over [25]. It should be received at least 10-15 mg since it is poorly absorbed (usually at the level of 10-20%). Iron is the main element of hemoglobin and myoglobin. Iron is a part of many enzymes involved in catalysts of redox processes. Iron deficiency is associated with widespread anaemia, especially in pregnant women. Iron and copper have a synergistic effect.

1.8 Copper (Cu)

Although copper (Cu) is recognized as an essential trace element, uncertainties remain regarding Cu reference values for humans, as illustrated by discrepancies between recommendations issued by different national authorities. Results from balance studies suggest that daily intakes below 0.8 mg/day lead to net Cu losses, while net gains are consistently observed above 2.4 mg/day. However, because of an incomplete collection of losses in all studies, a precise estimation of Cu requirements cannot be derived from available data [30]. Copper is involved in hematopoiesis and a large number of metabolic reactions, being an integral part of many enzymes. The need for copper increases with inflammatory diseases and a person's tendency to have joint diseases. Copper, zinc and iron have a synergistic effect on each other. Therefore, when eliminating the deficiency of one of these trace elements, it is important to take into account their synergistic properties and include sources of the other two in the diet.

1.9 Manganese (Mn)

The daily requirement of an adult for manganese is 2,3 mg for men and 1.8 mg for women [25]. With food, however, taking into account its digestibility, one should receive 5-10 mg. Like other trace elements, manganese is involved in all types of metabolism, activating the function of many enzymes. Manganese is of particular importance in the implementation of the functions of the sex glands, musculoskeletal system, and nervous system. It is believed that it can have a preventive effect against the development of coronary artery insufficiency, diabetes, thyroid pathology, and disorders of carbohydrate and lipid metabolism. With age, the digestibility of manganese decreases, so after 50 years, a deficiency of this trace mineral may occur.

1.10 Molybdenum (Mo)

Daily intake by an adult is around 45 mcg per day in supplement form [25]. It is a part of many enzymes involved in the detoxification of substances that are foreign to the body. It promotes the retention of fluoride in the body and thus prevents the development of caries, as well as iron metabolism in the liver. The most important function of molybdenum is considered to be the ability to accelerate the breakdown of purines and remove uric acid from the body, which, with optimal intake, helps prevent the development of gout. However, with an excessive intake of molybdenum in the body, "molybdenum gout" can develop, which should be checked when taking medications containing this trace element. Its daily amount should not exceed the recommended dose.

1.11 Cobalt (Co)

There is no RDA figure, but the American FDA suggests that a daily intake of between 50 and 200 mcg is both safe and sufficient [23]. Cobalt is a part of vitamin B12 and participates in the metabolism of fatty acids, carbohydrate metabolism and the implementation of the function of folic acid. Its main biological effect is to help synthesize hemoglobin.

1.12 Chrome (Cr)

The approximate need for an adult for this trace element is 25-35 mcg. Only trivalent chromium exhibits biological activity in humans. It helps maintain blood sugar levels, prevents atherosclerosis and cardiovascular disorders, and reduces the level of cholesterol in the blood. According to published data, Africans have twice as much chromium in their bodies, residents of the Middle East have almost 4.5 times more, and Asian have 5 times more chromium than Western countries. It is believed that this is one of the reasons that in the East much less common degenerative diseases that are characteristic of Westerners.

1.13 Selenium (Se)

The need for an adult is 150-200 mcg. Some Se levels in relation to Se status are given in Lewis's work [31]. For example, Se toxicity occurs at intakes of >900 mcg/day, whereas deficiency occurs at <19 mcg/day. Average UK intake is 75 mcg/day versus 93 mcg/day in females in USA. It has pronounced antioxidant properties, which makes it possible to use this trace element for the prevention of oncological diseases provoked by chemical influences and radiation. Selenium stimulates the formation of antibodies and thereby increases the body's defense against infectious diseases and colds. It participates in the production of red blood cells and contributes to the maintenance and prolongation of sexual activity. Almost half of the selenium contained in the male body is found in the seminal tubules of the testicles. It gets lost with the ejaculate. So, for men who lead an active sexual life, the need for this trace element is higher than in women. Selenium activity increases in the presence of another antioxidant, vitamin E. In areas where selenium consumption is insufficient, there is an increase in cancer. The diet of the population of industrially developed countries is poor in this trace element, so additional sources of it are required.

1.14 Iodine (I)

The daily requirement of an adult is 150 mcg. Iodine is necessary for the normal functioning of the thyroid gland and is a part of its hormones (thyroxine, triiodothyronine). If there is a lack of iodine, endemic goiter and cretinism could develop.

1.15 Silicon (Si)

The daily requirement of an adult for this trace element is presumably 9-14 mg. It is believed that it takes part in reactions that ensure the density of the structure of fibrous tissues, giving them elasticity. It is of particular importance for the formation of the structure of the skin, hair, and nails.

1.16 Vanadium (V)

Scientists don't know how much vanadium people need. The average diet provides 6 - 18 mcg. The safe upper limit is 1.8 mg. Higher doses may be toxic. Modern studies have shown that vanadium sulfate has a beneficial effect on both forms of diabetes-insulin-dependent (type 1) and insulin-independent (type 2) [32]. It is assumed that it participates in the metabolism of fats and carbohydrates, inhibits the formation of cholesterol in young people and reduces the content of lipids in the blood, and also prevents the development of caries, contributing to the mineralization of teeth and their preservation.

1.17 Sulfur (S)

The daily requirement of an adult healthy person is about 850 mg. Sulfur is found in the anti-neuralgic vitamin B1 (thiamine).

Especially rich in sulfur are the surface layers of the skin, where sulfur is contained in keratin and melanin. Melanin is a pigment that protects the lower layers of the skin from ultraviolet radiation (in the form of tanning). Increases resistance to radio emissions, and toxins, participates in the formation of insulin and promotes DNA repair.

1.18 Boron (B)

The adult body contains about 20 mg of boron. The daily requirement for boron in an adult is about 1 mg. More than half of the total amount of boron is found in bone tissue, and boron is also found in the liver, kidneys, lungs, spleen, muscles, nervous tissue and brain, blood and fat. Boron in the human body performs several functions: it improves the structure of the bone skeleton, improves the metabolism of calcium, phosphorus, fluorine, zinc and magnesium, and also affects the conversion of vitamin D in the body [33-38].

According to the modern classification [26], minerals are divided according to their effect on the immune system:

- for essential substances for the immune system: Fe, I, Cu, Zn, Co, Cr, Mo, Se, Mn, Li;
- immunotoxic drugs: Al, As, B, Ni, Cd, Pb, Hg, Be, Vi, Tl, Ge, Au, Sn.

Table 1 shows min and max values concentration obtain using Fluorescence analysis [37] in blood plasma.

Element	min, mcg/ml	max, mcg/ml
K	140	207
Ca	90	110
Cl	3400	3800
S	1050	1200
Fe	0.6	1.6
Zn	0.7	1.2
Cu	1.3	16
Mn	0.04	0.16
Se	0.07	0.15
Cr	0.03	0.12
I	0.04	0.08
Mo	0.003	0.07
Co	0.001	0.04
Ni	0.02	0.33
Sn	0.1	0.14
As	0.02	0.2
Bi	0.01	0.4
Ag	0.01	0.024
Pb	0.05	0.2
Rb	0.05	5
W	0.1	0.7
Hg	0.01	0.05
Cd	0.01	0.027
Zr	0.01	0.04
Br	50	1500
Ti	0.023	0.7
Sr	0.039	0.15
Sb	0.0	0.1

Table 1: Content of Macro-, Microelements and Heavy Metals in Human Blood Plasma

The given data are substantially refined in the scientific literature [39-40].

K, Ca, Cl, S, Fe, Zn, Cu, Mn, Se, Cr, Ni, Sn, As, Bi, Pb, Rb, W, Br, Ti, and Sr are defined within normal values. For Mo, Co, Ag, Hg, Cd, Zr, and Sb only excess quantities are detected. Fluorescence analysis of blood plasma, as a rule, is accompanied by the measurement of minerals in the urine at a certain point in time [41].

Fluorescence analysis of the tissue hair for mineral content (**MAV diagnostics**) [42,43]. It is a study of the content of "useful" and "harmful" chemical elements in the human body, limited only to hair tissue. The main difference between **Fluorescence** analysis of blood plasma and hair analysis is that blood is a dynamic medium, the parameters of which change during the day, so the determination of minerals in blood plasma allows you to detect their deficiency or excess only at one-time point [44]. Hair analysis provides information about the distribution of trace elements at the tissue level, and the results obtained will display the **macro-microelement status for an average of three months** [45]. It is this fact that causes the desire of researchers to work with the hair tissue as a more stable data source for understanding the regularity, and not the current state. But, unfortunately, for today, which also follows from the analysis of the information of scientific periodicals, there are no proven grounds for this. But there is hope that the works of scientists will bring results, and if patterns are found, it will be necessary to prove formally the corresponding statement in the form of a theorem [46-48]. It will be easy to apply the Methodology of axiomatic modelling based on an expanded range of basic theorems without destroying an already-built scientific building. Researchers, adherents of the discussed direction, are close to the goal, but until the only theorem about the nature of the causal dependence of human health on the chemical composition of his hair appears, any, even the most attractive hypotheses will not become a science. And today we can analyze the effect of changes in the quantitative index of minerals on health only by blood composition. At the same time, it is possible to use the results of blood plasma analysis to use LDM to determine the necessary dynamic balance of minerals for diagnosis.

The list of minerals in MAV diagnostics does not differ from the list of minerals in the mineral measurements of blood plasma, but the concentrations differ very much. For example (compare the following Table 2 of MAV diagnostics with Table 1 analysis of blood plasma):

Element	MAV, min, mcg/g	MAV, max, mcg/g	Blood, min, mcg/ml	Blood, max, mcg/ml
K	70	170	140	207
Ca	300	700	90	110
Cl	60	560	3400	3800
I	0.4	4.0	0.04	0.08
Fe	15	35	0.6	1.6
Zn	120	200	0.7	1.2
Cu	9.0	30	1.3	1.6
Br	2.0	12	50	1500
Sr	0.0	3.0	0.039	0.15

Table 2: List of Minerals in MAV Diagnostics and Microelements and Heavy Metals in Human Blood Plasma

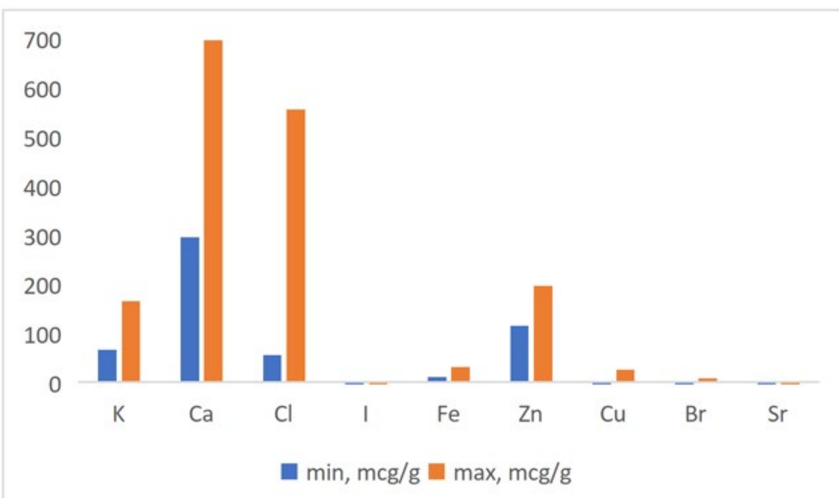

Figure 1: Diagram of Minerals in MAV Diagnostics

Nowadays, many laboratories offer services for the quantitative determination of the content of trace minerals in hair [42-43]. Studies of trace element composition are also analyzed in connection with diseases, for example, diseases of the thyroid gland [47]. More reliable data on the activity of the thyroid gland, for example, are measurements in the blood of two hormones - T4 and T3, which are formed in the cell using iodine [41].

A total of 120 children were examined [1]. 108 (90%) of the examined children had various ailments, but there were no grounds to make a specific diagnosis. Various diseases were diagnosed in 102 (74%) children, and 12 (10%) children were healthy.

We have obtained the following statistical results TP=102, FP=6, TN=9, FN=3,
With Accuracy=93%, Sensitivity=97%, Precision=94%, Specificity=60%.

We tracks a well-justified interest in the topic of the mineral composition of hair, because sometimes the dependence of diseases on this composition seems almost obvious [41]. The irregularity of the composition of the hair of the inhabitants of the region on the high content of certain trace elements in soil and water has been proven [48]. And yet, until such dependencies are defined and formally prove until the nature of these dependencies in science is determined and proven, LDM will not allow this method to be applied. The article aims to draw attention to this fact as a significant advantage of using formalization in the form of Axiomatic Modelling Methodology.

However, despite the paradox just noted, there is a theoretical basis for creating an LDM model taking into account the necessary complex of minerals, provided that the regulatory indicators of the mineral content in the hair are approved by regulatory authorities. At the same time, it is possible to use the results of blood plasma analysis to use LDM to determine the necessary dynamic balance of minerals for diagnosis. LDM in the text of the article can be seen in the work.

First, we define LDM predicates, which are operands of the model, i.e. logical relations, functionally fully characterizing each dynamic state of the system (see Table 1):

Kamount01(X, K = (140 - 207mcg/ml)) – in humans X the potassium content in one millilitre of blood plasma is in the range of 140 – 207 mcg.

Caamount02x, Ca = (90 - 110mcg/ml)) – in humans X the calcium content in one millilitre of blood plasma is in the range of 90 – 110 mcg.

Clamount03(X, Cl = (3400 - 3800mcg/ml)) – in humans X the chlorine content in one millilitre of blood plasma is in the range of 3400 – 3800 m.....

Niamount14(X, Ni = (0.02 – 0.33mcglml)) – in humans X the nickel content in one millilitre of blood plasma is in the range of 0.02 – 0.33 mcg.
…
Tiamount26(X, Ti = (0.023 – 0.7mc /ml)) – in humans X titanium content in one millilitre of blood plasma is in the range of 0.023 – 0.7 mcg.

Sramount27(X, Sr = (0.039 – 0.15mcg/ml)) – in humans X strontium content in one millilitre of blood plasma is in the range of 0.039 – 0.15 mcg.

Sbamount28(X, Sb = (0.0 – 0.1mcg/ml)) – in humans X the antimony content in one millilitre of blood plasma is in the range of 0.0 – 0.1 mcg.
Healthya29(X, A) – the human body X is in a potentially healthy state A, as it is provided with the necessary dynamic balance of minerals.

Obviously, in the case of the truth of each of the predicates in the list No. 1-No. 29, which are assigned the status of axioms confirmed by literature, in the theory of first-order predicate logic, not only the conjunction of these predicates will be true, but also the statement of a logical consequence made up of these predicates.

Axioms are experimentally obtained laws or facts, unconditionally confirmed by experts in the relevant fields of knowledge, with the obligatory indication of authorship. They are formulated concisely in a verbal format and written in the language of first-order mathematical logic. The rules for translating facts into axioms require a pre-created standard procedure in a single format for all axioms, due to the presence of a single construction for meaningful and formal proof of theorems [5].

2. The Truth of the Conjunction of Predicates # 1 – # 28 Logically Implies the Deductibility of the True Value of Predicate #29

If all 28 standard minerals are present in the human body X quantities between min and max, then the human body X is in a potentially healthy state A.

So, the formula of this statement looks like

(∀X)((kAmount01 Λ caAmount02
Λ clAmount03 Λ...Λ niAmount14
Λ…Λ tiAmount26 Λ srAmount27
Λ sbAmount28) => healthyA29) [1]

In the formula version, the truth of the theorem is proved using the methodology of formal automatic proof of theorems [41] in formal theories, reflected using the language of first-order predicate logic. For this purpose, the formula [1] is characterized by its addition to one of the interpretations of this formula.

(X)((kAmount01Λ caAmount02 Λ clAmount03 Λ…Λ niAmount14 Λ…Λ tiAmount26 Λ
Λ srAmount27 Λ sbAmount28) => healthyA29) =>
(X) ((kAmount01 Λ caAmount02 Λ clAmount03 Λ…Λ niAmount14 Λ…Λ tiAmount2

Λ srAmount27 Λ sbAmount28) => healthyA29)
[2]

In order to significantly reduce the number of formal symbols in the formula [2], we denote:
by the identifier F1 formula:

(kAmount01 Λ caAmount02 Λ clAmount03 Λ…Λ niAmount14 Λ…Λ tiAmount26 Λ

Λ srAmount27 Λ sbAmount28

The formula [2] will take a new form:

[(X)(ΙF1 V healthyA29)] => [(ƎX) (ΊF1 V healthyA29)] [3]

The structure of formula [3] includes two separate formulas connected by the implication operation:

F2(X) ≡ [(X)(ΊF1 V healthyA29];
F3(X) ≡ [(ƎX) (ΊF1 V healthyA29].

In the theory of automatic proof of theorems, to bring logical formulas to a canonical format containing only axioms and three logical operations (conjunctions, disjunctions and negations), 27 formal rules for equivalent transformations of first-order predicate logic formulas are defined and proved.
Two of them look like this:

(F2(X) => F3(X)) ≡ (ΊF2(X) V F3(X))
(F2(X) => F3(X)) ≡ (F2(X) Λ ΊF3(X))

One of the rules prescribes releasing the formula from all quantifiers of generality if there are no other quantifiers in the formula.

If we use these last four rules, then the formula [3] will take the form:

ΊF1 V healthy A 29 Λ Ί(ΊF1 V healthy A 29) [4]

Formula [4] is a conjunction of only two contrarian components.

This testifies to its inconsistency, but also testifies to the truth of the theorem as a whole, since the methodology of automatic proof of theorems is based on the conclusion of the inconsistency of the formula of the theorem as a whole.

The formula [4] is a conjunction of only two components, so indicates the truths of the theorem, since the method of automatic proof of theorems is based on deducing the inconsistency of the formula of the theorem as a whole.

3. Results

As can be seen from the proof, the theorem is about establishing a fact-finding the human body X in a potentially healthy state A from the point of view of the dynamic balance of minerals. However, if clinicians create correct additional recommendations to be approved by regulatory authorities for specific minerals, then the LDM will remain unchanged but will be supplemented with formulas that reflect the meaning of the additional ratios between minerals [49-54].

The results are in the article [1]. They were confirmed by appropriate diagnoses made by qualified pediatricians. Other studies are developing personalized blood-based nutritional therapy for patients with malaise [49]. According to the authors of the article, physiologists, physicists and chemists, specialists in related fields of sciences studying the nature of metabolism can help formulate the desired theorems. Axiomatic modelling methodology effectively combines common efforts in a set of formal theorems. The authors are happy to welcome such cooperation.

Moreover, LDM allows you to conclude even in the absence of sufficient data necessary for statistical methods of analysis in medicine. So, we could make logical conclusions understandable by practitioners.

Until recently, there was no single correct methodology for the formalization of knowledge, justified from the point of view of human physiology. LDM, as a unified methodology for the formalization of knowledge, is itself based on tools for the logical modelling of physiological processes.

The simplicity and compactness of LDM and the formal proof procedure, and the fact that the resulting solution is accurate, allow considering LDM to use in medical practice.

4. Discussion

LDM involves creating a set of axioms, or foundational principles, that can be used to make logical deductions and conclusions. In the field of diagnostics, this approach could be helpful in several ways:

- Identifying potential causes: By using axioms to analyze the symptoms and other available information, a diagnostic model could help identify the most likely causes of a particular condition or issue.
- Making predictions: Using the axioms as a foundation, a diagnostic model could be used to make predictions about the likely outcomes or progression of a condition, allowing for more accurate treatment planning.
- Testing hypotheses: LDM allows for the testing of different hypotheses and the elimination of unlikely causes, which can help narrow down the possibilities and improve the accuracy of a diagnosis.
- Improving efficiency: By automating the process of identifying and testing potential causes, LDM can save time and improve the efficiency of diagnostic workflows.

Overall, LDM can provide a structured, logical approach to diagnostics that can help identify the root causes of problems and guide more effective treatment planning.

However, LDM can also be limited, since it may not take into account the complexity and diversity of natural systems and may not always accurately cover the entire spectrum of behaviour and interactions within these systems. To apply it necessary in the context of a complete Methodology of axiomatic modelling and consistently from each scientific fact to the next is extremely important for comprehensive (scientific with so-called related scientific fields) maximum coverage of the studied issues.

The disadvantage of its application is the need for constant close cooperation of scientists. But the result is worth it.

5. AI and LDM

LDM can be used in artificial intelligence (AI) systems to improve the accuracy and efficiency of diagnostic processes. For example, an AI system could be designed to use axioms as a foundation for analyzing patient data and identifying potential causes of a particular condition.. This approach could be particularly useful in situations where there is a large amount of data to analyze, as the AI could quickly and accurately process this information and provide recommendations based on the axioms. Additionally, the use of axioms in an AI system could help reduce the risk of bias or errors, as the system would be following a set of predetermined principles rather than relying on subjective judgement.

Overall, the use of LDM in AI diagnostics could help improve the accuracy and efficiency of the diagnostic process, ultimately leading to better patient outcomes

6. Systems Medicine and LDM

Systems biology/biology medicine is an interdisciplinary field that uses computational and mathematical approaches to study and model complex biological systems. This includes the use of computational models to understand the behaviour of cells, organs, and entire organisms, as well as the use of data-driven approaches to study the interactions between different biological systems. LDM is a method used in systems medicine to represent biological systems using logical statements. These statements are used to describe the relationships between different components of the system, such as genes, proteins, and biochemical reactions. Axiomatic modelling was already applied for the description of regulatory networks [55]. LDM models are useful for understanding the behaviour of biological systems, predicting their behaviour under different conditions, and identifying potential interventions that could be used to manipulate the system.

The use of LDM and axiomatic modelling Methodology for diagnostic purposes makes it possible to analyze not only specific symptoms of diseases but also to determine trends in the development of the disease for a particular person, to analyze the correctness of the treatment process. The solutions and the formulation of the problem itself are also analyzed for truth, by constructing an optimal physical model of the phenomenon, as well as its formal mathematical model.

One of the key benefits of using LDM is that they allow researchers to formally reason about the behaviour of biological systems. This can be particularly useful for understanding complex systems that may be difficult to study using traditional experimental approaches. Additionally, because LDM is based on logical statements, they can be tested and refined using a rigorous, mathematical approach, which can help to increase the reliability and accuracy of the models. This can be useful for doctors in evaluating patients and making accurate diagnoses promptly [56-59].

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