Праці НТШ
Мед. науки 2015. Т. XLIII. С. 206–212
Лекція

Proc. Shevchenko Sci. Soc.
Medicine 2015. Vol. XLIII. P. 206–212
Lecture

УДК 612+612.8)(091)(092)

Adolf BECK

LIFE PHENOMENA AND THEIR METHODS OF INVESTIGATION

The inaugural lecture of Dr. Adolf Beck, Professor of Physiology Department of University of Lwów given at the 29th of October 1895*

Dear Gentlemen!

The first year of doctor education in our local department gives you a possibility to study the phenomena that take place in the human organism. The profound knowledge of descriptive anatomy, shape and structure of organs constituting organism is crucial for the understanding of connections between the functions of different organs and the general picture they provide which is called „life".

On the one hand, information obtained from the complementary sciences, especially such disciplines as physics and chemistry will help you, at least partially, understand conditions, rules and actions of life functioning.

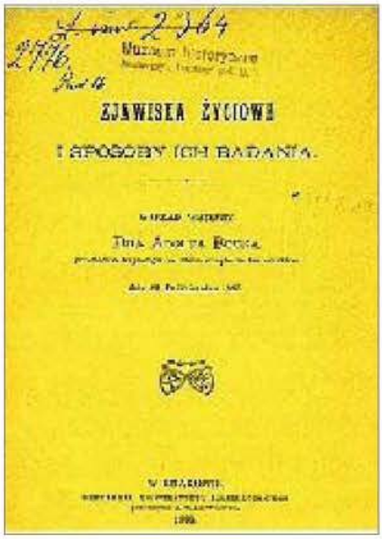
Equipped with such information, you will proceed to study one of the most important branches of Medical Science, which is the subject of my lectures.

A Physiologist is the name nature explorers have born since antiquity. The difference between physiology and physics had not established at that time. Moreover, the meaning of the word "physiology" was coined just in the last century, therefore splitting those two, leaving exploration of inorganic world to physics whereas research of living, organic matters to physiology.

---

* Translation into English and comments by Oksana Zayachkivska: Beck A. Zjawiska życiowe i sposoby ich badania. Wykład wstepny Dra Adolfa Becka profesora fizyologii w Uniwersytecie Lwowskim dnia 29 Października 1895 / Adolf Beck. – Kraków: Drukarnia Uniwersytetu Jagiellońskiego, 1895. – 17 s.

By now, we may encounter many connections between those two disciplines as if two streams were coming from one source coming closer and closer to each other and creating an impression that one day these two streams will merge into one single river.



This is the cover page of the booklet with the first Beck's lecture delivered in 1895 at the University of Lwów.

From now on, it is not sufficient to consider physics and chemistry to be complementary sciences. We will say that physiology is, in fact, applied physics and chemistry.

During my lectures, you will see that chemical and physical principles are referring to the inorganic world and can be also applied to see phenomena that take part in living organisms, the exploration of which will henceforth be our main task.

The belief of Plato[1], Aristotle[2] and others that phenomena taking place in living creatures are the influence of some higher stimulus which appears to be immaterial and influences the matter of the organism in a mysterious way prevailed since antiquity, throughout the Middle Ages and until the beginning of the present century. That concept received a

[1] Plato, (424/423 BC–348/347 BC) was a Classical Greek philosopher, mathematician, writer of philosophical dialogues, and founder of the Academy in Athens, the first institution of higher learning in the Western world.

[2] Aristotle (384 BC–322 BC) was a Greek philosopher and polymath, his writings cover many subjects, including physics, metaphysics, biology, and zoology. Aristotle's classification of living things contains some elements that still existed in the 19th century. What the modern zoologist would call vertebrates and invertebrates, Aristotle called 'animals with blood' and 'animals without blood' (he was not to know that complex invertebrates do make use of hemoglobin, but of a different kind from vertebrates).

scientific form at the beginning of the century from Sthal[3], who named it vitalism and animalism.

Stahl, nonetheless a great chemist, was against the thoughts of the so-called iatrochemists, who were trying to explain every aspect of life with the chemical notions. He claimed, that not only forces, whose outcome is life, are different from chemistry and physics, but they are also poles apart, antagonistic. Moreover he speculated that the force of life is in constant fight with chemical and physical forces, which aim to destroy the organism.

According to Stahl, life is apparently a set of victories of life forces over the powers ruling the inanimate world, whereas death comes when life faces failure and loses the fight. Then the inanimate world power starts their process of destruction (decay, decomposition, rotting, which were considered strictly chemical).

The theory of forces was unsettled when Lavoisier[4] and Laplace[5] proved that heat

[3] Stahl Georg Ernst (1659–1734) was a German chemist and physician. Having graduated in medicine at the University of Jena in 1683, he became court physician to Duke Johann Ernst of Sachsen Weimar in 1687; from 1694 to 1716 he held the chair of medicine at Halle, and was then appointed physician to King Friedrich Wilhelm I of Prussia in Berlin. He hypothesized that all matter had a vital force, or a soul of sorts and also propounded a view of fermentation. He burned wood, and crediting the lower mass of the ashes compared to the original wood to the leaving of the vital force, because the wood had been killed in the process of burning. Moreover, he professed an animistic system, in opposition to the materialism of Hermann Boerhaave and Friedrich Hoffmann.

[4] Lavoisier Antoine (1743–1794), the «father of modern chemistry,» was a French nobleman prominent in the histories of chemistry and biology. He named both oxygen (1778) and hydrogen (1783) and predicted silicon (1787). He helped construct the metric system, put together the first extensive list of elements, and helped to reform chemical nomenclature. He was also the first to establish that sulfur was an element (1777) rather than a compound. He discovered that, although matter may change its form or shape, its mass always remains the same. Lavoisier demonstrated the role of oxygen in the rusting of metal, as well as oxygen's role in animal and plant respiration. Working with Pierre-Simon Laplace, Lavoisier conducted experiments that showed that respiration was essentially a slow combustion of organic material using inhaled oxygen. Lavoisier's explanation of combustion disproved the phlogiston theory, which postulated that materials released a substance called phlogiston when they burned. Lavoisier investigated the composition of water and air, which at the time were considered elements. He determined that the components of water were oxygen and hydrogen, and that air was a mixture of gases, primarily nitrogen and oxygen. Lavoisier used careful measurement and thoughtful experiments to turn chemistry into a science. He also explained the experiments of others, such as Joseph Priestley's discovery of oxygen and Henry Cavendish's production of water from hydrogen and oxygen. Lavoisier used the results of other chemists and his own experiments to create the modern theory of fire and to explain the role of air in combustion and respiration.

[5] Laplace Pierre-Simon, marquis de Laplace (1749–1827) was a French mathematician and astronomer whose work was pivotal to the development of mathematical astronomy and statistics. He summarized and extended the work of his predecessors in his five-volume Mécanique Céleste (Celestial Mechanics) (1799–1825). This work translated the geometric study of classical mechanics to one based on calculus, opening up a broader range of problems. In statistics, the so-called Bayesian interpretation of probability was developed mainly by Laplace.Laplace formulated Laplace's

production in a human happened due to the process of burning something similar to oxidation, therefore, oxygen coming from respiration is to burn carbon and hydrogen out of which an organism consists. Hence, the two separate processes for the organic and inorganic aspects are in fact just one.

Thenceforth, thanks to discoveries in the field of life processes taking place due to laws of physics and chemistry, such as blood circulation and chemistry of digestion, the idea appeared that both organic and inorganic processes were driven, in fact, by the same force.

The importance of energy conservation issue for functions of organic world gives us, without any doubt, the right to claim that all processes taking place in living organisms may be explained on physicochemical grounds.

It is striking that the name of brilliant physiologist and physicist Helmholtz[6] is strongly connected with the energy conservation law, which drove physics and physiology to a different path. It is almost certain that his experience of heat production during muscle activity and rotting and fermentation, a purely biological research, led the abovementioned scientist to his famous work on energy conservation.

Currently, we are aware that the processes taking place in living organisms and in the entire nature are related to energy transformation.

As you know, according to Thompson[7], energy gathered in constant amount is in an endless dissipation process relying on ceaseless transformation, completed with heat production. Such process is to be finalised after some time with the balance of temperature.

Therefore the entire complex of life phenomena of both humans and animals relies on energy transformation. Such alteration takes place in all organisms regardless of species, starting from unicellular organisms. Constant motion, mechanical work, and, therefore, constant heat production make animals called warm blooded and maintain constant body temperature regardless of the ambient temperature.

---

equation, and pioneered the Laplace transform that appears in many branches of mathematical physics, a field that he took a leading role in forming. The Laplacian differential operator, widely used in mathematics, is also named after him. He restated and developed the nebular hypothesis of the origin of the solar system and was one of the first scientists to postulate the existence of black holes and the notion of gravitational collapse.

[6] von Helmholtz Hermann Ludwig Ferdinand (1821–1894) was a German physician and physicist who made significant contributions to several widely varied areas of modern science. In physiology and psychology, he is known for his mathematics of the eye, theories of vision, ideas on the visual perception of space, color vision research, and on the sensation of tone, perception of sound, and empiricism. In physics, he is known for his theories on the conservation of energy, work in electrodynamics, chemical thermodynamics, and on a mechanical foundation of thermodynamics.

[7] Thompson - Sir Benjamin Thompson (1753–1814) was an American-born British physicist and inventor who developed the idea that heat is a form of kinetic energy that was the part of the 19th century revolution in thermodynamics.

The abovementioned metamorphosis in organisms, however, progresses under different conditions than in the inorganic world, where it is usually a consequence of chemical issue. That is the cause why the issue of those changes, and hence the issue of life itself, could not be acknowledged. These conditions remain unknown.

The issue of burning in the organism is different than in the case of burning of inorganic objects. Oxidation, as all chemical processes in an organism, takes place at a relatively low temperature, at which the objects with high oxygen content are usually burnt. As you know, objects burn faster in pure oxygen than in the atmospheric air, however, Lavoisier[8] and Seguin[9] showed, that organisms, regardless of whether they breathe air or pure oxygen, have the same burning capacity. In addition, a living cell accepts the amount of oxygen needed, not more, not less, regardless of the supply. Therefore, if we deliver less oxygen, it will be compensated for by a higher respiration rate.

Current researchers do not clarify the difference between chemical and physical processes occurring in the organisms and will not explain them soon despite numerous theories and hypotheses.

What seems rational is the fact that we face the state of shaky balance of particles constituting the organism, both of physical and chemical nature. We have reached such conclusion basing on the fact that little is demanded to trigger some processes.

Muscle prick with a needle evokes contraction of the mentioned muscle, hence motion, mechanical work, heat production, CO_2 release, and finally electric motion in the form of current. Therefore, even a small stimulus triggers a sequence of physical and chemical events whose sum of energy is much bigger than the one contained in the stimulus itself.

In the rifle prepared to shoot, the energy is already gathered and needs just a spark to give a bullet certain speed. Energy in the gunpowder is dormant. Therefore, we may, in a similar manner, imagine life processes, which are also the result of some forms of energy release.

In fact, together with the development of our research we increasingly come to the conclusion that in order to trigger each and every organism activity, a stimulus of some sort is needed. The stimulus may be of endogenous and exogenous nature although in our research we encountered stimuli considered as automatic, being evoked spontaneously.

That, however, does not explain to you, Gentlemen, the nature of life processes, does not give a reason why we classify the processes into chemical and physical, neither does it

8 Lavoisier - Antoine-Laurent de Lavoisier (1743–1794) was a French nobleman and chemist central to the 18th-century chemical revolution and had a large influence on Chemistry and Biology, discovering of the role oxygen plays in vital processes.

9 Seguin - Armand Séguin (1767–1835) was a French chemist and physiologist, experimental partner of Lavoisier in study thermodynamic laws in body weight control.

explain why those processes occur. Hence, even though we may examine almost precisely the work of the stimulated muscle, measure amount of heat and indicate which processes are physical and which ones are chemical, and describe the electric current changes, we are not capable of pointing out the reason for all those changes.

This is the hurdle that we hope to overcome in future with the use of new methods.

Maybe in future we will find out that there are some other types of energy in the organisms, and not the mysterious Stahl's life power.

Now, I would like to speak about the methodology that we use in the current physiological research.

The first and the simplest method is direct observation with the use of senses, where we use all of them, mainly sight, hearing and touch. Proper observation is a crucial condition of examination for both physiological and generally physical research. That is so, because in future you, Gentlemen, will observe deviations in those functions and diagnose diseases on grounds of proper observations. Therefore you have to practice a lot in order not to allow any single change in normal function escape your attention!

Observation of the organism allows us to get acquainted with functions of organs and their correlation with the outside world. A mere observation, however, is not sufficient. Most of the organs that are crucial for life are hidden in the cavities and opening those cavities is the only way to get access to them. For that purpose, we use animals; examining their guts we observe their functions, hence, coming to conclusions about functions of human organs.

Examination of some organs might be most comfortable after their removal from the organism. That is, however, a simplification because the phenomena under analysis are separated from other phenomena that might or might not affect it simultaneously. It is to be noted that the examined organ or tissue should be alive. Therefore, the organs extracted from cold-blooded animals are most useful for that purpose, since they preserve their functions in a certain environment for a certain time after extraction. Such observation, whether of entire organism or single organs, does not bring us to our goal due to the inaccuracy of our sensory systems. The required level of accuracy may only be achieved by using specialized equipment. Microscope, which was found very useful in morphology, seems to be perfect for physiological observations, for example in observing microcirculation.

Unreachable for our senses are the current electric changes that take place in some tissues and organs. We can get acquainted with them by means of a galvanometer, electrometer or telephone. Similarly, we do not have the ability to estimate absolute temperature, though, however, we have thermometers, both mercury and electric ones.

We use equipment for graphic representation and recording of certain phenomena, which gives us the possibility to analyse them more closely.

You will learn more facts about those methods during your detailed physiology lectures. Those methods are not very different from those used in chemistry or physics, however, small modifications will allow us to dwell on the knowledge of physiology.

All I was talking about referring to physiological examination is not sufficient for complete explanation of life phenomena. A profound knowledge of as many properties of the organism, as is only possible is necessary to understand the underlying causes of life functions. We need to answer many questions addressed to nature: How will a certain organ act if we introduce a certain change?

The art of experiment lies in modification of conditions, in asking many questions, and forcing the nature to answer them.

Gentlemen, you have got acquainted with the paths that physiology takes to get to the truths hidden in nature, as well as with the methods it uses to determine the laws of life functions.

With the development of ours science, more and more facts are being gathered simultaneously multiplying the amount of examination methods aimed at revealing mysteries. The amount of research instruments is increasing and the instruments themselves are constantly being modified for the use of this facility.

Such modern and beautiful facility is now given to the Faculty of Medicine thanks to the generosity of the lovingly ruling Monarch[10].

The constructed and furnished facility is now amongst the top facilities around the world and it is here to help achieve two goals: facilitation of education process and research work. Both of these aims were taken into account, and I hope that this facility will allow us to fulfil them. You are welcome to take advantage of such opportunities to make your work fruitful.

To sum up, I would like to use the words by du Bois-Reymond[11]: “Physiology is mostly a way of thinking. You will come to know the phenomena of nature, explain them, and connect their details”.

Whoever will walk through lectures, laboratory classes and seminars will surely be, in future, as a doctor, deprived of thoughtlessness, routine and slow speculative philosophy.

---

[10] Monarch - Franz Joseph I or Francis Joseph I (1830–1916) was Emperor of Austria, King of Hungary, Croatia and Bohemia.

[11] Emil du Bois-Reymond (1818–1896) was a German physician and physiologist, the discoverer of nerve action potential, and the father of experimental electrophysiology.