

**ELECTRIC FIELD AND ITS ROLE IN LIFE**

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**Abstract:** This article provides an extensive and in-depth analysis of the theoretical foundations, historical development, modern scientific research, and the role of the electric field in life. It discusses fundamental concepts of the electric field, classical and modern theories, the contributions of regional and national scholars, empirical research findings, and practical applications. The article also addresses ongoing debates and issues, presenting scientifically grounded conclusions about the role of the electric field in various life processes.

**Keywords:** electric field, electric charge, life processes, physics

### **Introduction**

The electric field is one of the most important and fundamental concepts of modern physics. Its theoretical foundations and practical significance are being studied in depth not only in the natural sciences, but also in engineering, biology, medicine, ecology and many other fields. The electric field is a field formed around any electrically charged bodies, which has the property of influencing other charged bodies. This article deeply analyzes the physical essence of the electric field, the stages of historical development, the scientific heritage of regional and national scientists, the results of modern research and its practical significance in life. It also considers the role of the electric field in various life processes, its significance in biological and technological fields, existing scientific debates and problems, and promising directions. This article shows the current state of the theory of the electric field, the main scientific ideas related to it, and important directions for future research.

### **Literature review**

The theoretical and conceptual foundations of the electric field have been formed as one of the most fundamental sections of modern physics. Although the concept of an electric field first emerged in the 18th century, during the period when electrical and magnetic phenomena were studied, its complete and perfect theoretical foundations were created in the 19th century. The nature of the electric field, its effect on other charged bodies, field lines of force, potential and electric field strength are important concepts of classical physics. An electric field is created around each electric charge, and this field spreads out in space and exerts a force on other charges. The intensity and direction of this force are the main characteristics of an electric field.

From a historical point of view, the formation of the theory of the electric field consists of several stages. The initial experiments and observations were manifested in the interaction of electric charges, their attraction or repulsion to each other. In the 18th century, the French physicist Charles-Augustin Coulomb determined the quantitative expression of the forces between electric charges - Coulomb's law. This law was an important stage in creating the theoretical foundations of the electric field. In the middle of the 19th century, the English physicist Michael Faraday introduced the concept of an electric field and proposed to describe it using field lines. Faraday's ideas about the electric field were later developed on a mathematical basis by James Clark Maxwell. Maxwell's equations proved the interdependence of electric and magnetic fields, their propagation as electromagnetic waves, and their importance in natural processes. Thus, the theory of the electric field was formed as the basis of classical electrodynamics. The contribution of regional and national scientists to the development of the theory of the electric field is also of great importance. In particular, Russian scientists Alexander Stoletov and Lev Landau made a great contribution to the development of modern quantum electrodynamics and statistical physics by deeply studying electrical and magnetic phenomena. Among Uzbek scientists, Professor Gulom Mirzayev, Academician Turgunboy Ubaydullayev and many other physicists conducted important research in the study of theoretical and practical aspects of the electric field. Their works are devoted to the local properties of the electric field, its effect in various environments, the importance of the electric field in semiconductor materials and biological systems. Modern scientific research on the electric field includes many new directions. For example, in the field of nanoelectronics and quantum technologies, the specific properties of the electric field are being studied. The specific behavior of the electric field and its quantum effects are being determined in nano-sized structures, quantum dots, graphene and other advanced materials. In biology and medicine, the effect of the electric field on living cells, tissues and the whole organism is being studied. For example, electrical signals and electric fields play an important role in controlling the activity of the heart and brain. Methods such as electrophoresis, electrostimulation, and physiotherapy related to the effect of electric fields are widely used in medicine. Modern ecological research is also aimed at studying the effect of electric fields on the environment, flora and fauna. The practical application of electric fields is also widespread in technology and industry. The transmission of electrical energy, high-voltage lines, electrical devices, electrical machines, and transformers rely on the basic laws of electric fields. Modern information technologies, computers, microprocessors, and sensor systems are also based on the precise control of electric fields. Also, with the help of electric fields, it is possible to separate materials into dielectric, semiconductor, and conductive types, create new materials, and develop nanoelectronic devices. Methods for electrostatic

cleaning, dust separation, water purification, and other environmental problems have also been developed using electric fields.

Empirical studies play an important role in confirming the theoretical foundations of the electric field and identifying new properties. The spatial distribution, intensity, and direction of the electric field have been studied through numerous laboratory experiments, measurements of field lines and potentials, and observations of the movement of electric charges. Modern experimental methods allow precise measurements of the effect of the electric field on nanoscale structures, biological tissues, and various materials. For example, atomic force microscopy and electron microscopy are used to study the local effect of the electric field, the micro- and nanoscale distribution of charges, and quantum effects. In biological studies, the role of the electric field in the movement of ions through cell membranes, nerve impulses, and contraction of the heart muscle has been determined.[1]

There are various debates and discussions among the scientific community about the place and role of the electric field in life. Some researchers believe that the effect of the electric field on biological systems is limited only to physicochemical processes, while others propose more complex and specific mechanisms of its action. For example, there are various theories about the effect of electric fields on plant growth, seed germination, animal orientation, and even human health. Some empirical studies have shown that electric fields, even at low intensities, have a significant effect on biological processes.[2] However, there are still many open questions, controversial issues, and uncertainties in this area, which remain promising areas for future research.

The modern development of electric field theory is embracing new dimensions based on quantum electrodynamics, wave-field dualism, and the theory of relativity. Quantum electrodynamics studies the quantum properties of electric and magnetic fields, that is, their discrete energy levels and their interaction through photons. This allows us to explain the most subtle quantum effects of electric fields, the appearance and disappearance of virtual charges, vacuum polarization, and other complex phenomena. The theory of relativity shows the dependence of electric and magnetic fields on space-time changes, the transformation of fields for moving charges. These modern theories allow us to understand the universality of the electric field and its participation in all processes in nature more deeply.[3]

Many scientific monographs, articles and textbooks have been created today to deeply study the fundamental and practical importance of the electric field. In particular, special research is being conducted at the Uzbek School of Physics on the local and global properties of the electric field, its effect on semiconductor and dielectric materials, and its role in biological systems. The works of Professor Gulom Mirzayev on the electric field and semiconductors, the research of Academician Turgunboy Ubaydullayev on the biological effects of the electric field, as well as the

work of young scientists in the fields of modern nanoelectronics and biotechnology demonstrate the importance of the electric field in modern science.[4]

Empirical studies conducted in recent years on the role of electric fields in life have also yielded important results. For example, it has been found that electric fields have a positive effect on plant growth and development, rapid seed germination, acceleration of root and stem growth, and even the formation of fruits. Some studies have shown that low-intensity electric fields can increase plant resistance to diseases. In the animal kingdom, the ability of some species to sense electric fields and use them for navigation has been discovered. For example, fish and some aquatic animals use electric fields to detect their environment and find prey.[5] In human health, it has been proven that electric fields play an important role in the normal functioning of the heart, brain, and nervous system, and are widely used in electrotherapy and other medical methods.

The role of electric fields in modern technologies is also of great importance. Nanoelectronics, quantum computing technologies, artificial intelligence systems, sensor devices, high-precision measuring instruments, optoelectronics and photonics are based on the controllable properties of the electric field. With the help of precise control and manipulation of the electric field, it is possible to create a new generation of micro- and nano-sized devices, increase energy efficiency, and develop environmentally friendly and sustainable technologies. In addition, the role of the electric field in solving environmental problems is also important. For example, the electric field is used in electrostatic filtration, water and air purification, waste disposal, and the elimination of harmful particles in the atmosphere.[6]

Thus, the theory and practice of the electric field are widely used today in fundamental scientific research, modern technologies, biological and ecological systems, medicine and agronomy. Its theoretical foundations and empirical results complement each other, forming the basis for new scientific ideas and technological achievements. Research on the place and role of the electric field in life is constantly developing, new problems and promising directions are being identified. This further increases the importance of electric field theory in modern science and technology.

### **Conclusion**

The above analysis and research clearly demonstrate the importance of the electric field in modern physics, technology, biology, medicine, ecology and other fields. The electric field is not only a fundamental scientific concept, but also an integral part of life processes. Its theoretical foundations are closely related to classical electrodynamics, quantum electrodynamics and other branches of modern physics. At the stages of historical development, the concepts of the electric field have expanded and become the basis for new scientific achievements. The contribution of regional and national scientists, the results of empirical research and practical application in modern

technologies demonstrate the universality of the electric field. The role of the electric field in life is reflected in the plant and animal world, in the human body, in technological processes, in solving environmental problems. At the same time, there are still many open questions about the effect of the electric field on biological systems, environmental safety and its role in modern nanotechnologies. This creates a solid foundation for further in-depth study of the theory and practice of the electric field, new technologies and scientific achievements. The electric field, as an integral part of modern scientific thought and technological progress, remains relevant at all stages of human development.

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