Citation article: Lysetskyi B., Vesova O., Kindras I., Kryvosheieva A., Kaminskyy, V. Theoretical medicine: the foundation of the future of medicine. *Futur Med [Internet].* 2024;3(2): 45-56. Available from: https://doi.org/10.57125/FEM.2024.06.30.05

Theoretical medicine: the foundation of the future of medicine

Bohdan Lysetskyi[1*], Olena Vesova[2], Ihor Kindras[3], Anna Kryvosheieva[4], Valery Kaminskyy[5]

[1]*Lviv National Medical University named after Danylo Halytskyi, Lviv, Ukraine, https://orcid.org/0009-0002-5907-631X*

[2] *Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine, https://orcid.org/0000-0002-7018-0487*

[3] *Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine, https://orcid.org/0009-0009-1936-4895*

[4]*Kyiv Medical University, Kyiv, Ukraine, https://orcid.org/0000-0002-6663-4052*

[5] *Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine, https://orcid.org/0000-0002-2693-9003*

Abstract

When comparing the current capabilities of medicine in diagnosis and treatment with those of twenty years ago, one can certainly say that back then, such advancements were merely a dream. The success in diagnosis, treatment, and prevention is usually the result of knowledge synthesis accumulated over several centuries. This becomes possible due to the development of such disciplines as molecular biology, genetic engineering, systems biology, nanomedicine, and regenerative medicine. Modern technologies make it possible to manage many processes and digitisation covers more and more fields of medicine.

Aim: of the research was to carry out a literature search concerning the importance of fundamental sciences knowledge, to familiarise with some modern directions: genetic engineering, molecular biology, nanotechnology and others, to demonstrate the successful implementation of their assets in diagnostic and therapeutic measures.

Methodology: a generalisation and scientific publications analysis over the past 5 years on the topic of this study has been carried out. To search for literary sources, databases and search engines, focusing primarily on PubMed for the research topic were utilised.

Results: Following a literature analysis, undeniable confirmation that biomedical sciences–physiology, pathophysiology, pathomorphology, and microbiology–were the essential foundation without which success in treatment and diagnosis would be unattainable was discovered. The accumulation of the database opened up new promising ways of theoretical medicine. The success of molecular biology and biochemistry has become a source for the successful development of nanotechnology, genetic engineering and regenerative medicine.

Scientific Novelty: the novelty of this research is in tracking the correlation between fundamental medical and biological sciences and the development of modern areas of medicine.

Conclusion: the presented literature search demonstrated that the theoretical foundations of medicine are extremely important and allow to successfully develop modern directions of medicine and introduce them into clinical medicine.

Keywords: biomedical sciences, pathophysiology, clinical research, molecular medicine, genetic engineering, regenerative medicine, pharmacological innovations, diagnostic methods, systems biology, nanomedicine.

Received: January 22, 2024
Revised: February 3, 2024
Accepted: April 28, 2024
Published: May 14, 2024

* CONTACT: b.lisetskii@gmail.com.
DOI: https://doi.org/10.57125/FEM.2024.06.30.05

Introduction

Theoretical medicine is the necessary step leading to clinical medicine. Without a comprehensive understanding of biomedical sciences, including knowledge of physiological norms and pathophysiological mechanisms, it will be challenging for a student, then a doctor, or a scientist to comprehend how diseases progress, what complications may arise, and which measures for treatment or prevention should be pursued. Theoretical medicine accumulated all this knowledge over a long period of time. To date, using these assets, computer programs have been successfully implemented in medical and diagnostic work, which included data on the symptoms of the disease and treatment. In the era of advanced technologies, facilitated conditions for conducting clinical research, and the knowledge accumulated over the past decades, there is a need to organise and systematise them. Medicine has gone through a multi-stage and thorny path of development from ancient times to the present. The discovery of antibiotics in 1928 by Alexander Fleming became a new chapter in medical history. However, if considering the challenges that medicine faces today, then modern treatment methods cannot be considered completely perfect. Areas of theoretical medicine: biomedical sciences, physiology, pathophysiology, clinical research, molecular medicine, genetic engineering, regenerative medicine, pharmacological innovations, diagnostic methods, systems biology, nanomedicine [1,2].

Research Problem

The development of biomedical sciences, the accumulation of a large database, technological progress in recent years allowed scientists to move from the experimental study of biological objects to the implementation of accumulated knowledge in the practical plane, which led to the emergence and development of such sciences as genetic engineering, molecular biology, systems biology, regenerative medicine, nano-technologies. This leads modern science to fundamentally new approaches to scientific research using new technological capabilities. The acquaintance with the achievements of modern theoretical medicine is crucial for finding new strategies for scientific research.

Research Focus

The conducted research was aimed at acquainting the audience with modern achievements of biomedical sciences: pathophysiology, pathomorphology, genetic engineering, molecular biology, systems biology, regenerative medicine, nano-technologies. It also aimed to systematise the obtained data and evaluate the stages of development of the sciences of theoretical medicine.

Research Aim

1. To analyse modern literature on the state of biomedical disciplines development: pathophysiology, pathomorphology, genetic engineering, molecular biology, systems biology, regenerative medicine, nano-technologies.

2. To study the modern achievements of biomedical sciences of theoretical medicine.

3. To analyse the contribution of modern directions of theoretical medicine to practical medicine: to diagnostic procedures, to changing the tactics of treating diseases.

4. To describe the current directions of theoretical medicine and evaluate their development at the current stage.

Research Questions

1. What are the most developed modern directions of theoretical medicine?

2. What are the achievements in the field of: pathophysiology, pathomorphology, genetic engineering, molecular biology, systems biology, regenerative medicine, nano-technologies at the current stage?

3. How are the achievements of modern theoretical medicine implemented in modern practical medicine?

4. At what stage of development are the modern branches of theoretical medicine?

Research Methodology

General Background

The main task of medicine was and still is to overcome diseases. To solve this problem, coordination of all branches of modern medicine is necessary: the practical one, as well as theoretical. Theoretical medicine serves as a cornerstone for the development and enhancement of diagnostics and treatment in practical medicine. The accumulation of theoretical knowledge by biomedical sciences has contributed to the development of new branches of modern medicine: genetic engineering, molecular biology, systems biology, regenerative medicine, nanotechnologies, which open new ways to treatment and diagnostics [1].

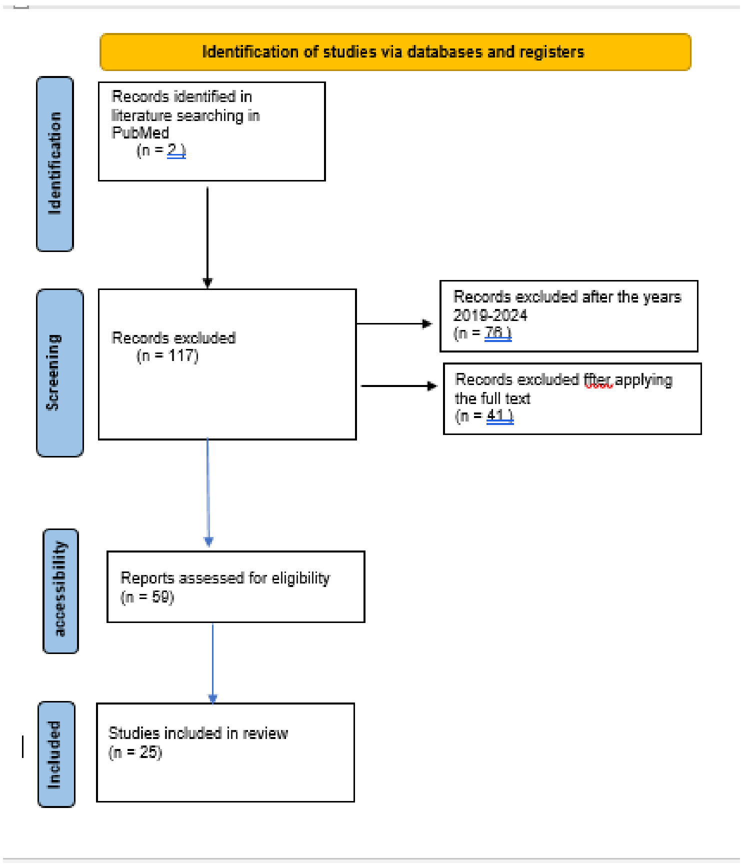

Figure 1. PRISMA flow diagram

Sample / Participants / Group

A literature review utilising the following keywords was conducted: biomedical sciences; pathophysiology; clinical research; molecular medicine; genetic engineering; regenerative medicine; pharmacological innovations; diagnostic methods; systems biology; nanomedicine. 230 publications based on the key words in the Pubmed database were received. Among them, 154 belonged to the period from 2019 to 2024, of which 98 were freely available. Publications that contained a complete list of keywords: 34 that contained a combination of several "genetic engineering" and "regenerative medicine", "genetic engineering" and "systems biology", "nanotechnology" and "genetic engineering". Of the studied sources, 25 were considered relevant and contributed to the understanding of modern medicine development, as a result of the development of theoretical branches of biomedical sciences. These statistical data provided a complete overview of the volume, availability, language distribution and relevance of publications on this topic on PubMed for the specified period.

Instruments and Procedures

During the narrative review, a systematic methodology was used. In the PubMed search, specific keywords biomedical sciences; pathophysiology; clinical research; molecular medicine; genetic engineering; regenerative medicine; pharmacological innovations; diagnostic methods; systems" were used in order to search for relevant sources of literature from 2019 to 2024.The procedure included several main stages:

1. The search terms "biomedical sciences" AND "genetic engineering", "biomedical sciences" and "nanotechnology", "biomedical sciences" and "molecular biology", "biomedical sciences" and "regenerative medicine", "biomedical sciences" and "pharmacological innovations ", were entered into the PubMed search bar. This action focused a literature search that examined articles showing the relationship of a particular field to the biomedical sciences [1].

2. For the review, articles for the 2019-2024 period only were selected.

3. This allowed familiarising with the novel achievements of modern branches of theoretical medicine. For further processing, articles that fit the research topic were selected.

4. Only the full-text versions of the articles for a full review were used. Relevant data were extracted from the selected articles during a thorough review of each publication.

5. The articles selected for consideration were carefully analysed.

6. The evaluation of the results were critically approached that determined the direction of further research.

Data Analysis

During the literature review, a series of sequential steps to develop theoretical knowledge about the current state of certain theoretical areas of biomedical sciences and uncover their latest achievements were followed. When processing the literature and systematising information from the reviewed sources, the aim was to create a coherent narrative. The key findings on the research topic were identified and a description of each modern direction in biomedical sciences was provided.

Research Results

Figure 2 shows the literature search data that were processed during the study of scientific literature. Articles that were descriptive in nature were chosen, as well as articles with the results of experimental and clinical studies, there were also review articles and data from meta-analyses. The chosen topic for elaboration included a significant list of areas of medicine, articles from each area that revealed the successes of this area to a greater extent were chosen. 12 review articles, clinical and experimental studies were processed and made up the majority of the material - 28, meta-analyses – 5 (Fig. 2).

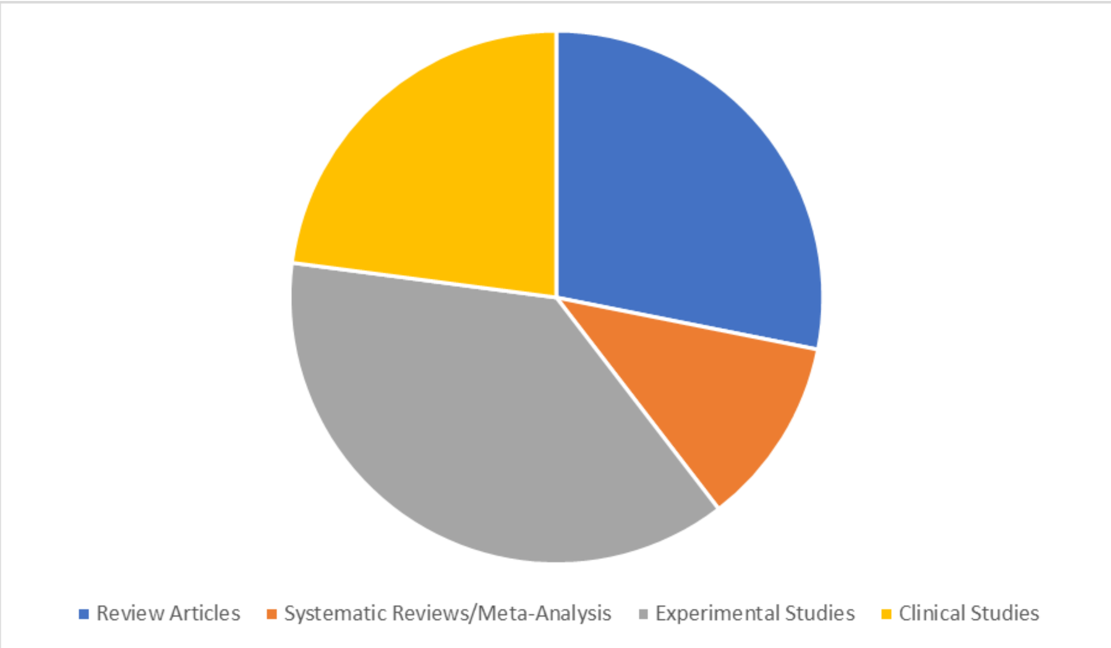

Figure 2. Frequency distribution of study design

The main laws obtained by theoretical medicine are based on the data of experimental studies. The value of the experiment is undeniable. The method of experimental research led to the discovery of the following fundamental laws of the physiology of excitable tissues: the presence of resting and action potentials, which form the basis of a living cell [1]. These are the biopotentials of excitable cells, which include nerve, glandular and muscle tissue, that made it possible to discover and introduce current methods of ECG and EEG research into diagnostics. They are based on the registration of biopotentials that occur during the conduction of a nerve impulse [2]. It is the experimental data of the electrophysiology of excitable tissues, which have their historical roots from the Italian physiologist L. Galvani and the subsequent discoveries of V. Chagovets and Y. Bernshtein, V. Danilevsky and R. Keton, that became the theoretical basis for understanding the mechanisms: the origin and conduction of a nerve impulse, secretion and release of digestive juices: saliva, gastric and intestinal secretions, secretion and work of endocrine glands, processes of filtration and reabsorption of urine and many others [3]. The understanding of these mechanisms and possible deviations from the norm opened the way to successful treatment. The fundamental laws of the cardiovascular system: the Frank-Starling law, the Anrep phenomenon, sympathetic and parasympathetic regulation of internal organs were also discovered by experiment [3, 4].

The discovery of new cardiac drugs in modern days is based on the effect of drugs on the potential, or chemodependent channels, of typical or atypical cardiomyocytes. The journey from developing a medicinal preparation to its availability on pharmacy shelves is lengthy. It may take up to 10 years to account for the various consequences of the drug's actions. Among the factors that stimulate pharmaceutical science to search for new drugs is the request due to the ineffective action of drugs, the presence of side effects [4].

For successful treatment, which is the main task of modern medicine, it is important to understand the physiological features of the processes in a healthy body and the pathophysiological mechanisms of diseases. Without a thorough knowledge of pathophysiology, it is difficult to understand the clinical course of the disease and to apply drugs. The subject of the study of pathological physiology is the study of general regularities at all levels of functioning (molecular, organ, organ systems, organismal) of the occurrence and course of diseases. Pathophysiological regularities were studied mainly experimentally on laboratory animals. In the conditions of a chronic or acute experiment, pathophysiologists model possible diseases. These can be models of diabetes. Experimental models of alloxan and streptozotocin-induced diabetes have been widely used [4, 5]. The pathophysiological mechanism consists in the destruction of beta cells of the islets of Langerhans of the pancreas, which brings this model closer to understanding the pathogenetic mechanisms of insulin-dependent diabetes. There are many models: Alzheimer's disease using the stereotaxic method of introducing beta-amyloid into certain areas of the brain, Parkinson's disease, which allows studying dopamine deficiency by destroying the substantia nigra of the basal ganglia. Models for inducing hypertension are also utilised; in recent years, a line of rats with spontaneously occurring arterial hypertension has been developed [6, 7]. The study of physiological and pathophysiological processes that occur in endocrine glands is also carried out experimentally. Endocrinology as a field of medicine is relatively young. The first studies in the field of endocrinology studied the role of the pancreas as an organ of endocrine regulation [4, 6]. The initial experiments involving the removal of the pancreas were conducted on dogs and revealed glucosuria, stemming from impaired glucose reabsorption in the proximal tubules of the nephrons. Experiments involving the eradication of endocrine glands enabled the establishment of both the physiological significance and the exploration of pathophysiological mechanisms associated with the loss of function of this organ [8,9]. Reproduction in rat models of infectious diseases made it possible to study this process and the possibilities of treatment. It is on animals that new drugs are tested, which made it possible to overcome many diseases, but new challenges also appeared. Today, the world medical community is concerned about the growing antibiotic resistance, polypharmacy, the rapid aging of the population and the emergence of a large number of chronic diseases in connection with this. A major role in the reboot of modern medicine was played by the pandemic, COVID-19, which became a serious confirmation of the pathophysiological concept of "cytokine storm" and whose negative consequences moved treatment methods to a new level. In both treatment and rehabilitation, attention to timeliness, complexity and a multidisciplinary approach has intensified. The paradoxical nature of the course of COVID-19 pneumonia has led to a reassessment of existing knowledge, since this type of pneumonia can have serious consequences both for people with a provoked history (CVD, diabetes, etc.) and for physically active young people who regularly do sports. Molecular and biotechnological methods, which introduced the technology of DNA and RNA sequencing, turned out to be especially useful. Taking into account how quickly the pandemic unfolded, experts from all over the world received a challenge to quickly diagnose, find methods of treatment and prevention of the disease. The loss of time cost the world the loss of new lives. The acquisition of theoretical medicine, which has accumulated information about the pathogenesis of viral diseases, the peculiarities of the course of viral pneumonias and the possibility of mutations, made it possible to find ways of diagnosis, treatment and prevention [3, 6, 10].

In addition, a major challenge for society as a whole is cardiovascular disease and the rejuvenation of stroke. Despite the large number of cardiac rehabilitation programs, the number of postinfarction patients who participate in them cannot be considered satisfactory. Given the phasing of such programs, it is difficult to immediately determine in which link the defect is present. That is why the coordinated interaction of theoretical scientists, clinical scientists, and practicing doctors is necessary for success in meeting the challenges of modern medicine. A key and relatively new question is the role of psychosomatic factors and stress in the emergence of new nosologies, which may be novel to practitioners and are sometimes not immediately recognized by physicians. Thus, great hopes are placed on medical theory, since its main tools are rethinking the foundations, searching for new ways and models [11].

Today there is an organism-centered view of health and disease, which was proposed by Ludwig von Bertalanffy. He believed that systemic theoretical medicine can make a more significant contribution to the understanding of pathologies and suggests considering non-linear relationships that arise between phenomena, as well as integrating data on functional subsystems. A similar concept is followed in the works of M. Mesarovych and D. Muller, who proposed multilevel models of living systems [1, 3, 12]. A mandatory component of such systems are the control organs, which include the hypothalamic-pituitary system, which controls the homeostasis of almost all indicators of the body. The principle of operation of this system is negative reverse. In other words, the body endeavors to maintain certain constants, which may encompass factors such as the blood glucose level, calcium level, hormone levels, blood cell counts, and numerous others. The hypothalamic-pituitary system regulates the level of hormones and supports the indicators of the endocrine system: glucose, calcium, phosphorus. The immune system carries out a complex process of regulating the body's defenses by integrating with other systems: endocrine, nervous, and digestive. Successes in the treatment of hematological diseases, according to experts, are the result of the knowledge accumulated over the last dozen years regarding pathogenetic mechanisms, which allows to open new areas of application of medicines. Pathology is a key concept of medicine, which can be divided into subsystems and will allow considering changes in the body under the condition of a pathological process at anatomical, histological, biochemical, physiological levels. Loss of function begins with loss of structure, so histology acquisitions are important in this context. Histological preparations have been created, which are collected in histological atlases and with the help of modern digital technologies, high-quality images can be reproduced. Studies systematized in this way allow for quick analysis. Patho-anatomical changes, which are studied by specialists at the macroscopic and microscopic levels, are the most accurate method of diagnosis. Pathology makes it possible to study morphological changes in organs and tissues, to determine the etiology of these changes. Pathology makes it possible to compare morphological changes with the data of biochemical studies. The successes in the development of pathology, as an important area of medicine, are directly related to technical progress. The first studies are macromorphological changes, the next ones are microscopic and molecular biological. The discovery of microscopy gave wide opportunities. The creation of histological preparations is based on the properties of tissues and organs and on the susceptibility to various chemical reagents. Unlike optical microscopes, modern light microscopes use the fluorescence method, which allows you to see structures at the molecular level. Therefore, this direction of theoretical medicine will continue to develop in the future [5, 6, 13].

Increasing knowledge of the pathophysiology of most diseases has opened a new era in pharmacological innovation. Modern fields of medicine: nanomedicine, molecular medicine and genetic engineering require the creation of new medicines taking into account the features of the above methods. Theoretical medicine assumes a pivotal role in the development of cutting-edge pharmaceuticals, with forecasts in pharmacy innovation showing promise in the creation of personalised medications. Presently, programs have been devised to simulate and evaluate the outcomes of drug usage (including the development of diagnostic biomarkers). The latest algorithms include RNAi technologies, which will allow in the future to discover new drugs that will be aimed at new targets and will allow the treatment of complex pathologies. The use of computer programs will make it possible to control chemical synthesis [7]. The introduction of docking analysis allows you to conduct a virtual experiment in which you can observe the interaction between the drug and the receptor. Innovation in pharmacology is not a change in the form or color of drugs, but the creation of a new molecule of a medicinal substance, or the improvement of an already known medicinal substance with significantly improved characteristics. Specialists have systematized the possible innovations of medicines: basic, these are medicines that are developed on modern scientific technologies, created for the first time and have no analogues; incremental changes significantly improve the drug and modifying innovations are related to changing the decor. At the current stage, there are new principles regarding the development of new drugs: focus on diseases, mandatory use of biomarkers of effectiveness and safe use of drugs [8,12].

Today it is difficult to overestimate the role of nanobiotechnologies. Nano means a particle size that does not exceed 100 nm. The rapid development of this field will allow to achieve such a level of treatment of complex pathologies without significant side effects. Nanotherapy is based on the activation of nanosensitizers that activate reactive radicals aimed at the pathological focus. The effect of drugs strongly depends on their physical and chemical properties. At the current stage, the following are distinguished: sonodynamic, thermodynamic, electrodynamic, piezoelectric, pyroelectric, dynamic, radiodynamic, chemodynamic therapy [9, 10]. Nanotherapy is widely used in the diagnosis and treatment of oncological diseases. Nanoparticles have a high adsorption capacity and antibacterial properties, which allows the use of drugs for wound healing. Treatment of wounds involves the removal of dead tissue with the use of antibacterial drugs [11, 12]. The discovery of nanotechnologies in this field opens up new opportunities, namely the transfer of DNA/RNA biomolecules by nanoparticles, which enhances the regeneration of damaged tissues. The ability to transfer drugs directly into the cell is more effective and a positive result is achieved faster. Modern technology of electrospinning of nanofibers made it possible to create bandages with wound-healing properties [13, 14].

A separate branch of regenerative medicine is designed to develop effective methods of tissue regeneration, in particular bone tissue. Bone fractures may arise from trauma or concomitant diseases, such as osteoporosis in women. The issue of restoring bone tissue is acute in patients with deforming osteoarthritis. Joint replacement is an expensive procedure that requires a long rehabilitation period. Meanwhile, there are possible risks of complications in the postoperative period, in particular the addition of infections [14, 15].

Successful osteosynthesis requires the presence of such conditions as: the presence of osteogenic cells, platforms for bone growth, as well as growth factors. To reproduce an accurate model of the bone, it is necessary that it be as close as possible to the anatomical one, and also be a substrate for the course of physiological processes in it. Biological nanomaterials make it possible to build up the base of the bone, and also represent a necessary substrate for the delivery of drugs and nutritional proteins. In addition to these advantages, nanomaterials of biological origin can also be combined with metals for greater reliability. These materials also exhibit biodegradability and high biological affinity. Successful osteosynthesis necessitates several properties of nanomaterials, including the capacity to influence the differentiation and proliferation of osteoblasts. Materials such as chitosan, which also has the ability to biodegrade, as well as cellulose, hydroxyapatite, and calcium phosphate, are used for substrate strength [18]. The development and implementation of technologies in the clinical process is the task of modern molecular medicine. This branch of medicine allows applying modern knowledge of molecular processes in the diagnosis and treatment of diseases that were considered incurable. Molecular medicine combines the achievements of physics, chemistry, biology and medicine. For example, the development of thalassemia and sickle cell anemia, which are associated with a change in the shape of erythrocytes due to changes at the molecular level. These diseases belong to hemoglobinopathies. One of the areas of treatment is genetic engineering with the introduction of genes and hematopoietic stem cells, the next stage was the correction of the DNA section responsible for the regulation of the process of transition of fetal hemoglobin into an adult. The achievement of this method allowed us to correct these hereditary anomalies and opens a window of opportunity for understanding similar processes. Scientists place great hopes on molecular biology for the treatment of neurodegenerative diseases [19, 20, 21].

The use of the achievements of genetic engineering allows at the modern stage to overcome genetic anomalies in utero. With the help of molecular biology technologies, genetic engineering allows you to change the DNA sequence. DNA is the unit of heredity, which is responsible for the synthesis of matrix RNA and the subsequent synthesis of proteins. The discovery of molecular biology tools allows scientists to study how DNA controls heredity [20]. One of the directions of genetic engineering is the creation of lines of knockout mice, which allows us to understand the role of this gene. Thousands of gene knockouts have been created, bringing us closer to understanding genetic diseases and giving hope for their correction. Experiments with the activation of endonuclease I-CreI will allow creating a line of transgenic mice and rats. The specificity of I-CreI targets only a certain DNA sequence, which limits its application. ZFN technology allows chromosomes to be broken at the desired location to facilitate genetic modification. With the help of this method, knockout, knockin and flocked mouse models were created. With the help of genetic engineering, modifications can be made to the genome. The discovery of enzymes, the activation of which makes it possible to specifically cut DNA regions, has expanded the possibilities of making changes: knockouts - removal of a DNA region, knockins - insertions of a DNA region, and substitutions - replacement of the sequence of a DNA region. Removal of a section of DNA, or deletion, can be used to suppress gene expression. With the help of deletions, gene expression can be regulated: suppressed or activated. These effects can be achieved by altering the structure of proteins through modifications in the DNA coding sequence. Following a chromosomal break, a crucial step is the non-homologous repair of the ends of the broken molecule. Modern genetic engineering technology, such as CRISPR/Cas9, facilitates the introduction of single sections of DNA without disrupting endogenous genes or breaking both strands of the DNA molecule, thereby preventing the occurrence of unwanted mutations in the genome. CRISPR technology is important in clinical research where mutations resulting from DNA double-strand breaks can have unpredictable consequences for patients. This improved method of CRISPR technology is the method of genetic engineering of the future [13, 21].

One of the modern directions of science is systems biology, which combines basic knowledge from the fields of biomedical disciplines and bioinformatics. Systems biology makes it possible to study new properties in biological systems through programming. Some of the topics that can be explored in this domain include genome sequencing methods, gene clustering utilizing the String database computer program, the feasibility of constructing a Volcano plot, generating heat maps depicting gene expression across various samples, and constructing Venn diagrams [21, 22].

Pandemics that may potentially appear in the future require a fundamentally new approach. One of these diseases is disease X. There is still no specific description of disease X, but the World Health Organization is already concerned about its possible appearance [22, 23]. Scientists and researchers assume that disease X will have much more serious symptoms and consequences for humanity. The experience of the COVID-19 pandemic has shown that modern medicine must face challenges. The concept of prevention (protection with masks and antiseptics) can be considered only partially effective since people today do not have the habit of using masks all the time. A characteristic feature that led to the spread of the covid virus was its contagiousness. A major role was played by the underestimation of the covid pandemic by the society [22]. Given this fact, it can be concluded that the level of public perception of warnings was quite low, which can also be considered as a manifestation of the imperfection of interaction between higher medical authorities and the population. The Covid is able to affect almost all organ systems and persist in the body for a long time. The rapid development of acute respiratory distress syndrome, its rapid reproduction in the blood, potentiation of its coagulation, damage to nerve endings is a trigger for the start of a cytokine storm. On the one hand, it is possible to slow down the cytokine storm with immunosuppressive agents, but it is worth noting that the theoretical basis of the cytokine storm is still not sufficiently described. Today, many studies are conducted on the course of immune reactions. Nevertheless, effective mechanisms of intervention in the cytokine storm process at its later stages have not yet been proven. Similar to the cytokine storm, the development of multiple organ failure syndrome, characterised by the shutdown of the function of 2 or more body systems, which occurs as a result of an acute illness or injury, as well as the syndrome of disseminated intravascular coagulation, the most likely cause of which is the release of endogenous thromboplastin, is a rapid process. According to the recent studies, one of the trigger molecules capable of triggering neutrophilic inflammation and interleukin (IL)-1β proinflammatory cytokine release. Determined catalysts of uric acid are xanthine oxidase. plays a major role in the occurrence of myocardial infarction, COPD, pulmonary hypertension and diabetes of both types. According to the findings of Huang's study, in the blood of intensive care unit patients with confirmed COVID, the concentration of neutrophils increased. The appearance of extracellular ATP is a sign of pulmonary fibrosis.IL-1α and IL-1β also play a significant role in stimulating the cytokine storm. The appearance of these two types of interleukins is due to the interaction of cells of type AT1, which are found in large numbers in the alveoli of the lungs, and the coronavirus. The uric acid also affects the release of interleukin-6. Severe inflammation in patients diagnosed with COVID 19 was also associated with the secretion of chemokines. Acute hypoxic damage to the lungs occurs as a result of uncontrolled adhesion of neutrophils and accumulation of platelets on the endothelium of vessels [5, 22, 23, 24].

According to some data, similar reactions occur during a gout attack, the pathogenesis of which is associated with the accumulation of uric acid in the synovial fluid. However, according to the results of certain studies, the level of uric acid in the blood does not correlate with the intensity of gout manifestations. Thus, in patients with gout, the levels of uric acid in the blood may be within the normal range, which calls into question the great importance of uric acid in triggering the cytokine storm. However, studies have shown that the use of allopurinol and colchicine for gout was associated with hospitalizations, mechanical ventilation, and mortality (25%, 50%, and 44%, respectively). The relative cheapness of allopurinol and colchicine drugs indicates the benefit of their use. The situation with the treatment of patients with concomitant pathologies (cardiovascular diseases and type 2 diabetes, COPD, etc.) still remains difficult [10, 12]. The severity of Covid's progression in these patients is attributed to the vulnerability of blood vessels. In cardiovascular diseases, the accumulation of atherosclerotic plaques on the endothelium of vessels occurs, while in diabetes, glycated proteins in the vascular wall exacerbate the negative course. Moreover, reflex spasms of the microcirculatory channels in the lungs due to microthrombi formation contribute to dyspnea, impairing the patient's ability to assess their condition adequately during pneumonia. It's worth noting that the coronavirus exhibits tropism to nerve fibers, further complicating its course. Some post-Covid patients have been diagnosed with Parkinson's disease, wherein nervous system damage predominates [24, 25]. Although today the coronavirus disease is classified as SARS, the task of leading medical organizations remains to maintain a high level of vigilance in society [20, 25]. The increase in the number of industrial enterprises, the synthesis of new substances, the high level of air pollution in cities, harmful working conditions puts society in front of unknown health challenges. The health situation of the population differs significantly in different countries. Nevertheless, the most common pathology for all countries remains the pathology of the cardiovascular system [43]. Most often, this is an ischemic heart disease, the consequence of which can be an acute myocardial infarction. Despite the large number of options for heart surgery, its successful performance does not guarantee the absence of symptoms of heart failure in the future [44, 45]. Corrections of mechanical blood flow disorders (aortic stenosis, atherosclerosis of coronary arteries), although they are effective in saving the patient's life, do not always lead to an improvement in the quality of life, since the phenomenon of ischemia-reperfusion plays a major role, when metabolic processes are at a lower level of energy consumption, due to that saturation of cells with oxygen can only become a factor in the deterioration of the condition of cells. Researchers Hangyu Pan1 Kexin Hu1 Qiao Wu2 Yan Tu1 Zhigang Guo2 found that the process of increased atherosclerosis in blood vessels is quite likely related to the level of Lp. Lp is one of the low-density lipoprotein antigens. Even post-infarction patients with stabilized low-density lipoprotein levels on statins are at risk of recurrent cardiac events.IL-6 molecules have a receptor for interaction with Lp, which causes the appearance of inflammation. This changes the approach to treatment, since monoclonal antibodies (evolocumab) are effective in reducing the level of Lp-antigen [24, 26, 27].

In conclusion, it can be stated that the inflammatory process and the immune reactions into which it is divided are the basis of many diseases, which are a big problem for modern society. The task of scientific researchers is to systematise the existing knowledge about the inflammatory process and adapt it to the level of textbooks of medical universities. Considering the results of the above studies, it becomes clear that the physiology of the immune system has great prospects [20, 22, 23].

This approach makes it possible to combine existing information from different areas: neurophysiology, endocrinology, immunology, genetics. The integration of these areas of medicine will provide a key to the understanding of polypharmacological treatment and increasing mortality rates for various pathologies. A systemic view helps to calculate the possible risks of using vaccines and medicines, combinations of medicines [5,24,25].

Having studied and analysed literary sources, it was established that fundamental biomedical sciences such as physiology, pathological physiology, pathomorphology became the theoretical basis for the emergence of new directions of modern medicine. Biogenic engineering, systems biology, nanotechnology, and regenerative medicine have a large database in their arsenal, which is gradually being introduced into practical medicine, and modern technological advances open up a wide range of opportunities for these disciplines. If we compare which direction has gained the most development in recent years, then genetic engineering and nanotechnology from the literary sources we reviewed in the search engine were presented the most in the last 5 years [26, 27] (Fig.3).

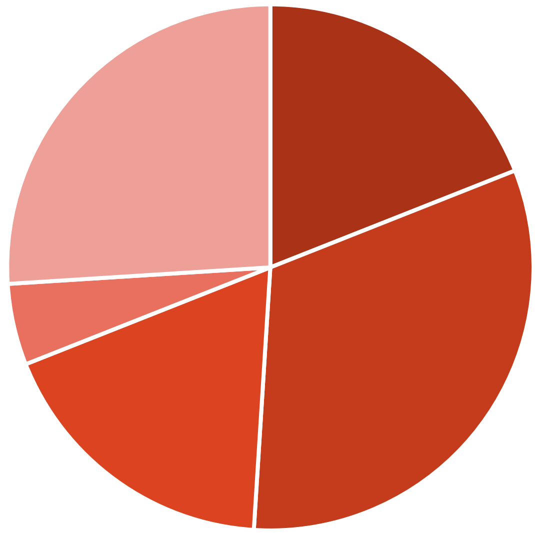

Figure 3. Research fields in medicine span across various frequencies

The scientific analysis of the features and effectiveness of assistance during the Covid-19 pandemic revealed that computer modeling of processes and molecular medicine played pivotal roles in overcoming the pandemic, using the knowledge accumulated during the epidemic of the Ebola, SARS pneumonia, and the Spanish flu. At the same time, this pandemic showed different approaches to the understanding of pathogenesis and, accordingly, to treatment, which required political decisions to unite efforts to fight the pandemic.

Discussion

Fundamental studies of medical and biological disciplines created a theoretical basis for the further development of modern areas of medicine. The questions of the medical disciplines considered by this study: physiology, pathophysiology, pathomorphology have significant properties that allowed the understanding of the mechanisms of the course of most diseases [1,5,25]. The accumulation of such a large amount of data, on the one hand, deepened the knowledge of specialists, and on the other, it required systematisation of the acquired knowledge, which allowed creating software and introducing innovative technologies into clinical practice [2,27,29]. It was the COVID pandemic that became a challenge for both theoretical and practical medicine. It exposed many problems and pointed to the need for synchronisation between scientists around the world, regarding approaches under these conditions, especially that the world is expecting new pandemics, the data was presented in the literature [28] . The SARS-CoV-2 virus is expressed on the apical surface of pneumocytes, which causes apoptosis and subsequent destruction of these cells. As a result, atelectasis develops in the lungs, which cause pulmonary edema in the future. The cell destruction triggers a cascade of pathological reactions with the involvement of biologically active substances, chemokines, growth regulatory oncogenes, interleukins (IL-8), interferons (γ), macrophage proteins (MIP-1α, MIP-1β), as well as regulators of cellular expression. The release of these substances is caused by the involvement of neutrophils, basophils, macrophages, eosinophils, and polymorphonuclear leukocytes in the focus of inflammation. Such a response involving the immune system is a normal response to any virus. A special feature of the SARS-CoV-2 virus is the production by epitheliocytes of granulocyte-macrophage factor, which stimulate the growth of the cells towards the formation of neutrophils, which causes the proliferation of a large number of neutrophils in the focus of inflammation. Research conducted on mice established that the deficiency of granulocyte factor was the cause of the lowered immune response and was the cause of the poor prognosis in patients [29, 30, 31, 32] .

Studies of the mechanisms of action of the SARS-CoV-2 virus revealed its aggressive effect on the endothelium of blood vessels. The virus is tropic to angiotensin-converting enzymes ACE 2. It blocks these receptors, which disrupts hemovascular control and changes in the angiotensin/bradykinin ratio with the launch of a cytokine storm associated with endothelial dysfunction and multiple vascular disorders associated with multiple organ failure. The study of pathogenetic mechanisms made it possible to understand the points of application of drugs in order to prevent the outbreak of the disease with the development of unpredictable consequences [30, 33, 34]. Theoretical disciplines, grounded in experimental studies, have served as a catalyst for the emergence of new branches of medicine [7, 34, 35]. But this became possible only with technical possibilities, which started from optical microscopes to light microscopy, which studies molecular structures. According to the literature, the implementation of molecular medicine and genetic engineering made it possible to correct sections of DNA [5,8,30]. Advances in genetic engineering made it possible to synthesise interferon, insulin, growth factors, as well as the synthesis of vaccines, which is extremely relevant in the conditions of constant mutation of viruses [46]. A thorough study of the pathogenetic mechanisms of diseases makes it became possible to introduce innovative pharmacological technologies. The nanotechnology has created "laboratories on a chip", nanorobots that can be programmed to perform operations in the human body and silicon-based nanoparticles that transport medicinal substances into the middle of the cell [35, 37] Fundamental research in theoretical medicine is the basis for improving diagnostic methods and development of new, more effective medicines. It is the medical and biological disciplines that are the necessary stepping stone that allows the future doctor to successfully master clinical disciplines, and the practicing doctor to introduce the latest modern achievements of genetic engineering, molecular biology, and systems biology into the medical and diagnostic process [4, 37, 38].

Conclusions and Implications

The current literature search demonstrated that the future is for the areas of theoretical medicine: genetic engineering, molecular biology, nanotechnology, and systems biology. Proceeding from experimental research, these areas are currently successfully implementing the acquired knowledge into diagnostics and treatment. Genetic engineering is a promising branch of medicine, regarding the prediction and treatment of hereditary diseases that are associated with changes in the DNA molecule. At the current stage, the newest drugs are under consideration - antisense oligonucleotides, which can be used as sites to replace problem areas. In recent years, techniques have been improved that cannot destroy the double-stranded structure of DNA but cut out sections of one strand and replace it, or simply cut it out [39]. Nanomedicine, whose successful development is closely related to molecular biology, is a very promising direction of modern medicine, which has passed the path of experiments and is widely implemented in the treatment and diagnostics. Nanomedicine makes it possible to treat or diagnose a targeted pathological focus by using nano-robots. Specialists envision it as the future of cancer treatment [40,42]. These sciences are closely intertwined as they are studied, diagnosed or treated at micro levels. It is the possibility of acting on the cause of the disease at the molecular level that is promising for the creation of new approaches to treatment and diagnosis.

Conflicts of Interest

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

Institutional Review Board Statement

Not Applicable

Informed Consent Statement

Not Applicable

References

1. Lysetskyi, B., Kobyletskyi, O., Shchybovyk, D., Zubova M., Litvin, O. Neuroplasticity in the pathogenesis and treatment of chronic pain syndrome: new research and therapeutic perspectives. Futur Med [Internet]. 2024;3(1): 45-58. Available from: https://doi.org/10.57125/FEM.2024.03.30.05
2. Tretter F, Löffler-Stastka H. Medical knowledge integration and "systems medicine": Needs, ambitions, limitations and options. Med Hypotheses. [Internet]. 2019; Dec;133:109386. Available from: https://pubmed.ncbi.nlm.nih.gov/31541780/
3. Gore JC. Artificial intelligence in medical imaging. Magn Reson Imaging. [Internet]. 2020; May;68:A1-A4. Available from: https://pubmed.ncbi.nlm.nih.gov/31857130/
4. Tai-MacArthur S, Lombardi G, Shangaris P. The Theoretical Basis of In Utero Hematopoietic Stem Cell Transplantation and Its Use in the Treatment of Blood Disorders. Stem Cells Dev. [Internet]. 2021;Jan 15;30(2):49-58. Available from: https://pubmed.ncbi.nlm.nih.gov/33280478/
5. Stevenson R, Samokhina E, Mangat A, Rossetti I, Purushotham SS, Malladi CS, Morley JW, Buskila Y. Astrocytic K+ clearance during disease progression in amyotrophic lateral sclerosis. Glia. [Internet]. 2023; Oct;71(10):2456-2472. Available from: https://pubmed.ncbi.nlm.nih.gov/37395323/
6. Tretter F, Wolkenhauer O, Meyer-Hermann M, Dietrich JW, Green S, Marcum J, Weckwerth W. The Quest for System-Theoretical Medicine in the COVID-19 Era. Front Med (Lausanne). [Internet]. 2021; Mar 29;8:640974. Available from: https://www.frontiersin.org/articles/10.3389/fmed.2021.640974/full

7. Krenner HJ, Westerhausen C. Handy nanoquakes. Nat Mater. [Internet]. 2022; May;21(5):499-501. Available from: https://pubmed.ncbi.nlm.nih.gov/35505228/

8. Nogales C, Mamdouh ZM, List M, Kiel C, Casas AI, Schmidt HHHW. Network pharmacology: curing causal mechanisms instead of treating symptoms. Trends Pharmacol Sci. [Internet]. 2022; Available from: Feb;43(2):136-150. https://pubmed.ncbi.nlm.nih.gov/34895945/

9. Shi M, Shen Z, Zhang N, Wang L, Yu C, Yang Z. CRISPR/Cas9 technology in disease research and therapy: a review. Sheng Wu Gong Cheng Xue Bao. [Internet]. 2021; Apr 25;37(4):1205-1228. Available from: https://pubmed.ncbi.nlm.nih.gov/33973436/

10. Hu H, Feng W, Qian X, Yu L, Chen Y, Li Y. Emerging Nanomedicine-Enabled/Enhanced Nanodynamic Therapies beyond Traditional Photodynamics. Adv Mater. [Internet]. 2021; Mar;33(12):e2005062. Available from: https://pubmed.ncbi.nlm.nih.gov/33565157/

11. Papathomas TG, Nosé V. New and Emerging Biomarkers in Endocrine Pathology. Adv Anat Pathol. [Internet]. 2019; May;26(3):198-209. Available from: https://pubmed.ncbi.nlm.nih.gov/30730313/

12. Zhang B, Huang Y, Huang Y. Advances in Nanodynamic Therapy for Cancer Treatment. Nanomaterials (Basel). [Internet]. 2024; Apr 8;14(7):648. Available from: https://www.mdpi.com/2079-4991/14/7/648.

13. Merker L, Bautsch BW, Ebert T, Guthoff M, Isermann B. Nephropathy in Diabetes. Exp Clin Endocrinol Diabetes. [Internet]. 2021; Aug;129(S 01):S60-S63. Available from: https://pubmed.ncbi.nlm.nih.gov/33395705/

14. Lanigan TM, Kopera HC, Saunders TL. Principles of Genetic Engineering. Genes (Basel). [Internet]. 2020; Mar 10;11(3):291. Available from: https://pubmed.ncbi.nlm.nih.gov/32164255/

15. Cacheiro P, Haendel MA, Smedley D; International Mouse Phenotyping Consortium and the Monarch Initiative. New models for human disease from the International Mouse Phenotyping Consortium. Mamm Genome. [Internet]. 2019; Jun;30(5-6):143-150. Available from: https://pubmed.ncbi.nlm.nih.gov/31127358/.

16. Zhao K, Kang SX, Yang YY, Yu DG. Electrospun functional nanofiber membrane for antibiotic removal in water: Review. Polymers (Basel). [Internet]. 2021;13(2):226. Available from: https://www.mdpi.com/2073-4360/13/2/226

17. Chopra H, Mohanta YK, Mahanta S, Mohanta TK, Singh I, Avula SK, et al. Recent updates in nanotechnological advances for wound healing: A narrative review. Nanotechnol Rev [Internet]. 2023;12(1). Available from: http://dx.doi.org/10.1515/ntrev-2023-0129

18. Nauman S, Lubineau G, Alharbi HF. Post processing strategies for the enhancement of mechanical properties of enms (Electrospun nanofibrous membranes): A review. Membranes (Basel). [Internet]. 2021;11(1):39. 10.3390. Available from: https://www.mdpi.com/2077-0375/11/1/39.

19. Déjardin LM, Perry KL, von Pfeil DJF, Guiot LP. Interlocking Nails and Minimally Invasive Osteosynthesis. Vet Clin North Am Small Anim Pract. [Internet]. 2020; Jan;50(1):67-100. Available from: https://pubmed.ncbi.nlm.nih.gov/31668598/

20. Pandya R, Talib Z. A scoping review of regenerative medicine in medical education. BMC Med Educ. [Internet]. 2022; Nov 5;22(1):758. Available from: https://pubmed.ncbi.nlm.nih.gov/36335360/

21. Tretter F, Wolkenhauer O, Meyer-Hermann M, Dietrich JW, Green S, Marcum J and Weckwerth W. The Quest for System-Theoretical Medicine in the COVID-19 Era. Front. Med. [Internet]. 2021; 8:640974. Available from: https://philarchive.org/archive/TRETQF

22. Xiaochen R, Moyuan Z, Blake L, Mikaël MM, Ziad J. Growth Factor Engineering Strategies for Regenerative Medicine Applications. Frontiers in Bioengineering and Biotechnology. [Internet]. 2020;7. Available from: https://www.frontiersin.org/articles/10.3389/fbioe.2019.00469/full

23. Chandrasegaran S, Scanlan RL, Clark P, Pease L, Wordsworth J, Shanley DP. Systems Biology of Ageing. Subcell Biochem. [Internet]. 2023;102:415-424. Available from: https://pubmed.ncbi.nlm.nih.gov/36600142/

24. Aguas R, White L, Hupert N, Shretta R, Pan-Ngum W, Celhay O, et al. Modelling the COVID-19 pandemic in context: an international participatory approach. BMJ Global Health. [Internet]. 2020;5:e003126. Available from: https://pubmed.ncbi.nlm.nih.gov/33361188/

25. Lightner AL, Chan T. Precision regenerative medicine. Stem Cell Res Ther [Internet]. 2021;12(1). Available from: http://dx.doi.org/10.1186/s13287-020-02092-w

26. Han Y, Li X, Zhang Y, Han Y, Chang F, Ding J. Mesenchymal Stem Cells for Regenerative Medicine. Cells. 2019;8(8):886. Available from: https://doi.org/10.3390/cells8080886

27. Nii T, Katayama Y. Biomaterial-Assisted Regenerative Medicine. International Journal of Molecular Sciences. 2021;22(16):8657. Available from: https://doi.org/10.3390/ijms22168657

28. Catoira MC, Fusaro L, Di Francesco D. Overview of natural hydrogels for regenerative medicine applications. J Mater Sci: Mater Med. 2019;30:115. Available from: https://doi.org/10.1007/s10856-019-6318-7

29. Basiri A, Pazhouhnia Z, Beheshtizadeh N. Regenerative Medicine in COVID-19 Treatment: Real Opportunities and Range of Promises. Stem Cell Rev and Rep. 2021;17:163–175. Available from: https://doi.org/10.1007/s12015020-09994-5

30. Tufan A, Avanoglu Güler A, Matucci-Cerinic M. COVID-19, immune system response, hyperinflammation and repurposing antirheumatic drugs. Turk J Med Sci. [Internet]. 2020; 50:620–32. Available from: https://pubmed.ncbi.nlm.nih.gov/32299202/

31. Blumenthal D, Fowler EJ, Abrams M, Collins SR. Covid-19 — implications for the health care system. N Engl J Med. [Internet]. 2020; 383:1483–8. Available from: https://www.nejm.org/doi/full/10.1056/NEJMsb2021088
32. Ma H, Burger C, Chu B, Hsiao BS. Electrospun nanofibers for environmental protection. Handb Fibrous Mater. [Internet]. 2020;11(10):770. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/9783527342587.ch28
33. Burns TC, Quinones-Hinojosa A. Regenerative medicine for neurological diseases—will regenerative neurosurgery deliver? BMJ. [Internet]. 2021;373:n955. Available from: https://pubmed.ncbi.nlm.nih.gov/34162530/
34. Kerr M. The Family Movement, Bowen Theory, and Theoretical Medicine: A View from the 21st Century. Aust N Z J Fam Ther. [Internet]. 2019;40:308-318. Available from: https://doi.org/10.1002/anzf.1381
35. Veit W. Experimental philosophy of medicine and the concepts of health and disease. Theor Med Bioeth. 2021;42:169–186. Available from: https://doi.org/10.1007/s11017-021-09550-3
36. Marcum JA. Professing clinical medicine in an evolving health care network. Theor Med Bioeth. [Internet]. 2019;40:197–215. Available from: https://doi.org/10.1007/s11017-019-09492-x
37. Smits A, Annaert P, Cavallaro G, De Cock PAJG, de Wildt SN, Kindblom JM, Lagler FB, Moreno C, Pokorna P, Schreuder MF, Standing JF, Turner MA, Vitiello B, Zhao W, Weingberg AM, Willmann R, van den Anker J, Allegaert K. Current knowledge, challenges and innovations in developmental pharmacology: A combined conect4children Expert Group and European Society for Developmental, Perinatal and Paediatric Pharmacology White Paper. Br J Clin Pharmacol. [Internet]. 2022 Dec;88(12):4965-4984. Available from: https://pubmed.ncbi.nlm.nih.gov/34180088/
38. Mehandru S, Merad M. Pathological sequelae of long-haul COVID. Nat Immunol. [Internet]. 2022 Feb;23(2):194-202. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9127978/
39. Seo SK, van der Graaf PH. How a Pandemic Simultaneously Strengthened Existing Fundamentals and Drove New Innovations in Clinical Pharmacology. Clin Pharmacol Ther. [Internet]. 2022; Available from: https://pubmed.ncbi.nlm.nih.gov/36403083/
40. Lee SH et al. Depression as a mediator of chronic fatigue and post-traumatic stress symptoms in Middle East respiratory syndrome survivors. Psychiatry Invest. [Internet]. 2019; 16: 59–64 Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6354037/
41. Rogers JP, Chesney E, Oliver D, Pollak TA, McGuire P, Fusar-Poli P, et al. Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: a systematic review and meta-analysis with comparison to the COVID-19 pandemic. Lancet Psychiatry [Internet]. 2020 [cited 2024 May 11];7(7):611–27. Available from: http://dx.doi.org/10.1016/s2215-0366(20)30203-0
42. Magne TM, Vieira de O, Alencar LMR. Graphene and its derivatives: understanding the main chemical and medicinal chemistry roles for biomedical applications. J Nanostruct Chem. 2022;12:693–727. Available from: https://doi.org/10.1007/s40097-021-00444-3
43. Edgar L, Pu T, Porter B, Aziz JM, La Pointe C, Asthana A, Orlando G. Regenerative medicine, organ bioengineering and transplantation. Br J Surg. [Internet]. 2020; Jun.107(7):793-800. Available from: https://pubmed.ncbi.nlm.nih.gov/32463143/
44. Tretter F, Loffler-Stastka H. The human ecological perspective and biopsychosocial medicine. Int J Environ Res Public Health. [Internet]. 2019; 16:4230. Available from: https://www.mdpi.com/1660-4601/16/21/4230
45. Peirone B, Rovesti GL, Baroncelli AB, Piras LA. Minimally Invasive Plate Osteosynthesis Fracture Reduction Techniques in Small Animals. Vet Clin North Am Small Anim Pract. [Internet]. 2020; Jan;50(1):23-47. Available from: https://pubmed.ncbi.nlm.nih.gov/31635912/
46. Zupanic A, Bernstein HC, Heiland I. Systems biology: current status and challenges. Cell Mol Life Sci. [Internet]. 2020; Feb;77(3):379-380. Available from: https://pubmed.ncbi.nlm.nih.gov/3193285