



THE HISTORY OF THE DEVELOPMENT OF FORENSIC MEDICINE.

Baxtiyorov Baxodir Baxtiyorovich
Ahmedov Zafar Hamroevich

Tashkent State Medical University (Tashkent, Uzbekistan)
<https://doi.org/10.5281/zenodo.19110998>

Abstract. The article provides an overview of the historical development of forensic medicine — from its origins in ancient civilizations to its current state as a high-tech scientific discipline. It outlines the key stages in the evolution of forensic medicine: in antiquity, the Middle Ages, the Renaissance, the 18th–19th centuries, during the scientific and technological progress of the 20th century, and in the modern era. Special attention is given to the formation of institutional structures, the implementation of molecular and imaging technologies, digitalization, the advancement of forensic genetics, and the adoption of international standards. The role of forensic medicine in the justice system is emphasized, along with prospects for its future development. The work is based on annotated international literature and reflects the interdisciplinary nature of this field.

Keywords: forensic Medicine, history, forensic expertise, toxicology, forensic genetics, virtual autopsy, digitization, molecular methods, law and medicine, forensic Pathology

Introduction. Forensic medicine constitutes an independent interdisciplinary field of scientific knowledge formed at the intersection of clinical medicine, biology, and jurisprudence. Its primary function is to provide the justice system with objective medical data obtained through scientifically validated methods of investigation. Within both criminal and civil proceedings, forensic medicine addresses a wide range of tasks, including the determination of the cause and mechanism of death, assessment of the nature and severity of bodily injuries, estimation of injury timing, examination of biological evidence, and reconstruction of the circumstances of an incident [3].

In the context of the growing emphasis on evidence-based justice and increasing demands for scientific reliability and reproducibility of expert conclusions, the role of forensic medicine has significantly expanded. Modern judicial systems rely on validated, standardized, and technologically advanced methodologies, which has led to the transformation of forensic medical examination into a high-technology expert domain integrating advances in molecular genetics, digital imaging, spectrometry, and bioinformatics. Today, forensic medical expertise represents an essential component of the legal infrastructure in most countries and serves as a critical instrument for ensuring justice and the protection of human rights [3].

The historical development of forensic medicine reflects the evolution of scientific thought, methodological approaches, and institutional frameworks of expert practice. From early empirical observations in ancient civilizations to the establishment of specialized academic departments, scientific schools, and international professional associations, this process has been characterized by progressive methodological standardization and the formation of an evidence-based paradigm [11,20].

The aim of this article is to conduct a historical and scientific analysis of the evolution of forensic medicine from its early origins to its contemporary stage, characterized by the

implementation of molecular, imaging, and digital technologies. In accordance with this aim, the objectives of the study are: (1) to provide a systematic overview of the key historical stages in the development of the discipline; (2) to identify significant figures, scientific schools, and technological breakthroughs that have shaped forensic medicine; and (3) to analyze its current state and outline перспективные направления дальнейшего развития в контексте глобализации и цифровизации судебно-экспертной деятельности [11,20].

Relevance of the Topic. The relevance of this topic is determined by the increasing role of forensic medical examination in the administration of justice and the necessity of understanding its historical foundations for the formation of professional identity among future physicians, forensic specialists, and legal practitioners. Furthermore, the analysis of the historical development of forensic medicine makes it possible to identify patterns in the evolution of scientific knowledge, the refinement of investigative methodologies, and the transformation of the social role of the medical expert within society [13].

Origins of Forensic Medicine in Antiquity. The origins of forensic medicine can be traced back to the early stages of human civilization. As early as the Code of Hammurabi (18th century BCE), legal provisions addressed punishments and compensation for bodily injuries based on medical assessment of harm to health [6]. This represents one of the earliest known instances of formal recognition of the necessity for medical interpretation of injuries within a legal framework.

In Ancient Egypt, the practice of embalming required substantial knowledge of anatomy and physiology. Priests and physicians were capable of determining the cause of death based on examination of the body, which may be regarded as a primitive form of forensic diagnostic practice [16]. Particularly advanced forensic practices developed in Ancient China. Around 1247 CE, the Chinese official Song Ci authored the treatise *Xi Yuan Lu (The Washing Away of Wrongs)*, which provided detailed instructions on conducting post-mortem examinations, determining causes of death, reconstructing injuries, and even performing experiments involving insects to estimate the post-mortem interval [12]. This treatise is widely regarded as the world's first practical manual on forensic medicine and remains an important historical monument of Chinese legal and scientific thought. In Ancient India, references to the medical examination of bodily injuries and deceased individuals can be found in Ayurvedic texts and the *Laws of Manu*. Physicians were entrusted with performing examinations and documenting wounds, further demonstrating the early integration of medical expertise into legal processes [15]. Thus, despite the absence of a unified scientific discipline at that time, elements of forensic medicine existed across various cultures and served as essential instruments in the pursuit of justice at the dawn of civilization.

The Middle Ages and the Renaissance. During the Middle Ages, Europe experienced a decline in anatomical research and forensic medical practice under the dominant influence of the Church. Human dissection was often prohibited or strictly restricted, which significantly impeded the development of anatomy and medicine as a whole [19]. Nevertheless, in certain cities of Italy and France, dissections were permitted within the framework of university education and judicial investigations, allowing limited continuity of anatomical knowledge. The situation changed markedly during the Renaissance, when scientific inquiry gradually began to emancipate itself from religious constraints. Renewed interest in human anatomy had a profound impact on the advancement of forensic medicine. Andreas Vesalius (1514–1564), the

Flemish physician and anatomist, was among the first to systematically describe the human body based on his own dissections. His seminal work *De humani corporis fabrica* (1543) represented a milestone in the development of anatomy and indirectly contributed to the methodological foundation of forensic medicine [18]. A significant legal development occurred in 1532 with the adoption of the *Constitutio Criminalis Carolina* (Carolina Codex) of the Holy Roman Empire, which formally mandated the involvement of physicians in the investigation of homicide and severe bodily injuries [24]. This legislative act marked an important step toward the institutionalization of forensic medical expertise within the judicial system. Thus, despite the religious limitations characteristic of the medieval period, the fifteenth and sixteenth centuries witnessed the gradual formation of the scientific foundations of forensic medicine at the intersection of law, anatomy, and clinical practice.

The Eighteenth and Nineteenth Centuries: The Formation of Forensic Medicine as a Scientific Discipline. The eighteenth and nineteenth centuries were decisive in establishing forensic medicine as an independent scientific discipline. During this period, it ceased to function merely as an adjunct to anatomy or legal practice and acquired institutional recognition within universities and judicial systems. One of the central figures of this era was Mathieu Joseph Bonaventure Orfila (1787–1853), a French physician, chemist, and professor at the University of Paris, widely regarded as the founder of forensic toxicology. His pioneering works on poisoning and the chemical detection of toxic substances laid the foundations of modern toxicological analysis [2]. Orfila introduced a systematic scientific approach to the study of poisons and demonstrated the essential role of the medical expert in judicial proceedings. Concurrently, academic departments of forensic medicine were established across Europe, including in Germany, France, Italy, England, and Russia. In the Russian Empire, the first Department of Forensic Medicine was founded in 1803 at the Imperial Medico-Surgical Academy in Saint Petersburg [4]. From that point onward, the training of medical experts became an organized and integral component of medical education.

Throughout the nineteenth century, several key branches of forensic medicine underwent significant development, including:

- forensic toxicology;
- determination of the time of death (post-mortem interval estimation);
- assessment and classification of mechanical injuries;
- forensic gynecology and sexology;
- forensic psychiatry.

Microscopy, chemical analytical techniques, photography, and standardized forms of forensic medical documentation began to be systematically implemented in practice [24]. Thus, it was during the eighteenth and nineteenth centuries that the foundations of modern forensic medicine were established as a clinical–legal and scientific discipline.

The Twentieth Century: The Era of Scientific and Technological Progress. The twentieth century became a period of rapid advancement in forensic medicine against the backdrop of unprecedented scientific, technological, and medical progress. Forensic practice actively integrated methodologies from related disciplines, including radiology, histology, chemistry, genetics, biophysics, and computer science. This century also marked the definitive consolidation of forensic medicine as an essential component of both the justice system and public health infrastructure [20]. One of the pivotal milestones was the introduction of

radiological diagnostics into forensic practice. X-ray imaging made it possible to detect fractures, foreign objects (such as bullets and knife fragments), and skeletal characteristics relevant to personal identification, significantly enhancing investigative efficiency [17]. Histological techniques, involving microscopic examination of tissues, enabled accurate determination of wound vitality, stages of inflammation, mechanisms of hemorrhage, and other features critical to forensic investigation [13]. During the twentieth century, forensic toxicology evolved into an independent and highly specialized discipline. Increasingly sensitive methods for detecting poisons and pharmaceutical substances in blood, tissues, urine, and gastric contents were introduced, including spectrophotometry and gas chromatography [10].

Institutional Consolidation. In many countries, forensic medicine became a mandatory component of medical and legal education. Forensic centers and expert laboratories were established, and national as well as international protocols for autopsy procedures and medico-legal reporting were developed. A structured expert system gradually emerged, incorporating specialized subdivisions such as forensic histology, traumatology, toxicology, odontology, and genetics [24]. In states with centralized healthcare systems, forensic medicine acquired the status of a state-regulated expert service, ensuring professional participation in criminal investigations, civil proceedings, and medical certification processes.

The Emergence of Forensic Genetics. One of the most significant breakthroughs of the twentieth century was the introduction of DNA analysis into forensic practice. In 1985, the British geneticist Alec Jeffreys first applied DNA polymorphism for personal identification [8]. This innovation inaugurated a new era in criminal investigation, enabling highly accurate identification of victims and suspects and facilitating the re-examination of previously adjudicated cases. With the development of polymerase chain reaction (PCR) technology, forensic scientists gained the ability to analyze minute quantities of biological material—including hair, bloodstains, saliva, and other trace evidence—previously unsuitable for examination. DNA-based methodologies profoundly transformed evidentiary standards within judicial systems worldwide.

Forensic Photography and Digital Reconstruction. Forensic photography, including detailed macro-imaging of injuries and crime scenes, became an obligatory component of medico-legal documentation. Computer-assisted facial reconstruction from skeletal remains, wound trajectory modeling, and visualization using infrared and ultraviolet spectroscopy further enhanced evidentiary precision [21]. Thus, the twentieth century represented a period of systemic and comprehensive growth in forensic medicine. The integration of scientific discoveries, institutional development, and methodological standardization significantly increased the reliability and evidentiary value of forensic conclusions in criminal, civil, and administrative law.

The Contemporary Stage of Forensic Medicine. Modern forensic medicine operates at the intersection of high technology, molecular biology, and digital innovation. In the context of globalization and increasing standardization of expert activity, the discipline has undergone a qualitative transformation—from a predominantly visual and morphological approach to a multidisciplinary, digital, and evidence-based model. Contemporary forensic practice actively incorporates advances in genetics, biochemistry, imaging technologies, and artificial intelligence [22].

Digitalization and Virtual Autopsy. One of the most prominent trends of recent decades is the implementation of virtual autopsy (virtopsy), a non-invasive post-mortem examination method utilizing MRI, CT scanning, and three-dimensional modeling. This approach is particularly relevant in countries where traditional autopsies are limited by religious or cultural considerations [22]. Advanced software systems enable three-dimensional reconstruction of injuries, visualization of wound channels, determination of bullet trajectories, and highly detailed reconstruction of incident scenarios [5].

Molecular Approaches and “Omics” Technologies. Modern forensic medicine increasingly employs genomic, proteomic, and metabolomic methods to determine causes of death, estimate the post-mortem interval, and assess wound vitality [14]. Rapid RNA marker analysis, identification of specific proteins and metabolites, and molecular profiling allow investigators to evaluate injury timing, hypoxic conditions, cellular death mechanisms, and tissue responses to trauma [9].

Next-Generation Forensic Genetics. Next-generation sequencing (NGS) technologies are progressively complementing and, in some contexts, replacing traditional STR analysis. These methods enable the extraction of more comprehensive information from minimal biological samples, facilitate phylogenetic and population analyses, and support forensic DNA phenotyping—the prediction of externally visible characteristics based on genetic data [9]. Contemporary genetic technologies are applied not only in routine identification but also in the review of wrongful convictions. In several countries, case re-examination based on advanced DNA methodologies has prompted significant legal reforms and reinforced standards of evidentiary reliability [7].

Interdisciplinarity and International Standards. The modern forensic expert operates in close collaboration with criminologists, legal professionals, toxicologists, bioinformaticians, and imaging specialists. International organizations such as ENFSI, ISFG, UNODC, and Interpol develop unified protocols governing forensic investigation, laboratory accreditation, and ethical standards. Forensic medicine increasingly extends beyond classical autopsy practice to encompass medical law, human rights investigations, documentation of torture, assessment of healthcare quality, and the investigation of sudden unexpected death in infancy (SUDI) [23]. In conclusion, contemporary forensic medicine represents a high-technology, ethically grounded, and scientifically robust discipline capable of adapting to evolving societal and legal challenges. Its continued development is driven by methodological innovation, international collaboration, and a sustained commitment to objectivity and justice.

Conclusion. The history of forensic medicine represents a trajectory from empirical observations in Ancient Babylon and China to a highly technological discipline grounded in molecular and digital methodologies. Over the centuries, forensic medicine has evolved from an applied branch of anatomy into an independent scientific field closely interconnected with law, criminalistics, and medical ethics. Each historical stage—from the legal and medical treatises of ancient civilizations to the establishment of university departments and international expert institutions—has contributed significantly to shaping its contemporary structure and methodological foundations.

Today, forensic medicine plays a pivotal role in ensuring justice, safeguarding human rights, and investigating crimes. Its findings are applied not only in criminal proceedings but also in civil litigation, medico-legal evaluations, cases of medical malpractice, paternity and

guardianship disputes, as well as in humanitarian identification efforts during mass disasters and armed conflicts. Forensic medical expertise ensures objectivity in judicial decision-making and serves as a scientific cornerstone of modern justice systems.

The future of forensic medicine is closely associated with the implementation of artificial intelligence, robotic-assisted autopsy systems, virtual and augmented reality technologies, omics-based approaches (including genomics, proteomics, and metabolomics), and big data analytics. The advancement of international cooperation, ethical regulation, and digital transformation will enhance not only the accuracy and reliability of expert conclusions but also the global accessibility of high-quality forensic services.

Forensic medicine remains one of the few scientific disciplines in which a humanitarian mission is directly intertwined with technological progress. In this field, medical knowledge functions not merely as a diagnostic tool, but as an instrument for the protection of human life, dignity, and the rule of law.

References:

1. Bauer M., Gramlich I., Polzin S., Patzelt D. (2003). Quantification of mRNA degradation as possible indicator of postmortem interval – a pilot study. *Legal Medicine*, 5(4), 220–227.
2. Burney I. (2006). *Poison, Detection and the Victorian Imagination*. Manchester University Press.
3. Byard R.W. (2020). *Forensic Pathology Reviews*. Springer.
4. Deryabin D.G. (2010). The Origins of Forensic Medicine in Russia. *Forensic Science International*, 202(1–3), e19–e22.
5. Ebert L.C., Thali M.J. (2011). Forensic Radiology and Virtopsy: Perspective on the Future. *Legal Medicine*, 13(1), 42–49.
6. Ganieva, N. (2025). FORENSIC EXAMINATION OF EYE INJURIES: INVESTIGATION, ANALYSIS, EXPERT PERSPECTIVES. *International journal of medical sciences*, 1(4), 299-305.
7. Ganieva, N. H., Kang, H., & Kang, H. (2025). A CHRONICLE OF FORENSIC SCIENCE AT THE TASHKENT MEDICAL ACADEMY: FROM FOUNDATIONS TO MODERN PRACTICE. *Modern education and development*, 25(3), 20-32.
8. Ganieva, N. K., & Nuridinov, A. K. (2025). ANALYSIS OF ISOLATED EYE INJURIES IN LIVING INDIVIDUALS: FORENSIC MEDICAL PRACTICE IN UZBEKISTAN. *Ustozlar uchun*, 71(2), 394-397.
9. Guthrie D. (1945). *A History of Medicine*. Thomas Nelson & Sons.
10. Hudayberganovich, J. E., Khamraevna, G. N., & Beshimbaevich, Y. A. (2025). CURRENT PROBLEMS OF INTERNAL DISEASES IN MECHANICAL INJURIES. *AMERICAN JOURNAL OF APPLIED MEDICAL SCIENCE*, 3(9), 41-50.
11. Innocence Project (2023). DNA Exonerations in the United States. HYPERLINK "<https://www.innocenceproject.org>" \t "_new" www.innocenceproject.org
12. Jeffreys A.J., Wilson V., Thein S.L. (1985). Hypervariable 'Minisatellite' Regions in Human DNA. *Nature*, 314(6006), 67–73.
13. Kayser M. (2015). Forensic DNA Phenotyping: Predicting Human Appearance from Crime Scene Material for Investigative Purposes. *Forensic Science International: Genetics*, 18, 33–48.
14. Khamroevna, G. N. (2025). EYE INJURIES OF FORENSIC EXAMINATION: INVESTIGATION, ANALYSIS, EXPERT PERSPECTIVES. *Journal of new century innovations*, 76(1), 462-470.
15. Kintz P., Villain M., Cirimele V. (2006). *Hair Analysis in Forensic Toxicology*. Elsevier.



- 16.Knight B. (2022). Forensic Pathology (4th ed.). CRC Press.
- 17.MacCormack G. (1991). The Spirit of Traditional Chinese Law. University of Georgia Press.
- 18.Madea B. (2017). Recent Developments in Forensic Histopathology. Forensic Science International, 165(2-3), 203-211.
- 19.Madea B. (2019). Advances in Forensic Molecular Pathology. Forensic Science International, 297, 13-23.
- 20.Mukhopadhyay B.B. (2014). Forensic Medicine in Ancient India: A Historical Perspective. Journal of Indian Academy of Forensic Medicine, 36(1), 4-8.
- 21.Nazarovich, L. F., Khamroevna, G. N., & Khamroevich, A. Z. (2025). THE INVESTIGATION OF AVIATION INCIDENTS. AMERICAN JOURNAL OF APPLIED MEDICAL SCIENCE, 3(4), 145-151.
- 22.Nazarovich, L. F., Khamroevna, G. N., Khamroevich, A. Z., & Navruzjon, K. (2025). MORTALITY AMONG THE POPULATION OF THE CITY OF ALMALYK ACCORDING TO FORENSIC MEDICAL EXAMINATION DATA FROM RESPIRATORY DISEASES. AMERICAN JOURNAL OF APPLIED MEDICAL SCIENCE, 3(5), 30-35.
- 23.Nunn J.F. (1996). Ancient Egyptian Medicine. British Museum Press.
- 24.Oehmichen M., König H.G., Meissner C. (2009). Forensic Radiology. Springer.
- 25.O'Malley C.D. (1964). Andreas Vesalius of Brussels, 1514-1564. University of California Press.
- 26.Persaud T.V.N. (1997). Early History of Human Anatomy. Charles C Thomas Publisher.
- 27.Saukko P., Knight B. (2015). Knight's Forensic Pathology (3rd ed.). CRC Press.
- 28.Taylor M.C. (2001). Forensic Art and Illustration. CRC Press.
- 29.Thali M.J., Yen K., Schweitzer W. et al. (2003). Virtopsy: A New Imaging Horizon in Forensic Pathology. European Radiology, 13(2), 275-288.
- 30.UNODC. (2020). Guidelines for Forensic Medical Investigations of Torture and Ill-Treatment. United Nations.
- 31.Watson K.D. (2011). Forensic Medicine in Western Society: A History. Routledge.
- 32.Xamrayevna, G. N., & Kamolitdin o'g'li, N. A. (2025). TOXIC VISION: FORENSIC INTERPRETATION OF CHEMICAL OCULAR LESIONS IN THE 21ST CENTURY. AMERICAN JOURNAL OF APPLIED MEDICAL SCIENCE, 3(9), 24-34.

