Сеченовский Университет

Федеральное государственное автономное образовательное учреждение высшего образования Первый Московский государственный медицинский университет имени И.М. Сеченова Министерства здравоохранения Российской Федерации (Сеченовский Университет)

TEXTBOOK

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FORENSIC MEDICINE

Министерство науки и высшего образования РФ

Рекомендовано Координационным советом по области образования «Здравоохранение и медицинские науки» в качестве учебника для использования в образовательных учреждениях, реализующих основные профессиональные образовательные программы высшего образования по направлениям подготовки специалитета 31.05.01 «Лечебное дело», 31.05.02 «Педиатрия», 31.05.03 «Стоматология», 32.05.01 «Медико-профилактическое дело»

Регистрационный номер рецензии 283 ЭКУ от 17 мая 2018 года

Москва
ИЗДАТЕЛЬСКАЯ ГРУППА
«ГЭОТАР-Медиа»
2019

CONTENTS

LIST OF ABBREVIATIONS

ARS — acute radiation sickness
ATP — adenosine triphosphate
CC — criminal code
CNS — central nervous system
CO — carbon monoxide
DNA — deoxyribonucleic acid
EEG — electroencephalogram
GIT — gastrointestinal tract
HIV — human immunodeficiency virus
LSD — lysergic acid diethylamide
MDA — 3,4-Methylenedioxyamphetamine
MDMA — 3,4-Methylenedioxymethamphetamine, ecstasy
NADP — nicotinamide adenine dinucleotide phosphate
PCP — phencyclidine, angel dust
RBC — red blood cell
RBC — ribonucleic acid
WBC — white blood cell

INTRODUCTION

Implementation of state educational standards of higher professional education, qualification profile for Medical University graduates, the Federal law "On State Medicolegal Activity", normative legal documents regulating the procedure of determining the extent of bodily harm, as well as the fact that training services are now offered internationally, required creation of a new type of educational forensic text, which not only reflects the current level of expertise in this discipline but also meets the requirements of education science and psychology of higher education.

In this textbook, forensic medicine is presented in the form of a system of interrelated modules related to forensic traumatology, tanatology, identification. Modern methods of dealing with fundamental forensic medical problems are described. A consistent presentation of material accompanied by tables, diagrams, algorithms and illustrations provide an easy and reliable access to the necessary information for the reader.

The main purpose of the training course of forensic medicine is training students to perform the duties of forensic experts in the future. Familiarizing future doctors with offenses of medical workers that entail criminal liability is of great importance in shaping the mindset of health care providers.

The textbook was compiled in accordance with the curriculum for medical students.

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Module 1
FORENSIC PATHOLOGY

SUBMODULE 1.1. CONCEPT, SUBJECT AND ORGANIZATION OF FORENSIC PATHOLOGY

Forensic medicine is a medical discipline, which is a system of scientific knowledge about the causal mechanisms, research methods and expert evaluation of medical facts used as a source of evidence during investigation and in court.

The **subject of forensic pathology** is the theory and practice of forensic examination. Forensic pathology searches for solutions to medical and biological problems arising in investigations and trials. Relevant scientific issues constitute the content of forensic pathology.

In practice, a forensic pathologist most often evaluates the degree of damage to human health resulting from criminal activity. This damage is caused by external influence and is called an injury. Both injuries and external influences vary greatly. Identifying the regularities in the emergence of injuries, research methods and expert evaluation is one of the main issues of forensic pathology — **forensic doctrine of injuries**.

Forensic doctrine of death an postmortem processes (forensic thanatology) includes confirmation of a living being's death, establishment of its cause and time, the effects produced by animate and inorganic nature on the dead body, as well as methods and techniques helping to identify these facts and provide an adequate expert evaluation.

Forensic knowledge is required to identify an unknown, dismembered or skeletonized cadaver as well as a suspect, victim and other people related to the case. The theoretic and practical issues of identification according to medical and biological criteria constitute another domain of forensic pathology, **forensic identification**.

An important aspect of forensic pathology is **forensic examination** — a set of practical methods to utilize scientific data on injuries, death and identifica-

tion. The concept of forensic examination has a double meaning. On the one hand, it is a practical forensic procedure resulting in a specific expert conclusion complying with legal requirements; on the other hand, it is a section of forensic pathology dealing with developing the techniques, rules and methods of forensic practice.

SUBMODULE 1.2. OBJECTS AND METHODS OF FORENSIC PATHOLOGY

Objects of forensic examination are living people, dead bodies and pieces of evidence (artefacts), which were used as weapons of crime and left traces indicating who the objects of criminal activity were, etc.

The data on objects (cadavers, living people, material evidence) can result from forensic examination or can be obtained from various documents, both medical (medical records of in- and outpatients, occupational health record) and non-medical (crime scene examination report, vehicle examination report, reference materials on weather conditions, body water hydroengineering description, etc.). Since these documents are, as a rule, included in the investigation and court files, they are referred to as "case papers". In forensic examination, case papers are normally considered the fourth object of pathologist investigation.

Most frequently, a forensic pathologist examines several objects. For example, forensic examination of a victim who died of a stab wound in hospital will involve the cadaver, medical record (case papers), damaged victim's clothes and the instrument of crime, the knife (material evidence).

Forensic examination is based on various scientific methods, which can be classified into four groups: essential, general, specific and special methods.

Essential cognitive methods are derived from philosophy and logic.

A forensic conclusion is based on deductive reasoning to explain the discovered and described facts. Explanation is reasoning involving description of empiric knowledge of the object laid into the foundation of a model, and the consequent conclusion. Special importance is given to the demonstration where the verity or falsity of a judgment is substantiated by other arguments whose verity is beyond doubt. A forensic pathologist most often uses direct proof: a sequence of arguments leading to the conclusion on the verity or falsity of a proposed point.

Point argumentation rules:
- the point should be clear;
- the point should remain unchanged through the demonstration;
- the argument should be supported with true facts, definitions, axioms, previously demonstrated scientific concepts;
- the arguments should not contradict;
- the arguments should be independent from the point;
- each subsequent argument should follow the preceding one;
- the point should result from a set of arguments.

To demonstrate the point it may be insufficient just to enumerate the supporting facts. The discovery of at least a single contradicting fact may result in full or partial disproof. That is why a pathologist should collect full factual materials for each specific case.

Complex cases necessitate dialectic logic which provides a more profound description of the laws of truth cognition.

Identity and difference are related only in what concerns certain specific properties of compared phenomena within a definite period. Thus, the crime scene examined by an investigator or a forensic pathologist is not identical to the place where the crime was originally committed since the criminal seeks to destroy the evidence. Therefore one needs to know what might have happened to the evidence and how the crime circumstances can be reconstructed from the existing evidence.

General methods characteristic for any science as well as forensic pathology, include the following methods.

- **Observation** is purposeful perception of an object or a phenomenon. Observation can be direct with a naked eye, or indirect, when special instruments are used.
- **Description** is recording of the observation or experiment results with a definite (unified for a given scientific domain) system of designation. Unknown cadavers are provided with a "verbal description" that follows a standard set of features and a standardized order of description.
- **Measurement** is a set of actions to obtain a numeric value of a parameter in question in standardized measurement units. The measurement results are compared against quantitative characteristics of known scientific phenomena (reference values, various disorders, etc.).
- **Calculation** involves mathematic operations in numeric information processing:
  - computer technologies provide quantitative and spatial characteristics of the studied phenomena in all variability of its relations to the environment;

- statistical methods increase the demonstrative power of the conclusions, calculate biases and errors so as to establish the effect of various factors on the dynamics of the studied object, etc.

- **Modeling** is a method involving development and research of other objects with similar properties.
- **Experiment** is reproduction of a cognition object. An experiment should be repeatedly tested for sustainability of results.

Specific cognitive methods are various methods from physics, chemistry, biology and other exact sciences. The choice and sequence of the methods depend on the questions posed before a pathologist.

Physical methods include a wide spectrum of optical instruments: from a simple magnifying glass and a biological microscope to complex optical devices including image analysis system; and if required, an electron microscope and laser equipment are used.

Quick and static phenomena are investigated with movie or video cameras, used both with and without a computer. In the latter case, research software is used, e.g. face recognition, alignment of postmortem skull X-rays with intravitam pictures, etc.

Photographic methods include scale bar pictures, color and color separating pictures, infrared and ultraviolet pictures (including those made through a microscope), registration of visible and infrared luminescence, as well as image alignment to establish the identity of objects. These methods require digital cameras.

Physical properties of tissues and biological fluids are researched with thermometric methods, electric resistance measurement, etc.

In radiation diagnostic methods, X-ray tests are preferable. X-ray images are processed with an analyzer with virtual 3D, optical density selection and densitometry modes.

Spectral analytical methods, e.g., microspectroscopy and fluorescent microspectroscopy, are used to examine forensic biological objects; spectroscopy, flame photometry, emission spectral and atomic absorption analysis are used for medical and criminalistic issues, X-ray spectral fluorescent analysis is used in forensic chemical investigations

Chemical analysis methods are mainly used to identify the quality and quantity of poisonous substances in the body's biological tissues and media as well as to reveal the origin of the substances. Chemical methods allow identification of chemical elements in the area of gunshot injuries both on targets and thin histological slices; methods of classical drip analysis; methods of thin-layer and gas-liquid chromatography, gas chromatography and mass spectrometry, etc.

Biological methods. Immunological methods range from precipitation reaction to immune electrophoresis, chromosome and molecular genetic analysis of biological objects (traces of blood and discharge, hair, etc.).

The morphologic method includes a special sectional method of cadaver examination and histological method of cadaver organ and tissue examination.

Histochemical and immune histochemical methods are the study of distribution of various substances in tissues. These substances are stained with specific dyes or react with specific marked serums. The methods also include light optic, polarizing, phase contrast, fluorescent and electron microscopy.

Morphometric methods are quantitative study of biological structures at all levels: the level of the body, organ, tissue, cell, and the ultrastructural level.

Special forensic methods are based on medical, biological and forensic study of the injury mechanism reconstruction and identification of the person in question.

SUBMODULE 1.3. BRIEF OVERVIEW OF FORENSIC PATHOLOGY

The ancient world lacked forensic medicine since no legal institutions existed. The punishment for a murder was up to the victim's relatives with vendetta practices followed. At the same time, forensic knowledge was accumulated: the Book of Moses mentions abortions, infanticide, rape, debauchery, virginity and injuries.

The history of forensic pathology includes three stages.

1. **Empirical stage** characterized by sporadic use of scientific knowledge. Insufficient scientific knowledge was accompanied by confessions obtained by torture and other irrational methods (e.g., ancient people believed that if the murderer touched the corpse, it would cause bleeding from the corpse's wounds). The ancient laws of Babylon (17th century BC) and Rome (8th–2nd centuries BC) stipulated punishment for medical errors, sexual crimes, infanticide, lethal injuries, etc. Victims' bodies were put on public display so that anyone could suggest their version of the cause of death and the circumstances of the crime.

The physician first participated in legislative and judicial practice in ancient Sparta. The laws of Lycurgus (9th–8th centuries BC) stipulated medical investigation of male impotence, physical status of females, children and slaves. Three centuries later, special legal tables included rules for forensic examination of people who died violent deaths, for establishing the gestation age and live birth,

diagnosis of lethal poisoning, etc. These rules were developed by Hippocrates (460–370 BC), Aristotle (384–322 BC) and Archimedes (287–212 BC).

An example of applying practical scientific knowledge is the participation of a Roman physician Marcus Antistius (44 BC) in public examination of the late Julius Ceasar, whose body had 23 wounds with only 1 wound recognized as lethal.

In the 6th century AD, Emperor Justinian (482–565 AD) united all previous legislation in a single code, later referred to as *Codex Justinianus*. This code described the position of a physician in a trial: "physicians are judges rather than witnesses". Physicians were to establish the lethality of injuries, feigned illnesses, abortions, etc.

In 1209, the canon law of Pope Innocentius III (1161–1216) declared the exclusive competence of physicians in the judgment of injuries, later confirmed by Pope Gregorius IX (1145–1241). In the 14th century, the King of France introduced the position of a royal surgeon at the Paris court. In the mid-13th century city physician Hugo Lucca presented a forensic report before the tribunal in Bologna, Italy.

2. **Theoretic stage**. Systematic use of scientific knowledge.

Systematic use of medical knowledge in court trials started with *Bambergensis constitutio criminalis* (Bamberg criminal constitution, 1504), which was laid into the foundation of the famous Carolina (*Constitutio Criminalis Carolina*) — the first body of German criminal law, which was so efficient that remained in use for two centuries till the late 18th century. The Carolina required physician participation in the trials involving infliction of deadly wounds, infanticide, spontaneous abortions, poisoning and mental disorders as well as establishment of age. The physician participating in trial took oath. Similar law was passed in other European countries. However, that law was predominantly addressed to lawyers since it stipulated when a physician was supposed to testify in court and what questions of the judge a physician was supposed to answer. The physician did not need any special knowledge different from that they used in their routine diagnosis and treatment. Neither *Codex Justinianus* nor the Carolina included forensic issues. Thus, forensic pathology did not exist as a separate scientific domain in Europe until the 16th century.

Forensic pathology originated in China where excavations revealed the oldest forensic records. The *Zhang Young GeMu* treatise (Points of investigation and forensic examination) goes back to the 10th century. In particular the treatise dwells upon the cadaveric examination. Si Yuen Lu guidelines (1247–1248) written by criminal court counsel Sun Tzu contain data on description and examination of various lethal and non-lethal injuries, on forensic diagnos-

tics in cases of violent and non-violent death. Chinese lawyers and physicians used these guidelines for centuries.

3. **Scientific period**, emergence of forensic pathology as a single scientific domain, foundation of forensic departments in medical universities.

In Europe, cadaveric examination became possible as late as in the 16th century resulting in the first treatises in forensic pathology by Ambroise Pare (1575) (fig. 1.1), famous for his works in the field of surgery, and Fortunato Fidelis (1598) and Paolo Zacchia (1621) (fig. 1.2) who were followers of Andreas Vesalius. In that period, forensic pathology was a combination of scattered knowledge from medical and non-medical sciences. Until the 18th century, there was no single term for forensic pathology: it was referred to as medical jurisprudence, court physics, etc.

Fig. 1.1. A. Pare (1575)

France, Germany and Austria-Hungary were the countries where forensic pathology developed most intensively. On the borderline between 18th–19th cen-

Fig. 1.2. Italy: works on forensic medicine by Paolo Zacchaeus (1621)

turies, Germany and Austria-Hungary had a unified state medicine who dealt with forensic pathology and public hygiene issues. The Napoleonic code of criminal procedure prohibited secret trials, which practiced tortures, and laid the foundation of a new court system. In 1689, Johann Bonn introduced the term *forensic pathology* in his book *Medicinae Forensis Specimen* and systematized the knowledge in this scientific field. In 1682, Dr. Schreier demonstrated a method of establishing a live birth judging by the presence of air in the lungs. In the 18th century, works by J.E. Hebenstreit *Forensic Anthropology* and I. Plank's *Toxicology or Science of Poisons and Antidotes* (1775) and *The Elements of Forensic Pathology in Surgery* (1781) were published. The latter book was published in Russian, and for a long time it was the only handbook in forensic pathology for Russian students and physicians. In mid-19th century, J.L. Casper, state medicine professor from Berlin (Germany) published *Practical Handbook on Forensic Pathology*, which was translated into Russian in the 1870s.

The success of forensic pathology was determined by achievements in fundamental sciences, especially in pathologic anatomy. J.L. Casper introduced microscopy in forensic pathology, which he used to examine the evidence. C. von Rokitansky explained the causes of *livor mortis*. R. Virchow studied adipocere, described fat embolism in fractures, proposed a reagent to detect red blood cells in old bloodstains. In his *Guidelines to Pathology*, J. Orth described various fractures, developed diagnostic criteria of live birth, etc. E. von Hofmann, professor from Vienna, was the first in history to use a microscope for histological examination of tissues adjacent to an injury; he described reactive processes in a wounded area, and reconstructed a putrefied cadaver for the purpose of identification. He contributed a lot to diagnostics of gunshot injuries (examination of close range gunshot wounds, abrasion ring characteristics, skin marks resulting from gunshot effects, etc.).

Fig. 1.3. A. Tardieu

The French forensic pathologists A. Tardieu (fig. 1.3), A. Lacassagne and P. Bruardel devoted the greater part of their studies to the development of diagnostic criteria and thanatogenesis of mechanical asphyxia.

A. Taylor, the founder of the British forensic pathology, proposed *livor mortis* classification. Cadaveric phenomena (cooling, *rigor mortis*, putrification) were described in detail by I.L. Casper.

The French researcher M.J.B. Orfila studied the effects of arsenic laying the foundation for forensic toxicology. The works by J.S. Stas and A. Tardieu started the forensic diagnosis of alkaloids in cadaveric tissues and differentiated them from cadaveric metabolites. The alkaloid diagnosis was substantially improved in 1903 when the Russian botanist M. Tsvet introduced chromatography.

F.Y. Chistovich (fig. 1.4), P. Uhlenhut, and A. von Wasserman developed a method of serologic diagnostic of biological fluids based on the precipitation reaction. A. Bertillon (fig. 1.5) developed methods of anthropometric identification of the criminal, followed by dactyloscopy of V. Hershel (fig. 1.6) and H. Faulds. Dactyloscopy remained the most accurate method of identification until 1985 when A. Jeffreys developed DNA-dactyloscopy based on the restriction fragment length polymorphism in the DNA.

Fig. 1.4. F.Y. Chistovich

Fig. 1.5. A. Bertilen

Fig. 1.6. V. Hershel

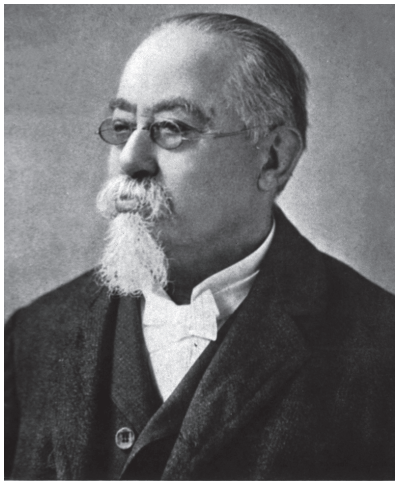

Fig. 1.7. C. Lombroso

For a short time, forensic pathology was dominated by anthropological criminology, which considered a crime as a natural biological phenomenon. C. Lombroso (1835–1909) (fig. 1.7) was one of the proponents of this doctrine; he pointed out that a delinquent human has specific physiological stigmata (irregular shape of the skull, asymmetric face, protruding lower jaw, etc.). The Lambrosian theory was refuted by D. Zernov, who studied a large sample of criminals and demonstrated that habitual criminals lacked any specific characteristics.

The studies of how electricity, increased and decreased barometric pressure and ionizing radiation affect the human body began later, after introduction of relevant technologies. In 1820, Russian physician Homel studied the effect of compressed air in diving bells and found that divers developed neuralgia after working in the bells. In 1902, German physician Frieben described skin cancer in an X-ray tube factory employee. In 1927, Austrian physician Jellinec did research in electric current marks.

In the developed European countries, universities or large clinical centers have departments of forensic pathology performing all types of forensic investigations. The USA have a system of forensic institutions similar to those in Europe. Besides that, the USA have special coroner services which perform forensic inquiry and examination in case of violent or suspected violent death (forensic examination of living people is normally done by clinical physicians). There is no standardized requirement for coroner training, and in many states, coroners are elected from among the population without any medical background. Laboratory tests are done in forensic institutions.

Emergence of forensic pathology in Russia

In Russia, physicians were called on to make a conclusion for the court in the times of tsar Ivan IV (Ivan the Terrible). In 1572, Eliselius Bomelius, the physician of Ivan IV, made a postmortem examination (without an autopsy) of the dead tsar's wife and concluded that she had been poisoned. In the 16th century, a special pharmaceutical department was founded. Its archives con-

tain many documents about physicians' participation in the research required by court procedures.

Forensic practice in Russia goes back to the 18th century, when Peter I described the physician's role in the court procedure in Article 154 of Military manual (1716) (fig. 1.8), which required forensic examination of traumatic death. Since 1733, forensic examinations and autopsies were performed by stadt-physicians, and later by physicians from the Fisicas (medical offices) which additionally performed sanitary and epidemiological functions. In 1797, medical departments were established which registered all forensic examination reports whoever performed them (including forensic professors), checked the content, form and timely delivery of the report copies.


ІНСТРУКЦІИ
И
АРТІКУЛЫ
ВОЕННЫЕ,
ПРИТОМЖЕ
ИКРАТКАЯ ПРІМѢЧАНІЯ:
Напечатаны повелѣніемъ
ЦАРСКОГО ВЕЛІЧЕСТВА.
ВЪ САНКТЪПІТЕРБУРХѢ,
Лѣта Господня, 1714.
Декабря въ 22 день.

Fig. 1.8. Military regulations of Peter I

Further development of forensic pathology is associated with organization of forensic departments in medical schools at universities. Training in forensic pathology in Russia goes back to 1755 when Pr. Erasmus launched a course in medical-judicial science. In Russia the first forensic pathology department was set up in Saint-Petersburg medical and surgical academy in 1798, then in Dorpat (now Tartu, 1802), Moscow (1804) universities, followed by similar departments in Kharkov, Kazan, Novorossiysk, Tomsk and Saratov universities. The first Russian textbook in forensic pathology by Pr. S.A. Gromov was published in 1832 (fig. 1.8), followed by a textbook in forensic pathology for lawyers written by G.I. Blosfeld in 1847.

In the early 19th century, the Russian ministry of inner affairs established the Medical council. In 1823, the council included 4 medical positions for physicians specializing in forensic medicine and in medical police. In 1836 the council functions included: 1) censorship of medical papers and public announcements related to forensic medicine and medical police; 2) investigation of sudden deaths; 3) revision of doubtful medical certificates in criminal and civil cases; 4) chemical test upon court requests. Later, a special medical department on forensic medicine and medical police was established.

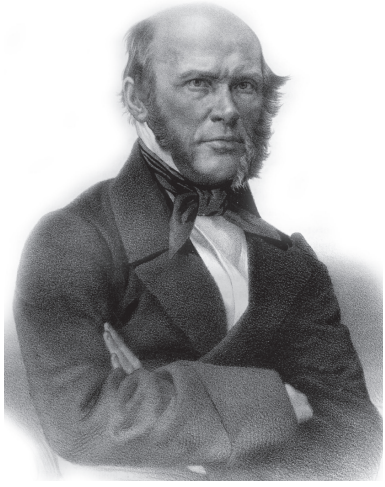

Fig. 1.9. N.I. Pirogov

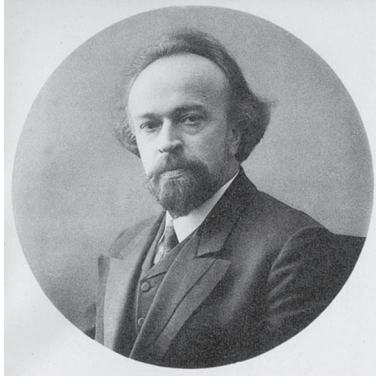

Fig. 1.10. P.A. Minakov

The 1864 the judicial reform contributed a lot to the development of forensic medicine. The reform made the court procedure public and required better training of forensic pathologists.

In the late 19th century, fundamental forensic pathology works were published. In 1849, N.I. Pirogov (fig. 1.9) described tissue defect as a feature allowing distinguishing between entry and exit bullet wounds. Professors of Saint-Petersburg medical and surgical (since 1871 — Emperor's military medical) academy E.V. Pelikan, M.M. Sorokin and D.P. Kosorotov laid the foundation for Russian forensic toxicology. In 1865 E.V. Pelikan founded the first Russian forensic pathology journal *The Archives of Forensic Medicine and Public Hygiene*. D.P. Kosorotov wrote the first Russian *Textbook In Forensic Toxicology*.

In Moscow studies were performed at the department of forensic pathology at the medical faculty of Moscow university, especially by Prof. D.E. Min (the 1860–1870s) and Prof. I.I. Neiding (the 1880–1890s), who wrote the first fundamental work in medical histology on intravital or postmortem ligature marks based on reactive changes. In 1891, the department was transformed in the first Russian institute of forensic pathology. The institute researchers developed new spheres of forensic science — forensic ballistics and the concept of substantial evidence. The fundamental dissertation of P.A. Minakov (fig. 1.10) *On Hair In Forensic Pathology* followed by his *Atlas* with detailed description and images of human and animal hair still remain the desk-book of forensic biologists.

Forensic thanatology was successfully developed by Prof. N.A. Obolonsky, a forensic pathologist from Kiev, the author of fundamental *Handbook of Cadaveric Forensic Investigation and Examination of Substantial Evidence*.

Changes in Russian social system affected forensic pathology. A forensic subdivision was established in the People's Commissariat of Health, later reorganized in a separate division in 1919. In the same year, the statute of rights and obligations of forensic pathologists was adopted. For the first time in the history of forensic pathology, forensic examinations, which belong to the domain of the Ministry of the Interior, were transferred to the Ministry of Health and became independent from the investigative bodies.

In 1935, the structure of the forensic service followed the administrative structure of the country. On October 21, an independent forensic examination service was set up in the armed forces (head forensic pathologist Academy Corresponding Member M.I. Avdeev). During the WWII, this service included forensic laboratories of the fronts and forensic pathologists of the armies. In 1947 the All-Union (later Russian) Scientific Forensic Society was established. In 1956 the forensic service was reorganized and new forensic institutions were set up: forensic bureau, chief forensic bureau of republics, republican forensic bureaus (in autonomous republics), regional and city forensic bureaus (in Moscow and Leningrad). Methodological guidance was provided by the Research Institute for Forensic Pathology. In 1958 the first issue of *Sudebno-Medicinskaya Expertiza* (Forensic medical expertise) was published. By 1991, there were 53 forensic departments in medical institutes and universities.

Social and political changes in Russia were accompanied by reforms in forensic pathology: in 1993, the Research Institute for Forensic Pathology was merged with the Russian Republican Forensic Bureau into the Russian Center of Forensic Investigation of the Russian Ministry of Health. In the regions, forensic investigations are performed by regional, republican and city (in Moscow and Saint-Petersburg) forensic bureaus.

Control questions

1. Describe the notion and subject of forensic pathology.
2. Enumerate the main stages of forensic pathology development.
3. Enumerate the objects of study and methods of forensic pathology.