№ 2/2026

ISSN 2411-1457(print), ISSN 2415-346X(online)

СХІДНОЄВРОПЕЙСЬКИЙ ЖУРНАЛ ВНУТРІШНЬОЇ ТА СІМЕЙНОЇ МЕДИЦИНИ

THE EAST EUROPE JOURNAL OF INTERNAL AND FAMILY MEDICINE

Засновники
Харківська медична академія післядипломної освіти,
Харківська обласна організація «Асоціація лікарів загальної практики — сімейної медицини»

Рекомендовано до друку Правлінням асоціації лікарів загальної практики-сімейної медицини (Протокол №4 від 22.04.2026 р.)
Заснований у 2014 року. Виходить 2 рази на рік

Свідоцтво про державну реєстрацію
друкованого засобу масової інформації
серія КВ 322107-12007117 від 25.03.2016 р.

Науково-практичний журнал з дистанційної освіти

Журнал внесено в міжнародні наукометрічні системи: Cross Ref, Index Copernicus, Academic Resource Index, WorldCat, Scientific Indexing Services, DRJI, ROAD, Citefactor, Open Academic Journals Index, Global Impact Factor, ESCI, Universal Impact Factor, Science Index, Google Scholar, база даних «Наукова періодика України».

Відповідальний секретар Сікало Ю.К
Заст. відповідального секретаря
Хоменко Л.О., Журавльова А.К., Лопіна Н.А.
Розробники та модератори сайту журнала
Лопіна Н.А., Рогачова Т.А.

Дизайн обкладинки Кулик В.В.
Комп'ютерна верстка Дєсятникова М.В.
Ум. друк. арк. 12,00.

Електронна адреса журналу:
http://www.internalmed-journal.in.ua/
Для кореспонденції: **teraprevm@med.edu.ua**

ФАКТ

Видавництво «ФАКТ»
61166, Харків, вул. Євгена Єніна (Бакуліна), 11.
Тел./факс: (050) 323-22-01. E-mail: publish_fakt@ukr.net
Свідоцтво суб'єкта видавничої справи ДК № 3172 від 22.04.2008.

Виготовлено у ФОП В. Є. Гудзинський
Україна, 61072, м. Харків, вул. 23-го Серпня, 27.
Тел./факс: (050)343-66-17.

Журнал внесено до Переліку наукових фахових видань України з медичних наук Додаток 1 до наказу N 409 від 17.03.2020 р.

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UDC 069.51:611(091):378.6:61(477.54-25)KhNMU(045)
Індекс DOI 10.15407/internalmed2026.02.056



O. Semenenko, R. Sukhonosov, O. Vynohradova
Kharkiv National Medical University

Anatomical teaching models from the workshopos of Adolf Ziegler and Louis Auzoux in the collection of the «Museum of Medicine» Complex at Kharkiv National Medical University

Materials and methods. This qualitative historical study combines the analysis of published historical sources with descriptive and comparative analysis of nineteenth-century anatomical and embryological teaching models preserved at the 'Museum of Medicine' Complex of Kharkiv National Medical University. The principal objects considered are the detachable papier-mâché models of Louis Auzoux and the wax embryological series of Adolf Ziegler. Works by Hasselmeyer and Maison Tramond provide additional context for the development of the university's teaching collection and its connections with European model-making.

The source base includes the surviving models, their labels and numbering systems, the 1897 guide to the university's anatomical museum, and the centenary history of its Faculty of Medicine, published in 1905–1906. These materials are supplemented by scholarly publications on anatomical model production, embryological visualisation and conservation. Historical accounts of acquisitions were compared with the surviving collection to trace its formation and subsequent losses. Acquisition dates were treated separately from dates of manufacture.

The descriptive analysis considers the anatomical structures and developmental stages represented, materials, relative scale, colour schemes, detachable components, mounting systems and surviving labels.

The discussion of preservation is based on visible deterioration and previous interventions described in the collection's history. Particular attention is given to missing components, cracking, delamination, paint loss, deformation, overpainting and inappropriate repairs. These observations support a qualitative account of the collection's condition and conservation needs; material composition and causes of deterioration are interpreted through the relevant literature rather than established through laboratory analysis.

Results and discussion. The teaching of human anatomy, which is now an integral part of medical education, faced numerous challenges over the centuries before it became established as one of the key academic disciplines. Despite the fierce criticism of dissections in the past, the study of the human body has always held a fascination for anatomists, doctors, students and artists.

During the heyday of medical education in the 18th and 19th centuries, the teaching of anatomy required new teaching aids to help overcome the shortage of bodies for dissection and the difficulties in obtaining them. At that time, many books and atlases on anatomy were published, which largely met the needs of medical students. However, anatomical illustrations had a significant limitation: they depicted the structure of the human body in only two dimensions. Under these circumstances, numerous workshops sprang up, mainly in Italy and France, where three-dimensional anatomical models were crafted from wood, fabric, wax and papier-mâché.

With the development in the 20th century of methods for preserving anatomical specimens and technologies for visualising the human body, anatomical models gradually lost their educational significance. Universities stored them in unsuitable conditions or even discarded them. Today, these objects are once again attracting attention and becoming the subject of in-depth scientific research. Their historical and aesthetic value, as well as the renewed interest in them, necessitate their preservation, restoration, study and promotion.

Artificial anatomical models, created for teaching purposes, are valuable testimonies to the development of

anatomy and embryology and the methods used to teach them. At the same time, they form part of the medical and artistic heritage and reflect the history and cultural legacy of the institutions in which they are held.

To preserve these collections and pass them on to future generations, it is necessary to compile detailed scholarly catalogues and implement preventive conservation measures.

The aim of this article is to introduce the general public to the collection of three-dimensional anatomical and embryological models by renowned European masters held at the 'Museum of Medicine' Complex of Kharkiv National Medical University. In particular, it is important to raise the issue of the proper conservation, preservation and restoration of this collection amidst a full-scale war that has threatened museum work in Ukraine.

The 19th century marked a golden age for European workshops specialising in the production of artificial anatomical models. Papier-mâché proved to be a true revolution among the materials used to make anatomical models — a versatile material that made it possible to create stronger, more durable models with moving parts (Sousa, Borges, p. 77).

The Frenchman Louis Jérôme Auzoux (1797–1880) was a pioneer in the use of this material for the production of anatomical models. In 1830, after many years of painstaking work, he presented to the Academy of Medicine a life-size model of the human body, approximately 1.9 metres tall, consisting of 139 parts and reproducing 1,700 anatomical details. L. Auzoux perfected the papier-mâché technique by developing a mixture of paper, shredded fabric, oak wood, calcium carbonate and cork powder. This mixture made it possible to produce disassembled anatomical models and enlarged copies of the fine structures of the human body with a high degree of detail (Sousa, Borges, p. 77). Lighter, detachable parts were made in plaster moulds from strips of paper soaked in starch paste, using the 'papier-collé' method. The dried halves were stitched together with iron wire, which was then concealed with paper. Larger supporting parts were moulded in metal moulds made from Jean Darsé's alloy. These were lined with glued paper and filled with 'terre' — a mixture of flour paste, shredded paper, rags, calcium carbonate and cork powder. The halves were compressed in a press until completely dry, after which the surface was covered with paper in preparation for painting. Blood vessels were made from iron wire wrapped in ramie thread and secured with nails. Artists drew the anatomical details by hand (Peel, p. 75). Names were applied directly to the larger parts of the model, whilst the smaller ones were marked with numbered labels and identified using a corresponding table (Maerker, p. 49). A serial number accompanied by a symbol of a right hand with an outstretched index finger indicated that the part could be detached. Smaller numbers or letters were used to denote individual anatomical structures. Typically, a part was held in place by two projections. The number on the label indicated the sequence in which the parts were to be removed and the point from which to begin detaching them (Thillaud, Glon, p. 12).

In 1833, L. Auzoux expanded his production and began manufacturing models of individual organs and body parts, including the eyes, ears, heart and limbs, both life-size and on a larger scale. L. Auzoux called them 'Anatomie clastique' — from the Greek word klao ('to break'), as they could be taken apart to reveal the structure and arrangement of muscles, nerves, blood vessels and internal organs (Peel, p. 73). Thanks to the variety and quality of his products, he became one of the leading producers of papier-mâché anatomical models in the 19th century. Initially, the models were intended for the professional training of medical practitioners and for educating the general public with an interest in human anatomy. Today, they have become rare and valuable exhibits, possessing both scientific and artistic value, and are preserved in universities and museums around the world (Sousa, Borges, p. 78).

The traditional material used to make anatomical models was wax. It allowed for the realistic reproduction of the shape, colour and texture of the human body and its internal organs (Maerker, p. 48). One of the most famous European model-makers to work with wax was the German model-maker Adolf Ziegler (1820–1889) — an outstanding master of the craft of making embryological and anatomical models. Embryologists of that time faced difficulties in studying the stages of embryonic development. Firstly, it was difficult to obtain embryos, especially in the early stages of development. Secondly, due to the fragility of the specimens, it was either impossible to preserve them at all, or they remained suitable for study only for a short time. Consequently, there was a need for durable visual aids that could replace the perishable natural specimens. Illustrations and wall charts partially met this need, but their size was limited. A. Ziegler and O Ecker, a professor of physiology in Freiburg, Germany, joined forces to create three-dimensional models based on two-dimensional images of embryos. Their collaboration contributed to rapid changes in the methods of embryological research and, to some extent, in the teaching of embryology. A. Ziegler's enlarged wax models made it possible to visually reproduce the complex microscopic structures of embryos and demonstrate their changes at various stages of development (Hopwood, p. 18).

In 1867, A. Ziegler opened his own workshop — the 'Atelier für wissenschaftliche Unterrichtsmodelle' ('Workshop for Scientific Teaching Models'). His embryo models soon became highly sought after, and having his own workshop enabled him to establish a profitable trade with universities, museums and private collectors. Thanks to their sturdiness, the models withstood transport well, which helped to spread them abroad. A. Ziegler gained international recognition through his participation in world exhibitions in Paris (France, 1867) and Vienna (Austria, 1873), where his embryo models were displayed (Hopwood, p. 22).

The work of L Auzoux and A Ziegler demonstrates two complementary directions in this development. Auzoux's detachable papier-mâché models allowed students to examine the internal organisation of the body through the sequential removal of individual parts. Ziegler's

enlarged wax models made fragile and often inaccessible embryonic structures available for repeated observation and comparison across developmental stages. These models therefore did more than reproduce bodily forms: their construction shaped how anatomical structures and developmental processes could be demonstrated and understood. Specialised workshops, international trade and participation in exhibitions extended their circulation beyond their places of manufacture.

The history of Kharkiv National Medical University dates back to 1804, when Kharkiv University and its Faculty of Medicine were established. The formation of its teaching collection coincided with a period of close exchange within the European scientific community. International connections enabled the university's lecturers to follow developments in medical education and acquire teaching materials from leading manufacturers. The Department of Anatomy, Physiology and Forensic Medicine commissioned anatomical models that reflected contemporary advances in scientific model-making. As a result, the university's museum collection now includes works by L. Auzoux, A. Ziegler, La Maison 'Tramond' and other prominent European producers (Медицинский факультет, С. 196).

Jakob Vannoti (1771–1819), a native of Freiburg, Germany, served as the first head of the Department of Anatomy, Physiology and Forensic Medicine at Kharkiv University's Faculty of Medicine from 1805 to 1810. In addition to organising anatomical teaching, he established the university's first anatomical theatre in a building in the University Gardens. There, in 1807, he prepared 44 anatomical specimens, laying the foundations for an anatomical museum that would develop into an important scientific and teaching collection (Медицинский факультет, С. 197).

J. Vannoti also acquired the department's first illustrated anatomical manuals. In 1809, he commissioned 37 wax anatomical tableaux from Hasselmeyer in Leipzig, Germany. Distinguished by their craftsmanship and attention to detail, these tableaux depicted dissected muscles, blood vessels, nerves, sensory organs, body cavities and internal organs, as well as surgical procedures. Despite their small scale, the models reproduced anatomical structures with considerable precision (Медицинский факультет, С. 198). Seven survive today, one of which requires extensive restoration.

The figure 1 shows one of these wax tableaux, comprising two relief representations of the human heart arranged vertically within a dark wooden frame. Rendered in flesh-coloured and ochre tones, they illustrate the organ's external and internal anatomy. The upper relief depicts the heart's external contours, the major vessels at its base and the coronary arteries branching across its surface. The lower relief presents an opened heart, exposing the valves, chordae tendineae, papillary muscles and internal contours of the ventricles. The properties of wax allowed the model-maker to reproduce both the thick muscular walls and delicate, thread-like structures. Together, the reliefs enable a direct comparison between the heart's external form and internal organisation (Collection of the "Museum of Medicine" Complex. MC5590).



Fig. 1. A wax model by Haselmeier depicting the human heart. 1809. Collection of the 'Museum of Medicine' Complex. OF5590

In 1850, Petro Naranovych, Head of the Department of Anatomy, acquired a series of seven papier-mâché models of the pregnant uterus made by L. Auzoux (Медицинский факультет, С. 207). Five survive, although the embryos are missing from two. The models require extensive restoration and controlled storage conditions; their paint layers show cracking attributed to drying.

The figure 2 shows one model from this series with its anterior wall removed, exposing the layered foetal membranes and the foetus within. Its detachable construction allowed students to examine the uterus, membranes and foetus sequentially. The foetal figure has a curved body, a large rounded head and limbs drawn towards the torso. A section of the umbilical cord is visible above it, while fine reddish fibres in the upper part of the cavity represent vascular structures. Small circular paper labels survive on several components. The flesh-coloured foetus contrasts with the greyish-ochre membranes, and red and blue lines identify blood vessels on the uterine walls. The layered construction and colour scheme make the spatial relationships between these structures easier to understand. The model displays substantial damage. The thin edges of the membranes are deformed, torn and locally delaminated, with areas of material loss. Cracks, abrasions and paint losses expose the fibrous papier-mâché beneath. A projecting component has damaged edges around its central opening and chips along its perimeter. Nevertheless, the principal structures, the foetal figure and some of the labels survive, preserving evidence of the model's original teaching function (Collection of the "Museum of Medicine" Complex. MC5599).



Fig. 2. A model of a pregnant uterus made from papier-mâché (L. Ozu, 19th century). Collection of the 'Museum of Medicine' Complex. OF5599



Fig. 3. A series of wax models by A. Ziegler illustrating the development of the external genitalia

By 1867, the department had acquired a total of 27 models by L. Auzoux (Попов, С. 4).

In 1869, Johann Wagner, Head of the Department of Human Anatomy, acquired three series of wax models by A. Ziegler illustrating the development of the heart, reproductive organs and embryo (Медицинский факультет, С. 218). Ten models of the reproductive organs and eight embryonic models survive as well as three hearts.

The figure 3 shows the series 'Development of the external genitalia of the human embryo', comprising ten models that illustrate successive changes in form and sexual differentiation. These enlarged reliefs are mounted on three black rectangular panels, with four models on one panel and three on each of the others (Hopwood, p. 138).

The models depict the perineal region at successive developmental stages. Early stages show small projections and folds surrounding a central depression; later stages reveal increasingly differentiated forms and changing proportions. Enlargement makes fine grooves, openings and surface contours visible and facilitates comparison between corresponding structures. Flesh-coloured, yellowish and pink tones contrast with the black panels.

The series underwent unsuccessful restoration attempts in the second half of the twentieth century, when missing portions of five models were replaced with ordinary candle wax. In the 2000s, the models were overpainted. The team at the 'Museum of Medicine' Complex has since undertaken an initial phase of restoration, removing the overpaint and cleaning the surfaces. This work revealed smooth, glossy surfaces and clearly defined relief, although local irregularities and chips remain. Despite these alterations and losses, the series retains its historical and educational significance (Collection of the "Museum of Medicine" Complex. MC5602-5612).

The figure 4 shows embryonic model No. 5, which represents an early stage of intrauterine development. Its elongated, curved body has a large, forward-tilting head and a curved lower extremity. A metal support secures it vertically to a shaped black base. The enlarged scale reveals details that would be difficult to distinguish at natural size. A cutaway section of the body wall exposes internal structures and their spatial relationships. Ochre and yellow surfaces contrast with red and brown internal elements, helping to distinguish their contours. The rounded head region leads into fine longitudinal structures in the torso and a series of raised ridges below. The model demonstrates the complexity of embryonic anatomy before recognisably human proportions emerge (Collection of the "Museum of Medicine" Complex. MC5615).



Fig. 4. A wax model of an embryo by A. Ziegler. Collection of the ‘Museum of Medicine’ Complex. OF5615



Fig. 6. A female pelvis made of papier-mâché, showing the organs contained within it. Collection of the “Museum of Medicine” Complex

The figure 5 shows three wax models illustrating embryonic heart development. Each is mounted on a short metal support above a round black base. Surviving paper labels bear the numbers ‘6’, ‘8’ and ‘9’, identifying their positions within the series. Their enlarged forms reveal the contours of the developing heart’s constituent regions. Yellowish-ochre lower portions meet pinkish-brown upper portions with rounded, sometimes lobed projections. In models No. 6 and No. 8, an elongated tubular structure with an open end extends upwards. Differences in proportions, constrictions and projections allow comparison of successive changes in external form. In model No. 9, a section of the anterior wall of the upper chamber has been removed, exposing the cavity and a smaller opening within it. This cutaway supplements the external view with an illustration of internal anatomy (Collection of the “Museum of Medicine” Complex. MC5621, MC5623, MC5624).

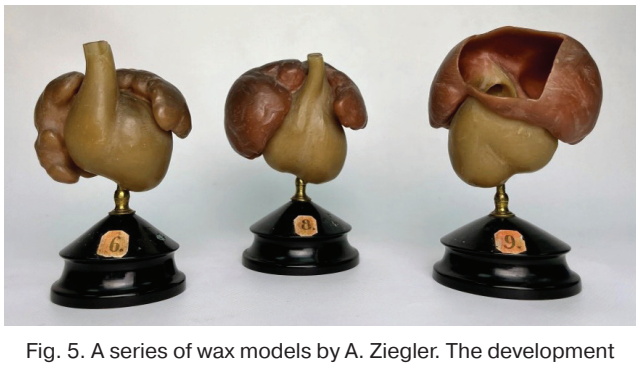


Fig. 5. A series of wax models by A. Ziegler. The development of the human heart. Collection of the ‘Museum of Medicine’ Complex. OF5621, OF5623, OF5624

During J. Wagner’s tenure, the museum acquired 18 papier-mâché and wax models by L. Auzoux and the ‘Tramond’ company, together with 15 wax models by A. Ziegler. The latter acquisitions included a series illustrating heart development, purchased in 1874 (Попов, С. 5).

The figure 6 shows L. Auzoux’s model of the female pelvis with abdominal organs. Extending from the diaphragm to the lower pelvis, it demonstrates the spatial relationships between organs, blood vessels and nerves. Its open anterior aspect and detachable components allowed structures to be examined progressively as overlying parts were removed. The upper section includes the diaphragm and part of the liver, with the kidneys and adrenal glands below. The aorta and inferior vena cava run centrally, accompanied by numerous vascular branches. On the viewer’s right, the descending colon continues into the sigmoid colon. The exposed pelvis reveals the pelvic organs and adjacent vessels and nerves. Red arteries, blue veins and pale nerve trunks contrast with the muted brown, pink and grey surfaces of the surrounding structures. Small paper labels survive

on individual components, and fastening mechanisms remain visible at their junctions.

The model exhibits extensive surface deterioration. A dense network of cracks covers the coating, with raised flakes and substantial losses exposing the pale papier-mâché substrate. Losses are particularly pronounced along the blue surface of the inferior vena cava, the intestine and the pelvic components. Delamination is visible along the upper edge, and some slender projections have broken tips. Nevertheless, the principal anatomical forms, much of the vascular and nervous branching, and some labels remain intact, preserving evidence of the model's detailed construction and educational use (Collection of the "Museum of Medicine" Complex. MC5627).

The figure 7 shows an enlarged, detachable model of the hand and part of the forearm by L. Auzoux. It illustrates the arrangement of muscles, tendons, blood vessels and nerves, with the fingers extended and slightly separated and the thumb directed outwards. The skin is omitted to expose structures on both the palmar and dorsal surfaces. On the palm, the model displays the muscles at the base of the thumb, long pale tendons extending towards the fingers and transverse structures at the wrist. A red vascular arch crosses the palm, while fine yellow nerves follow the hand and sides of the fingers. On the dorsal surface, a branching network of blue veins overlies the longitudinal tendons.



Fig. 7. An enlarged papier-mâché model of a hand, (L. Ozu, 19th century). Collection of the 'Museum

The model was overpainted in the second half of the twentieth century, presenting a substantial restoration challenge for the staff of the 'Museum of Medicine' Complex. Gaps are visible between components, and some delicate vessels and nerves have detached or broken. The tip of the middle finger is also damaged. Despite these losses, the muscular contours, most tendons and many fine vascular and nervous branches survive, retaining much of the anatomical detail central to the model's teaching function (Collection of the "Museum of Medicine" Complex. MC5628).

Three models from A. Ziegler's heart development series survive, bearing the numbers '2', '3' and '6' (**Figure 8**). They illustrate changes in the heart's form during embryonic development. Their orange and reddish-brown surfaces have a subtle sheen. Each is supported by a gold-coloured arched metal holder mounted on a shaped black stand with a stepped circular base (Hopwood, p. 134).

Model No. 2 forms a broad, curved loop with rounded expansions separated by a constriction; additional structures are partially visible behind and below it. Model No. 3 comprises two prominent sections arranged vertically: an elongated upper section curves upwards, while the rounded lower section has a short lateral projection. Model No. 6 has two openings of different diameters through which the internal cavities can be viewed. Differences in the contours and arrangement of these forms allow comparison of the developmental stages represented (Collection of the "Museum of Medicine" Complex. MC5629, MC5630, MC5631).

The collection also includes a model produced by Maison Tramond, a Parisian firm established in the mid-nineteenth century. Specialising in osteology and anatomical ceroplasty, the workshop supplied medical faculties with models and specimens made using wax, horsehair, human bone and papier-mâché. The 1897 catalogue records 13 models from the workshop in the anatomical museum of Kharkiv University's Faculty of Medicine (Попов, С. 6).

The figure 9 shows a model of 'the veins of the spinal canal, the cranial cavity and the major venous trunks of the neck, thoracic, abdominal and pelvic cavities'. Its vertical arrangement incorporates part of the skull,



Fig. 8. A series of wax models by A. Ziegler. The development of the human heart. Collection of the 'Museum of Medicine' Complex. OF5629, OF5630, OF5631



Fig. 9. Illustration of the veins of the spinal canal, the cranial cavity and the major venous trunks (Tramon, 1879). Collection of the 'Museum of Medicine' Complex. OF5632

the vertebral column, sections of ribs and pelvic bones. Dark blue vessels contrast with the pale yellowish-ochre skeletal structures, allowing their course to be followed from the head to the pelvis. Large venous trunks descend along either side of the cervical region and converge near the upper thorax. Longitudinal vessels with numerous lateral tributaries follow the spine, while smaller branches extend along the surviving rib segments. Below, the inferior vena cava connects with the iliac veins, and a branching venous network occupies the inner pelvis and sacral region. The combination of vessels and skeletal landmarks illustrates the topography of the venous system and the connections between its different regions.

The model shows uneven coloration, abrasions and localised coating losses. Several skeletal elements have chipped or irregular edges, particularly in the lower pelvis and along the side of the skull. Some fine vascular branches terminate abruptly. Nevertheless, the main venous trunks and many smaller branches remain clearly defined, preserving the model's capacity to demonstrate anatomical relationships (Collection of the "Museum of Medicine" Complex. MC5632).

The survival of historical anatomical models has often depended on chance. Once considered obsolete, many were designated for disposal or relegated to boxes in attics and cellars. Exposure to dust, dirt and temperature extremes caused severe, sometimes irreversible damage (Appelboom, Merode, Gouriveau, Hanse, p. 28).

The 'Museum of Medicine' Complex at Kharkiv National Medical University seeks to preserve, research and interpret this heritage as evidence of the development of medical education in Kharkiv and Ukraine. Conservation is complicated by the models' composite construction. Papier-mâché models incorporate metal supports and painted layers containing pigments and gelatine glue, while wax models present distinct conservation requirements. Their treatment therefore calls for collaboration among conservators with expertise in paper-based materials, painted surfaces, metals and wax. Assembling such teams and providing suitable working conditions remain particularly difficult during wartime.

Through scholarly and popular science publications, guided tours and social media, the Complex's team introduces these objects to wider audiences, explains their role in medical teaching and draws attention to the need for their preservation.

Conclusion. The anatomical and embryological models examined in this article demonstrate how European model-makers combined scientific knowledge, craftsmanship and material innovation to address the practical needs of medical teaching. Wax tableaux, detachable papier-mâché models and enlarged embryological series offered different ways of presenting structures that were difficult to obtain, preserve or examine in natural specimens. Their construction enabled students to explore spatial relationships, reveal successive anatomical layers and compare developmental stages.

The acquisition of models by Hasselmeyer, Louis Auzoux, Adolf Ziegler and Maison Tramond situates the development of anatomical teaching in Kharkiv within the wider European circulation of scientific knowledge and teaching materials. The surviving objects document both the work of these producers and the university's sustained investment in visual and practical instruction during the nineteenth century. Their labels, detachable components, colour schemes and mounting systems remain valuable evidence of how anatomical knowledge was organised and communicated.

The condition of the collection also reveals the consequences of changing attitudes towards historical teaching aids. Missing components, deteriorating surfaces, overpainting and inappropriate repairs have compromised some of their original features. Nevertheless, the surviving anatomical detail and construction elements retain considerable research value. Their preservation requires systematic documentation, a scholarly catalogue and conservation strategies adapted to the different materials and previous interventions represented in the collection.

The full-scale war in Ukraine adds urgency to this work while restricting access to specialist expertise and suitable conservation conditions. Preventive conservation and professional assessment must therefore underpin further restoration, alongside continued historical research and public interpretation. Safeguarding this collection will preserve material evidence of the connections between European model-making and medical education in Kharkiv, ensuring that these objects remain available for future study.

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Анатомічні навчальні моделі з майстерень Адольфа Циглера та Луї Озу у фондах комплексу «Музей медицини» Харківського національного медичного університету

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У статті розглянуто європейські анатомічні та ембріологічні моделі із зібрання Харківського національного медичного університету, історію їх придбання, навчальне призначення й технології виготовлення. Висвітлено їхню історичну цінність, проаналізовано стан збереженості та проблеми консервації і реставрації в умовах повномасштабної війни в Україні.

Ключові слова: анатомічні моделі; ембріологічні моделі; Луї Озу; Адольф Циглер; історія медичної освіти; Харківський національний медичний університет.

Anatomical teaching models from the workshopos of Adolf Ziegler and Louis Auzoux in the collection of the «Museum of Medicine» Complex at Kharkiv National Medical University

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This article examines European anatomical and embryological models preserved at Kharkiv National Medical University, tracing their acquisition, educational functions and manufacturing techniques. It highlights their historical significance, assesses their current condition and addresses conservation challenges during the war in Ukraine.

Keywords: anatomical models; embryological models; Louis Auzoux; Adolf Ziegler; history of medical education; Kharkiv National Medical University.

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Стаття надійшла до редакції 23.03.2026 р.