

The educational value, both past and present, of an ancient scientific collection: the collection of anatomical preparations illustrating the various phases of bone development, from the second month of intrauterine life to adulthood

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Abstract

Italy's museums possess an enormous patrimony of historical scientific artefacts. This raises important questions regarding the conservation and safeguard of such materials and prompts reflection as to the utility of current modalities of popularising science. The collections housed in scientific museums were created in order to promote scientific education by making science more accessible and more comprehensible. The authors ask whether this heritage can still be used for educational purposes today, and examine a collection of preparations on the ossification of human bones in the Anatomical Museum of the University of Siena. They conclude that such materials can still be of educational value if they are made part of exhibitions that meet the needs of the public and of students in training. Indeed, it is essential to bear witness to the long pathway of the development of scientific knowledge and, in particular, to the value of the research on which this knowledge is based. Through the implementation of ad hoc exhibitions, this precious historical scientific patrimony can continue to play an important role in presenting medical/healthcare issues of topical interest without losing sight of the relevance of past experience to basic teaching.

Keywords

educational value, ethics, ancient scientific collection, medical education, anatomical preparations, Museum of Siena, Italy.

Introduction

The evolution of knowledge and its diversification into distinct fields have led the most ancient universities and research institutes to become the custodians of an extraordinary cultural heritage. Built up or acquired over the centuries for the purposes of research or teaching, this rich patrimony, which bears witness to the evolution of knowledge, has not yet been sufficiently mined and deserves to be valued more highly.

Back in 1924, the Florentine physician and science historian, Andrea Corsini, in his essay *“Per il patrimonio storico-scientifico italiano”*, which appeared in the journal

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“Archivio di Storia della Scienza”, drew attention to that enormous scientific patrimony that was “destined to decay and to be lost”, as it was “neglected and unsupervised” [Corsini, 1924]. He therefore made the truly revolutionary proposal that science and its instruments should be regarded as a “cultural heritage” in the modern sense, i.e. that it should be safeguarded and preserved in the collective memory.

Italy, which had been unified only a few decades earlier, had inherited a considerable and heterogeneous scientific patrimony, in some cases from private collections dating back to the Renaissance period – a patrimony that was scattered throughout the country and was often used for teaching or research purposes. What worried Corsini and his colleagues who constituted the group for the safeguard of the national scientific heritage was that this wealth of material would continue to be dilapidated and lost and that the original collections might be further fragmented, not least as a result of the rapid development of technology and of the scientific disciplines themselves.

Throughout the 1920s, an ample debate raged as to the fate of historical scientific material in Italy. Despite the support of the Minister of Education Giovanni Gentile, however, the need to safeguard the national scientific heritage remained unrecognised. Indeed, Law N.1089 of 1 June 1939, “Safeguard of Material of Artistic or Historical Interest” focused on material that presented “artistic, historical, archaeological or ethnographic interest”, including “palaeontology, prehistory and primitive civilisations”; most scientific material was therefore excluded.

Only in 2004 did such material come under protection, when the Code of Cultural Heritage (Legislative Decree n. 42 of 22 January 2004) recognised “materials and instruments more than 50 years old of interest to the history of science and technology” among “objects of specific dispositions of safeguard” (article 11). In addition to normative issues, it must also be borne in mind that one of the greatest difficulties in protecting this scientific heritage lay in the very nature of the materials themselves: often, they were objects of everyday use, which were thrown away once their utility had ceased; sometimes they were too specialistic to be of interest to the ordinary citizen; in other cases, their scientific purpose was deemed too important for them to become “museum exhibits”.

The aim of the present article is to highlight the value of this rich heritage. This value is not merely economic; indeed, this patrimony is far more important, in that it bears witness to the history and evolution of science, while at the same time maintaining the memory of ancient institutions. And it is precisely this latter aspect that carries a specific meaning: the museum is the “repository of the memory and identity of a community”.

First of all, it is important to examine the dynamics that led to the formation of these museum collections and to try to determine what the function of an antique scientific collection should be in the 21st century.

A collection of preparations regarding the ossification of human bones

Here, by way of example, we present a collection of preparations kept in the “Leonetto Comparini” Anatomical Museum of the University of Siena. In the 1990s, the university took the decision to safeguard and conserve its own scientific materials

that were no longer in use, to study them and to make them available in the museum setting [Vannozzi, 2017]. This decision was regarded as a “rescue operation” in a context of surprising abandonment and, at the end of the 20th century, constituted a change of mentality that marked the beginning of the systematic recovery of scientific historical materials. Having been studied and catalogued, these are now on display in the eight museums of the Siena University Museum System - SIMUS.

The Anatomical Museum of the University of Siena can be traced back to 1850, when the director of the Institute of Anatomy, Giovanni Battista Vaselli, was given the title of “Praefectus of the Anatomical Museum”. Subsequently, in 1883, Guglielmo Romiti (1850-1936), a lecturer in anatomy, rearranged the collections with the help of the dissector Pilade Lachi, starting from Paolo Mascagni’s valuable preparations. On that occasion, the catalogue of the Anatomical Museum of the Royal University of Siena [Romiti, 1883] was published. Among the exhibits listed in the catalogue (numbers 50-84) was the collection of preparations regarding human bone development, which had been created by Pilade Lachi.

Lachi had the idea of putting together this collection of anatomical preparations after seeing a similar collection at the Orfila Museum in Paris, subsequently named the Delmas-Orfila-Rouviere Museum of Anatomy. Housed in the building of the Faculty of Medicine of the René Descartes University, this museum boasted almost 6000 exhibits, including numerous preparations of brain, skeletons, craniums and a fabulous collection of anatomical wax models.

On 2011 the collections were donated to the University of Montpellier and exhibited in the medical faculties.

At the Orfila Museum, Lachi saw what he did not hesitate to call “the finest of collections concerning osteology. [...] It is made up of all the bones of our body, but each is presented in various periods of bone development: from the first months of intrauterine life up to adulthood. Thus, the mode of growth of each bone can be studied, the nuclei of ossification and the age at which these nuclei combine to constitute a single piece of bone as we see it in manhood” [Lachi, 1880].

On returning to Siena, Lachi decided to put together a similar collection for the Anatomical Museum of the University. This was the origin of the osteological collection illustrating the various phases of bone development, from the second month of intrauterine life up to adulthood, which is the subject of the present article.

The realisation of the collection was no simple matter; not only was it necessary to “supervise the maceration of the tiny skeletons, so as not to miss any of the bony centres”, Lachi also needed to “have the subjects necessary in order to catch ossification in its various phases” [8]. Indeed, procuring the necessary cadavers was certainly the greatest difficulty and resulted in lengthy delays in the creation of the preparations. In order to highlight the passage from one stage of ossification to the next, each bone was presented in its development at 65 days of intrauterine life and – according to the case – at 3, 4, 4.5, 5, 6 and 9 months of gestation, and then at the ages of 1, 2, 4, 7, 13, 15, 18, 21 and 30 years, “this latter being the period in which the bones constantly display their complete development” [Lachi, 1880].

Even today, these preparations are presented in this way: “On as many panels as there are bones in our body (he arranged) in rows the various stages of each bone, such that, on picking up each panel, you can take in at a glance the changes that each bone undergoes before reaching its final state. Next to each phase, the age of the bone

is reported, so that, as well as recognising the above-mentioned changes, you can realise the age at which they occur" [Lachi, 1880].

The preparation that is the "true and clear demonstration" of the fruits of research

A preparation of this kind is "nothing less than the exposition and true and clear demonstration of observations that have come under our senses" [Lachi, 1880]; that is to say, it is the result of the research carried out at the Anatomical Institute of the University of Siena, set up as a teaching aid. And it was precisely on such pieces that the anatomists of the time based their ideas concerning the process of ossification, while at the same time finding in them their founding proof.

Indeed, Lachi and his colleagues admitted primary and secondary points of ossification. These latter, "not being constant in terms of either existence or period of development" [Lachi, 1883], had given rise to considerable dispute among scholars. And it was for this reason that, in the introduction to the published brochure that presented the collection, Lachi saw fit to dwell on the meaning of "point of ossification" and "centre of ossification".

Today, the most recent studies in embryology have shown that the formation of the skeleton during embryonic life, and also the remodelling that takes place during the postnatal period, occur through the interaction of various factors. Indeed, environmental signals, intracellular signalling pathways, transcription factors and co-regulators, such as vitamins, are able to support the differentiation of the mesenchymal cells towards the mature osteocyte of mineralised bone. During the third week of embryonic life, gastrulation takes place, a fundamental developmental stage in which three pri-



Figure 1. P. Lachi, *Anatomical preparation on the development of the bones of the hand* – Anatomical Museum L. Comparini Università di Siena, Images Archives SIMUS.



Figure 2. P. Lachi, *Anatomical preparation on the development of the humerus* – Anatomical Museum L. Comparini University of Siena, Images Archives SIMUS.

mary germ layers are formed: ectoderm, mesoderm and entoderm, from which various apparatuses will derive. The skeletal apparatus develops from the mesoderm (paraxial and somatic) and from the neural crest. The paraxial component of the mesoderm is arranged in a series of “small pieces” of tissue, known as somites, located alongside the neural tube, and from which, at the end of the fourth week of embryonic life, the mesenchymal cells will derive; these latter have the characteristic of migrating and differentiating into various cell lines, such as fibroblasts, chondroblasts and osteoblasts.

At that time, however, Lachi, who also integrated his knowledge of anatomy with that of histology, embryology, comparative anatomy and physiology, obviously did not have all this information. He could not therefore know that there are two modalities of skeletal accretion: direct or membranous ossification and indirect or endochondral ossification; each of these modalities is proper to different bones. Direct ossification begins from the mesenchymal cells; these transform into osteoblasts, which in turn produce non-lamellar bony tissue. After mineralisation, this will be replaced by



Figure 3. P. Lachi, *Anatomical preparation on the development of the ethmoid* – Anatomical Museum L. Comparini Università di Siena, Images Archives SIMUS.

bony tissue. This process is typical of the bones of the cranial vault, the face and the clavicle. By contrast, indirect ossification, which regards all the other sites, derives from mesenchymal cells that transform into chondroblasts; these, in turn, produce cartilaginous tissue. In this way, “bone drafts” are formed; these are made up of cartilage and will be replaced by bony tissue. This type of ossification occurs from several centres of ossification and takes place over a fairly long period. Indeed, ossification of the long bones begins around the eighth week of embryonic life and is complete by the age of 18-20 years.

However, the knowledge available to the anatomists of the middle of the 19th century was obviously much more limited, and the debate revolved around the above-mentioned concepts of “point of ossification” and “centre of ossification”. By “point of ossification” – Lachi wrote – “we should mean the most limited and smallest part in which ossification is deployed to a given portion of membranous or cartilaginous skeleton, and whence it radiates to constitute a clearly visible piece of bone. Now, one of two things may happen: either more than one of these parts contribute to the formation of a single bone, uniting and fusing together very early, such that we do not have enough time to recognise their primitive separation; or, by contrast, these points remain separate for a more or less long period of time. [...], in which case, as the term has a very restricted meaning, it should be replaced by the expression “centre of ossification” [...], as this suggests a more or less large area of tissue in which the first traces of ossification are manifested, and from which it radiates in all directions until it unites, more or less late, with similar areas, giving rise to the complete bone” [Lachi, 1883].



Figure 4. P. Lachi, *Anatomical preparation on the development of the tibia* – Anatomical Museum L. Comparini Università di Siena, Images Archives SIMUS.

On the basis of these presuppositions, each panel displaying Lachi's bone preparations in their various phases of accretion was accompanied by a thorough description of the features of each phase, the principal modifications to be noted between one phase and the next, and the most innovative studies conducted on each specific issue; for this purpose, he reviewed the works of the leading scholars of anatomy and embryology of his day, from Alexis Boyer to Luigi Calori, and from Theodor Karl Gustav von Leber to Rudolf Albert von Kölliker.

This collection is therefore the result of attentive observations and in-depth studies by this teacher, who created a useful aid for the teaching and the study of anatomy. It is, to all intents and purposes, a set of preparations for educational use, responding in excellent fashion to the medical student's need to "see" how the human body is made up. Indeed, anatomy is the art of sectioning the human body so that it can be seen. And it is in this way that the student observes and learns. It is no coincidence that the main place of anatomical dissection is the anatomy theatre, the etymology of which harks back to the root of the Greek verb *θεάομαι*, meaning "I look".

Conclusions

Drawings, preparations, models and contrivances have always been used to do scientific work and to communicate scientific knowledge. Over the centuries, these materials have accumulated in the laboratories and lecture theatres of universities

and other institutions, in some cases constituting valuable collections that are now exhibited in science museums. Moreover, it should be pointed out that similar devices are still used today in scientific communication, even though the pencil has been replaced by the digital drawing, and technological means of communication have replaced the observation of anatomical preparations. We might therefore be led to believe that the antique collections of educational tables, preparations and models that constitute the patrimony of many museums of anatomy are destined for oblivion or, at best, to be regarded as simple scientific curiosities from a past era.

In reality, this is not the case. At least, it will not be the case if we construct around this heritage projects of scientific communication aimed at explaining science to young people and to all those who are interested, in order to make them aware of how our current ample knowledge has been achieved – projects that explain this arduous pathway, sometimes strewn with error, and which can promote debate and dialogue among scholars.

Moreover, if we endorse the concept enunciated by Giulio Carlo Argan back in November 1951 at the UNESCO-ICOM meeting in Paris: “the foundation of the museum constitutes the positive recognition of its educational capacity” [Argan, 1949], we can well assert that collections of historical scientific material, such as that presented in this paper, constitute indispensable aids to the dissemination of science. For all these reasons, such collections should not be looked upon as dusty relics; rather, they represent a fundamental tessera in the mosaic of the history of science.

Thus, museums are not inert containers for antiquities that are surrounded by a sacred aura and accessible only to a cultural elite. Instead, in addition to being places for the conservation and safeguard of our cultural heritage, they become places of scientific research and dissemination – just like the Greek *museion* – places where moments of informal education and socialisation foster esteem for knowledge. In this way, this extraordinary “mine” of knowledge, which has been so assiduously safeguarded, can take on fresh life through the direct involvement of citizens, thereby contributing to the construction of a democratic society, fostering individual and social sustainability, creating new professional skills and promoting widespread well-being.

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Authors' contributions

MM and DO designed the study. MM and DO conceived the study; MM, DO and MA drafted the manuscript; MM, DO and MA revised the manuscript. MM, DO, MA

performed a search of the literature. All authors critically revised the manuscript. All authors have read and approved the latest version of the paper for publication.

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