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History of Medicine in Science Education: didactic resources on the Portuguese doctors Amato Lusitano and Garcia de Orta

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The addition of the history of medicine to teaching aims to develop scientific education and instill in students the understanding that scientific knowledge is not immutable but dynamic, being influenced by social, economic and political factors. However, the history of medicine is rarely used by teachers, and one of the main problems is the scarcity of materials. In this article, we present some didactic resources, appropriate for the classroom, about two recognized Portuguese doctors of the sixteenth century, Amato Lusitano (1511–1568) and Garcia de Orta (1501–1568). For the elaboration of these materials, we used only primary sources – that is, the original texts. Amato Lusitano was the author of internationally recognized works, such as *Index Dioscoridis* and *Curationum Medicinalium Centuriae Septem* (the *Centuries*), while Garcia de Orta published the *Colóquios*, which today occupies a prominent place among works about the medical matters of the Renaissance. The application of the History of Medicine in Science Teaching can be a valuable tool for improving the teaching-learning process of the students and consequently can help to increase their scientific literacy.

Keywords: *history of medicine, didactic resources, Amato Lusitano, Garcia de Orta, scientific literacy*

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The educational system in Portugal is organized in pre-school (3–5 years), basic education (6–10 years), High school (11–15 years), education and training of youths and adults and, lastly, higher education. In Portugal, equality of opportunity for study is promoted for students, full occupation of school days, implementation of teaching materials and appropriate intervention instruments for the acquisition of scientific knowledge, bets on action plans to improve results in Natural Science, Mathematics and Portuguese [1]. Vocational courses are accessed in particular for students with the risk of dropping out of school, representing a more technical offer to enable scholars to find practical work [2, 3]. The Portuguese education system also promotes adult literacy, so there are a number of vocational training courses aimed at regaining qualification levels of the adult population in areas with employability [4].

The relevance of History of Medicine (HM) to the formation of critical thinking skills in youth is mentioned in the curricula of Portuguese sciences [4]. The strong influence of science and technology in everyday life and society is undeniable, and in this context the school plays a key role, not only helping pupils to acquire relevant scientific and technical knowledge but also helping them to become citizens of the future and critical thinkers, implementing and evaluating the knowledge they have gained [4, p. 174].

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Another author adds that the teaching of HM can provide students with a conceptual, procedural, and contextual understanding of science as a body of knowledge and as a process for discovering that knowledge [5]. The introduction of HM in Science Teaching has the potential to make science more attractive to students and consequently may awaken their interest in learning scientific content [6].

According to important research, the benefits of applying the History of Medicine in Science Teaching are as follows [7, p. 259]:

a) promotes a better understanding of scientific concepts and scientific methodology;

b) allows a path for learning similar to that of the historical process of scientific development;

c) promotes HM as a "cultural heritage of humanity";

d) contributes to the understanding of the nature of scientific knowledge;

e) humanizes science and its practitioners;

f) evidences the interdisciplinarity of HM;

g) facilitates scientific education for citizenship.

In this way, HM may also allow teachers to approach important aspects of science in the classroom, such as the fact that the construction of scientific knowledge involves conflict and debate, as does any other human activity [8].

However, some authors comment that the effect of HM teaching on students' learning of scientific concepts is still controversial [9, 10]. In this context, we note some risks and difficulties in the use of HM in science teaching, with regard to distorted concepts that frequently appear in the literature: a) empirical-inductive and atheoretic conception; b) rigid vision; c) imperfect and ahistorical vision; d) exclusively analytical vision; e) cumulative view of linear growth of scientific knowledge and f) individualist and elitist vision of science and socially neutral view of science [11]. Furthermore, other difficulties in applying HM in Science Education arise, including the culture of teaching; teacher's skills, attitudes, and principles; the students' views and the nonexistence of HM in science books [5, 12, 13].

Teachers' use of HM in the classroom can help students develop critical thinking skills in regards to scientific questions and problems, which are fundamental for a citizen's role in decision-making and impact in the scientific community and in the humanities [5].

It is imperative that teachers recognize the diversity of ways to understand HM, each of which corresponds to a particular point of view and activities, which may lead to different learning objectives in the classroom [14].

As there are different ways to address HM, the decision to use HM as a pedagogical strategy depends on a variety of factors, including the following:

- directive influences (e.g., official documents of the Ministry of Education, internal decisions of the schools through their educational projects and/or decisions of the disciplinary groups);
- formative influences (knowledge from initial and continuous formation in practice teaching);
- professional influences (e.g., type of students, space-temporal factors, available pedagogical resources, evaluation);
- personal influences (capacity, personal taste for the area, motivation).

The inclusion of HM in the scientific curricula can be accomplished via the "inclusive approach" and the "integrated approach" [7, 15]. In the first approach, the contents of the science curriculum are complemented by the insertion of specific historical episodes. In the second approach, HM is integrated in the context of the sciences; that is, the historical perspective serves as a guiding line for all the scientific content in a given course. We consider that both approaches, integrated and inclusive, have their value in science teaching; however, they are minimally implemented [16].

The most significant problem related to the inclusion of HM in the classroom is the fact that it requires teachers with training in the selection of suitable historical material or even the construction of specific teaching-learning materials [3]. In addition, teachers reported that they had insufficient knowledge about HM [10]. In our opinion, teachers do not have enough training in the epistemology of science, and the available resources are very scarce and/or practically inaccessible. The didactic resources presented in this work are intended to provide teachers with materials that they can use with their students [16, p. 12]. The didactic resources consist of the interpretation of original documents; discussion

of historical controversies, justifications and historical illustrations; reconstruction of historical instruments; historical narratives (which may include fictional episodes), exploration of life and work reports of some scientists and/or experiments or demonstrations based on history; comparisons of different explanatory theories about a certain concept or theory; exploration of thoughtful experiences; stories about central ideas and relevant experiences relating to a scientific subject; and dramatizations.

All the teaching materials presented are intended for high school students for the subjects of Natural Sciences, History, Portuguese and Mathematics.

The objective of this work is to highlight the importance of the use of HM in teaching by presenting resources that may contribute to fostering the use of HM in the context of the classroom and by locating historical scientific events and exposing the main contributions of Portuguese researchers (Amato Lusitano and Garcia de Orta) to the development of the science of their time.

In the present work, we use a qualitative methodology with documentary analysis of primary sources, the most reliable data. Concerning Amato Lusitano, the following works were consulted to analyze the controversy about valves in the veins between Amato and Harvey: the *Curationem Medicinalium centuriae septem* (*Centuriae*), published in 1580 in Leon, and *De Motu Cordis* of William Harvey (1578–1657) edited in 1628 in Frankfurt. In relation to Garcia de Orta, we consulted the work *Colóquios*, edited in Goa in 1563. We chose to include differentiated resources to better visualize their applications in different subjects. We have included two short informative texts and some activity sheets about the authors. We present the references to Amato Lusitano first and then those to Garcia de Orta.

We can conclude that it is strategic to promote the teaching of sciences in schools, to invest in education and scientific dissemination and to increase the levels of scientific culture.

The didactic resources presented in this work concerning Amato Lusitano and Garcia de Orta aim to expose the main contributions of these Portuguese researchers to the scientific knowledge of the sixteenth century and to highlight their impact on current medicine. The present work aims to fill the shortage of didactic materials pointed out by teachers for the use of HM in the classroom. The didactic activities presented are addressed to educators of different levels of teaching and disciplines, and can guide teachers in the application of HM in the classroom. However, there is much additional work to be done in this area. We believe that the success of the inclusion of HM in science teaching depends on the elaboration of didactic resources for educators to use in the classroom with their students and also on the realization of teacher training courses in HM.

In our opinion, the use of HM in Science Teaching can also contribute to improving the scientific culture for young people through promoting and improving their scientific literacy.

ANNEX

Didactic Resources

A. Amato Lusitano

Informative text: Aspects of the life and work of Amato Lusitano

João Rodrigues, known as Amato Lusitano, was born in 1511 in Castelo Branco. After completing the medical course in Salamanca, he started a long journey, first through northern and then through southern Europe, and eventually passed away in 1568 in Salónica, today known as Thessaloniki in Greece. This important researcher of Renaissance medicine served as the doctor of Pope Julius III and of the Ottoman Empire and established contacts with innumerable illustrious figures of the time, among them the Belgian physician Andreas Vesalius (1514–1564) and the Italian anatomist Gabriele Falloppio (1523–1562)

[14]. Amato Lusitano published three works: *Index Dioscoridis; In Dioscorides de medica materia librum quinque ennarrationes* (known as *Enarrationes*) and *Curationum Medicinalium centuriae septem* (*Centuriae*). The first book was published in Antwerp in 1536 and is the only subscript that is signed with Amato's birth name [16].

The second book was published in Venice in 1556 and was recently translated into Portuguese by a group of researchers from the University of Aveiro, Portugal. These first two works primarily cover medical matter. In addition, the *Centuries* was published in a single volume after Amato's death; the first edition of the complete work was issued in 1580 in Leon [18].

The *Centuries* has been reissued 59 times and was translated into Portuguese by Firmino Crespo and published in 1980 in a four-volume edition through the Faculty of Medical Sciences of the New University of Lisbon. Recently, in 2010, a new two-volume version of the *Centuries* was published by the Medical Order [16]. Each Century, as its own name indicates, refers to 100 designated clinical cases of cures. The clinical cases are reported in such detail that they give readers an idea of Amato's sixteenth-century world, in medical as well in social, economic and political terms [17].

Activity sheet: Controversy of valves in the veins – Amato versus Harvey

Text 1. *Pleurite and the reason why pleurite should be bled*

The investigations of the Renaissance Portuguese doctor Amato Lusitano (1511–1568) were significant, having contributed to the discovery of blood circulation. With the help of the Italian physician Giambattista Canano (1515–1579), Amato performed in 1547, in Ferrara, Italy, the dissection of twelve human and animal bodies, during which they found valves that prevented the blood backlash. This episode led to a meeting of physicians.

Amato developed a clinical procedure that allowed an understanding of blood circulation; however, for sometime this discovery was attributed to Canano, probably due to a misinterpretation of Amato's Latin text. It is still attributed by some authors to the Italian Fabrici d'Acquapendente (1537–1619), since several famous authors of the time did not confirm in their observations the existence of these valves. However, it is important to emphasize that Fabrici d'Acquapendente took about thirty years to realize the scope of Amato's discovery, a fact that had a decisive influence on the English anatomist William Harvey (1578–1657) (a disciple of Fabrici) who, almost 80 years later, described blood circulation in his work *De Motu Cordis*, published in 1628 in Frankfurt [17].

Text 2. *Cure LII. Pleuritis and the reason why in pleurite cases the blood should be let from the same arm where the pain occurs*

"Vesalius of Brussels, a renowned anatomist and physician to the Emperor Charles V, a few years ago, had a public discussion on this subject, in which his argument was that in pleuritis cases we must always open the internal vein on the right side of the body. This is the reasoning of Vesalius... Therefore, it is well to know the complete reasoning of Vesalius; in the azygous vein (is a vein in the chest) the blood received does not return to the vena cava and is constituted in its orifice of some "ostioles" that open and then close themselves so that the blood is not sent back... This is the characteristic of this vein, which does not send back the blood received by the same route...is right and we tried it many times. In fact, in the year 1547, in Ferrara, we dissected twelve human and animal bodies, and we saw that in all of them this would happen. A great assembly of doctors was present; Giambattista Canano, an admirable anatomist, also observed".

[19; 20, pp. 120–121; 21]

Text 3.

Harvey's conclusions were based on several physiological experiments, as can be seen from the following passage from De Motu Cordis, quoted by Gottlob and May:

"And this I have experienced many times in my dissections of the veins: if I try to pass a probe from the veins to one of the smaller vessels, though I do it very carefully, it becomes impossible, because of the valves; on the contrary, it becomes easier to push it the opposite direction, from the inside, or the branches, toward the trunk and the roots....If the probe is introduced from the ends to the central portions, the valves, such as the floodgates of a

river, give way, and may be more easily introduced sideways. The effect of this procedure is clearly to prevent all movement of blood from the heart and vena cava, either upward toward the head, or downward toward the feet, or to either side, to the arms, or a drop may pass" [22].

A. According to the texts above, answer the following questions [17]:

1. Who was Amato Lusitano?

2. What was the designation given by Amato to the valves in the veins?

3. Transcribe from the text the phrase relating to that designation.

4. Indicate the function of the valves in the veins.

5. In Amato's exposition there is an incorrect description of the blood movement described. Identify the error.

6. Comment on the following statement from text 2:

"In fact, in the year 1547, in Ferrara, we dissected twelve human and animal bodies, and we saw that in all of them this would happen".

7. Refer to the importance of William Harvey's experiments in the discovery of blood circulation.

8. Compare the date of publication of Amato Lusitano's work and William Harvey's work. Give your opinion as to which investigator was responsible for the discovery of the existence of valves in the veins.

B. Research and respond [17]:

1. Who were Andreas Vesalius and Fabrici d'Acquapendente?

2. Refer to some of the contributions they made to the development of science.

C. Explore [17]:

1. Investigate news about the technological innovations applied to the treatment of existing deformities in conducting vessels.

B. GARCIA DE ORTA

Informative text: Aspects of the life and work of Garcia de Orta

In 1563 in Goa, Garcia de Orta, a Portuguese physician and naturalist, published his work the *Colóquios*, which today occupies a prominent place in the works about medical matter of the Renaissance. In the book's dialogue between Ruano and Orta, the character Ruano represents a scholar dissatisfied with his intellectual and scientific capability, while Orta appears as a scholar with solid new knowledge, accumulated over the years, who imparts his knowledge to the illustrious disciple. The power of observation and scientific rigor in this work reveal the author's strong intellectual skills. The *Colóquios* was an innovative work that took some years to be acknowledged because it was written in Portuguese and was published in Asia [16]. Orta spent most of his life in the East, and thus far from the main centers of science; however, he knew the science of his time, the legacy of the great ancient authors and the works of his contemporaries well. In addition, he read the most important Greek and Roman authors, as well the Arab medicine books, and followed with great curiosity the modern authors. Garcia de Orta cites Hippocrates only briefly but refers many times to Dioscorides and Pliny, the two classical authors who devoted themselves to medical matters and to botany [17].

His work, rich in new facts, attracted the interest of many researchers, especially chemists. In addition, Orta indicates and defines the materials he used and the results of their separation and purification, referring to their applications. All this data was pioneering for the time. At the botanical level, Orta's work displays the characteristics and potential of numerous Indian plants, his main concern being to correct or clarify erroneous information. The large number of reprints and translations of the *Colóquios*, including those undertaken in Portugal, shows the global audience reached by Orta's work, though with some delay, and its influence in the study of vegetal substances for therapeutic use, not only in the sixteenth century but also in the centuries following [24].

Although Garcia de Orta and the Portuguese physician Amato Lusitano lived in the same period, there is no record that they knew each other personally. They had identical educational

backgrounds, and the beginnings of their professional careers were similar. However, in 1534, their personal journeys diverged: Garcia de Orta left for India and Amato for the privileged centers of European knowledge [25]. Amato does not mention Orta in his works, even though Orta quotes Amato in his *Colóquios*; as Orta was far from Europe, it was natural that his work would be delayed in coming to the main European centers [26]. This work was intermediated by the translation by Belgian physician and botanist Charles l'Écluse or Carolus Clusius (1525–1609) from Portuguese to Latin, published in 1567 in Antwerp four years after the original and the translation. Orta died the year following the publication of the Clusius translation, which, unlike the original, circulated throughout Europe [16].

Activity sheets: Garcia de Orta and the Saffron

Saffron, which is classified as *Crocus Sativus* and belongs to the family *Irudaceae*, is a spice with a long and interesting history. It has been cultivated and appreciated throughout the Mediterranean basin as a coloring, flavoring and medicinal substance since antiquity [17].

The price of saffron has always been high. It is estimated that 100 to 150 thousand flowers are needed to obtain 1 kg of this spice, and it is the only spice that equals its weight in gold [28].

The Egyptians cultivated saffron as a sacred plant and used it to paint mummies. In Babylon, it was used for making perfume, the Greeks used it to paint the hair, and many other people used it as a fabric dye, a food coloring, or a medicine (for example, for soothing teething infants) [17]. In 1714, Van Leeuwenhoek was the first to use it as a dye in histology [27]. Garcia de Orta (1500–1568), Portuguese doctor of the Renaissance, describes the plant "Indian Saffron"[1] or *Croco Indiaco* or *Curcuma* in Colloquium 18:

"It is born in Malabar, in Calicut... it also occurs here in Goa but in a small amount... Avicenna seems to mention it... Usually they use this root to dye and fertilize the food, both here and among the Arabs and Persians, for the reason of being bought cheaper than our saffron, which is also given in their land; It is also applied in medicine, especially in eye medications and for scabies"[23].

A. Answer the following questions according to the text [17]:

1. Who was Garcia de Orta?
2. Identify the name of his work.
3. Refer to the contacts or relations that existed between Garcia de Orta and Amato Lusitano.
4. Identify the properties of the plant pointed out by Garcia de Orta.
5. Explain the meaning of the term *Crocus Sativus*.
6. Why is the expression *Crocus Sativus* written in italics?
7. Compares the prices of saffron with other spices and comment on the statement "It is the only one that equals its weight in gold".

B. Research and respond [17]:

1. Explain the scientific area designated as histology.
2. Investigate the differences between plant and animal histology.
3. What is the purpose of using a dye in histology?
4. Research other dyes that are used to stain tissues. Identify their ways of acting.

C. Explore [17]:

1. Ask your family members if they use saffron and if so, for what purpose.
2. Find out if saffron is cultivated in your region.
3. Investigate some culinary traditions involving saffron in your region.
4. Investigate news about the production of saffron in Portugal.

Activity sheet: Luís de Camões and Garcia de Orta

That one example
of heroic fortress and audacity,
that he deserved in the temple
of eternity, to have perpetual day
the grain son of Thetis, that ten years
scourge were the miserable Trojans;

[1] It seems that Garcia de Orta's subject here is turmeric, not saffron. In South India, turmeric was used in place of saffron and thus had the same name. – *Editor's note.*

no less taught
was in the herbs and medical news
that right-handed and customary
in the superb exercise of the militia:
so the hands that gave so many death,
also to many could give life.

(...)

The fruit from that Orta where they flourish
The new plants, which the learned do not know.
Look for those in your years
produce an Orta insigne several herbs
in the Lusitanian fields,
which, those some *protervas*
which some herbals
Medea and Circe never knew,
since the laws of Magic exceeded

Excerpt from the poem "That One Example",
Ode VIII,
of Luis de Camões to the Count of Redondo,
Viceroy of India

A. Answer the following questions according to the poem presented [17]:

1. Identify the author of the text.
2. Identify the person to whom the text is addressed.
3. Explain the idea expressed in the text.
4. Discuss the last two verses of the second stanza.

B. Research and respond [17]:

1. Research information about the life and work of Luis de Camões.
2. Discuss how Luis de Camões influenced Portuguese culture.
3. Who was the Count of Redondo?
4. What was the relationship between Garcia de Orta and Luis de Camões?

C. Explore [17]:

1. Find other poems that allude to science or to scientists.
2. Give the names of some Portuguese scientists who are also poets.

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