Negotiating boundaries: Encyclopédie, romanticism, and the construction of science

Negociando fronteiras: Encyclopédie, romantismo e a construção da ciência

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Abstract

Natural history in the eighteenth and nineteenth centuries has been widely debated in the field of the social sciences. This paper explores the social negotiation of boundaries in the *Encyclopédie* and romantic science. Highlighting the importance of imagination and aesthetics to the scientific realms, we perceive a different comprehension of the scientific field through the empirical study of how scientific demarcation is constructed. Works by Erasmus Darwin, Goethe, and Humboldt illustrate how reliable science was performed through atypical scientific methods. After pointing out the links between literary, artistic, and scientific works, we then debate a series of changes that framed the scientific imagery of romantic and encyclopaedic sciences.

Keywords: romantic science; *Encyclopédie*; Erasmus Darwin (1731-1802), Johann Wolfgang von Goethe (1749-1832); Alexander von Humboldt (1769-1859).

Resumo

A história natural nos séculos XVIII e XIX tem sido amplamente debatida no campo das ciências sociais. Este artigo explora a negociação social de fronteiras na Encyclopédie *e na ciência romântica. Destacando a importância da imaginação e da estética para os domínios científicos, percebemos uma compreensão diferente do campo científico por meio do estudo empírico de como a demarcação científica é construída. Obras de Erasmus Darwin, Goethe e Humboldt ilustram como o conceito de ciência confiável foi elaborado por meio de métodos científicos atípicos. Depois de apontar os vínculos entre obras literárias, artísticas e científicas, discutimos uma série de mudanças que moldaram o imaginário científico das ciências romântica e enciclopédica.*

Palavras-chave: ciência romântica; Encyclopédie; Erasmus Darwin (1731-1802), Johann Wolfgang von Goethe (1749-1832); Alexander von Humboldt (1769-1859).

Accounts of romanticism are mainly dedicated to the arts, namely analysis of literary and pictorial *oeuvres* produced in the late eighteenth and first half of the nineteenth centuries. According to Lovejoy (1965), the concept of romanticism, even when restricted to the literary and artistic domains, presents a set of different meanings, which illustrates the difficulty of addressing it in the social sciences. For Abrams (1971, 1973), romanticism shares a set of social values that limit the ways its adherents understood reality: life, love, happiness, and freedom are core components of the romantic cognitive viewpoint. Wellek (1975) argued that romanticism has a kind of epistemological unity in terms of how the romantics shaped their ideas about the sensible reality. Unlike Lovejoy, Wellek claimed that romanticism was mainly based on notions such as imagination, symbolism, and myth. In this way, he maintained, romanticism as a literary movement tried to make sense of the hidden dimensions of modernity. Peckham (1951), another important name in romantic theory, defined romanticism as a cultural movement associated with the rise of a criticism of mechanical philosophy. In his view, romanticism represents a style of thinking associated with dynamism and vitalism, two cultural perspectives based on a diversified reality in a perpetual movement of change. Moreover, creativity, imagination and subjectivity appear as central features constituting the way romantics act and comprehend reality.

Intellectuals such as Schenk (1969) argued that the concept of romanticism illustrates the ambiguities of modern times, and consequently has a singular cultural character. Sayre and Lowy (1992) recently reopened this controversial debate on the definition of romanticism by considering it a *Weltanschauung*, or a world view expressing the contradictory social forces of particular historical periods. These authors state that the concept highlights central moments of the modern era, such as changes in modes of production and the development of the culture of capitalism in western societies. In this way, they maintain, romanticism no longer appears as a cultural movement restricted to aesthetics, since it also impacted the ways which politics and economy were historically shaped over the last three centuries. By pointing out how the disenchantment of the world, culture of quantification, mechanical philosophy, rationalism, and disintegration of communal social relations were taken up and explored by the romantics, Sayre and Lowy present an image of romanticism which is fruitful for science studies. As a result, in this paper we aim to address an unexplored dimension of the romantic *Weltanschauung*: the romantic conception of science, and its struggles towards reliability, validity, and objectivity.

Studies in the field of science have focused not only on how the romantics produced a singular aesthetic analytical pattern, but also on how romanticism may have started a possible second scientific revolution (Eichner, 1982; Holmes, 2008; Richards, 2002). Social theorists usually explore how romantic scientists and natural philosophers constructed new epistemological narratives for formally connecting subject and object, which has reinforced the existence of concerns around objectivity within the romantic movement (Cunningham, Jardine, 1990; Jardine, 1996; Knight, 2009; Richards, 2002). In this sense, the romantics framed a new place for imagination in the field of science, while they simultaneously created new characters for scientists. In order to do this, romantics developed new methods and analytical procedures such as poetical scientific communication and landscape paintings for scientific applications.

This paper explores some of the new scientific procedures introduced by the romantic scientists, especially those epistemological tools that modified the place of imagination in science. In this way, our main focus is on questions like how scientists from different social perspectives built boundaries including and excluding aesthetics from the set of acceptable methodological procedures in science, and how they constructed an image of what science "is" in order to conceptualize a reliable image of their scientific activities. We present an analysis of scientific imagery in traditional and romantic science, using the *Lumière* encyclopaedic movement and part of the romantic movement as case studies. By comparing these styles of knowledge, we detail their differences and analyze how they shaped different perspectives on objectivity in the scientific field.

This paper is divided into three analytical sections. The first section presents a case study of the encyclopaedic movement, exploring how the French Enlightenment culture shaped a social division of labor that modified the constitution of scientific knowledge. The second section addresses ideas British romantics contributed to science, by pointing out how Wordsworth and Erasmus Darwin renovated scientific thinking. The final section debates the German romantic tradition through an analysis of the new science of Goethe, Novalis, and Humboldt. We are mainly concerned with how the distinctions, involvements, and elective affinities between aesthetic reason (landscape paintings + science), lyrical reason (literature + science), and scientific reason (Cartesian-Baconian science) were used by the romantics as strategies for reinventing the boundaries of science.

A short note on methodology

Science and technology studies (STS) understands science to be a product of society and history (Shapin, 1982; Shapin, Schaffer, 1989; Zammito, 2004; Golinski, 2005). Science is a social phenomenon like any other: the heroic image, the clean, pure and glorious visions of science were challenged by academics interested in showing an empirical version of the sciences (Bloor, 1991; Spiegel-Rosing, 1977). STS attempts to explain the existence, strengthening, organization, growth, and reproduction of science and its discoveries through the analysis of science's ambiguous relation to history, culture, politics, and economics (Jasanoff, 2004). In doing so, STS has introduced some interesting problems to the history and sociology of science, in turn triggering a process of reinvention for the understanding of science in modern societies.

These changes impacted the selection of empirical sources for the study of past scientific activities. Without an automatically accepted view conditioning the understanding of science, it has become possible to incorporate extra-scientific facts into the history of science, especially facts that are related to the social negotiation of boundaries. In this way, boundary-work analysis has made a series of interesting contributions to fields like the sociology of science and history of science (Gieryn, 1983, 1995, 1999).

For these reasons, we do not consider romanticism as being exclusively related to the arts; they also explain why we agree with Sayre and Lowy (1992) when they claim romanticism to be a social vision of a world historically shaped by contradictory forces. This paper explores an empirical image of science as it was developed by social agents struggling for power, prestige,

and social reliability (Schaffer, 2002). Using concept from STS, we mainly focus on topics related to the sense behind the idea of scientific validation, such as how scientific methods and analytical procedures are socially constructed (Daston, Lunbeck, 2011).

The *Encyclopédie* enlightened reason

The *Encyclopédie*, or *Dictionnaire raisonné des sciences, des arts et des métiers*, was one of the most famous scientific projects of the French *Lumière* movement. Headed by Diderot and D'Alembert (1751), the *Encyclopédie* project presented different and interesting goals, as we shall see below.[1] It was not only designed to be a collection of all western thinking, it was equally envisioned as a repository for all artistic, moral, and religious ideas of the modern era, i.e., a catalog of all knowledge propositions. In this sense, the *Encyclopédie* was a synthesis of the philosophical, scientific and critical spirit that characterized the French intellectual scene in the latter half of the eighteenth century. Despite the existence of different modes of thought in France (and in Europe in general), the encyclopaedia movement appears central for sociologists of science because it depicts the impacts of one of the most important eighteenth-century intellectual movements on the theoretical and social organization of science, and this will guide our exploration.

Theoretically speaking, the *Encyclopédie* was based on a mixture of rationalism and empiricism: reality was the main key to reaching scientific truths, while rationality was the abstract base for constructing a global imagery of what science is, what scientists should do, and what scientists should look for to produce reliable knowledge about nature (Moscovici, 2000). This second empirical dimension is directly associated with the construction of boundaries separating science from "non-science," a classic case in demarcation. Thus, the *Encyclopédie* showed particular concern towards the description, analysis, and classification of empirical objects, facts, and ideas gathered via the culture of travel during western imperial expansion. On the other hand, the theoretical organization of science was also an important topic for encyclopaedists, a historical outcome shaped by the need to construct a universalistic procedure applied to the organization of a narrative based on a network of heterogeneous artefacts.

Consequently, the *Encyclopédie* elaborated a theory of knowledge aimed at rationally organizing science. This desire was clearly stated in its introduction ("Le discours preliminaire"), in which D'Alembert focused on how to consolidate a general theoretical scheme for the production of knowledge, constructing a social division of the scientific labor that was mirrored by an epistemic division of scientific knowledge. He also intended to create a systematic scheme for producing, reproducing, and justifying the propositions of this knowledge; in other words, a rational system separating good science from bad science. According to D'Alembert, isolated empirical facts were the central elements of a closed concept of truth, a systematic procedure to be incorporated by those promoting reliable knowledge through the eyes of science. This rationalization can be better explored by analyzing the frontispiece to the 1772 *Encyclopédie* by Benoît Louis Prévost. The image shows the ways in which encyclopaedic science elaborated a form of life, or a philosophical expertise, that promoted categorization of the different kinds of science and scientists according to their specific social roles. Using

their social performances in the scientific republic as a social indicator for each scientific specialty, encyclopaedists formulated a general scientific system (Figure 1).

The frontispiece synthetizes the way in which science was socially organized. In the upper section of the engraving, at center, we see Truth covered by a veil. At her right are Reason and Philosophy, who both remove the veil covering the body of Truth: one lifts the veil while the other tears it, symbolizing the scientific explanation of nature by analyzing empirical facts. Kneeling at Truth's feet is Theology, bathed in the same light illuminating Truth. Continuing to the right are Memory, Ancient History, Modern History, Written History and Time, emerging as supporters and pillars for the rational procedures of science. Below them are Geometry, Astrology, and Physics, and farther below are Optics, Botany, Chemistry, and Agriculture. At bottom are the representations of Professionals and Craftsmen, social entities responsible for the general dissemination of science among society.[2] At the top and to the left of Truth is Imagination, whose function is to beautify and to crown Truth. Below is Poetry in its different genres: Epic, Dramatic, Satirical and Pastoral. These are followed by the arts of imitation: Music, Painting, Sculpture and Architecture. According to Prévost, this encounter takes place in the Sanctuary of Truth. With this vision of science in mind, we can return to our analysis of the *Encyclopédie*'s introductory chapter.

In the introductory note, D'Alembert (1751) points out the academic place in which encyclopaedic reasoning should be positioned among the formal knowledge of the period. In the first place, the *Encyclopédie* was an encyclopaedia, but it was also a dictionary. "As an Encyclopaedia it must expose the sequencing order of human knowledge"[3] (Diderot, D'Alembert, 1751, p.I); "as a Dictionary of Sciences, Arts, and Crafts, it must expose to every science and to every occupation, liberal or mechanical, the main principles and essential details representing their bodies and substances (p.I)." Finally, in the final page of the introduction, D'Alembert introduces the "figurative system of human knowledge" (*systême figuré des connoissances humaines*), a kind of tree of knowledge stating the key principles of the organization and production of systematic scientific knowledge. According to this system, the understanding of nature was shaped by three dimensions: memory, reason, and imagination. For each dimension, new divisions of knowledge were indicated by D'Alembert: history, philosophy, and poetry (new ramifications were also presented for each: sacred, ecclesiastical, civil and modern, natural, metaphysical, the science of God, the science of man, the science of nature, sacred poetry, and profane poetry (Adams, 2006).

The frontispiece and tree of knowledge in the *Encyclopédie* symbolize the social construction of science in its multiple dimensions, a social imagery constructed in three different acts: the "rational," the "practical," and the "empirical." "Imagination" appears only as a complementary dimension of Reason. For example, Prévost's illustration shows the main characters of the French intellectual environment from which the *Encyclopédie* emerged, at the same time that it develops a normative conception of the general organization of science. These are complementary schemes, since the former symbolizes the structure of science's social organization and the latter symbolizes the rational formalization of scientific discovery processes. Consequently, demarcation of science in the *Encyclopédie* seems to be shaped by

Figure 1: Frontispiece to the *Encyclopédie*, Benoît Louis Prévost, 1772

twin logical procedures: the social organization of science, and the rational organization of knowledge. Moreover, in the encyclopaedic style of knowledge, scientific knowledge has a "disciplinary procedure" (with simultaneous social and rational meanings) that transforms the literate man into a specialist.

According to the encyclopaedists, the discovery of truth beliefs resulted from specific intellectual activities, and each character had a specific social function in terms of how scientific knowledge was produced. For instance, Reason and Philosophy were central characters for encyclopaedists because they played an important role in the rational explanation of nature, which was a core component of true beliefs since totality resulted from the synthesis of isolated parts observed empirically in the natural system. Consequently, reason and philosophy were the pillars of the encyclopaedic scientific discovery process, and imagination only played a secondary role in the discovery of valid knowledge (despite the central position of its personification in the frontispiece). Imagination only "beautifies" science's analytical procedure, according to encyclopaedists. Although her character is close to Truth in the image, Imagination has little formal functionality in the scheme presented by Diderot and D'Alembert. The hard tasks of science extend to the function of reason and philosophy, and the same can be said of the remaining characters on the artistic side of the engraving, such as Poetry, Music, and Painting. Scientific discovery is consequently driven by empirical evidence and experimentation, so the pairs empiricism-experimentation and philosophy-reason appear as the main engines of the theory of encyclopaedic knowledge. As a result, facts were not only central elements to encyclopaedists, they were the fundamental fuel of a style of knowledge committed to understanding the totality of nature through analyzing its isolated parts.

The empirical nature of encyclopaedic ideas can be easily identified. The culture of travel in the seventeenth and eighteenth centuries played a central role in the writing of the articles within the *Encyclopédie*. The encyclopaedic era was linked to the golden age of scientific expeditions, a time at which navigation, exploration, and the collection of facts and ideas were achieved through the actions of naturalist-travelers who viewed the world as a study subject.[4] Journeys all over the world were sponsored by the Royal Society and the Académie des Sciences, and undertaken by La Condamine, La Pérouse, Bougainville, Captain Cook, and many others. Terms such as "voyage" and "voyageur" appear more than 2000 times in the text edited by Diderot and D'Alembert. They were the central subjects as well as the empirical sources for the topics debated in the articles. In other words, these travels provided the empirical material that increased the social legitimation of the *Encyclopédie* as a scientific way of thinking.

The link between these travels and the *Encyclopédie* does not indicate the ways in which *Encyclopédie*'s theory of knowledge was produced, but it does give us some clues about how *Lumière* philosophers linked empirical experience with the rational classificatory procedures of traditional science. In this sense, transformation of the empirical world into general ideas was sustained by (1) the materiality of heterogeneous objects, facts, and artefacts collected during these journeys and (2) the rational procedures of the *Encyclopédie* presented in the introductory chapter. In some sense, the *Encyclopédie* created a theoretical method for classifying and organizing empirical evidence during these travels, while the evidence collected during these

journeys simultaneously helped philosophers from the *Lumière* movement shape the rational procedures of the scientific analysis published in the dictionary.[5]

Romantic science and the unity of nature

A detailed account of the links connecting reason and fruition tends to reinforce the scientific importance of what has only recently been admitted as a singular type of scientific reasoning: romantic science. Comprehension of the social construction of this particular way of thinking sheds light on contemporary scientific issues such as Charles Darwin's theory of evolution, Faraday's electromagnetism, and Oersted's theory of magnetic fields (Magalhães, 2005). Einstein's theory of general relativity is also mentioned in the academic literature as a type of scientific reasoning with strong connections to the romantic conception of science (Holton, 1998).

Examples like these introduce renewed intellectual imagery to romantic science, changing the negative preconception of the impacts resulting from the romantic conception of life (Dettelbach, 1996; Frye, 1991; Ho, 1991; Nichols, 2004; Peckham, 1951; Riskin, 2002). Initially viewed as an "anti-scientific" or even as a "pseudo-scientific" movement, romanticism in science is currently acknowledged as a cultural movement which presented interesting critiques of the limits of Cartesian and Baconian sciences, especially those limits concerning the impossibility of an isolated "scientific reason" providing valid ideas on the "totality" of nature. Let's examine how this occurred.

Romantic science created a different concept of imagination while changing the ways reality could or could not be fragmented into its elementary components. To the romantics, "vitalism" and "holism" were the chief concepts behind any scientific effort, and fragmentation as a scientific procedure was considered improper for dealing with the forces of nature. This view did not state that traditional scientific reason was completely wrong in its methodological procedures, but rather that traditional scientific reason alone was not able to fulfill the modern ambition of capturing the essence of nature. Science, according to romantic thinkers, required an internal analytical correction consisting of the introduction of subjective observations connecting object and subject. As we shall see, that link connecting subject and object triggered what can be called a period of scientific revolution.

To the romantics, imagination played a central role in science, as crucial as reason and philosophy were to the encyclopaedists. Imagination was a "biophysical principle," a calling conditioning the practice of science in its external (social) and internal (epistemological) dimensions (Rousseau, 1969). Consequently, imagination was a key component for the construction of valid beliefs in science. In order to make this possible, the romantic philosophers created an anthropocentric imagery of science, proposing an epistemology that was based on the association between humans and non-humans (Eichner, 1982). For them, nature and nurture were correlated and essential dimensions of the same scientific reality. For instance, the frontispiece to Erasmus Darwin's *Temple of Nature* (1803) illustrates the core differences between romantic science and the *Encyclopédie* in terms of how they positioned imagination within the scientific realm. Henri Fuseli's engraving was not chosen without reason by the grandfather of Charles Darwin to illustrate science: it perfectly

symbolizes the imagery of Nature (Truth) as it was imagined by the romantic scientists, as opposed to the Cartesian/Baconian view of nature. The image provides us an opportunity for a detailed look at these lyrical and aesthetical reasons, as they were formulated by the British romantic scientists (see Figure 2).

At the center of the engraving, Nature is personified by Diana of Ephesus, goddess of wild nature and purity. Through this prosopopoeia, Darwin developed a vivid identity for Nature which inspired neoclassical critics and electrified Enlightenment readers (Daston, 2004). According to Lorraine Daston (2004, p.124), Darwin desired to improve "the arts of bringing objects before the eyes, or of expressing sentiments in the language of vision." Back to Fuseli's mezzotint, at the left of Nature personified, the "image depicts the goddess of poetry pulling aside a curtain to reveal the many-breasted" Nature (Nichols, 2004, p.128). Nichols reminds us that Erasmus Darwin's "synthetic mind worked consistently to question the notion of immutable species" (p.11). The kind of science claimed by Darwin required modifications to how traditional scientific thinking was produced, a change that would impact the ways in which nature was comprehended in the scientific field.

Erasmus Darwin required a personified and humanized conception of nature, something to represent a world living in a constant process of change. Moreover, "equally important to romantic ideas about natural history was the suggestion that emotion, specifically pleasure and pain, might not be restricted to the human realm" (Nichols, 2004, p.12). Plants, in Darwin's view, had sensations and volitions like humans. Ideas like these changed the imagery of science, especially connections between subject and object. A personified Nature could only be comprehended by the minds of special natural philosophers, not by the mind of a single, cold specialist. The representation of nature pictured in Fuseli's engraving also reveals some interesting clues to how romantics were making sense of themselves: it created an image of science, and a social identity for those engaged in romantic scientific activities. To properly perform this kind of science, lyrical reason was formulated as a key act of knowledge.

Erasmus Darwin was concerned with the limits of traditional scientific reason (Cartesian and Baconian science). Fuseli's illustration is a metaphor for the functioning system of romantic science: it gives poetry a central place in scientific discovery. This metaphor was designed to represent science not as something based on causal explanation, but instead as a process of deciphering occult meanings behind a vivid and dynamic nature. It brings a critical sense to traditional science, because traditional science (a) promotes a dehumanized image of nature, (b) incorrectly separates object from subject, and (c) represents nature as a mechanical device (i.e., as a regular and predictable fact). It also formulates a critique of scientists, because they are (a) protagonists of a cold, objective, neutral, impartial and therefore sterile type of knowledge, (b) incapable of escaping the determinism of their own thoughts, (c) incapable of perceiving in nature its totalizing unity (i.e., nature's intrinsic harmony). Traditional scientific reason, as observed by the romantics, was acknowledged as an analytical procedure without a general synthesis: in their view, isolated portions of nature do not make sense at all without the perception of a full, vivid sense of the totality. Specialists were not able to provide reliable knowledge about nature because their spirits were also fragmented, which tended to weaken the capacity to understand the multiple dimensions of nature. In this way, romantic natural philosophers were indicated as predestined social agents divinely

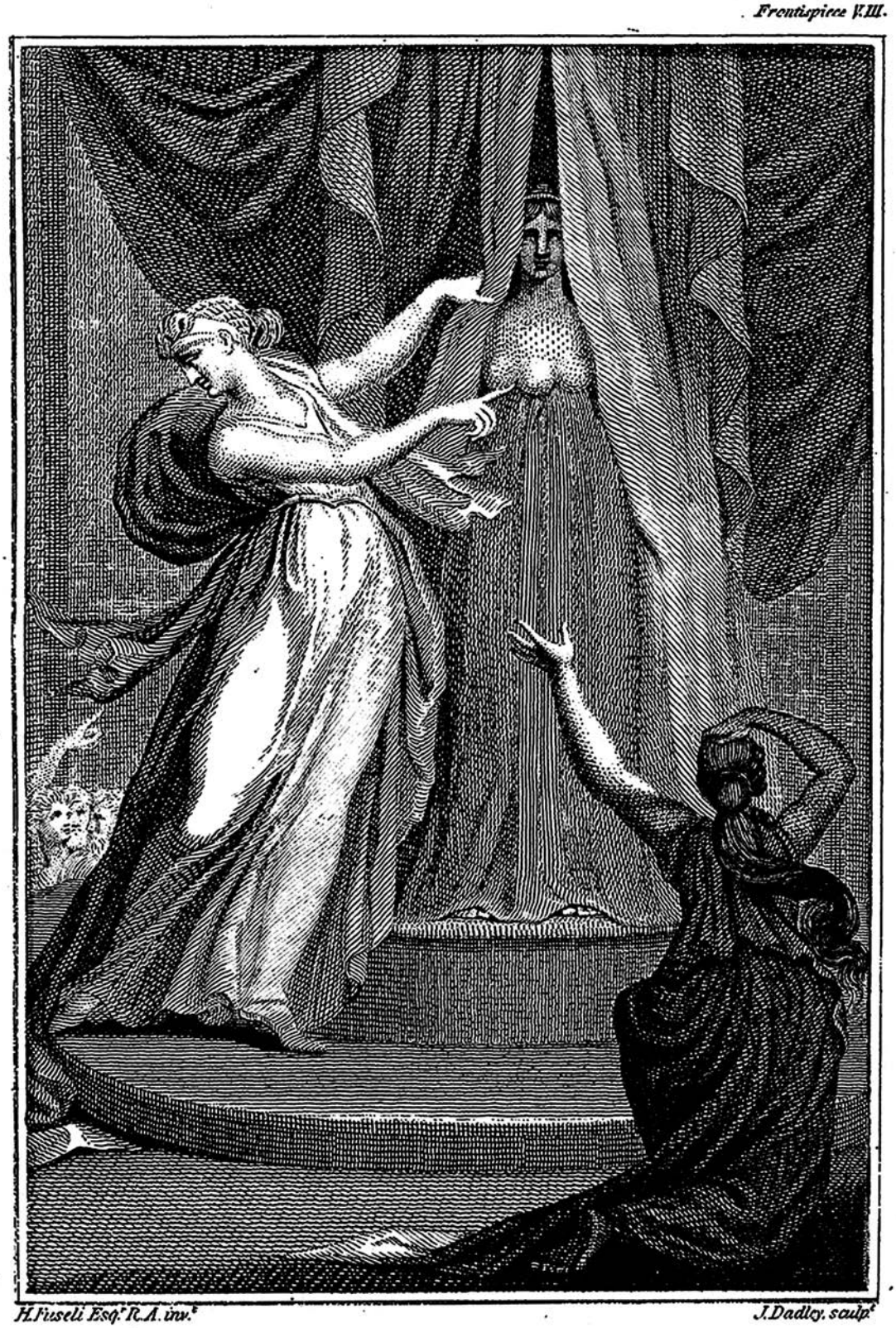

Figure 2: Frontispiece to *Temple of Nature* (Worship at the Temple of Nature), John Henry Fuseli, 1793

designed to communicate nature's real truths to the world; they cannot learn how to do it, they are born with a calling, with special skills.

Romantic ideas were influenced by a utopic sense of the possibility to escape determinism, empiricism, and mechanicism. Romantic metaphysics "affirmed that characteristics found in isolated parts of nature ought to compose the entire natural system, though under different and modified forms – reduced or expanded" (Nichols, 2004, p.18). The notion of "unit," typical in traditional science, was replaced in romantic science by a different notion based on "unity." As a result of this ontological turn, the romantic knowledge of nature required a special commitment to knowledge based on a sense of "totality." In order to perform science, romantics embraced the Hegelian claim "the truth is the whole," which expanded the scientific territory. According to romantic science, traditional reason had a limited scientific sense, because it accepted an arbitrary ontological concept based on a fragmentary reality. The problem pointed out by the romantics was that the totality could not be properly conceived through the synthesis of isolated pieces of nature: reality is more than the sum of its parts. In order to reach totality, romantic science argued that science required more than specialists, experimental methods, and simple tools of communication. Totality, as they claimed, only could be reached through a link connecting reason and fruition.

Imagination was therefore introduced as one of the chief epistemological requirements of science, a fundamental fact for romantic scientists. Often mediated by literary communication, with poetry in a special position, imagination was positioned by the romantics as a key element to produce valid beliefs about nature. Moreover, imagination was the perfect mediation between human values and nature, allowing the romantics to adjust the way in which science arbitrarily shaped the links between subject and object. Feelings, emotions, pleasure, and suffering were not restricted to humans, because according to romantic science, subject and object were connected to each other. This idea created a completely new sense of how reality was constructed and communicated by scientists. An example of this new methodological tool created by romantics is the use of poetry in the scientific narrative.

The romantics were searching for a universal language, an improved procedure for communication that would allow science to deal with totality, objectivity, and subjectivity together. Wordsworth and Coleridge (2001) diverged from Erasmus Darwin on the need for science to provide a personified image of nature, but they agreed with him on the need for romantic science to create universal language procedures. They indicated poetry as the essential language for communicating valid and universal beliefs. This was a win-win proposition in their view: poets would gain inspiration from adopting a scientific sense of reality in dealing with nature, while scientists would improve their analytical capacity towards totality by using poetic language. For romantics, communication was a central component of truth beliefs, and it would not be wrong to say that truth beliefs were based on how they were constructed by the arts of imaginative communication. Therefore, the romantic sense of objectivity (i.e., the extent to which science was precise, systematic, and visibly separated from non-science) reinvented the boundaries of traditional science by nominating the communication of aesthetics as an elementary condition for reaching totality, and consequently for constructing valid beliefs about reality.

According to the British romantics, a new scientific character was also required. Romantics replaced the traditional philosopher with a kind of "poet of nature," who was meant to improve the construction of knowledge through its ability to undergo a personal, material, and spiritual immersion in the totality. Poetry was as a chief communicative tool for mediating the links between humans and nature, a way to replace the false forms of nature and to transform them into abstract and reliable ideas. Wordsworth (2001) listed the main features of the poet of nature: a person who speaks and thinks with lively sensibility, enthusiasm and tenderness, a comprehensive soul pleased with his own passions and volitions, celebrating the spirit of life within. The poet, delighted with the goings-on of the Universe, has "a disposition to be affected more than other men by absent things as if they were present" (Wordsworth, Coleridge, 2001, p.278). The poet of nature had greater "power in expressing what he thinks and feels, especially those thoughts and feelings arising in him without immediate external excitement" (p.278). Poetry and the poet, in the view of Wordsworth and Coleridge, had sufficient epistemological powers to identify and to improve the shortcomings presented by traditional science.

Poetry creates a true image of reality by connecting humans and nature, and taking into account the importance of subjective feelings in science. The poet of nature has decisive comparative advantages over "men of science." By overcoming the linear and instrumental relationship between object and subject, the romantics expected to create an improved system of knowledge. According to Wordsworth, the poet of nature considers man and nature as adapted to each other, and the mind of man naturally mirrors nature. The idea of pleasure was also presented by the romantics as a goal to be sought by the poet and by the man of science while pursuing knowledge. The poet's knowledge of nature is a necessary part of human existence, the natural and unalienable inheritance of human nature. In contrast, the man of science's knowledge "is a personal and individual acquisition" (Wordsworth, 2001, p.281). Moreover, "the Man of science seeks truth as a remote and unknown benefactor; he cherishes and loves it in his solitude" (p.281). Meanwhile, "the Poet, singing a song in which all human beings join with him, rejoices in the presence of truth as our visible friend and hourly companion" (p.281). Finally, the British romantics pointed out that "Poetry is the breath and finer spirit of all knowledge; it is the impassioned expression which is in the countenance of all Science" (p.281).

"New Science" and feeling nature

German romanticism improved lyrical reason by framing a powerful aesthetic scientific tool: landscaping paintings applied to science. Like the British, the German romantics were also struggling on how to make sense of "totality." They agreed that traditional scientific reason had structural anomalies preventing science from communicating a universal and reliable image of nature. Like Erasmus Darwin and Wordsworth, the Germans outlined a new system of knowledge in which imagination also played a central role. They, too, required literary communication (subjective experience) for a revitalized conception of nature, science, and the natural philosopher's knowledge. In doing so, the German romantics produced a new methodological procedure for science at the same time that they shaped

a new scientific character, renovating the cold and impersonal form of life constructed by traditional scientific reason. Along with philosophical idealism, intellectuals from different backgrounds designed *Naturphilosophie*, highlighting form as the core element of universal truths. Although important, poetry was not sufficient for them to address the unity of forces organizing nature, and landscape paintings were introduced, a mechanism allowing scientists to amalgamate heterogeneous elements into universal representations of reality. Consequently, lyrical reason was improved by aesthetical reason: an artistic and scientific manner of transforming empirical expressions of reality into eternal beliefs about nature.

This focus on form as a key element of knowledge was not a novelty introduced by the German romantics. The history of form is linked to the invention of the Germanic identity by proto-national movements. Johann Joachim Winckelmann, for instance, constructed a type of knowledge idealizing the Greeks, an intellectual attempt to construct the singularity of the German people based on imitation of the classical world (Bornheim, 2009). This was not only a movement towards the classics, but also highlighted the similarities between the Germans and the Greeks in terms of how both cultures presented the impossibility of imitating beauty and uniqueness. According to Werle (2000), Winckelmann, Lessing, and Herder claimed the Germans were as special as the Greeks and consequently merited similar treatment as a singular culture. By emphasizing the special skills of the German people, the generation of Goethe, Schiller, Hegel, the Schlegel brothers, Novalis, Hölderlin, Humboldt, Schopenhauer and Nietzsche consolidated a systematic program towards the universal comprehension of reality. The *Goethezeit* thus cast light on the social and political conditions of a society living in a "bad dream" which required reformation by the minds of brilliant men of letters (absolutism, undesired external cultural influences, and so on). Together, they formed a local *intelligentsia* which inspired cultural movements like romanticism and Idealism; *Sturm und Drang*, one of the most important romantic movements of this period, was one result of this changing social order.

German ideas on arts and literature changed the ways in which reality was scientifically understood. The romantics not only saw poetry as a component of science, but the pictorial arts (particularly landscape paintings) were a fundamental tool for making sense of nature. Without these components, science could never produce a reliable image of reality; poetry and painting were therefore key procedures for constructing a valid and universal system of knowledge. In this way, imagination played a central role for the German romantics: imagination appeared as a medium synthesizing all the sensible parts of reality (evidence) by transforming them into universal knowledge (essence). They were also concerned with a living, rich, and dynamic concept of nature. Friedrich von Hardenberg's (2005) ideas exemplify this movement perfectly. According to Novalis, there are many differences between men of science and poets in terms of their capacity to create a reliable image of nature, but poets have the advantage. He states that men of science improperly fragmented Nature, making her image lifeless and meaningless. Demonstrating intimacy, the poet "has given ear to her divinely animate fancies and exalted her above the level of quotidian existence" (p.27). Nature invites the natural philosopher to her side only in moments of illness or conscience: according to Novalis, Nature prefers the company of the poet. At his side, she has the freedom required for a "frankly given answer to each of his questions" (p.27). Novalis argues that (a) those

who wish to understand Nature's essence must seek her in the company of the poet, and (b) those who wish to understand the isolated parts of Nature must visit her in the scientist's sick-room, the place in which science dissects the dead parts of Nature.

It is clear that "the loss of the unity of nature will not be answered by reason, but guided by intuition on the traces, singularities, and visions of the private world" (Jardine, 1996, p.231). This is the spirit of the romantics. The point here is how scientists could "learn with nature," not how science could explain what nature "is" by dissecting nature's component parts. Writings by Herder (1834) and Schelling (1913, 1988), for instance, focused on the concept of alienation as a key for constructing a full comprehension of the links between subject and object (subjective consciousness): in traditional science, the subject and object were improperly separated, producing a faulty (alienated) imagery of reality. They struggled simultaneously with how to recover the lost totality between object and subject (humans and non-humans) and how to produce systematic, objective, and impartial universal beliefs about nature. Therefore, singularity, individuality, and substantiality were key concepts suggested by the German romantics for creating a reliable knowledge of nature, a move intended to recover the links between consciousness and reality (the essence mediated by the existence). This system was designed to overcome the shortcomings presented by the previous paradigm in terms of alienation, and at the same time could formulate an objective system based on subjective experiments performed by the philosopher of nature. Jardine (1996) identified three pathways *Naturphilosophie* used to fulfill this task: expressive poetry, landscape painting, and absolute music. Let's take a better look at landscape painting, focusing on how German romantic natural history shaped a new scientific character, the "painter of nature."

Goethe's ideas on science and aesthetics deserve special attention because of their connection with J.P. Hackert, the famous landscape painter. Goethe has a central place in the history of German romanticism, not only because of his literary writings but also for his scientific thoughts and natural philosophical investigations. Mixing a creative and artistic perception with scientific inquiries, Goethe linked Hackert's style of painting with the quest for totality, helping his generation to develop a common analytical identity. For example, he used the concept of *Bildung* (formation) to connect reality (the external world) to subjective experience (the internal world), two important dimensions for German romantic science. Landscape paintings and literature appear as reliable tools for helping scientists transform intuitions into universal beliefs. In this way, aesthetics helped scientists build ideal archetypes, the core of romantic science for Goethe. Science was also acknowledged by the romantics as a process of cultural formation impacting knowledge and self-knowledge, which helped them develop a systematic process of self-perception and self-experimentation in the scientific realm. Finally, Goethe unified both styles of knowledge, creating a science for the totality of nature by using "form" as a key concept (Goethe, 1840).

In *Theory of colors*, Goethe (1840) argues that human beings are only attracted by those phenomena they have a deep connection with or are interested in. Knowledge, he says, is shaped by a "vital force." "We are forced to separate, to distinguish, and again to combine; by which means at least a certain order arises which admits of being surveyed with more or less satisfaction" (p.XXXVII). However, scientists "prefer substituting a general theoretical view, or some system of explanation, for the facts themselves, instead of taking the trouble

to make themselves first acquainted with cases in detail and then constructing a whole" (p.XXXVII). What Goethe intended to demonstrate here is that "nature's hard shell" twists processes of scientific understanding. Universal truths are products of a creative pure reason, and only aesthetics can produce them properly. Landscape paintings were a methodological procedure for scientists interested in synthetizing the totality of nature into a single image (Mattos, 2004, 2008).

Alexander von Humboldt, whose new science was based on a deepened connection between aesthetics, literature, and comparative science, empirically applied Goethe's procedure. *Views of Nature* (*Ansichten der Natur*) is a good sampling of his thoughts on the possibility of universal understanding of all the forces of nature through artistic and aesthetical tools. One of these artistic methodological procedures was the bird's eye view which is often used in landscape paintings. This systematic procedure allowed scientists empirical access to what they saw as the totality (the unity of all the forces of nature) of an environment. Summarizing and comparing all the forces of nature, Humboldt's views of nature were complemented by the concept of "feelings of nature," the subjective dimension of the empirical perception of reality. According to Humboldt (1826, 1850, 1875), scientific knowledge was simultaneously methodical (scientific) and delightful (aesthetical) (Ricota, 2003).

Humboldt (1850) knew that the search for totality was not a simple epistemological task. The abundance of forces of nature produces an accumulation of isolated images, which disturbs the perception of totality by the naturalist. Humboldt's view resembles Goethe's argument on the difficulties related to producing reliable knowledge by considering ideal archetypes as epistemological procedures. Humboldt argued that the combination of aesthetic reason and pure scientific aims tends to improve the cognitive abilities ideally required by natural philosophers. Moreover, the epistemological blend defended by Humboldt should help scientists in the task of purifying the chaotic set of signs and clues with which they interact, through sensory perception. For Humboldt, imagination plays a central role only when shaped by the desire to transforming the "unit" into "unity," "a pretension which is difficult to accomplish" (p.XI). To do this, science would need a new form of communication, a new scientific character as well as a new set of methodological tools (Humboldt, 1850). Moreover, science would need more than a simple philosopher in order to make sense of nature, it would need a painter of nature.

These necessary changes pointed out by Humboldt were required because of a self-destructive tendency the romantics observed in science. According to Humboldt, there were three reasons behind this tendency: knowledge constructed by an emotionless relation between subject and object, the existence of a sterile type of scientific narrative, and the presence of rational aims manipulating scientific activity. Humboldt was not only concerned with the limitations of traditional science, its instrumental reductionism and its superficiality, he was also worried about overcoming those shortcomings by introducing changes on the basis of scientific reasoning. Like Hegelian idealism, Humboldt also believed that the truth was the whole. Moreover, totality (the core of Humboldtian new science) would not only be reached through the addition of literary procedures on science: to him, "pleasure" was also needed for those interested in taking totality into account. Humboldt's new science was trying to avoid "a condition of insensitivity and monotony similar to that

which results from the enumeration of a multiplicity of private factors" (Humboldt, 1875, p.VIIII). It was a science interested in considering the "reviving breath" of nature, Humboldt argued. Like Novalis, Humboldt was considering a living nature, to its beauty, freedom, and dynamism. Consequently, in his opinion science should also take into consideration the sensations and feelings experienced by the philosopher when immersed in the different forces of nature. This is the spirit of the nature painter in German romantic science.

Finally, Humboldt's new science presented very interesting aims. First, Humboldt was concerned with a precise system for measuring and describing the physical world; second, he was worried about the influence of the exterior world over the imagination and feelings, and on how they shaped each other; third, Humboldt wanted to consider the importance of contemplating nature to the natural history system of knowledge; last, Humboldt's new science was attentive to the idea of Cosmos, which means he was trying to capture the progressive development of the planet. The new science was thus a systematic science, to the same extent that it was an artistic type of scientific reasoning. Moreover, Humboldt's total impression of nature was based on the unification of science, poetry, and landscape painting, namely a science intended to present a synthesis of all different forces of nature by different methods.

Final considerations

The romantic conception of science is still under-explored as a component of the history of modern scientific thinking. As a social movement, it does not represent the deterioration of traditional scientific reason or appear as an anti-scientific approach, as it has traditionally been considered. As we have highlighted herein, the main differences between romantic science and encyclopaedic science can be seen in the epistemological position occupied by imagination in the process of scientific discovery. For the romantics, imagination has a privileged position because it allows scientists to create systematic links between reason and fruition; in their view, this new boundary shaped a type of science characterized by a systematic search for knowledge based on freedom. Romantics were not concerned with refuting Cartesian science procedures or aims, but rather were attempting to avoid a type of reductionism that blocked an overall comprehension of all forces of nature. In order to reach this total knowledge of reality, they crafted a system of knowledge based on aesthetical methodological procedures.

The changes introduced by the romantic scientists were meant to fine-tune the procedures of traditional scientific reason. In their view, the shortcomings seen in the experimental culture of precision would be repaired by the perceptions of nature poets and nature paints. Their aesthetic scientific language would be necessary for those interested in communicating valid beliefs on nature. Since traditional science failed to fulfil this task, romantic science shaped new ways of understanding and communicating science: poetry and landscape paintings have been used as formal methodological tools applied to measuring and comparing different natural phenomena. This epistemological turn is responsible for the emergence of new forms of scientific communication, observation, and analysis of empirical data, which allowed romantic scientists to pay attention to unexplored dimensions of reality. Contributions in this area by William Wordsworth, Erasmus Darwin, Novalis, Goethe, and

Humboldt are essential, because they constructed a network of heterogeneous methodological procedures showing the limitations of Cartesian science.

It seems reasonable to conceptualize romantic science as part of a large historical movement, as stated by Sayre and Lowy (1992). The new scientific demarcations presented by the romantics were linked to social changes impacting politics, economy, and culture that reshaped the western social order. These changes constituted a *Weltanschauung* which also impacted the structure of science, bringing us back to the initial idea of this paper; the boundaries of science are under continuous construction, and the cases studied show how this negotiation in science includes heterogeneous social elements. Poetry, literary writings, landscape paintings and other media (depending on the specificities of each historical moment) are taken to be reliable components of the formal procedures of science. The cases explored herein reveal how groups of scientists attempted to open up the boundaries of traditional science to study. Similar movements reshaping science happen all the time, which makes defining science a problematic procedure for sociologists and historians of science. Romantic science helps us understand how the forces of science are embedded in the forces of society, and how they together construct the boundaries that separate science from non-science. Finally, to the romantics literature, poetry, and aesthetics were chief components of science, and without them, science would not be a reliable system of knowledge.

NOTES

[1] The original plan of the *Encyclopédie* has been debated, as well as the originator of the project; see Roosbroeck (1930).

[2] For more details on the notion of character in the *Encyclopédie*, see Coleman (1979).

[3] In this and other citations of texts from non-English languages, a free translation has been provided.

[4] *Histoire Générale des Voyages ou nouvelle collection de toutes les relation de voyages par mer e par terre* by Antoine François Prévost (1749) is as a central example. Prévost published a version of the *Encyclopédie* exclusively dedicated to knowledge on the "Science of the Ocean and Travels:" 15 volumes about expeditions and travels gathered until the eighteenth century.

[5] According to Simon Schaffer (2009), even the modern sense of scientific disciplinarization seems to be related to travels to unknown places of Earth.

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