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Othering Processes and STS Curricula: From Nineteenth Century Scientific Discourse on Interracial Competition and Racial Extinction to Othering in Biomedical Technosciences

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Abstract This paper analyzes the debates on "interracial competition" and "racial extinction" in the biological discourse on human evolution during the second half of the nineteenth century. Our intention is to discuss the ideological function of these biological concepts as tools for the naturalization and scientific legitimation of racial hierarchies during that period. We argue that the examination of these scientific discussions about race from a historical perspective can play the role of a critical platform for students and teachers to think about the role of science in current othering processes, such as those related to biomedical technosciences. If they learn how biological ideas played an ideological function concerning interracial relationships in the past, they can be compelled to ask which ideological functions the biological knowledge they are teaching and learning might play now. If this is properly balanced, they can eventually both value scientific knowledge for its contributions and have a critical appraisal of some of its implications. We propose, here, a number of initial design principles for the construction of teaching sequences about scientific racism and science-technology-society relationships, yet to be empirically tested by iterative cycles of implementation in basic education and teacher education classrooms.

1 Introduction

In the first pages of his seminal work on the origins of man, Charles Darwin made an effort to introduce his readers to the questions that the new science of evolution was posing with

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regard to the nature and fate of the distinct populations of our own species. At some point, he reveals what he thinks to be the important issue at stake:

> The enquirer would next come to the important point, whether man tends to increase at so rapid a rate, as to lead to occasional severe struggles for existence, and consequently to beneficial variations, whether in body or mind, being preserved, and injurious ones eliminated. Do the races or species of men, whichever term may be applied, encroach on and replace each other, so that some finally become extinct? We shall see that all these questions, as indeed is obvious in respect to most of them, must be answered in the affirmative, in the same manner as with the lower animals (Darwin 1871, p. 10).

Even though the Darwinian theory has been the subject of raucous controversy in nineteenth century biology, we can say that, generally speaking, the scientific community which was at that time involved in the discussion of the biological relationships between the different human groups agreed with the great English naturalist in this regard: the issues of racial competition and the extinction of human races were among the most important points at stake, when considering the problem of human evolution. Consequently, they became objects of high scientific interest for Darwin's contemporaries.

As we will discuss below, during the second half of the nineteenth century, from the most conservative to the most advanced sectors, among both monogenists and polygenists,[1] the community of scientists dealing with the biological study of human varieties considered that many native populations were at the verge of extinction, as a consequence of the competition with the "civilized races", regarded as evolutionarily superior.[2]

Nineteenth century *physical anthropology* provided, thus, a scientific support to an old thesis of the European *political anthropology*, which had its roots in a much more remote historical period. One of the thinkers who better expressed this thesis was Thomas Hobbes, who advanced in 1,651 the following statement:

> Competition of riches, honour, command, or other power inclineth to contention, enmity, and war, because the way of one competitor to the attainment of his desire is to kill, subdue, supplant, or repel the other (Hobbes [1651] 2008, p. 66).

This view of human nature, which emerged on the eve of the first great bourgeois revolution in history, would ultimately find a "scientific confirmation" in the second half of the nineteenth century, thanks to the emerging evolutionary theories about the role of "interracial competition" and "racial extinction" in the biological history of our species. The evolutionary concepts introduced by some of the major nineteenth century naturalists, such as Carl Vogt, Paul Broca, Thomas Huxley, Ernst Haeckel, Ludwig Büchner and Darwin himself, contributed to mystify in scientific terms the Victorian racial hierarchies in the collective imagination of the white bourgeoisie of that time.[3]

[1] These groups were advocates, respectively, of the unity or diversity of the human species. Polygenists thought that humans could be divided into a variable number of primate species, including white man as the most evolved of them. Monogenists, in turn, regarded humans as pertaining to a single species, and, thus, believed that all human beings had a single origin, either evolutionary or supernatural. About the belief of remarkable monogenists on the irreversible extinction of many indigenous peoples, see below.

[2] As it is always the case, we can find several to many exceptions to any historical generalization. For a more detailed discussion of the history of scientific racism, see Barkan (1992), Blanckaert (2009), Desmond and Moore (2009), Gould (1981), Haller (1995), Haraway (1989), Montagu (1997), Sánchez Arteaga (2008), Stepan (1982, 1991), Stocking (1968, 1988). About the more specific topic of biological theories about the evolution of the distinct "racial" groups in the nineteenth century, and the concepts of "interracial competition" and "racial extinction", see Sánchez Arteaga (2006).

[3] Although we could have selected as examples any of the authors aforementioned, we chose to treat in the following section mainly Darwin and Büchner.

This was summed up in 1889 by the president of the Paris Municipal Council, Monsieur Chautemps, during the celebration in the *Hôtel de Ville* of the 10th International Meeting of Anthropology, attended by the best physical anthropologists of the period:

> Politics is effectively indebted to anthropology, and Darwin, by proclaiming the law of natural selection by the survival of the fittest, has clarified in an enlightening manner the social phenomena that we witness every day (Chautemps 1891, p. 29).

We will show in this paper that, during the second half of the nineteenth century, the *scientific rationality* of human biology provided an apparatus of symbolic legitimation of contemporary imperialism. We will do so without addressing, for reasons of space and to keep the focus of the arguments on our goals in this paper, neither the general history of scientific racism, nor other extrapolations of Darwinism to the social, political, and economical spheres which were fashionable at that time, such as social Darwinism.[4]

After addressing how nineteenth century human biology managed to legitimate contemporary imperialism through a historical examination of some prominent scientific discussions about the evolutionary biology of human races, focused on the concepts of "interracial competition" and "racial extinction", we will discuss how these historical developments can play, if considered in the context of science education, the role of a critical platform for students and teachers to think in a balanced way—considering both its contributions and its limits or dangers—about the role of science in current times. This discussion is presented in the fourth part of the paper.

What can we draw from the history of the scientific discourse on interracial competition and racial extinction to present-day science teaching and learning? From our historical studies on this topic, we are beginning to work on a research project about the use of the developments in the history of science discussed in the next two sections in science education initiatives aiming at students' learning about STS relationships. In the fourth section, we will discuss the first outcomes of this project, namely, a series of initial guiding principles or *principles of design* which were basically derived from our assumptions about what would work in such initiatives, grounded on the historical, philosophical, and educational literature with which we have been dealing. Our work is aligned with *educational design research*, which aims at advancing our knowledge about the characteristics of innovative educational interventions to deal with complex issues in the classroom and the processes of designing and developing them. We are quite aware that *design principles* emerge, in this approach, from the analysis of iterative cycles of testing curricular innovations. This is not the case of the principles discussed in this paper, which were theoretically derived and should still be incorporated into the proposal of teaching sequences, which, by being developed in a series of prototypes, tested in the classroom context, will allow us to test empirically the design principles discussed preliminarily in this paper.

Thus, our goal here will be, first, to review the historical episodes at stake and then discuss a series of design principles that can be assumed as bases for the initial construction of educational interventions using the history of scientific discourse on human evolution as a basis for learning about science-technology-society (STS) relationships and the nature of science (NOS).

[4] Even limiting our examples to the restricted field of Human Biology and Physical Anthropology at the end of the nineteenth century, we do not intend here to summarize the enormous complexity of the racial debates among the scientific community at that time, but just refer to some paradigmatic scientific ideas of the racial debates of the period, as they were presented by a selected sample of representative authors.

2 The Concepts of Competition and Struggle for Existence in Nineteenth Century Biological Models About Human Evolution

We will begin by considering an example taken from Brazilian science.[5] At July 29th 1882, the First Brazilian Anthropological Exposition ('Primeira Exposição Antropológica Brazileira'[6]) was inaugurated in the National Museum of Rio de Janeiro, with the exhibition of a group of *Botocudos*, a Brazilian native group, as representatives of "one of the more brutalized indigenous races" (Lacerda 1882, p. 22). This was one of the most important scientific events that took place in Brazil in the nineteenth century and it is by no means an exclusive feature of Brazilian science.

Human beings were commonly exhibited in zoological institutions and also in anthropological congresses and universal exhibitions in a way quite similar to animal displays, and even integrated with them, during the last half of the nineteenth century (Lindfors 1999; Rothfels 2002; Bancel et al. 2002; Abbatista 2005). As a matter of fact, the tradition of exhibiting non-Western peoples in Europe goes back to centuries ago (Rothfels 2002, p. 86). From Roman exhibitions of Asian and African slaves, the practice of showing exotic natives when coming back to Europe had become an almost ordinary habit for all kinds of conquerors and/or explorers along history, from Columbus' and Vespucci's Indians to Cook's Tahitians and Robert Fitzroy's (the Beagle's captain) Fueguians. But for the first time in history, at the turn of the twentieth century, "people shows"—as they were known—began to be considered primarily as exhibitions of high scientific value:

> For scientists of all kinds—not simply physical anthropologists and physicians, but ethnologists, linguists, musicologists, and all manner of specialists (…) the exhibits provided repeated opportunities to investigate little known peoples both without the expense and danger of travelling around the globe (Rothfels 2002, p. 93).

In an article included in the *Brazilian Anthropological Exposition Magazine*, published at the occasion of the event, the Brazilian anthropologist Eunapio Deiró attempted to summarize the major conclusions that could be derived, to his understanding, from contemporary scientific studies on human evolution:

> Man—no matter if he comes from a noble and divine origin, modeled in the image and likeness of God; no matter if he is, by the law of selection, the last improved representative of the gorilla or the monkey—possesses brutal instincts, largely exerts its faculty of destroying the other natural beings. […]. To destroy, to kill, is the inevitable condition of life. […]. In the primitive state, the human vertebrate, under the pressure of physical necessities, compelled by the instinct of life preservation, destroyed his fellow beings with the brutality of the irrational. He fatally obeyed the inexorable law of the struggle for existence. […]. When hunger is satiated, the beast rests; however, man imagines and turns war into an attraction, a habit, a glory. […]. It is certain [···] that in the primitive times fight was permanent, just as it is in civilized times. War seems inseparable from the human genus. […]. War will not cease to be a state of mankind: civilization will not abolish it (Deiró 1882, pp. 18 and 34).

In the last third of the nineteenth century, ideas such as those presented by Deiró had become the biological orthodoxy in many countries. In 1900, the German doctor Ludwig Wilser stated in the twelth International Anthropological Congress, in Paris:

[5] For detailed discussions of scientific racism in Brazil, see Maio and Santos (Eds.) (1996, 2010). See also Correa (1998), Graham (1990), Sánchez Arteaga (2009), Sánchez Arteaga and El-Hani (2010), Schwarcz (1993), Seyferth (1985), Skidmore (1976), Stepan (1991).

[6] On the First Brazilian Anthropological Exposition, see Langer and Rankel (2004), Andermann (2005), Sánchez Arteaga and El-Hani (2010). The Brazilian Anthropological Exposition Magazine ('Revista da Exposição Antropológica Brazileira') can be downloaded at http://www.obrasraras.museunacional.ufrj.br/o/0029/0029.pdf.

> Although Man occupies the top of the organic scale, he has not an exceptional position in nature, and is subject to the same eternal laws as all other organisms. Its history is nothing else than the struggle between human races that arise, grow, get dominated, bloom, or fall into decay. Without any doubt, the strongest, more ingenious, and more progressive of all races is the white race. (Wilser 1900, p. 189)

A similar conception of the biological history of our species was reflected upon the remarkable words uttered by Francisco María Tubino, at the time the General Secretary of the Spanish Anthropological Society, in an allegedly objective and neutral interpretation of contemporary evolutionary theories:

> Natural selection works by means of the continuous maintenance of the advantageous changes, and thence, each new variation, in any sufficiently populated territory, would have a tendency to exterminate and replace its own less perfect relatives […]. The procedures of extinction and natural selection walk together (Tubino 1874, p. 435).

In effect, for a very representative part of *fin de siècle* human biology, the Hobbesian war of man against man had been converted into the *basic evolutionary engine* of *hominization* since the beginnings of history. Yet another example—showing how orthodox these ideas were at the time—is provided by the renowned Belgium paleoanthropologist Edouard Dupont, a pioneer of world paleoanthropology and a recognized expert in the scientific exploration of prehistoric caves. Dupont was one of the most trusted advocates of the idea that the passage from the Paleolithic to the Neolithic in Europe took place because of a *total ethnic elimination* of the archaic people who lived in the old continent by other "superior" human races or species: "It is easy to understand how this hiatus was produced. There was a full invasion, a suppression of the troglodytes" (DuPont et al. 1872, p. 311).

This theory of a total genocide that would have supposedly happened in the transition from the Paleolithic to the Neolithic, and could explain a "cultural hiatus" perceived by the archaeology of the period,[7] was generally accepted as one of the main conclusions of the International Anthropological Congress that took place in Brussels in 1872 (DuPont et al. 1872, p. 315). According to Dupont, the races that had begun to polish their stone tools fully *exterminated* the rough tool makers who had occupied European caves in the previous period. Similarly, the theories of the Belgium geologists François Cornet and Alphonse Briart depicted the Belgian Quaternary as an authentic scenario of prehistoric massacres and ethnocides. According to them, the Neolithic race of the Belgium region of Hainaut, evolutionarily more advanced than its contemporary neighbors, conquered the other prehistoric people with a truly genocidal spirit:

> The Hainaut men slowly acquired a great physical and moral preponderance over its neighbors. But, as all peoples in the wild or barbarian state, soon abused of this preponderance, exterminating and suppressing the poorly armed people surrounding them (Cornett and Briart 1872, p. 279).

The biological history of the genus *Homo* was thus presented by the nineteenth century science as a tortuous path of progress through the *destruction of all lower hominid varieties*, less fit for survival.[8] In the conceptual scheme proposed by contemporary Darwinian

[7] The idea of a cultural hiatus separating the Paleolithic from the Neolithic was originally proposed by Gabriel de Mortillet (1869, 1872). In the beginning of the twentieth century, this was a completely discredited idea (*cf.* Capitan 1900), and it was not without its detractors in the nineteenth century, as we can see in Vilanova (1880, 1881).

[8] There are remarkable exceptions that should be mentioned here, such as Quatrefages, for whom "None of the fossil human races has disappeared; all of them can be recognized in the midst of the subsequent populations with which they were mixed" (de Quatrefages and Hamy 1876, p. 311). Another interesting case is that of the renowned archaeologist and prehistorian Cazalis de Fondouce, who claimed that the primitive races had not eliminated one another in the frontier from the Paleolithic to the Neolithic, but, rather, that the new races had replaced the old ones by absorbing them without destroying their stock (Cazalis de Fondouce 1876). Another opponent was Louis Lartet, for whom it could not be inferred that industrial refinements necessarily indicated racial overlays (Lartet and Dupart 1876).

anthropology, the genocide of some hominid varieties by others was turned into a general evolutionary principle of human evolution. In 1869, during one of the talks of the Anthropological Congress in Copenhagen, the French anthropologist and prehistorian Analote Roujou revealed in a clear manner the ideological background of those ideas: "archaeologists may say, modifying a famous phrase, that the earth and the sky proclaim the glory of the Indo-Europeans" (Roujou 1875, p. 83).

The new *anthropogenesis* provided by such theories concerning the differential evolution of human populations by means of the "biological laws" of competition and extinction undoubtedly provided an improved tool for the scientific legitimation of the *status quo* regarding the racial hierarchies *de facto* established in the international political order, in a period where Western imperialism was at its apogee. Therefore, during the whole second half of the nineteenth century, the expansionist policy of European potencies could receive a biological justification, under the approval of some of the best physical anthropologists of the time. The ideological value of these scientific theories was clearly reflected in the strong economical and institutional support that the European states gave at the end of the century to studies about human evolution, even though they seemed at first to offer no straightforward consequences, other than its ideological implications (Richard 1995; Sánchez Arteaga 2006).

3 The Biological Causes of the Extinction of Human Races

In *The descent of man*, Charles Darwin devoted a whole section of chapter VII to the major problem of "the extinction of the races of man" (Darwin 1871, I, p. 236ff). There, the British naturalist states that "the partial and complete extinction of many races and sub-races of man are historically known events" (p. 236). In spite of Darwin's own position and personal commitment against slavery and racial oppression (Desmond and Moore 2009), the interpretation suggested by his theory to the contemporaries was one in which the gradual (partial or complete) disappearance of "inferior races" could be understood as a sort of Darwinian corollary of the colonial process, conceived in terms of biological groups struggling for their existence.[9]

Darwin had no doubt in proposing a biological parallelism between the "future fate" of the native races "with that of the native rat almost exterminated by the European rat" (p. 240). Darwin urged the naturalists, since the first edition of *Descent*, to investigate the "inferior races", since they would be close to extinction. The subject was pressing, due to the state of evident *biological regression* of the savages in the face of the inexorable power of the white race in the five continents. In effect, the disappearance of those peoples, alongside with the likely future extinction of the great apes, would mean the irreparable loss of a first-class scientific material for the study of the ancestral hominid stages of the white man:

> At some future period, not very distant as measured by centuries, the civilised races of man will almost certainly exterminate and replace throughout the world the savage races. At the same time the anthropomorphous apes, as Professor Schaaffhausen has remarked, will no doubt be exterminated. The break will then be rendered wider, for it will intervene between man in a more civilised state, as we may hope, than the Caucasian, and some ape as low as a baboon, instead of as at present between the negro or Australian and the gorilla. (Darwin 1871, I, p. 201).

[9] See, for example, Bendyshe (1864), Lee (1864), Hillier Giglioli (1874).

In perfect harmony with the British naturalist, Ernst Haeckel—in his *Natürliche Schöpfungsgeschichte* (*Natural History of Creation*) (1868), which would become one of the more influential biological works of all times—showed no doubt in claiming, from an exclusively biological point of view, that the Germanic race would prevail over the rest of the world (Haeckel 1868, p. 127). Moreover, for Haeckel, "the steady progress of civilization by means of improving the permanent armies" (Haeckel 1877, p. 155) was a natural corollary of the laws of human evolution that had led to the Indo-European supremacy. According to him, it was due to nature herself that "wars became naturally more and more frequent" (Haeckel 1868, p. 127). Consequently, one could regard as futile any attempt to use artificial measures to oppose the *natural* process of expansion of the white rule over the rest of the human races—for Haeckel, distinct primate species.

Similarly, Ludwig Büchner—author of one of the greatest bestsellers among popular science texts of the period, *Man in the past, present and future*—maintained that the interracial struggle for existence would primarily benefit the brain:

> For as man now-a-days carries on his struggle for existence chiefly by means of this organ, and this will be the case more and more hereafter, so the beneficial and propulsive consequences of this struggle will also be favourable to this organ and its activity, as indeed we know from experience it has been in the past" (Büchner 1894, p. 193).

For this author, the war between races was not something to bemoan, but rather to celebrate as a blessing from heaven for the Caucasian group, whose *prodigious brain organ* would have evolved specifically from the combat, by the combat and for the combat:

> Even backward peoples or races when, favored by their small personal requirements, they come into competition with civilized man, (as in the case of the Chinese and Africans in America,) can only stand this competition permanently when they at the same time adopt all the existing aids of civilization and follow the same general course by which humanity is at present striving to reach its ideal of civilization. But by this means they also are carried away, perhaps unwillingly or at least unconsciously, by the general movement of civilization which has been set going by the more highly developed brain of the Europeans, and thus sink more or less as specially characterized races (Büchner 1894, p. 193)

The inexorable future of the biological extinction of many indigenous peoples was an accepted fact even for some authors who had been the most distinguished among those defending the biological unity of our species (monogenism) and fighting against slavery, such as Armand de Quatrefages, Juan Vilanova, and Darwin himself. For the Spanish physical anthropologist Vilanova, for instance, the peoples of Polynesia were "getting close to extinction very quickly" (Vilanova 1884, p. 229). Similarly, the Bushmen people, according to Vilanova, a true relic of ancient Paleolithic races, would soon become extinct under the pressure of superior races, leaving their beautiful rock paintings as the only testimony of their ancient presence on the planet:

> The Paleolithic artists were defeated by the least artist, but agricultural, Neolithic populations. The remnants of those peoples are still among us, and Bushmen, for sure, will soon disappear, not leaving any other tracks of their history but the drawings made by themselves on the rocks (Vilanova 1884, p. 226).

The rush to study the savages of distant continents, before their predictable extinction at the hands of the white race, was beginning, however, to bear fruit as an unprecedented proliferation of scientific (ethnological, anthropometric etc.) descriptions of those people. In due time, these anthropological studies would result in a change of perspective on the indigenous people. But this would have to wait for the mid-twentieth century. At the end of the nineteenth century, these technical studies led authorities of the European ethnology,

such as Sir John Lubbock (who never left the old continent[10]), to establish with plain certainty the existence of an impenetrable border separating the European brain from the brain of the other human populations on Earth:

> The whole mental condition of a savage is so different from ours, that it is often very difficult to follow what is passing in his mind, or to understand the motives by which he is influenced. Many things appear natural and almost self-evident to him, which produce a very different impression on us. 'What!' said a negro to Burton, 'am I to starve, while my sister has children whom she can sell?' (Lubbock 1889, p. 7)

Similarly, Darwin himself had provided a serious biological justification for this view, when he stressed that, in certain cases, the degree of self-consciousness shown by the savages might not be much higher than that shown by the most intelligent mammals:

> But can we feel sure that an old dog with an excellent memory and some power of imagination, as shown by his dreams, never reflects on his past pleasures in the chase? And this would be a form of self-consciousness. On the other hand; as Büchner has remarked, how little can the hard-worked wife of a degraded Australian savage, who uses hardly any abstract words and cannot count above four, exert her self-consciousness, or reflect on the nature of her own existence (Darwin 1871, I, p. 62).

Indeed, Büchner had clearly shown his scientific opinions with regard to the zoological status of the Australian populations. From a strictly biological point of view, the renowned German biologist asked if it was indeed possible to say that many savages were truly human, in the same sense as the European were. For Büchner, the answer was less clear than common sense or the philanthropic spirit of the scientifically uninformed would suggest:

> There are men and tribes and conditions of human life upon the surface of the earth characterized by such an absence of every thing that the cultivated European is accustomed to regard as the eternal and indispensable attribute of humanity (…). Articulate language (…) the most characteristic attribute of man (…), occurs among some savage tribes in such a rude and imperfect condition that it can hardly be called language in the human sense of that word (Büchner 1894, pp. 168–171)

In short, the scientific *animalization* of non Western peoples, taking place by a process of *othering* (Kitchin 1998; Johnson et al. 2004; Grove and Zwi 2006) strongly grounded on science, reached at the end of the nineteenth century its theoretical summit, its maximal degree of rationalization in all historical times. For the anthropologists aligned with polygenism,[11] the extinction of numerous native peoples during the colonial process was an issue whose causes were exclusively in the biological field. In this regard, it is worth remembering a claim made by the great North-American physical anthropologist Josiah Nott to the effect that the history of the non European people (which presumably comprised also the history of their extinction) was only a chapter of *natural history* (Nott 1866, IV, p. 103, *apud* Haller 1995, p. 81).

At the end of the nineteenth century, according to the discourse of many naturalists, the *Homo europaeus albescens* described by Linnaeus in the previous century was striving for scientifically proving that, in the case of the non white populations,

> all the supposed specific distinctive characters between man and animals fall away, and even those attributes of humanity which are regarded as most characteristic, such as the intellectual and moral qualities, the upright gait and free use of the hands, the human physiognomy and articulate language, social existence and religious feeling, etc. lose their value or become merely relative as soon as we

[10] Symptomatically, the quotation "We may sit in our library and yet be in all quarters of the earth" is usually attributed to Lubbock.

[11] The polygenists included many of the most orthodox evolutionists of the time, such as Haeckel, Broca, Topinard, Vogt, while others, like Darwin himself, were monogenists.

> have recourse to a thoroughgoing comparison founded upon facts. In this, however, we must not, as is usual, confine our attention to the most highly cultivated Europeans, but must also take into the account those types of man which approach most nearly to the animals, and which have had no opportunity of raising themselves from the rude, primitive, natural state to the grade of the civilized man (Büchner 1894, pp. 166–167).

4 Learning About STS Relationships from the History of the Scientific Discourse on Interracial Competition and Racial Extinction

By dealing with the original works discussed above, which convey historical discourses on interracial competition and racial extinction, we got to the conclusion that valuable contributions to science education curricula, along the line of STS approaches, can result from dealing with those historical cases. This launched us in a research program for developing and testing teaching sequences with this nature, from which we derive this paper, as a first outgrowth. Certainly, we could have chosen other historical cases instead of the literature on interracial competition and racial extinction, addressing other ideas in orthodox debates about human biological diversity, which supported scientific racism in the past, but we think that literature provides us with a proper background for what we intend to do. The main rationale for our proposal of building such teaching sequences is that to address in the science classroom those discourses on interracial competition and racial extinction can play a relevant role in current science education, as a platform for a critical appraisal of the contributions and risks associated with scientific knowledge in relation to society and technology, both in the past and in the present.

In particular, we are interested in the connections between scientific knowledge and processes of *othering*, i.e., of generating others, of marking and naming those thought to be different from oneself, or from the idealistic "Us" which conforms our own community (Weiss 1995; Grove and Zwi 2006). nineteenth century's biological discourses on interracial struggle constitute one topic that gives room to meaningful classroom discussions on the significance of othering practices in the history of the biomedical sciences. It would have resulted equally instructing had we talked about scientific attempts to prove the intellectual superiority of men above women, so common during the nineteenth century (Sánchez Arteaga 2007), not to say about nineteenth and twentieth century's eugenic movements, which had terrible practical consequences in many different countries of Europe, America, and Oceania. As it is well known, up to the 1940's, hundreds of thousands of people suffered, throughout most of North America and Europe, from radical marginalisation practices based on an essentialist understanding of what constituted the acceptable biomedical standards of human nature, erroneously assuming that there might be an uncontested biological definition for able and disable bodies. Those extreme othering practices varied from sterilisation to direct execution, as in the case of the more than 250,000 disabled people murdered during the period of National Socialism in Germany (Hansen et al. 2008), following policies which were based on the eugenic knowledge of the time and, while taken to an extreme by National Socialism, cannot be regarded as just its creation.

But it is not our goal here to present a comprehensive history of othering in the biomedical technosciences, as it was not our intention to summarize the history of scientific racism in the previous two sections. We chose the example of interracial competition and racial extinction just to show that, many times, the history of science can remind us—scientists, science students, and science teachers—that the practical implementations

of biomedical theories and discourses in modern societies cannot be correctly understood unless we take into account the socio-political and historical contexts in which they actually take place (Browne 2007).

History of science can play an important role in the education of both science students in basic education and future researchers and teachers in colleges and universities by addressing the biomedical technosciences, allowing them to be consciously aware of the biomedical potentiality to fall into marginalizing and othering practices. Taking a historical distance for analyzing scientific othering practices makes it easier for students to understand that scientific marginalization always occur within complex social webs of culturally mediated assumptions. Our basic idea is that, while it might seem very easy for the students to dismiss developments of the past scientific work as uninformed and irrelevant, if we begin with the nineteenth century discourses on interracial competition and racial extinction, and manage to bring home the lessons about othering that they can teach us, we can build a platform to put contemporary examples under a more critical light. Surely, this is at this stage a theoretical proposal that needs testing in the classroom, in order to see if this move is really feasible. That is precisely where we are going now with this project.

However, a pedagogical usage of the historical episodes at stake needs to be counterbalanced by a discussion of the benefits of science in relation to society and technology, including those connected with racial issues, in such a manner that the critical appraisal of STS relationships can be properly balanced, avoiding merely anti-science discourses or unbridled criticism of science. Our goal is not only to use these historical developments as a platform for criticism, but, most of all, for properly balanced criticism, i.e., which recognizes not only the risks and perils of science, but also its benefits, contributions, and role in human culture. Nevertheless, an appreciation for science does not need to be an uncritical praise; rather, it is vital that students, to be properly educated in science, recognize the ideological functions of discourses derived from scientific theories and findings. One of the best ways to do so is to make use of the advantages of a historical perspective, examining the ideological roles of scientific discourses of the past in order to bring to light the ideological undertones of present-day discourses which are related to contents now addressed in science education.

Our work is aligned with a research approach named *educational design research*, which we regard as adequate to address the theoretical and methodological challenges of developing complex interventions in classroom settings (Brown 1992). Education design research can be understood as the systematic study of designing, implementing, evaluating, and maintaining innovative educational interventions (or, to put it differently, learning environments) as solutions to complex problems in educational practice (Baumgartner et al. 2003; Plomp 2009). Design research can be used as a common label for a family of related approaches, which may vary to some extent in goals and characteristics—design studies, design experiments, design-based research, developmental research, formative research, (educational) engineering research (Van den Akker et al. 2006). The goal is not only to develop the educational interventions per se, but also to advance our knowledge about the characteristics of these interventions (design principles) and the processes of designing and developing them. Our approach to educational design research is also in constant dialogue with the view that contextual approaches to science education, as advocated for a long time by many authors (e.g., Robinson 1965; Lederman 1992, 2007; Matthews 1994; Driver et al. 1996; Carvalho and Vannucchi 2000; McComas 1998), pose complex educational problems.

The main research question in an educational research project carried out from this perspective is to establish what are the characteristics or design principles of an

intervention X for obtaining the outcome $Y(Y_1, Y_2, \ldots, Y_n)$ in context Z (Plomp 2009). The design principles should be proposed on the grounds of both the relevant literature and the empirical investigation of intervention prototypes, i.e., successive versions of the intervention submitted to empirical studies at real classroom settings. The literature at stake can be related to educational theories, existing design principles, technological innovations, and other literature regarded as relevant to the particular educational intervention under investigation.

The present paper addresses a first step in the construction of an intervention prototype dealing with STS relationships by using scientific racism and, in particular, the literature on interracial competition and racial extinction as a ground to treat in the classroom the complex relationships between science and society. The design principles discussed in the next section will still have to be empirically grounded on iterative testing of teaching sequences in the classroom. However, as we do not think that we can build a teaching sequence from a theoretical vacuum, we regard as an important step to derive from the historical, philosophical and educational literature, as well as from our experience as researchers and teachers, initial proposals about principles to guide the building of teaching sequences through which they will be subsequently tested.

5 Initial Design Principles for Building Teaching Sequences About Scientific Racism and STS Relationships

From primary sources on interracial competition and racial extinction, secondary sources on the history of scientific racism, the HPS literature, and our experiences as researchers and teachers, we derive in this paper some initial design principles to develop and implement innovative educational interventions for discussing scientific racism and STS relationships in the classroom.

A first design principle concerns the curricular approach that seems more adequate for the development of the intervention at stake. In our view, STS approaches are a natural choice for a proposal of using the history of scientific racism, more specifically, the discussions about interracial competition and racial extinction as a platform for examining biological discourses in current times and their putative ideological functions. After all, STS curricula seek to put into question the ideological, political, economical, sociocultural, environmental and ethical values, interests and actions interconnecting scientific investigations, technological developments, and social processes. Moreover, the educational intervention at stake here share with STS curricula the goal of promoting a learning environment that makes it possible to educate individuals who are capable of participating in a critical and informed manner in debates about scientific and technological development, and, thus, of playing some role, at least, in decision making processes related to science and technology that can affect their individual and collective lives (Pinheiro et al. 2007).

STS curricula have been studied and discussed from different perspectives and with diverse intentions (e.g., Solomon and Aikenhead 1994; Santos and dos Mortimer 2002; Pinheiro et al. 2007; Nashon et al. 2008; Cassiani and Linsingen 2009; Aikenhead 2009; Yager et al. 2009; Lee 2010). Here, we are particularly interested in the association between these curricula and contextual approaches to science education (e.g., Matthews 1994; McComas 1998; Celik and Bayrakceken 2006; Lederman 2007; Praia et al. 2007), which makes it possible to combine a treatment of NOS, considering the epistemological,

historical, and sociocultural dimensions of scientific work, with a critical understanding of STS relationships.

A second design principle in an educational intervention addressing the uses and ideological functions of scientific knowledge in relation to racial issues is, thus, to address STS relationships while giving enough attention to NOS, for example, to the views about what constituted valid scientific knowledge in the nineteenth century and how it could be obtained. In this manner, we can treat the historical developments under consideration here without losing from sight, for instance, the need of their proper historical contextualization, in such a manner that the students can access the circumstances in which they took place. This may avoid that students simply project either the past into the present or, anachronistically, the present into the past when interpreting historical and current studies that bear on our views about race.

A third design principle is that the treatment of the relationships between human biology and racial issues must be balanced, avoiding merely praising or demonizing scientific knowledge or conveying the idea that it would bring only positive or negative consequences. It is advisable to address in the classroom both the contributions and the limits or risks of scientific knowledge and its practical applications.

If we consider, for instance, evolution teaching, which is an appropriate context within biological education for the discussion of scientific racism, our understanding is that, before addressing the ideological function of evolutionary thinking with regard to the question of races, we need to consider through classes, texts, activities, its contributions to socioscientific issues. After all, evolution education has been regarded as fundamental to citizenship education, say, for decision making in specific socioscientific situations (Sadler 2005). A proper understanding of a variety of biological processes that have social bearings depends on evolutionary thinking, such as bacterial resistance to antibiotics and pandemics caused by emerging viruses (Futuyma 2002; Meyer and El-Hani 2005) or genetic improvement of plants and animals used by humans (Bull and Wichman 2001; Futuyma 2002). Moreover, evolutionary theory became in recent times, by means of phylogenetics, one of the grounds for disease monitoring and species identification for medical, pharmacological, and conservation purposes. Recently, bioinformatics studies based on the application of evolutionary thinking became central for the planning of biotechnological protocols used in the production of new medicines and industrial enzymes, for defense against agricultural pests and resistant pathogenic organisms, and even for the development of new computer technologies (Bull and Wichman 2001; Meyer and El-Hani 2005). The understanding of biological evolution can thus empower people by making them able to position themselves in the face of challenges with direct consequences for their quality of life.

Once established in the classroom the value of evolutionary thinking, we can look into the past in order to pose questions that are consequential to the critical appraisal of scientific knowledge in the present. This look into the past can be fruitfully built around primary and secondary sources, many of them quoted in the previous sections, that can be, with due selection and adaptation, valuable resources for teachers' work, providing the students with access to the scientific discourse about interracial competition and racial extinction at the second half of the nineteenth century. There can be no doubt that a careful work of selecting and editing material from the primary sources is needed in order to build an adequate educational intervention. Similarly, suitable passages should be selected from the secondary sources, in particular works from historians of science that, once adapted for teachers and students, can make it possible that they understand the historical context in which the primary sources used were framed, interpreted and understood.

Accordingly, a fourth design principle for the educational intervention at stake here is to utilize selected and adapted passages of original, primary sources, as well as secondary sources, mainly works on history of science that can provide a due historical contextualization.

A fifth design principle is that one cannot simply jump from the nineteenth century scenario to present-day STS relationships. It is necessary to consider, even if in passing—due to the constraints of school time—the transformations that took place in both human biology and anthropology in the twentieth century.

It is important to give attention, for instance, to the emergence of cultural and social anthropology (Harris [1968] 2001). On the one hand, the anthropological articulation of the concept of culture resulted in a reaction to previous discourses based on a mere opposition between culture and nature. Indeed, this opposition was behind the contrasts between civilized and native men that were so often put forward by the nineteenth century physical anthropologists. On the other hand, the concept of sociality led anthropologists to focus on social groups and institutions, their roles and relationships, and this also counteracted the naturalization of categories such as "race". Culture and sociality, if conceived in these terms, transcend the opposition between natural and cultural states of human beings, making it possible to address humans in two different but complementary senses—as an animal, endowed with biological bases for his or her individual and collective behavior, and as a sociocultural being, whose behavior and social participation are *fundamentally* shaped by his or her development under the influence of a given sociocultural context.

With regard to human biology, it is vital to consider the changes suffered by our knowledge about evolution since the emergence of the evolutionary synthesis in the 1940s, and, more recently, with the debates on how we understand evolutionary patterns and processes (Gould 2002; Bowler 2003; Meyer and El-Hani 2005). Moreover, we cannot dispense with teaching and learning about new tools for investigation, such as genetic, molecular, genomic, and proteomic techniques, and their consequences to our state of knowledge about ourselves, our genetic heritage and evolutionary history. For example, it is germane to include in an educational intervention dealing with the relationship between biological discourses and races a discussion about the implications of current genetic research that put into question the very existence of races in the human species (e.g., Templeton 2003; Long and Kittles 2003; Royal and Dunston 2004; Koenig et al. 2008). On the one hand, this development can be seen as an important contribution of science to decrease racism nowadays. On the other hand, one may regret that biologists are dismissing races precisely when affirmative actions, strongly based on racial discourse, are increasingly proposed throughout the world. This is the kind of scenario that may bring to the forefront in the classroom the complexity and multifaceted nature of STS relationships.

In order to take in due account the changes in the discourses about races in twentieth century anthropology and biology, we need to develop programs and materials that recontextualize the academic discussions in these disciplines as part of school knowledge. This is, in fact, something that pervades all the efforts to build educational interventions. Scientific discourses need to suffer a series of transformation to be taught and learnt in the classroom.[12] These transformations are in themselves objects of investigation, to be addressed by means of the construction and testing of resources associated with the educational interventions. In the case of the current denial of the biological existence of races

[12] See, for instance, discussions about the construction of school scientific knowledge from the different perspectives of didactic transposition (Chevallard 1991; Astolfi and Develay 1991; Clément 2006) and pedagogic recontextualization (Bernstein 1996; Marandino 2004).

in the discourse of genetic research, the construction of such resources can benefit from the availability of newspaper and popular science texts addressing the issue (Leroi 2005; Schlemmermeyer 2005; Salzano 2007).

The prospects of combining a discussion of nineteenth century and 21st discourses on races from the perspective of biology become even more interesting when we consider the potential of addressing NOS issues by means of current controversies within biology itself about the denial of races on the basis of studies on human variability (e.g., Edwards 2003). And, if we do not limit ourselves to biology, the polemics becomes even more interesting, since the biological arguments do not allow one to deny, quite simply, the existence of race as a social category, capable of influencing collective and individual behavior, social dynamics, sociopolitical participation. It is crucial, then, to consider that biological arguments can indeed reconstruct racism on other grounds. As Smedley and Smedley (2005, p. 16) argue,

> Racialized science seeks to explain human population differences in health, intelligence, education, and wealth as the consequence of immutable, biologically based differences between "racial" groups. Recent advances in the sequencing of the human genome and in an understanding of biological correlates of behavior have fueled racialized science, despite evidence that racial groups are not genetically discrete, reliably measured, or scientifically meaningful.

The persistence of a racialized discourse in biology, as maintained by these authors, becomes clear when we consider recent examples of racialization practices in twenty-first century biomedical technosciences, which can be said to have reinvented processes of scientific othering. A sixth design principle, thus, is to address these current othering processes, as a way of connecting 19th historical cases of othering with knowledge that is being taught to students in the present-day classroom.

Despite all the discourses and perceptions of globalization, we still continue to create in our times symbolic boundaries between different human groups. We keep creating new "Others" of all kinds. We keep inventing reasons to think of those "Others" as profoundly diverse from "Ourselves", and we keep using those reasons to marginalize and stigmatize them. The Other is an inevitable construct, a cultural creation of our social minds which is part of our process of identity construction, present in all cultures across human history. However, the rate of its production has increased exponentially in modern and postmodern times, coinciding with the global multiplication of all kinds of contacts between communities that had remained (spatially or symbolically) separated, closed, or isolated before globalization.

By means of othering, we mark and name those thought to be different from ourselves (Weiss 1995). Othering processes serve as symbolic instruments for defending and strengthening one's own identity by means of excluding, segregating and/or marginalizing an (other), creating a gap between "us" and the "othered". In this manner, the Other is subjected to a diversity of ways of social exclusion and disempowerment (Grove and Zwi 2006). Since to produce "Others" is an inevitable part of the construction of identity, the point at stake cannot be to avoid othering processes from happening, but how we can become self aware of it, so as to put it into question the social consequences of our empowerment in the face of Others' disempowerment. Here, education has a crucial role to play, and, in particular, science education is in a key place to address othering processes, due to the fact that scientific developments have been used, throughout the history of science, to fuel othering processes. Indeed, the discourse on interracial competition and racial extinction, discussed in the previous sections, can be interpreted as an avenue for using scientific knowledge in order to build a notion of Others, which would be so different

from Ourselves to the point of not being humans, or being semi-animals. This is one of the reasons why we regard the historical developments related to the construction of that discourse so powerful to engage with in a STS curriculum.

However, as we have been stressing throughout this section, this is not a curriculum that should look only into the past, but, rather, use the past to illuminate the present. In particular, if we focus on biological education, one of main processes of producing symbolic boundaries between "Us" and "Others" in the present-day has its origins in biomedical technosciences, which exert an increasingly influential role in our social and individual lives. A seventh design principle, thus, is to incorporate in classroom work a discussion of biomedical technosciences that can empower students to act as critical and informed citizenships with regard to their role in technology and society. And this can even go beyond biomedical technosciences, since in many different contexts, the practical implementation of technoscientific knowledge in society has a potentiality to give rise to practices of othering and marginalization, even if these practices remain unnoticed or tacit most of the times (Browne 2007). In the next section, we will discuss some othering processes related to current science and technology that can play a role in a STS approach to scientific racism in the science classroom.

We presented in this section seven design principles to build teaching sequences for learning about STS relationships from the discussion of scientific racism and othering processes in the past and present. Such teaching sequences may help in the development of a critical and balanced understanding of STS relationships by the new generations of students. Obviously, we should put into question if high school students, for instance, can ever reach the kind of balanced criticism that we have in view, which demands a rather sophisticated reading of how science and technology are related to each other, and how both are mutually associated with society, in a manner that avoid Manichean interpretations that see in science and technology only the complete goodness or the greatest evil. After all, in order to attain such a balanced critical appraisal, one needs to build an adequate comprehension of the scientific enterprise and, moreover, be endowed with enough maturity to make the complex judgments required to evaluate the benefits and risks involved in STS relationships. We do not wish, however, to dispense with the possibility that high school students can reach such a critical and balanced standpoint merely for a priori reasons. We feel that this is something to be empirically investigated, even if we conclude, a posteriori, that the educational goals put forward in the interventions we are constructing cannot be reached at the high school level. If this conclusion is reached, however, it will still be the case that in teacher education and in the education of new generations of researchers, it is necessary to introduce the discussion of STS relationships related to the use of biological ideas to justify racialist practices.

6 Othering Processes in Current Biomedical Technoscience

There are several examples that can be used to address both past and present othering processes in STS curricula. We discussed above the debates on interracial competition and racial extinction as one apt example from the past. Let us mention now some current developments that can be used in such curricula. For example, othering processes based on disability, gender, health status, and ethnicity has been reported to have critical consequences for access to, and delivery of, health assistance all around the world (e.g., Kitchin 1998; Flowers 2001; Kang et al. 2003; Phillips and Drevdahl 2003; Johnson et al. 2004; Grove and Zwi 2006). Contemporary conceptions of culture, race, and ethnicity continue to

be constructed and applied in many local sociopolitical situations, including local contexts closely related to the biomedical technosciences, especially with regard to health care and even to health research (Browne 2007). Emergent new configurations of inequities keep exerting their distinctive effects in many new biomedical contexts, as shown by works about the effects of social exclusion, othering, and racialization on medical assistance. Michael Marmot, for instance, showed that indigenous peoples' health is worst than the mean health standards in the total population even in rich countries such as Canada, USA, New Zealand, and Australia (Marmot 2006). In each case, the gap between the indigenous groups and the total population is substantial. In New Zealand, for example, it has been showed that, at each socioeconomic level, Maoris have higher mortality than white people (Tobias and Cheung 2003; Marmot 2006). In the USA, Native Americans and Native Alaskans have lower life expectancy than the total population (Bramley et al. 2005). In a similar way, aboriginal people are the unhealthiest population in Canada, with aboriginal women experiencing a disproportionate burden of ill-health compared to both aboriginal men and other Canadian women (Browne 2007). We could naturalize these patterns, but the evidence points, rather, to unequal access to the benefits of medical assistance and, increasingly, of biomedical technosciences as a major factor in explaining the gap between the health of indigenous populations and the total populations of different countries.

Another example that can be used in the classroom to address biomedical inequalities based on race and ethnicity, with the benefit of historical perspective given by the examination of the nineteenth century racial discourses, is found in health services provided to immigrants and refugees in many developed countries, by means of discriminative public health systems. Normally, immigrants and refugees have specific health needs, because, in many cases, there has been high exposure to disease and ill-health conditions during their trips to the receiving countries or, else, in the socioeconomical conditions of their original countries. However, rather than acknowledging these special needs, they are treated as menacing agents by public health systems in many developed countries. According to some authors, many receiving countries have become concerned with positioning the immigrants' health problem as their "diseased state" and highlighting the risk that refugees pose to others in the community (Grove and Zwi 2006). Other researchers have underlined the racialist undertones of the political discourse that is normally employed in epidemiological debates in many receiving countries, in order to influence the public health systems. This discourse often establishes a direct link between immigrants and epidemics, conjuring images of contagion threats, and reinforcing the need for quarantine and separateness, with a presumed scientific justification of the role of mandatory detention for illegal immigrants and refugees (Koutrolis 2003). According to some authors, the desire of wealthy countries to present themselves as an unattractive option to "would-be refugees" is making the problem worse and worse, contributing to a progressive reduction in available public health supports and services for immigrants and refugees, a solution that, contrary to what is supposed, does not protect the broader community (Grove and Zwi 2006).

The renewed force of eugenics in the post-genomic era is another development that can be addressed in the STS curriculum proposed here. The fact that modern human genetics can be used to create new, unprecedented potential Others, is worryingly clear when we read documents such as the fierce manifesto for reprogenetics produced by Silver (2007). There we find an optimistic look at technoscientific biomedical knowledge that allows one to engineer life, in particular, the lives of one's children—if the parents can pay for accessing expensive technologies—at the expense of producing reprogenetically excluded Others. For Silver, the question is all too simple: the desire to endow one's children with the best possible advantages in life is a force that will overcome political and social

attempts to hinder the use of reprogenetics. It is in this tone that he advocates for the transformation of the (North-)American family by genetic engineering and cloning, in order to give it advantages, obviously to the disadvantage of Others. With a religious undertone, this is his manner of advocating that we can remake Eden. It is this kind of scientific offshoot that leads us to forcefully defend the need of STS initiatives that address othering processes in science education.

In a recent paper in *Lancet*, Hardy (2008), in a discussion about the present relationships between race concepts, genetics and medicine, alerted against the risks of using genetic data and studies only for the benefit of the richer part of the world population, and, also, about the risks of using these data to provide presumed scientific justifications for some value-laden and prejudicial pronouncements about some peoples. Indeed, when we read books like Silver's, we see that the same problems posed by past eugenic movements are with us, but assume new forms in the twenty-first century. Indeed, some leading academics in human genetics even suggest the possible development of a new kind of eugenics movement for the twenty-first century. This is not new among human geneticists. During the 1940's, many leaders of the old eugenics movement were calling for a "new eugenics", as a result of the widespread rejection of the Nazi's racial policy. Some authors claim that this process inaugurated the reformulation of eugenics under a more politically correct label, that of genetic counseling (Hansen et al. 2008).

Some of the more influential authors among the modern bioethicists, such as Allen Buchanan,[13] for example, argue that the eugenic policies of the past were not inherently wrong, but rather that they were wrongly applied in society (Buchanan 2000; for a discussion, see Hansen et al. 2008). Authors like Buchanan and colleagues "argue that disability is unlike sex, race, or other forms of diversity protected by human rights policy, and disabled people should not be protected from discriminatory treatment (…). They argue for a new, more finely honed eugenics—a modern application of Darwinism" (Hansen et al. 2008, pp. 106–107). Not surprisingly, it has been claimed that, from an ethical perspective on medical disability, the relative comfort of the general medical and bioethics communities to debate the human rights of disabled people as an academic matter is in itself an insult to disabled people (Hansen et al. 2008).

For us, it is clear that we are currently dealing with the possible justification of a modern version of radical genetic othering. This is, precisely, the picture in which we think that to look into past racialization processes related to science can be enlightening in the education of students for being capable of recognizing both the benefits and risks of science, of valuing science for its outstanding contributions to our lives, but also criticizing it when it gives support to developments such as those seen in current (repro)genetic justifications of othering.

There are disturbing similarities between Nazi arguments concerning "quality of life", "useless eaters", or "lives less worthy" and current discussions of disability taking place among leading biomedical professionals, advocating a value scale of humanness (Hansen et al. 2008). However, Nazi science is not so powerful a historical example for the STS curriculum proposed here, because it is quite easily put aside as a kind of marginal or second-rate science, even though historically it may be hard to support this claim (Proctor 2000).[14] It is more powerful and avoids unnecessary polemics to look into past

[13] Member of the USA President's Commission on Medical Ethics in 1983, and of the Advisory Council for the National Human Genome Research Institute, from 1996 to 2000.

[14] In a text published in *Dimensions: a journal of holocaust studies*, Robert Proctor (2000) forcefully states that "it is poor scholarship and perhaps even dangerous to caricature the Nazis as irrational or anti-science. What we have to look at more carefully is the relationship between science and ideology at this time".

developments that are not under such a suspicion, such as physical anthropological studies of the end of the nineteenth century.

7 Concluding Remarks

By the 1870s, after having been literally hunted with rifles by the English settlers for many years, the last of the aboriginal Tasmanians became "extinct". The last four survivors of that atrocious ethnocide were taken to Britain, where they were studied and exhibited, like wild human specimens, and where they eventually died, leaving few more traces of their existence than a handful of skeletons in various European anthropological museums. They became extinct… The rather neutral and aseptic term "extinct" was employed by the nineteenth century naturalists to describe their ethnic extermination as a direct effect of the "evolutionary principles" of interracial competition in the struggle for existence (e.g., Hillier Giglioli 1874). The scientific terminology used to describe the history of those populations from Tasmania disguised one of the best known examples of colonial ethnocides as a fatal alleged outcome of the laws of nature acting on human populations.

In this paper, we have tried to show the ideological significance of some scientific concepts (such as "interracial competition" and the "natural extinction of inferior races") that were normally used in the evolutionary biological debates of the end of the nineteenth century in order to explain the apparent "biological superiority" of Caucasians over all other human groups. In this sense, biological sciences provided a naturalistic legitimation for the imperialist colonial and racial order at that period. In short, as pointed out in 1882 by Ladislau Netto—the first director of the National Museum of Rio de Janeiro, in Brazil—it was even legitimate to doubt, on a scientific basis, whether some of the peoples living in the interior of the colonies—such as the Tasmanians, or the Botocudos displayed in the first *Brazilian Anthropological Exhibition*—could be called "people" at all. Apparently, as one can read in that exhibition's catalogue, according to the authoritative voice of Netto, these populations were composed by

> *creatures* that only had the shape and the physical nature of man; individuals who showed, in their almost total deprivation of a modulated language, in their rude gestures and simian habits, much of the character of the animals with whom they lived in promiscuous ferocity (Netto 1882, p. III).

However, the question we pose here is not just about the past of science. It also concerns the ideological functions of contemporary scientific discourses about race and othering. After all, there is no reason to believe that science may have been completely purged of all its ideological connections in the twenty-first century. From this perspective, we derived from the literature we have been working with some principles for designing educational interventions that can help in creating conditions for teachers and students to use the history of scientific racism and, also, current cases of othering processes related to science as a platform for thinking critically about science, technology, and society, considering both its contributions and risks, its relationship with our quality of life and welfare, as well as its relations with power and its potentiality to be used as an instrument to legitimate the exclusion, marginalization, and disempowerment of some human groups.

We framed this effort within *educational design research*. A design-based research project has many steps (McKenney 2001; Reeves 2006): first, researchers and practitioners need to identify and analyze an educational problem; second, prototypes—i.e., successive versions of educational interventions—should be developed, informed by available

knowledge, existing design principles, and technological innovations; third, iterative cycles of testing and refinement of the educational interventions must take place, in the context of educational practice and involving increasing numbers of participants (educational researchers, teachers-researchers, and students); finally, the fourth step is to reflect upon the results of the iterative interventions in order to refine the design principles used since the beginning of the study and to produce new principles. What is generalized and, thus, can be transferred to new teaching situations is not the educational intervention per se, i.e., the exact steps implemented in classroom practice, but the guiding principles to implement interventions of the same sort in different classrooms. That is, the intention is not to produce teaching plans that teachers adopt, but guiding principles that they can adapt to the circumstances of their practices.

In this paper, we identified and analyzed an educational problem, namely, the treatment of racialization and othering processes in the context of STS curricula, by means of examples both of the historical past (nineteenth century discourses on interracial competition and racial extinction) and the present (in biomedical technosciences). The basic idea is to use the historical perspective given by examining the nineteenth century developments in order to build a critical appraisal of current scientific work and its relationships to society. For this purpose, we proposed seven design principles to develop teaching sequences to address the problem above in the classroom.

The next step in this design-based research project is under development now, with the construction of the first prototypes of educational interventions to be put to test in high-school classrooms and teacher education programs, in a collaborative research team gathering high-school teachers-researchers, preservice biology teachers, and university educational researchers and teacher educators. In the construction of these teaching sequences, the design principles put forward in this paper have been playing a central role, and we hope they can play the same role in motivating or somehow assisting the educational work of other researchers and teachers.

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