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Genetic Determinism in School Textbooks: A Comparative Study Conducted Among Sixteen Countries

JÉRÉMY CASTÉRA (jeremy.castera@univ-lyon1.fr), and PIERRE CLÉMENT (pierre.clement@univ-lyon1.fr), LEPS/LIRDHIST, University Lyon 1, France
MONDHER ABROUGUI (abrouguimondher@yahoo.fr), ISEFC, Tunisia
OLYMPIA NISIFOROU (olianisiforou@gmail.com), and NICOS VALANIDES (nichri@ucy.ac.cy), University of Cyprus, Cyprus
JURGA TURCINAVICIENE (Jurga.Turcinaviciene@gf.vu.lt), University of Vilnius, Lithuania
TAGO SARAPUU, (tago@ut.ee), University of Tartu, Estonia
BOUJEMAA AGORRAM (bagorram@gmail.com), ENS Marrakech, Morocco
FLORBELA CALADO (flor_calado@yahoo.com), and FRANZ BOGNER (franz.bogner@uni-bayreuth.de), University of Bayreuth, Germany
GRAÇA CARVALHO (graca@iec.uminho.pt), University of Mienho, Portugal.

ABSTRACT: Genetic concepts have significantly evolved over the last ten years, and are now less connected to innate ideas and reductionism. Unique reference to genetic determinism has been replaced by the interaction between the genes and their environment (epigenetics). Our analyses relate to how current school biology textbooks present this new paradigm in 16 different countries (12 from Europe, and Tunisia, Morocco, Senegal, and Lebanon). Two precise criteria were used to analyse and compare the chapters dealing with the topic Human Genetics. The first criterion was the occurrence of the expression "genetic program" (which is typical of innate values). This was present in the textbooks of some countries, but were totally missing in some others. The existing differences seem to support the following: (i) in Eastern European countries, the absence is long-standing, and it is possibly linked to a previous influence of Lyssenko, (ii) in some other countries, the absence could be linked to various reactions during the Nazi period, (iii) in other cases, the observed diminution might be due to a modernisation of the scientific content, and, finally, (iv) in several countries, the notion of "genetic program" is still present, without any attempt for change. In contrast, there were no differences between countries with relation to the second criterion, that is, the twins' pictures present in the textbooks. The monozygotic twins were always dressed identically, and had the same hairstyle and body posture, as if these features could be genetically determined, providing thus evidence of a persistent implicit deterministic ideology. These results are discussed as interactions between implicit values and taught scientific knowledge.

KEY WORDS: Human genetics, school textbooks, twins.

Introduction: From Innate Ideas to Epigenesis

During the first half of the 20th century, research in genetics occurred within the scientific societies of "genetics and eugenics." The idea of genetic determinism was explicitly linked with the eugenism aimed at improving human "races." The Nazi doctrine and the horrors of the Second World War illustrated the possible consequences of this link (Séralini, 2003). During the second half of the 20th century, the separation between genetics and eugenism occurred, but the reduction of complex features to a genetic determinism was frequent, promoting the hereditary inheritance of human features, including behaviour, beliefs, and other intellectual competencies. According to the philosopher of Life Sciences Canguilhem (1977), such a reductionist approach can be called a "scientific ideology": when life sciences refer only to the molecular level, ignoring the complexity of life. In human genetics, reductionism and hereditarianism are convergent, whilst trying to explain the complexity of human phenotypes by genetic determinism only. They are also convergent with fatalism and social conservatism, when justifying the social inequalities by a natural order. In their book "No God, neither genes," the biologists Kupiec and Sonigo (2000) denounced the scientific ideology of the dictatorship of genes. Since the end of the 20th century and mainly since decoding the human DNA sequencing, biologists are becoming progressively more open to the theories of complexity, including epigenetic processes.

During the second half of the 20th century, several studies on genetics, using identical or fraternal twins, were sources of debates between innate and acquired human features (Lewontin, Rose, & Kamin, 1984; Schiff, Duyme, Dumaret, & Tomkiewicz, 1982). Schiff et al. (1982) indicated that adopted children had an IQ corresponding to that of their foster parents. The psychologist Zazzo (1984) published a synthesis of his research, describing "the paradox of twins," and indicating that identical twins (who are physically similar) tend to differ more by their respective behaviour and psychological characters than fraternal twins, or brothers and sisters that are not twins.

By the end of the 20th century, while the media were still continuing to publicly suggest, often by sensational means, the existence of genes for shyness, violence, obesity, or intelligence, biologists were claiming that the debate between innate and acquired characteristics was scientifically obsolete, because there is an inevitable interaction between the influences of both genotype and environment, both being necessary (Stewart 1993; Jacquard & Kahn 2001), and finally Atlan (1999) claimed "the end of all genetics" ("la fin du tout - génétique"; see also Kupiec & Sonigo, 2000). The first results for the sequencing of human DNA (Venter et al (285 co-authors), 2001; International human genome sequencing consortium, 2001) compromised the thesis of a simple genetic determinism of human intellectual performance, suggesting that 99.99% of the genes of a given human being are identical to those of any other human being. From this collective human genetic patrimony, specific intellectual performances are built progressively by the singular configuration of neuronal networks along each individual's history (cerebral epigenesist) (Changeux, 1983; Edelman, 1990). The notion of epigenesis is related to the morphogenesis of an organism, for instance, the development of the neuronal pathways.

More recently, the notion of epigenetics has been used for the study of heritable changes in the genome function, affecting a cell, an organ or an individual, but without affecting nucleotic sequence of DNA (mainly by chemical modifications of the proteins around the DNA in the chromatin, as possible methylation or acetylation (Pouteau, 2007).

These processes, which are controlled by environmental parameters, have a significant role in every phase of DNA activity, from self-repair (Friedberg, 2003) to protein synthesis (Morange, 2005a; 2005b). For instance, results of Fraga, Ballestar, Paz, Ropero, Setien, Ballestar, Heine-Suñer, Cigudosa, Urioste, Benitez, Boix-Chornet, Sanchez-Aguilera, Ling, Carlsson, Poulsen, Vaag, Stephan, Spector, Wu, Plass, and Esteller (2005) illustrate that in 35% of the monozygotic twins that were studied, there were differences in the methylation of their DNA and histones acetylation. These epigenetic differences were more important in the oldest twins and in twins with different lifestyle or medical history. In consequence, it appears that any phenotype is determined by an interaction between three parameters, genetic, epigenetic, and environmental.

Until recently, the notion of a "genetic program" was very important for the teaching of genetics in some countries, such as France. Research identifies signs of this hereditarianism in French textbooks (Abrougui & Clément, 1997b; Clément & Forissier, 2001; Forissier & Clément, 2003). It appeared as questionable, as it was suggesting an implicit reductionist and hereditarianist ideology. Atlan (1999) suggested its replacement with a less ideological expression, which is more scientifically correct, that is, "genetic information." Taking into account the results of several studies, curricula have recently changed in a number of countries. Some effects of these changes have been analysed in France (Castéra, Bruguière, & Clément, 2007). Nevertheless, with the exception of recent studies in Sweden (Gericke & Hagberg, 2006) and in Brazil (Pitombo, Almeida, & El-Hani, 2007), very little research has been done from this perspective in other countries. The present work is the first essay from a large-scale comparison among 16 countries.

Theoretical Background in Didactics of Biology: Our Research Question

The didactic background of our study was based on the concepts of didactic transposition and conceptions. Giordan and de Vecchi (1987) defined conceptions as "*a set of explanatory, coordinated ideas, and coherent images used by learners when confronted with a problematic situation" (p. 79).* Until now, most of the studies within the Didactics of Biology that were related to genetics focused on the learners' conceptions and difficulties, and they often suggested new ways to teach genetics and to improve students' conceptions (Rumelhard, 1986; Banet & Ayuso, 2000; Lewis, Leach, & Wood-Robinson, 2000; Marbach-Ad, & Stavy, 2000; Wood-Robinson & Lewis, 2000; Marbach-Ad, 2001; Lewis, 2004; Dass & Bradley, 2006). More recently, conceptions have been increasingly analyzed at the teacher's level as well. So, while the first international review of conceptions relative to scientific subjects concerned only learners (Pfundt & Duit, 1994), Duit's current site (IPN, Kiel), which contains an up-to-date list of these works, concerns both the conceptions of learners and teachers. After certain genetic studies realized the difficulty in defining the concept of "gene" (Griffihts & Neumann-Held, 1999; Falk, R., 2000; Chevassus-Au-Louis, 2001), and after the concept of epigenetics had been defined, a critical

analysis of school biology textbooks in France and Tunisia (Abrougui & Clément, 1997a, 2005, Castéra et al., 2007), as well as in Spain (Martinez-Gracia, Gil-Quilez, & Osada, 2006), and in Brazil (El-Hani, Roque, Vanzela, Souza, Marques, Viana, Kawasaki, Leme, Faria, Meyer, Omena, Oliveira, Assis, Fregoneze, Queiroz, Carvalho, Napoli, Cardoso, Silveira, Horta, Sano, Tidon, Silva, Rosa, & Rocha, 2007; Pitombo et al., 2007) started. Our research project, called BIOHEAD-CITIZEN, addressed teachers' conceptions on the one hand and recognizable conceptions in textbooks on the other hand. The present work concerned only textbooks.

Conceptions can be considered as the results of interactions among three poles: scientific knowledge (K), social practices (P), and values (V) (Clément 2006). K stands for scientific knowledge, as it is published by the scientific community. V stands for value systems in the widest definition, including opinions, faiths, ideologies, philosophical, and moral positions. And, finally, P stands for social practices, including not only professional practices (in this case, those of the textbook authors and publishers, as well as those of the other actors involved), but also influential social practices, whether civic, religious, ethical, or other. Shulman (1986) has already worked on the relations between scientific knowledge and pedagogical practices and proposed a breakdown of content knowledge and teacher knowledge each into three categories (subject matter content knowledge, pedagogical content knowledge, and curricular content knowledge).

Independently, Chevallard (1985), using the work of Verret (1975), proposed the schema of the didactic transposition from "scientific knowledge" to "knowledge to be taught," and then to "taught knowledge." Martinand (1986, 2000) insisted on the importance of social practices and not only knowledge at these three levels. Finally, Clément (1998, 2004, 2006, Clément & Hovart, 2000), from his research in Didactics of Biology and in Environmental Education, proposed the inclusion of KVP interactions at all levels of didactic transposition, using a modified model, which is not reduced to just three levels (Figure 1).

In other words, we refer to a new plan of didactic transposition (Clément, 2006), which (i) includes more steps, textbooks being one such step, than the plan originally defined by Verret (1975) and then by Chevallard (1985); (ii) is less linear and further differentiated by the possibility of feedback between all the steps, and (iii) is coupled with the analysis of the conceptions of the actors concerned in all these steps, and always includes the identification of the KVP interactions, allowing links with both the notion of social reference practice (Martinand, 2000), on the one hand, and with the anthropological approach to knowledge (Chevallard, 2005), on the other hand. Finally, especially for the subject treated here (Human Genetics), values are understood to be ideologies, as suggested by Canguilhem (1977), where an ideology is not a distortion of consciousness or science, but rather a product of history within a scientific context. As specific examples for the field of biology, Canguilhem cites anatomism, reductionism, and "the ideology of heredity," which we shall also call here "hereditarianism," "innate ideas," or even the ideology of "all genetics" (Atlan, 1999).

Our research focused on a precise step in didactic transposition: school textbooks. We also took into consideration other steps that influence school textbooks, such as, scientific literature, its popularization, and finally curricula and syllabuses,

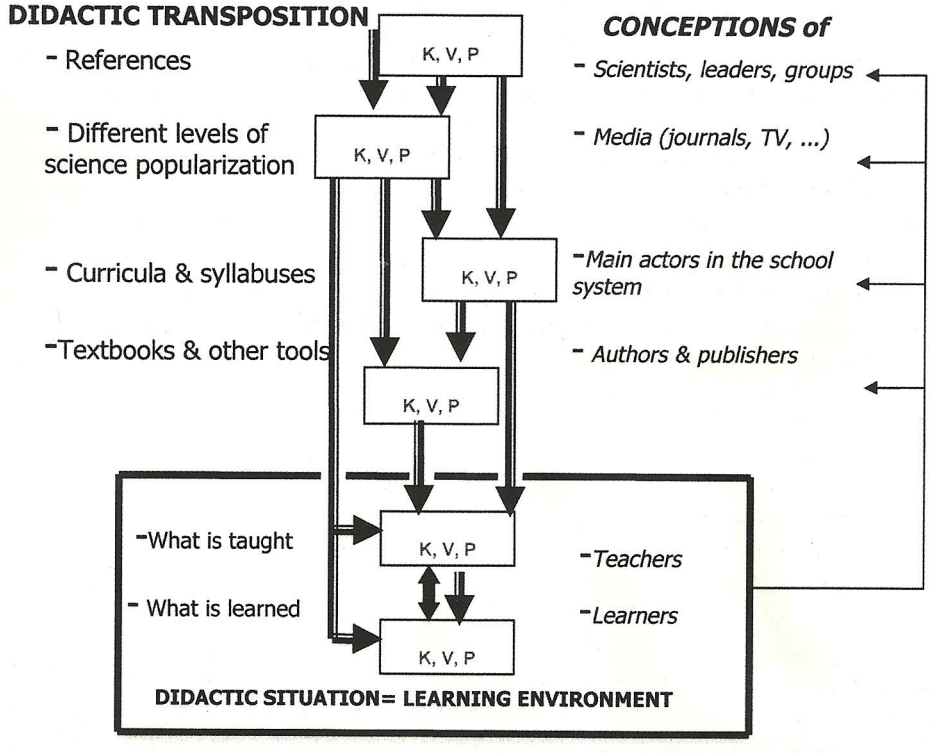

Figure 1. Schema of Didactic Transposition (modified from Clément, 2006).

focusing mainly on their propositions to teach Human Genetics. So, our precise research question was as follows: Are the new trends in Human Genetics research (epigenetics, genetic information) present in school textbooks? Or, on the contrary, are there still some signs of the precedent concepts (such as the "genetic program") and of implicit innate ideas, or hereditarianism?

Our hypothesis is that the change of syllabuses and textbooks is not an automatic consequence of the renewal of the scientific concepts by researchers, but is also strongly influenced by the socio-cultural context or the KVP interaction (Clement, 2006). To test this hypothesis, we decided to compare several countries, which contrast one another with respect to various parameters, such as, level of development, culture, religion, recent, and past political situation, etc.

Methodology

The Grid to Analyze the Textbooks

We collectively constructed and improved a specific grid to analyze the chapters dealing with Human Genetics in the textbooks of the 19 countries involved in the BIOHEAD-Citizen European research project (http://www.biohead-citizen.net/). The precise work on the topic Human Genetics took into account all the collective discussions during the Biohead-Citizen meetings, and mainly those

held in Algiers (April, 2005), Malta (May, 2005) and Lyon (October, 2005). After each of these meetings, the grid was tested in each country on a small sample of textbooks, and subsequently improved until the final grid was accepted at the Marrakech meeting (February, 2006). Later, most of the participating countries applied the grid to their textbooks, and the first data synthesis was performed during the Vilnius meeting (September, 2006), leading to the decision to write the present paper based on the data gathered from 16 countries. We decided to focus the present work on the results drawn from only two points in the grid, which were the two main points of our research question:

- *Occurrences of the expressions "genetic program" and "genetic information" (and other expressions with the same implicit value):* These terms are indeed significant, showing whether or not the textbooks present ideas from the "all genetics" values, and, according to which, we would be largely programmed by our genes (corresponding with a fatalist ideology in society and a reductionist ideology in the life sciences). We focused on the occurrences of the words "program" and "information," when associated (explicitly or implicitly) with the term "genetic," such as, "genetic program" and "genetic information." This method ("pivot-terms," defined by Harris 1952) has previously been used by Jacobi (1987), Abrougui (1997), and others to analyze biology-specific contents of school textbooks. The difficulty here was the language, because the initial collective grid was written in English, but 14 different languages were used in the textbooks that were analysed. We discussed the issues extensively in order to fully understand the two notions and have a common understanding of "genetic program" and "genetic information," while trying to identify their translation in each language, as well as a list of possible synonyms for every language.
- *Photos of human twins in textbooks:* These photos were considered as scientific images, because they convey a scientific message (Clément, 1996). In this specific case, the message was the morphological similitude of identical twins, which corresponds to the identity of their genotype. In contrast, some images intended to show morphological differences between fraternal twins. Nevertheless, the images of monozygotic twins can also have an implicit ideological message, when they strongly suggest that features, other than morphological ones, can be genetically determined, such as, the same clothes, the same hairstyle, the same behaviour, etc. Consequently, for each image of twins, we examined whether the twins were presented as having the same clothes, tastes and behaviour or, on the contrary, if they showed differences illustrating the paradox of the twins who tend to differ by characteristics, such as, clothing and socio-cultural appearances (Zazzo, 1984).

The Sample of Textbooks

The same grid, using these two indicators, was used in the 16 different countries involved in the BIOHEAD-citizen research project. Comparisons took into account the school level (corresponding to similar students' age) at which Human Genetics is taught in each country.

We analysed 50 textbooks, which are listed below after the references: France (11 textbooks), Italy (7), Portugal (4), Lebanon (4), Germany (3), Hungary (3), Lithuania (2), Tunisia (3), Cyprus (2), Estonia (2), Finland (2), Malta (2), Morocco (2), Poland (1), Romania (1), Senegal (1). There were two reasons for the differences in the numbers of textbooks from each country that were analyzed, such as: (i) in some countries, Human Genetics is taught at one school level only, while in other countries it is taught at two or more school levels, as indicated in Table 1; (ii) in some countries, there was only one official national publisher for school textbooks, while in others there are several private publishers. In this case, each team chose the most significant publishers. Each team filled out the grid corresponding to the textbooks of its country. All of the data were then collected in Lyon (France), and their interpretation was performed collectively.

Table 1
Students' Age at Which Human Genetics Is Taught in 16 Countries

Age of students (in years) / **Country**	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Cyprus					■		■	
Estonia				■		■		
Finland			■	■	■	■	■	■
France				■	■	■	■	
Germany				■			■	
Hungary						■	■	
Italy		■	■	■				
Lebanon			■		■	■		
Lithuania					■		■	
Malta	■				■			
Morocco			■				■	
Poland							■	
Portugal				■		■	■	
Romania							■	
Senegal								■
Tunisia				■			■	■

Differences among the Countries Concerning "Genetic Program" vs. "Genetic Information" An Implicit Hereditarianism Value with the Notion of "Genetic Program"

Results and Discussion

At What Level Is Human Genetics Taught?

The analysis of the syllabuses in the 16 participating countries indicated that Human Genetics is taught at different educational level(s) depending on the country. The teaching of human genetics is distributed over six age-levels in Finland (but with just two textbooks; it can be taught at two school levels or more), but it was found at only one age-level (for older students) in Romania, Poland, and Senegal. Generally, human genetics is first taught to students who are between the ages of 13- and 15-years old. In Malta, the teaching of Human Genetics begins earlier, with students who are between 11- and 12-years old.

In Table 2, the total occurrences of genetic program and expressions with the same implicit value are presented, while, in Table 3, there are the occurrences of genetic information and similar expressions.

Table 2
Total Occurrences of Genetic Program and Expressions with the Same Implicit Value

Textbooks devoted to students of	11-12 years old	12-13 years old	13-14 years old	14-15 years old	15-16 years old	16-17 years old	17-18 years old	18-19 years old
Country								
Cyprus					0		0	
Estonia				0		0		
Finland				17			53	
France				66-7 *	18-49*	1-2 *	0-0 *	
Germany				0			0-0	
Hungary						1	0-0*	
Italy		0-0-0*			0-2-0-0*			
Lebanon			27		3-0**	1		
Lithuania					0		1	
Malta	No textbook				10-1*			
Morocco			23				28	
Poland							0	
Portugal				2		2	0-1***	
Romania							5	
Senegal								1
Tunisia				0			0	0

Note: * Occurrences in textbooks from one publisher - another publisher.
** Occurrences in textbooks from the same publisher but from science section - from humanity section.
*** Occurrence in biology textbook - in psychology textbook.

In Maltese textbooks, "genetic information" as well as "genetic program" were never present. Nevertheless, at both levels where human genetics is taught (Table 1), the same expression was used. "... the DNA molecule forms a code, which instructs the cell" (ten occurrences and one occurrence, depending on the publisher, for 15–16 year-old students, as indicated in Table 2. The message was that the cells could simply follow these instructions to produce the phenotype, just like a program. This implicit way to suggest a genetic program has already been noticed by Clément (2007), when analyzing the cell concept in a Maltese textbook. Both textbooks that are still used in Malta are in fact British textbooks published in 1986. The presence of this hereditarianist expression in these textbooks seems to indicate that old textbooks emphasized hereditarianism with the notion of a "genetic

Table 3
Total Occurrences of Genetic Information or Expressions with the Same Implicit Value

Textbooks devoted to students of	11-12 years old	12-13 years old	13-14 years old	14-15 years old	15-16 years old	16-17 years old	17-18 years old	18-19 years old
Country								
Cyprus					8		17	
Estonia				5		9		
Finland				0			5	
France				9-73*	81-59*	27-28*	15-1*	
Germany				0			9-15*	
Hungary						6	2-53*	
Italy	Oftentimes found			Oftentimes found				
Lebanon			55		39-5**	2		
Lithuania					3		3	
Malta	No textbook				0-0*			
Morocco			0				10	
Poland							8	
Portugal				9		8	1-0***	
Romania							19	
Senegal								2
Tunisia				7			30	3

Note: * Occurrences in textbooks from one publisher - another publisher.
** Occurrences in textbooks from the same publisher but from science section - from humanity section.
*** Occurrence in biology textbook - in psychology textbook.

program" (or a similar expression). It would be interesting to analyze the most recent English textbooks from this perspective, in order to identify whether any changes relating to Human Genetics appear in English textbooks. The French textbooks from the same period, and even those published in 1995, also point to a clear presence of implicit hereditarianism (Abrougui, 1997, Clément & Forissier, 2001), but with substantial differences from one publisher to another (Forissier & Clément, 2003).

In Finnish textbooks, we found a strong presence of the notion of "genetic program," and 70 occurrences (vs. only five occurrences for "genetic information") in recently published textbooks (2004 and 2006). So, even though the scientific community no longer uses the expression "genetic program," the Finnish textbooks still do.

In France, we compared textbooks from three different publishers. In the textbooks published by Nathan, the occurrences of "genetic program" decreases from the youngest students to the oldest ones. In the textbooks published by Hatier, the

first level is dominated by the notion of "genetic information," the second level by "genetic program," and then again by "genetic information." We also analyzed the textbooks published by Bordas for the non-scientific curricula (students aged 15–16 years old, data not included in Tables 2 and 3), and we found ten occurrences for "genetic information" and one occurrence for "genetic program" in each textbook. Compared to syllabuses and French textbooks published in the 1990's, today the occurrence of the notion "genetic program" is infrequent, being increasingly replaced by the notion "genetic information." Nevertheless, the expression of "genetic program" did not disappear, suggesting the influence of other parameters. (i) The first such parameter is a pedagogical project, starting with "genetic program" for the youngest students, and progressively using "genetic information" more often. This initial simplification (to start with the message genotype → phenotype), is dangerous, because Clément, Forissier, and Carvalho (2003) indicated that the first concepts taught are those mostly remembered by students, and which are more resistant and cannot be easily replaced by more scientific concepts. (ii) The strategy of the publisher Nathan conforms more closely to the French syllabus, and this textbook is one of the mostly used in France. In contrast, the publisher Hatier is striving for originality in order to increase the audience. The image of identical twins with different clothes (see below) is another illustration of this strategy. (iii) Finally, it is possible that the difficulty in totally suppressing the notion of "genetic program" springs from the fact that it was extremely central to the precedent syllabuses. This notion and, possibly, its implicit ideology are still present in the authors' and publishers' conceptions and are thus present in the textbooks as well.

In Moroccan, Lebanese, and Senegalese textbooks, we found the same kind of results as in France, indicating a possible French influence that affects them after some time, indicating a time delay. In Morocco, Human Genetics is taught at only two levels, and the notion of a "genetic program" dominates the curriculum, even in cases where "genetic information" is also introduced during the last level of teaching (Tables 2 and 3). In Lebanon, the three textbooks analyzed were published in 1999 and in 2000. The occurrences of "genetic program" indicated the time delay with respect to the French texts, as well as a pedagogical project to start with the "simple" notion for the youngest students. A complementary explanation came from the analysis of Lebanese students' and teachers' conceptions about genetic determinism, showing a strong influence from hereditarianism (Tayeh, 2003). The same explanation can be offered for Morocco, where the occurrence of "genetic program" was frequent. In Senegal, the chapter devoted to Human Genetics was very short, and included only one occurrence of "genetic program" and two occurrences of "genetic information." These three countries (Morocco, Lebanon, and Senegal) seem to be evolving in the same way as France, diminishing the influence of "genetic program" and implicit hereditarianism, even though this trend was marked by a longer delay in Morocco, and a reduced importance of Human Genetics in Senegal.

In the Portuguese textbooks, throughout the different levels, there was both a persistence of the notion of a "genetic program" with at least one occurrence by level, and an absence of a truly clear evolution between the various levels. It seems that there is a difficulty in changing the scientific and ideological content of the chapter on Human Genetics.

On the contrary, Tunisian textbooks use only the concept of "genetic information" throughout the three levels where Human Genetics is taught. Nevertheless, the absence of the notion "genetic program" does not yet mean a total disappearance of innate ideas from the Tunisian textbooks (Clément, Mouelhi, & Abrougui 2006), nor from the Tunisian teachers' conceptions (Kochkar, 2007). It rather means that, for the chapters dealing with Human Genetics, the textbooks adopted the new scientific contents very quickly, and that the change is faster and more radical than in France. This fast change is an indication of the growing influence of Tunisian researchers in the Didactics of Biology.

In Germany, the students are first presented with human genetics between the ages of 14 and 15. At this school level, there was no use of "genetic program" nor "genetic information," but only "genetic constitution" and "hereditary disposition." The concept of "genetic information" is introduced at the highest level, where Human Genetics is taught. "Genetic program" is never used. Hereditarianism was the foundation for the majority of genetic research performed at the beginning of the 20th century in Germany. As in other Western European countries and the USA, German genetic research developed in eugenics institutes with the goal of building genealogical trees and tracking patterns of occurrence of diseases and disabilities, having considered that characters, such as poverty and criminality, were hereditary (Wolf, 2002). More recently, O'Mahony and Schäfer (2005), in their study dedicated to comparing German and Irish media discourse on Human Genome Research, indicated that Germany can be assumed to offer favourable conditions for extensive communication about this subject.

> *Moreover, it is a large country highly influenced by the enlightenment, but no less by enlightenment scepticism, contained within its religious, philosophical and social heritage, and by left-wing critique of capitalism* (p. 103).

According to these authors, the collective memory of the Nazis' eugenics program is an important background, increasing the communication in Human Genetics. Furthermore, co-dominance of both the Catholic and Protestant religions *"prevented the dominance of one confessional worldview and morality, a dominance that can inhibit communication about genetic issues" (p. 103).*

In the Italian textbooks, the precise expression, "genetic program," occurred only twice and just in one textbook (Boschetti, 2004), but in this textbook terms, like "hereditary patrimony," and "genetic patrimony," were very often used. They were also present in other textbooks (Leopardi, 2004; Miller, 2000; Colombi, 2006; Piseri, 2001). These expressions are more neutral than "genetic program," with less implicit value. This could show the same desire as in Germany to use caution in dealing with hereditarianist ideology. The common past of Germany and Italy during the Second World War certainly had an influence on the way human genetics is taught, albeit sometimes awkwardly. For example, in the Miller textbook (2000), the metaphor of the book of life is used:

> *The information that is necessary for the expression of an individual's characteristics is contained in the genes, which are like books; the genes are ordered on chromosomes, which are like bookshelves (p. 87).*

According to the metaphor of *"the book of life,* it would be enough to know the alphabet and the genetic syntax to reach the essence of the human being. It could be interesting to try to analyze whether this metaphor is further developed in the

Catholic culture. Today, such a conception is scientifically unacceptable and ethically dangerous. In the Piseri textbook (2001), an allusion to epigenetic processes is nevertheless found.

> *Each organism is often the result of a complex interaction among genes, environment, and causal events (p. 36).*

But, the same textbook uses another expression, reminiscent of the metaphor of *"the book of life"*:

> *...each cell is able to auto-construct itself and to function, because it contains a very precise project (DNA) and the structures that can interpret and drive it (p. 4).*

The expression *"precise project"* suggests that everything is written, neglecting that cellular differentiation is also the result of the interactions between cells in an organism. So, even if the precise expression, "genetic program," is almost absent from the Italian textbooks, other expressions show some implicit inneism (project, precise project, genetic project, hereditary instructions).

In the Lithuanian textbooks, there was just one occurrence that could be considered as a notion similar to "genetic program." *"... the reproduction of cells is programmed in genes" (p.147)*, but there was never the precise expression "genetic program." In Lithuania, the explanation for this absence seems to be deeply rooted in the past. The notion was traditionally absent in the precedent syllabuses and textbooks, as this was verified by analyzing the textbooks published since 1979.

Three other Eastern Europe countries (Estonia, Poland, and Hungary) that were included in our sample showed the same characteristics for the current textbooks analysed. In Poland, Human Genetics is taught at only one school level, but the textbook contains 40 pages of Human Genetics, but without any mention of "genetic program." In the Hungarian textbooks, we found only "genetic information" in the three textbooks that were analysed. More specifically, we encountered two occurrences in one textbook for 17–18-years old students, 53 occurrences in the other textbook for the same age of students and six occurrences in the textbook for 16–17-years old. Only one exception was found in the last textbook, where it was mentioned explicitly "programmed by a gene" (exactly the same expression found in the Lithuanian textbook). In Estonian textbooks, there was no trace of the notion of "genetic program."

Our hypothesis is that in East European countries, which were either included in or associated with the USSR, there was one official line to teach biology based on the work of Lyssenko and Mitchourine, based on a negation of the idea of a "genetic program," despite the fact that at the end of the 1960s, the ideas of Lyssenko and Mitchourine were not accepted anymore. The role of DNA in hereditary information was acceptable and presented in all textbooks. However, the differences between human individuals were also always explained by environmental or social conditions. As a rule, there was a chapter in these textbooks that criticized "bourgeois" ideological considerations, insisting that not all people are equal due to the differences in their genes. This situation was the same in most socialist countries, because textbooks were under Moscow's control for ideological and political reasons. Changes appeared at the end of the 1980s, when several socialist countries and some republics of the USSR (including the Baltic countries) started to write their own original textbooks, but these influences seem to exist even today.

In Romania, the topic Human Genetics was not really developed and five occurrences of "genetic program" and 19 occurrences of "genetic information" were found in the unique Romanian textbook that contained 13 pages devoted to Human Genetics.

In Cyprus, the textbooks used exclusively "genetic information." In the analyzed textbooks, there were eight occurrences in the textbooks for 15–16 year-old students and 17 occurrences in the textbooks for 17–18 year-old students. The absence of the notion of "genetic program" seems to indicate a desire to avoid using the metaphor of a computer program and a realization of the importance of environmental factors as well.

An Implicit Hereditarianism from the Photos of Twins

Among the 19 representative images of twins found in the 50 textbooks, 13 represented monozygotic twins, who had exactly the same hairstyle and the same clothes. Figure 2a illustrates one of these images. Among the six images showing differences, five were fraternal twins' photos and only one represented monozygotic twins (Hatier, France, 14–15 year-old students). This image is reproduced in Figure 2b, showing that there are only minor differences between the identical twins (hairstyle, clothing, and the way to cross the arms). All the monozygotic twins' images (with this single exception) illustrated a simple and direct relation between genotype and phenotype, and suggested that genes could determine much more than just physical resemblance, including choices of hairstyle or clothes, attitudes and behaviour. This illustrates both the parents' conceptions when these twins were young, and apparently dressed by their parents, as well as more general social representations of identical twins. Consequently, innate ideas are usually conveyed by these images as an implicit ideology. This appeared in all the countries where textbooks contained pictures of twins.

(a) (b)

Figure 2. Monozygotic twins.

(a) Monozygotic twins who have exactly the same hairstyle, the same clothes (Moroccan textbook: Afriquia Achark for 17-18 year-old students, page 6).

(b) The sole image found with some differences between two monozygotic twins (French textbook: Hatier publisher for 14-15 year olds, page 23).

We found twins' photos in the textbooks from nine countries (among the 16 countries involved in this research). In the other seven countries, time devoted to

human genetics education was sometimes very short (only one school level in Poland, Romania and Senegal, as indicated in Table 1, and/or there were no photos with colours in the textbooks (as in Tunisia or Cyprus). Finland and Lithuania were the only exceptions, but it was difficult to be sure whether the absence of images of identical twins was a real choice.

Therefore, a clear message that seems to persist internationally relates to the implicit hereditarianism that is expressed by these monozygotic twins' photos in all the countries, where these images were presented in textbooks. This result illustrates the KVP model presented in the introduction of this work. The knowledge (K) is the scientific message of these images, the morphological identity of twins. Nevertheless, another message is transmitted through these images, more ideological than scientific, the identity of hairstyle, clothes, body postures, and smile suggesting that these features are programmed by their identical genotype. The value (V) in this case is the implicit innate idea, hereditarianism, suggesting that human cultural and social features (such as hairstyle and dress) could be genetically determined. The social practice (P) is the authors' and publishers' way to work. A more detailed enquiry could be performed in each country. Nevertheless, it seems that the photos of twins included in the textbooks come from image banks, where twins of every age and nationality are as identical as possible. This identity is dominant in the media, which cover, for example, the international meetings of identical twins. In this way, media are still reinforcing the dominant ideology of hereditarianism. Only a very few magazines for the popularization of science have just recently started to present scientific knowledge on epigenesis using the example of differences between identical twins. For instance, in France a special issue of Sciences & Avenir did so in December 2006, explaining that they tried to find images of monozygotic twins showing differences in their hairstyles, clothes, etc, but with no success.

Conclusions

Two precise criteria were used to analyze and compare the chapters dealing with the topic Human Genetics. The first criterion was the occurrence of the expression "genetic program" (chosen because it is typical of innate values). It is present in some countries but totally missing in some others: (i) in the Eastern European countries of our sample (Estonia, Lithuania, Poland and Hungary), the (quasi)absence of the word program is not recent and is possibly linked to the influence of Lyssenko during the Soviet period; (ii) in Germany, the absence of the word "program" could be linked to reactions against the Nazi period; it could be the same in Italy, where nevertheless the word "project" seems to replace the word "program;" (iii) in France and francophone countries, as Morocco and Lebanon, but also in Finland, the notion of "genetic program" is still taught, and (iv) in Tunisia, the observed absence of the word "program" is recent and probably due to the influence of research in Didactics. More research should be done, including a historical approach of the syllabuses and textbooks, to test these hypotheses concerning the possible origins of the observed differences from one country to another. In contrast, there were no differences between countries in relation to the second criterion: the twins' pictures present in the textbooks. The monozygotic twins were always dressed identically and had the same hairstyle and body posture, as if these features could be genetically determined, providing thus evidence of a

persistent implicit hereditarianism.

These results show that the contents of textbooks are not just scientific knowledge, but could convey some implicit messages related to values (innatism, hereditarianism). The message is not reduced to a value: the monozygotic twins are really similar in their morphology and that is a scientific knowledge, but when the similarity is enlarged to cultural features (as the colour of dressing), the message is no more scientific, but rather ideological (in the sense of "ideology" defined by the philosopher Cangulihem, 1977). In these images of twins, there is in consequence a strong interaction between knowledge and values (the poles K and V of the KVP model of Clément 2004).

The results related to the occurrence of "genetic program" in the textbooks show mainly strong differences from one country to another, with two main trends:

1. In some countries, the use of this expression seems to be not traditional in the school textbooks. A deeper historical approach could validate this observation done in the ex-Soviet countries, but also in countries, which were for some time under the influence of the Nazi ideology. The recent results of the BIOHEAD-Citizen research on the conceptions of teachers in these countries show that this absence of "genetic program" in the textbooks is not always correlated to the absence of hereditarianist conceptions of the teachers (Castéra, Munoz, & Clément, 2007). In consequence, a deeper analysis of the content of the chapters on Human Genetics in the textbooks would be interesting to be done, but this analysis should not be limited to the occurrence of "genetic program."

2. In the other countries of our sample, the expression "genetic program" seemed to be very often used in the textbooks during the 1980's and 1990's years. During this period, this expression was not yet criticized by the researchers in Genetics. Then, after the new trends in research avoiding the use of "genetic program" and promoting the use of "genetic information," the syllabuses and curricula strongly changed in some countries as in Tunisia, just changed a little in some other countries (as in France), but seemed to stay the same in other countries (as in Morocco, Lebanon and Finland). Several parameters are probably involved in explaining these differences from one country to another, and could be identified in future research.

The current research being conducted through the BIOHEAD-Citizen European project on the conceptions of pre-service and in-service teachers in these 16 countries provides important information for the further interpretation of our data from the textbook analysis. The renewal in teaching this topic, introducing interaction between genetic, epigenetic, and environmental influences for the interpretation of the phenotype, represents an important step, responding to the challenge of improving citizenship at the school level.

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