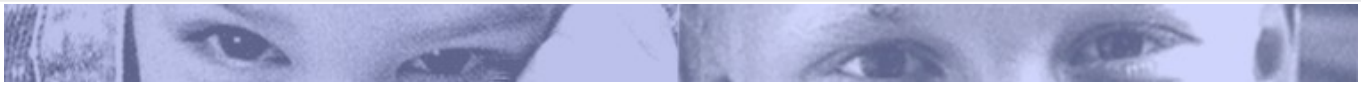

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Teaching evolution in France

Providing a framework for scientific work since the nineteen-fifties, the theory of evolution entered French syllabuses at the same time, without leading to any major controversy. Teaching it has now become a more sensitive issue: it is perceived as being related to questions of society which have long been agitating the American education system and which question the teaching of life sciences. Teaching evolution does indeed raise questions which go beyond the disciplinary field; it questions educational and non-educational knowledge and illustrates the relationships between "sciences and society".

After evoking the controversy stirring up American society and schools and which is being echoed in Europe, we should ask to what extent society and schools in France might be concerned by similar debates. Finally, the teaching of evolution will be looked at in its relationship with the classroom.

Note: *Part of this work was carried out within the framework of the ISCC-CNRS E2 - Enseigner l'évolution call for tender.*

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Evolution: a controversy in American society and education

The terms of the debate

Teaching evolution in France has recently been shaken by the American situation, which has received wide media coverage in Europe, often without reference to either history or context. Some concepts are recurrent ones and we offer a definition of these, necessarily brief given the complexity of the historical, scientific and philosophical foundations of the debate:

- Darwinism: "a *theory presented by Darwin (in* Origin of Species*, 1859) according to which species derive from each other according to the laws of natural selection*" (Robert, 2003). Jean Gayon (2000) points out that Darwinism, *"a conventional linguistic expression*", does not necessarily correspond fully to Darwin's thinking.
- **theory of evolution**: "*Recognising evolution leads to recognising the existence of a history, on Earth, of all living beings. Understanding evolution involves discovering the mechanisms which governed the structuring of biodiversity as it is today* […]. *Research underpinned by the concept of evolution can therefore be clearly separated into parts; one attempting to reconstruct the history of life, and the other seeking to understand the methods and processes of evolution*" (Guyader, 2003).
- **creationism**: a current of ideas according to which the Biblical accounts of Creation (Genesis) have a scientific content and value, which have been opposed to Darwin since the nineteenth century. The American legal system has not recognised creationism as having scientific status: it therefore cannot be taught in science lessons.

– **intelligent design (ID)**: a current of ideas which, "*while admitting the theory of evolution, sees in this the effects of a higher intelligence at work*" (Arnould, 2007). Its defenders are known as *Iders*.

To properly understand the terms of the debate in the United States, it is also important to be familiar with three specific features of American society:

– the special relationship between science and religion since the end of the eighteenth century, which has made scientist theology, a manifestation of natural theology, a current framework of thought explaining how it is that intelligent design has acclimatised so easily, and the persistence of the creationist movement;
– the very strong ties between politics and religion;
– certain aspects of schooling. The boards of education, elected at county level, and in which pupils' parents are represented, have to vote for school syllabuses and choose textbooks.

In this context, *Iders* such as Michael Bebe (*Darwin's Black Box*, 1996) or Phillip. E. Johnson (*Darwin On Trial*, 1993) claim that intelligent design is a scientific doctrine. If need be, taking over from creationism, they refer the matter to the federal courts for intelligent design to be ruled as having scientific and not religious value, thereby making it possible to legally require it to be taught in science classes in public schools, which the has judge refused. While giving up on the idea of prohibiting the teaching of evolution in public schools but at the same time imposing the teaching of "creation science " (according to the principle of *balanced treatment*), Arkansas and the dozen States concerned intended to circumvent the first amendment of the United States constitution, according to which it is "*forbidden to promulgate a law which would grant official recognition to any religion*"; hence the position of the federal district judge in January 1982: these laws - finally abolished in 1987 - "*are* […] *an attempt to introduce the Biblical version of creation into public education syllabuses*".

Analysing "*American creationism and its manifestations*", Dominique Lecourt associates it with the fundamentalist American Protestants: the lawsuit of Little Rock (Arkansas, 1981) reveals that intelligent design has reignited the creationist combat and created followers (Lecourt, 2007). In his *15 Answers to Creationist nonsense*, John Rennie (2002) is embarrassed to have to admit that **"in the 21st century, in the most scientifically advanced nation the world has ever known, creationists can still persuade politicians, judges and ordinary citizens**". The anti-evolutionist Philip E. Johnson recognises (in *Darwin onTrial*), that intelligent design is also a strategy for religious discourse to take possession of the science class. Teachers are more and more attacked on the subject of evolution, and they must be well aware both of the theory and at the same time the way in which it is led astray by its detractors, from the huge mistake to the specious argument. John Rennie provides teachers with a list of questions and answers to help them answer their pupils… or to justify themselves in front of the judge.

The scientific community is reacting: the Coalition of Scientific Societies brings together scientists and social science researchers to present actions aimed at the general public. The favourable image of scientists in American society (more than 70% of Americans have a favourable image of scientists) is an encouraging factor which should lead them to commit, especially as the majority of those questioned want scientists (more than 85% of these are researchers, science professors or doctors), and not the members of schools boards or celebrities, to talk to them about sciences. Concerning evolution, the public is looking for information from researchers, teachers and church people, testifying to possible frames of reference (Nelson, 2007). At any event, the commitment of scientists is a keystone (Coalition of Scientific Societies, 2008) for the teaching of evolution.

A century of debate

In 1925, the "Scopes Monkey Trial" first set the teaching of evolution in opposition to creationists. Since then, the courts have been weighed down with lawsuits about the teaching of evolution in public schools (Arnould, 2007). Support for teaching evolution is far from taken for granted, not only with the general public, but also within the teaching body: Lawrence S. Lerner reminds us that a Gallup poll in 1999 showed that "*68 percent of Americans favor teaching both creationism and evolution in the public schools*", while in 2000 a survey stated that "*half the respondents said that evolution is far from being proven scientifically*" (Lerner, 2000); Moore (2001) believes that life science teachers are in fact often creationists. Much pressure is put on those who are intent on respecting public school curricula from pupils, parents, politicians and associations (Moore, 2004).

While there is no longer any serious scientific debate about evolution, Lawrence S. Lerner states that teaching evolution is a controversial issue in the American social arena ("*this situation is nearly unique to the United States, in no other country is the teaching of biological evolution subject to similar nonscientific, nonpedagogical pressures*"), for political and, to a certain extent, religious reasons: the anti-evolutionists belong to various different circles, "*and teaching evolution thus leads to such broadly diverse social phenomena as atheism, communism, socialism, Nazism, inflation* […] *alcoholism and drug addiction, to name but a few*". Several factors need to be taken into account, including textbook selection, teachers' level of education and the organisation of the curriculum: the time devoted to teaching sciences and the quality of the training given impact the development of the scientific mind, and the States record disparate results from the standpoint of national scientific standards, from A (excellent) for California to F (disgraceful) for Kansas, a stronghold of creationism (Lerner, 2000). American scientists are therefore showing their concern as to the consequences of a falling-off in the level of science in their country, which would be cut off from both fundamental and applied research, for which the intellectual framework is that of evolution. Intelligent design poses an insidious threat for the development of sciences, particularly of medicine, and the public and professionals must be protected

from pseudo-sciences. For the same reasons, the physician Faouzia Charfi is also concerned about the decline of science in developing societies (Charfi, 2007). The issues of science teaching are not new: in 1957, J.F. Kennedy's reaction to the placing in orbit of the first Soviet spaceship was to reinforce the teaching of sciences, as a source of progress and power; today, within the framework of the promotion of modern biology, evolution is being reinforced in American syllabuses (Lepeltier, 2007).

The authors often bring up various "strategies" used to acclimatise creationism and intelligent design in society. The most striking of these is that of the ***wedge***, which refers to the offensive of the Discovery Institute in the media, public opinion and intellectual and political authorities. The Wedge Document has been doing the rounds on the Internet since the nineteen-nineties. The Institute claims to have long treated its detractors with contempt, is astonished by their "hysteria" and is taking time to comment on its strategy, whose 5 year plan is being rolled out in three phases. The first relates to research and scientific publication, a fundamental "wedge"; the second attempts to occupy the ground of teacher training and the media; the third brings in legal actions and getting the general public used to the ideas of intelligent design by organising televised debates and getting support from journalists and political leaders. When the first two phases are completed, phase three, that of "direct confrontation" with the materialist scientists, must be begun, in conferences within recognised scientific authorities. This project is planning 30 publications, 100 scientific articles, some well-placed articles in the national press (*Time, Newsweek*, etc), regular opinion columns and a number of articles in the tabloid press: satisfaction is the order of the day, since these objectives as a whole have been achieved, particularly with regard to the prestigious media (*NewYork Times*, *Wall Street Journal*, *Washington Post*).

In this context, the National Academy of Sciences (NAS) has again taken a very firm stance against the creationist theses (National Academy of Sciences, 2008). The various lawsuits have reaffirmed the basic principles of the secularity of teaching in public schools. Neither creation science nor intelligent design meets with the epistemological criteria of science. They therefore have no place in science lessons. The question of "American creationism" is not "*philosophical* [but] *deeply political*" (Lecourt, 2007), and the objectives of intelligent design are "*not scientific, but politico-religious*" (Lecointre, 2003).

See also

- Warnick Bryan R. (2007). « Does teaching creationism facilitate student autonomy? ». *Theory and Research in Education*, vol. 5, n° 3, p. 357-378.
- National Academy of Science (1998). *Teaching about evolution and the nature of science*. Washington: National Academy of Sciences.

Creationism and *intelligent design*: will the controversy cross the Atlantic?

France has remained aside from these political/scientific/religious debates which have been perturbing the United States for decades; its educational scientific culture was set up at a great remove from these debates, which explains the current differences: so can the American controversy ever enter the debate in France?

Pascal Picq believes that France is not under threat from creationism, having little historical or religious predisposition for this, but that it may be by intelligent design, represented by the UIP (Interdisciplinary University of Paris). The Little Rock lawsuit (1982) seemed to have put an end to the subject of creationism in the American classroom. "*When J. Arnould published* Les Créationnistes *in 1996 he could not have imagined such strong resurgence*" underlines Pascal Picq (2007). In a later work, Jacques Arnould gives the political and strategic issues of these new creationists, who are both Christian and Muslim. "*Defying the evolution of species is coming back into fashion*": according to the author, hard-line creationists (in favour of the *Young Earth Creation*, and who believe that God created the Earth in six 24-hour days) have no audience in Europe. They are losing ground in the United States, but are being taken over by the evolutionary creationists, who reconcile the Bible and evolution, and the *Iders*.

Laurent Testot points out that the on-line review *Religioscope* has given the world trends concerning the relationship between religions and society: the worldwide creationist offensive, going beyond the traditional American and Christian framework, has been the most outstanding event of the year 2007-2008. He recalls, moreover, that a survey by the *Pew Forum on Religion and Public Life* had already shown in 2006 that "*58% of Americans would be in favour of joint teaching of creationist and evolutionist theories in public schools*", while a survey by the French academy of sciences indicates that in Turkey, up to 75% of students believe Darwinism to be unfounded (Testot, 2008). In 2007, the large-scale distribution throughout European schools of the *Atlas of Creation* by the fundamentalist Turk Harun Yhaya caused a sudden awakening, against a background amalgamating denominational, historical, social and educational problems" (Picq, 2007). In Turkey, at the same time as this bulky *Atlas* for the classroom was sent out, a lighter version was widely distributed to the general public (Edis, 1999). The American press, attentive to the debate, took note of this creationist offensive on Europe: a journalist noted that sending the *Atlas* marked the entry of Islamic fundamentalists into the creationist offensive, hitherto the province of American fundamentalist Protestants. For Martin Enserik (2007), this was indeed a "glossy attack" aimed at Europe, historically and culturally not greatly concerned. The *Atlas* offensive made it possible to identify a "wedge strategy", after the example of the American wedge.

In a report by the OECD presented in September 2007, Anne Brasseur, former Education minister for Luxembourg, gave a warning statement: "*Many think that this phenomenon concerns only the United States* […]*. Nothing could be further from the truth, and we must urgently, in our 47 countries, take the necessary*

precautions". Thirteen countries are concerned, for various reasons. Harun Yahya's offensive targeted schools and universities in France, followed by Switzerland, Belgium and Spain. In Italy and Serbia in 2004, in the Netherlands in 2005 and in Poland in autumn 2006, political figures took a stance either against the theory of evolution, or in favour of creationism and its teachings. Lobbies spoke in the media or in universities in France (the UIP), in Switzerland (the European Biblical Centre, and ProGenesis which plans opening a creationist leisure park), in Russia (the orthodox Church), in Great Britain (the international creationists' symposium in 2006), in Germany (life and earth science teachers from a private school teaching creationism), in Turkey (creationist theses in the school textbooks) and in Sweden (the creationist museum in Uméa in 2006). In Greece, the commission notes that the theory of evolution is often relegated to the end of the syllabus, at the end of the school year and is therefore seldom studied for lack of time..

Resolution 1580 of the Council of Europe Parliamentary Assembly (PACE), in October 2007, stipulates in its first subparagraph that *"the objective* […] *is not to question or to fight against belief - the right to freedom of belief does not allow this The goal is to warn against certain trends towards making a belief pass for science. Belief must be separated from science. It is not a question of antagonism. Science and belief must be able to coexist. It is not a question of opposing belief to science, but belief must be prevented from opposing itself to science*". The Assembly encourages "*member States, and in particular their educational authorities, to defend and promote scientific knowledge, to reinforce the teaching of the basics of science, its history, its epistemology and its methods, side by side with the teaching of objective scientific knowledge, to make science more comprehensible, more attractive and closer to the realities of the contemporary world, to be firmly opposed to teaching creationism as a scientific discipline on the same basis as the theory of evolution, and, in general, to oppose creationist theses being presented within the framework of any discipline other than that of religion,* [and] *to promote the teaching of evolution as a fundamental scientific theory in the general curriculum*" We may add that in Great Britain, while the National Curriculum clearly states that teaching evolution occupies a central place in pupils' scientific education, the emergence of *faith schools* (schools depending on fundamentalist religious organisations), the government reform in progress (which grants more autonomy to religious groups for the management of state schools) and sites such as *Truth in Science* [sic], which screens life science syllabuses so that parents can be opposed to what is taught in them lead one to imagine that a radicalisation of this question is one the way in the country of Darwin. In Italy, evolution was part of the 1979 curriculum but the Moratti reform (legislative decree n° 59-2004) put aside explicit reference to evolution in curricula.

American debate should alert the French scientific community: before we attain the exaggerations of the English-speaking world, French scientists *"should better explain and promote the biology of evolution"* But the social, political, intellectual and religious context in France must be also be taken into account. The relevance of the metaphors used to evoke the offensive of American creationism. "Trojan Horse" (Forrest & & Gross, 2007), "biology wars" - must now be measured from the standpoint of the specific features of French society.

See also

- Perbal Laurence, Vercauteren Martine, Slachmuylder Jean-Louis & Susanne Charles (2006). « L'évolutionnisme et le créationnisme dans l'enseignement à Bruxelles : Enquête d'opinions ». *Anthropologica et praehistorica*, n° 117, p. 163-180.
- Selosse Marc-André & Godelle Bernard (2006). « Des leçons pour la France : Dieu menace-t-il Darwin ? ». *La Recherche*, n° 396, p. 51-52.

Specific features of the French context

« The mayor of Bordeaux and Montaigne have ever been two by very manifest separation ».
Montaigne, *Essays*, II, 10.

Institutional framework

Secularity is "a founding *value and essential principle of the Republic*" whose three "pillars" are - according to the way they are presented in the Commission report chaired by Bernard Stasi and the 2004 report of the Council of State - neutrality of the State, freedom of conscience and pluralism (Stasi, 2004).

❑ State

From the **constitutional** point of view: secularity is guaranteed by the Constitution of 4th October 1958: "*France is an indivisible, secular, democratic and social Republic*". The great lawyer and theorist of French public law Jean Rivero (*Recueil Dalloz* chron. XXXIII, 1949) stresses that "*for the lawyer the definition of secularity does not raise any major difficulty; extremely different conceptions could be developed by politicians* […] *but only one has found its way into official documents:* [they] have *always understood secularity in one way, and one way only: that of the religious neutrality of the State*". Jean Morange states that "*the secularity of the State, affirmed as a fact* [editor's note: the Age of Enlightenment, the Revolution, the Third Republic] *before being proclaimed in law, put an end to a traditional collaboration between the latter and, in particular, the Catholic church*" (Alland et Rials, 2003).

From the **legislative** point of view, the law dated 9th December 1905 concerning the separation of Church and State stipulates in its first article: "*the Republic ensures freedom of conscience. It guarantees freedom of*

worship with the provisos enacted hereafter in the interest of law and order", and in article 2: "*The Republic does not recognise, nor pay the salary of, nor subsidise any religion*".

❑ State education

Pascal Picq believes, however, that "*the French have always been able to express their attachment to the law of 1905, defending both public and private education* [editor's note: under contract to the State and therefore applying national curricula]". France enjoys a special historical heritage: the 1905 law dissociated religious teaching from school curricula, and "*so-called confessional teaching, whether under contract or not, respects the syllabuses*. […] *Teaching in France is national, which makes it less sensitive to the influences of well-organised movements*" (Picq, 2007). The Société Géologique de France (French geological society) recalls that the State education system required that the *Atlas of Creation*, "*which does not correspond to the contents of the syllabuses drawn up by the minister*" be withdrawn from school and university libraries. The syllabuses drawn up by the minister of state education, with their related documents, are the exclusive framework of reference for the teachers, themselves civil servants (in the current meaning of the term). The specifications for teacher training institutes (IUFM) decree that "*teacher training is an eminent responsibility which the republican State has entrusted to universities. They must guarantee the quality of this training throughout the national territory*" and that "*the professional teacher training syllabuses meet with national characteristics*". "*All teachers contribute to the social and civic training of their pupils. As a government official, he shows conscientiousness and is in keeping with deontological principles:*: […] *he respects, and has others respect, freedom of thought; he is attentive to developing an objective attitude; he is familiar with, and has others respect the principles of secularity, especially neutrality*". This is why the teacher "*knows the values of the Republic and the texts which they are based on: freedom, equality, fraternity, secularity*"; he is also familiar with "*the institutions* […] *which lay down and implement the nation's educational policy*". Consequently his attitude leads him "*to share the values of the Republic and make them comprehensible*" With regard to the particular question of textbooks, so sensitive in the United States, it is up to the teacher "*to assess the quality of teaching documents: school textbooks and their related teachers' books, documentary resources, teaching software etc.*". Finally, the teacher "*leads each pupil to view others and their differences in a positive light, while respecting the common republican values and rules*". (BO n° 1, 4 janvier 2007).

So according to both French constitutional and legal frameworks, only scientific theories may be taught. As legitimate as they may be, all other stances with regard to evolution, whether evolutionary (theistic evolution, materialist evolution) or otherwise, may be approached only outside scientific teaching proper.

See also

- Baubérot Jean (2007). « Laïcité de l'État, laïcité de la société française ». *Cahiers français*, n° 340.
- Frégosi Franck (2008). *Penser l'islam dans la laïcité : Les musulmans de France et la République*. Paris : Fayard.

Societal framework

❑ Secularisation

The reader will notice that, in the French arena, these debates are about intellectual issues, unlike American concerns, more often centred on points to do with morals or electoral policy. The French context also sets the tone of debates, in a country where Pascal Picq aims his book "*at all laymen, whether they are believers, agnostics or atheists*" (Picq, 2007), and where religious leaders of various confessions say that they are attached to the public school, in which can be found a creditable separation of genres and in which teachers' religious convictions or policies have not interfered with the content of their teaching (Bourbakeur, Lustiger & Keller, 2005).

In a recent article in *Le Monde*, Alain Wolfe, a sociologist of religion, also stresses the societal role of religion in the United States: while atheism and agnosticism are rarely to be found there, "*people's knowledge of theological questions is very poor*". Many documents deriving from creationist environments sidestep the fact that the Bible is not just the first chapters of Genesis or that there are two Biblical accounts of the creation of man. According to the figures of the Pew Forum, American society is made up of 51.3% Protestants, of which 26.3% are Pentecostists or Evangelists, 25% Catholics, 1.7% Jews and 0.6% Muslims. Next come Mormons, followed by Jehovah's Witnesses. The proportion of people who declare themselves to be without religion has doubled over the last thirty years. In his report, professor Jean-Pierre Machelon (2006) states that the French declare themselves to be 65% Catholic and 2% Protestant; 750,000 belong to "historical forms of Christianity" (the Orthodox Church, the Armenian Apostolic Church, and different Eastern Churches). Judaism counts 600 000 French people. Islam has become the second religion in France, "*not without a great diversity of opinion*", and concerns 6% of the population (14% of the 18-24 year age group). Buddhism, on the increase, has approximately 400,000 followers. Agnosticism (etymologically "the fact of not knowing": there is no identification with a religion, without meaning that one is "an *atheist or that one is not interested in spiritual questions*") is on the increase, as are diffuse or sectarian sacralities. In 2008 the Catholic Biblical Federation carried out an investigation in nine countries (the United States, the United Kingdom, the Netherlands, Germany, Spain, France, Italy, Poland and Russia), which concluded that France has "*the highest degree of secularisation*", noticing that less than half of the French have a Bible, against 93% of Americans, of whom, for all that, only 17% are able to answer basic questions on its contents, as against 11% of the French, for whom

the teaching of the factual aspect of religion is transversal, because it is dealt with notably in history; moreover, the July 2006 decree brings the teaching of the factual aspect of religion into common core knowledge.

Jean-Paul Willaime (2007b), the director of the European Institute of Religious Studies, presents the first results, for France, of a European investigation into the opinion of young people in the 14 to 16 age group. A thousand pupils in the fourth and fifth years of public and private (under contract) secondary schools were questioned at the beginning of the year: 68% said they learn about various religions at school. "*The vast majority believe that they find this beneficial: 70% of the pupils think that teaching about religions helps them live together, and 57% think that this helps to understand current affairs. This feeling is widespread: the difference between young people with or without religion is not very significant. France's decision to choose a transverse approach involving several disciplines seems to be appropriate, because only one third of the young people questioned would like a special course on religion. In addition, 63% of the pupils believe that teaching must firstly provide objective knowledge about religions. Young people* [are] *open and curious, but personally distant* […]*; with one or two exceptions, the opinions of pupils in private education under contract (90% Catholic) and those in public education are fairly comparable*", underlines Bernard Gorce in an article in *La Croix*.

❑ Evolution and religions

In France, the theory of evolution is generally accepted by religious authorities, without prejudging how it is interpreted in the spiritual field. As far as the United States is concerned, Dominique Lecourt underlines that "the [creationist] *interpretation of the Bible in American courts is supported neither by the Catholic authorities, nor by that of the Jewish community, nor even by any of the Protestant denominations*" (Lecourt, 2007). Churches historically established in Europe, Judaism in general and certain currents of Islam radically reject creationism, concordism and *ID*, and theism). The creationist and neo-creationist front is therefore defined by various authors as "fundamentalist". It sociologically cuts across the fundamentalist currents of Islam and certain currents of the Evangelist movement lately established in France (Picq, 2007). In addition, the literal reading (unambiguous and timeless) of Genesis is nowadays associated with creationism. Dominique Lecourt finally adds that the quotation marks are essential to indicate "creation science", because it is an "oneiric syntagm" specific to American society (Lecourt, 2007).

Except in certain movements that are poorly represented in France, **Judaism**, does not give a literal reading of the Torah, recognises Darwinism in the scientific field and, as a spiritual stance, "theistic evolution". Interpretation and commentary are some of the oldest reading methods used by practising Jews, and the literal meaning of the Biblical text is only the first of four levels of reading required. The philosopher Marc-Alain Ouaknin also says that the *Talmud* (the commentary of the *Torah*) is a way of thinking the question - "I question therefore I am" - and that the Talmudic dialogue (the *Mahloquèt*) is an "anti-*ideological situation par excellence. The contrasted and conflicting perspectives of meaning and the many interpretative possibilities form a tight fabric*" (Ouaknin, 2001).

While the media often indifferently use the term "Christians" to designate the American opponents to evolution, the historical, social and religious reality of **Christianity** is definitely more moderate. Moreover, the Dominican Jean-Louis Maldamé explains that the theory of evolution requires Christians *"to change the way they understand the action of God in nature, and the multiplication of lineages obliges one to abandon finalism and the dominant position of man, and to reconsider the action of man within the biosphere*"(Maldamé, 2003). While Patrick Dorléans (2003) points out that it is not the scientific nature of the theory of evolution which poses a problem for believers, but the deductions that arise from it: man's descending from the apes, the absence of a specific project for humanity, the role of chance, etc., Jacques Arnould affirms that to ignore the importance of chance, in particular in the history of living beings is a theological error (Arnould, 2003).

Within **Roman Catholicism**, relations between scientists and the Vatican are marked by the "Galileo affair", and remain contrasted, as Christian theologians with various sensitivities point out (Küng, 2008). The Roman Catholic Church has a doctrinal *corpus* of which we note the essential text from Pope John Paul II to the Pontifical Academy of Sciences in 1996, which establishes evolution as a fact (until the second Vatican council in 1962, the Catholic church had taken a stance against Darwinism) which does not of course mean that a philosophical and materialist interpretation of evolution can never be compatible with the Catholic dogma. Declan Butler reconsiders the article "Finding Design in Nature" by cardinal Schönborn, published in July 2005 in the *NewYork Times*, which expressed doubts about Darwinism and considered the possibility of intelligent design. Since then, says the author, the cardinal has made amends (Jean-François Maldamé, commenting on the cardinal's latest work, has a very different opinion) and Pope Benoît XVI decided in 2006 to devote the Castel Gandolfo Interviews, attended every year by philosophers, theologians and scientists, to the topic "creation and evolution". The Church accepts Darwinism and affirms, from the spiritual standpoint, a form of "theist evolution"; it explicitly rejects intelligent design, a form of theism. In addition, "*theology should not interfere with science*". The Catholic Church, however, reminds us that it disapproves of social Darwinism in any form and fears evolutionary interpretations in the field of economics or ethics (Butler, 2006). In *Schöpfung & Evolution*, (2007), Benoit XVI considers that evolution, accepted from the scientific standpoint by the Church, is "open *to debate between enlightened rationalists and the partisans of another, spiritually inspired vision of the world*"; theist evolution, *"an attitude common to many Christians and not only to Catholics, does not disavow knowledge of biological evolution, but postulates that God is the spiritual creator of every thing*". In an article in

La Croix, the biologist and journalist Dominique Lang believes that the contribution of cardinal Schönburn during these talks is "*problematic when he appropriates some scientific criticisms of Darwin's theory, deriving from theses similar to intelligent design*".

Where **European Protestantism** (the Reformed Church and Evangelist Churches) is concerned, it is necessary to underline the difficulty of giving an account of the diversity of religious reactions with regard to Protestants (Baptists, Lutherans, Presbyterians, Evangelists, etc.) because the various Churches deriving from the Reform do not have common doctrinal authority (Lepeltier, 2007). The Reform radically calls into question the allegorical interpretation of the Fathers of the Church and of the Papacy and prefers the "Bible alone" (*Sola Scriptura*) to this. But the current approach of the Reform Churches also involves commentary: the quest for origins has its roots in Christian theology, but scientists also teach us that the world is inscribed in the history of evolution. There are also other myths of creation than the Biblical account, and one might wonder how, and how far, the diversity of legitimate views should be articulated (Gisel & Kaennel, 1999). The biologist Roland Benz, writing on the blog of French-speaking Protestant Churches, says that to explain is *"a requirement of our intelligence which consists in injecting order into the disparate whole of things*" and that "*this is one of the great successes of modern sciences*". Scientific discourse has rightly replaced magic, mythical or theological discourse "*where the gods were used as an explanation for anything that astonished*". Recent research by Sebastien Fath, a researcher at the national centre for scientific research (CNRS) ,on evangelist forms of Protestantism deals with immigration Churches in France. He points out that the Evangelists have recently begun to transform the religious landscape in France: in the Paris region, 8 Protestants out of 10 are Afro-West-Indian and stand out from the historical Protestant Churches in Europe (Fath, 2007). Protestantism remains stable but is of varied composition: the numbers of Evangelists and Pentecostals have grown - in 2005 it was estimated that they represented nearly 30% of Protestants (Machelon, 2006). The latter are more sensitive to a literal interpretation of the Bible.

The second religion in France, **Islam** is mainly Sunnite (Boursin Lekov, 2007). Far from arousing unanimity, the *Atlas of Creation* by Harun Yahya, a Turkish Islamic preacher, made the Muslim community react, as witness an article in the *Nouvel Observateur*. Neither mediaeval Islam, fundamental for science, nor the Islam of the Enlightment protect against the advance of creationism, even though, as for other religions, this statement must be tempered in France, so numerous are the currents of Islam (Sunnites and Shiites, "lay Muslims", etc.) and so varied are the attitudes concerning relations between science and the Koran, while Muslims in France, whether liberal or traditionalist, are engaged in a process of secularisation (Boissière, 2007). In an interview given in October 2007 the sociologist Réda Benkirane was invited to comment on the entry of creationism into Islam: an overall lack of scientific education - the American Kitchner (2007) made the same observation - relayed by the politico-religious commitments of the Reagan and Bush years, is making fundamentalisms and "ideological polarisation" reappear: creationists and exponents of intelligent design against militant philosophical materialists. Réda Benkirane adds that "the *importation of evangelist creationism into Islam* […] *is an aberration*" because "*biological evolution does not create any particular metaphysical dead end* […]*, as God remains unknowable (the Koran: 112,1-4)*" (Benkirane, 2008). Francoise Lorcerie underlines the diversity of positions and divergences within Islam with regard to interpretations of the Koran. Neo-reformist interpretations of the Koran are current in France "*among educated middle-class Muslims*", but exist side by side with traditionalist readings or those related to political Islamism (Lorcerie, 2005).

The theory of evolution, accepted in French society, is analysed from materialist or spiritualist standpoints which refer to the interrogations and the interactions between sciences and society. Jean-Louis Schlegel (2007), a sociologist of religions, believes in this respect that "*individuals share less and less a common vision of religion* [as they do] *of science*", as sciences and religions each propose various visions of the world. As far as religions are concerned, there is "*a whole kaleidoscope*" of positions, ranging from superstition to rationalism. And, in spite of the drop in denominational membership since the nineteen-fifties, the religious aspect continues to occupy a real place in the life of very many Europeans, while appearing more and more apart from the main Churches: religions function as subcultures in *"post-Christian"* and *"post-secular"* societies: the return of religious beliefs does not call secularity into question but reshapes its relationship with politics and culture (Willaime, 2007a).

See also

- The Catechism of the Episcopal Church reminds us that though "*the Bible contains all things necessary to salvation*", it is not a scientific work: *"We discover scientific knowledge about God's universe in nature not Scripture".*
- Gross Benjamin (2007). *Un monde inachevé: Pour une liberté responsable*. Paris: Albin Michel.
- Bernardini Jean-Marc (1997). *Le Darwinisme social en France (1859-1918): Fascination et rejet d'une idéologie*. Paris: CNRS Éditions.

❑ Evolution and fundamentalism

Concordism, an attempt to reconcile the Bible and scientific discoveries, is intellectually and historically related to intelligent design. The argument of design, used by Concordists such as Buckland during the nineteenth century, comes from *Natural Theology* (1802) by William Paley, the reference for the partisans of intelligent design of today. Paley states that the fact that structures are able to adapt confirms the "design" argument, and is proof of a benevolent god (Lepeltier, 2007). André Steiger (2002) also stresses the fact that the first three

chapters of Genesis are the foundation of the Judeo-Christian civilisation, and that to confront this text with evolution is therefore a cultural and not a religious approach: in the light of modern palaeontology, biochemistry, genetics and astrophysics, the author believes it is possible to compare the Biblical (mythical) account and the scientific account of evolution. Jean-Michel Maldamé, however, strongly underlines that this work "*can only surprise a reader who is aware of the questions raised by the relationships between science and faith*", because it returns to a form of concordism that has been made over, it is true, but that is still dangerous, facilitated as it is by a lack of critical evaluation of registers of vocabulary and concepts. Theologians today do not mince words in denouncing the "laziness" and the "foibles of concordism" (Maldamé, 2003), as recent theological work "*dispenses the errors of concordism*", says Jacques Arnould (2003). In an article in *Libération*, Réda Benkirane too points out the danger of a Concordist interpretation of the Koran, something which is fairly current, and takes a stand against the "gutter popularisation" that is facilitated by the today's media, while Saïda Aroua recalls that Concordism "*betrays an ignorance of scientific methodology*" (Aroua, 2006).

Another concern:**intelligent design**. Thomas Lepeltier a historian notes the return of William Paley's "great watchmaker" and reminds us that for many believers, God could not be a "handyman"; only ignorance of biological systems, the lack of distinction between the methodological materialism of science and metaphysical materialism, as well as impatience in scientific research lead one to believe in intelligent design for the universe and for man Moreover, given the suffering which reigns on Earth, how can one speak of a good and intelligent god? The mixture of two different fields leads to a "dead end" (Lepeltier, 2007). Jacques Arnould refutes intelligent design in which God is "*just about good enough to fill the gaps in human ignorance*" Gustave Martelet goes one better: intelligent design, referring as it does to a "super-intelligence", is a form of deism: God has only a utilitarian role, "*thereby pointlessly doubling the empirical explanations that science suffices to provide us with*" (Martelet, 2006). A diocesan site defines intelligent design as a theist "allegation" based on a "supreme Being" and, on the blog of the French-speaking Reformed Churches, Roland Benz reminds us that God cannot be used as an explanation, because he is not an object that can be analysed by human intelligence: "*God cannot prove himself*" This is also what made it possible to define intelligent design as a religious and not a scientific subject, and thereby exclude it from science classes.

Many researchers identify the common denominator between the various creationist movements, whether these be Christian or Muslim, or "fundamentalist". Various reasons, especially moral or political ones, have justified the commitment of fundamentalist American Protestants for a century and impact the relationship between the Bible and science (Drees & Kremer, 2000). Creationism is a form of Biblical fundamentalism, especially familiar to certain Lutherans, Baptists and Adventists. Their presence in the media and on the Internet, must be treated with vigilance (Arnould, 2007). According to the physician Faouzia Charfi, Muslim fundamentalism began disturbing biology lessons in the nineteen-seventies using an approach similar to that of fundamentalist Protestants tied to a literal interpretation of the Bible; she believes that fundamentalist Muslims took their arguments and their method as a starting point and even "perfectly imitated" them, especially in developing their websites. She then notes that, after the example of intelligent design in the United States, a form of "re-appropriation of science" is at work, with a Concordist and anti-rationalist outlook. While the author considers it regrettable that the teaching of the famous Ibn Rochd (better known to Westerners under the name of Averroès), which contributed to the separation of faith and knowledge, has been set aside, she notes that this trend is to be found among both Protestant and Hindu fundamentalists (Charfi, 2007). In the Muslim world, "moderate" organisations are fighting against the rise of fundamentalist theses, while the Internet is becoming a "*battlefield between the moderate and the conservative*" (Testot, 2008). The metaphor of the "*spectre*" is used by Jean-Louis Schlegel, a sociologist of religion, as fundamentalism hangs over the modern world whose achievements it aims to cancel out. Without retreating in front of logical, social or spiritual antinomies, fundamentalism confuses the freedom of choice specific to the act of faith and submission to a set of certainties - for fundamentalists are quick to understand and interpret God in a way that is as infallible as it is final (Schlegel, 2003). As far as the literal approach to the texts is concerned, the "speech of the Bernardins" by pope Benoit XVI, in September 2008, states: "*The Scriptures need interpreting*" and the believer rejects "*all that today is called fundamentalism*". The Pontifical Biblical Commission uses a formula that gets straight to the point: "*Fundamentalism invites one* […] *to a form of thought suicide*". As for the authors of *Strong Religion*, they identify the "enemies" of fundamentalists: established religions, the secularised State and civil society (Almond, Appleby & Sival, 2002).

See also

- Schmid Anne-Françoise (2007). « La théorie de l'évolution face au créationnisme ». *Natures Sciences Sociétés*, vol. 15, n° 3, p. 280-284.
- Beaudoin Cyril & Brosseau Olivier (2008). *Les créationnismes : Une menace pour la société française ?* Paris : Éditions Syllepse.
- Clément P., Quessada M.P., Laurent C. & Carvalho G. (2008). « Science and Religion: Evolutionism and Creationism in Education. A survey of teachers' conceptions in 14 countries ». In *Proceedings of XIII IOSTE symposium, the use of science and technology education for peace and sustainable development*, Izmir.

❑ Evolution and scientific posture: the debate about NOMA

The philosopher Jean Gayon presents the three main modalities of the relationship between science and religion:

– conflict, from cultural competition to violent opposition;

– separation, because the goals are believed to belong to different orders which, "*as they meet with different human needs,* […] *should not in theory interfere*";
– "interaction" to varied degrees and with various modalities.

Given that these three kinds of relationships are idealisations and that nothing exists in a pure state (Lepeltier, 2007). The world-famous biologist Stephen J.Gould popularised the term **NOMA** (*Non-Overlap of Magistery*) in his famous work *Rocks of Ages: Science and Religion in the Fullness of Life* (1999). Jacques Arnould also chooses to distinguish the respective positions "*of rationalists and certain pietists*", without unduly separating them nor confusing them, as do the Concordists and those from conservative backgrounds (Arnould, 2007). François Euvé militates for a distinction between fields, and is not favourable to any form of "convergentism": "*both opposition and convergence*" are out of place (Euvé, 2004). Hans Küng refuses both confrontation and integration, and looks for a dialogue founded on mutual knowledge, with no attempt to reach a consensus and no proselytizing from either party, moreover requiring contemporary theology to take the challenges of science into account. For these authors, God can in any case only exist outside the scientific field (Küng, 2008).

The **Rationalist Union** calls for a science that is "*aware of its limits*": since the end of the eighteenth century, sciences "*deal only with issues of fact that can be understood through experiment*". Everyone must be able to think about the "*possible relationship between science and spirituality*", which, for the approach to be valid, involves identifying and delimiting the various forms of discourse about the world: scientific, spiritual, artistic, mythological, etc. "*Failure to identify the structure and the boundaries of each of these discourses leads to the impossibility of thinking and to apparent conflicts*", whereas the public must be able to tell the difference. In addition, the only modality for the relationship between science and religion is an "*irreducible antagonism*" (Dubessy & Lecointre, 2003): philosophical or ontological forms of materialism are logically opposed to the *NOMA*, which base science and religion on a principle of equality. Stephen J. Gould additionally neglects the fact that morals may not involve a religion (Dubessy & Lecointre, 2004).

For Pascal Picq, the issue is clear, though: "*Whether we are believers, church-goers, atheists, or agnostics, we belong to cultures often deriving from the same historical melting pot*" and "*this is about saving secularity*" because it will come out badly from any form of radicalisation. "*There is no match between two idols: Lucy and Eve*". "*Even though it is turning out to be not very easy to prevent the overlap of magisteries in absolute terms, and in spite of Galileo's expression of* [editor's note: "science says what the sky is like; the Bible tells you how to get to heaven"; translator's note*: the play on words in French between* le ciel *(the sky) and* le Ciel *(heaven) is lost in English)*] *and Stephen Jay Gould's wish* [the NOMA]*, its principle still remains an obligation*" (Picq, 2007). Thomas Lepeltier considers that a free-for-all between Christianity and Darwinism is "simplistic" and believes that this position has become a "myth", and henceforth "*a study subject for historians of ideas*", even though "*evolution is one of the rare historical cases* [along with Galileo] *of radical and long-lasting open conflict between sciences and religion*" (Lepeltier, 2007).

See also

- Lecourt Dominique (s. d.). « Les enjeux idéologiques autour de la paléontologie humaine », article introductif du dossier *À la recherche des origines de l'homme*, en ligne sur le site du CNRS.
- Farouki Nayla (1998). *La foi et la raison : Histoire d'un malentendu*. Paris: Flammarion.
- Russell Bertrand (2007). *Science et religion*. Paris: Gallimard. (1re éd. 1935).

The condition of scientific work: methodological materialism

Researchers' philosophical, political or spiritual choices should not cross the threshold of the laboratory, at the risk of invalidating the scientific nature of the work, based on "four pillars":
– initial scepticism about the facts, which must distance any, political or religious intrusion;
– a principle of realism;
– a principle of rationality and parsimony: failure to observe logic leads to the demonstration being refuted;
– a "methodological" or "epistemological" materialism, "*not to be confused with philosophical materialism*". This polysemous term needs to be accurately defined within the framework of scientific activity, so as to leave no ambiguity, intentional or otherwise: by definition, science does not work with immaterial categories. "*While science is materialistic in its method, it owes nothing in return* […] *to any philosophy*", according to an article by Guillaume Lecointre in the on-line CNRS file. "*Materialism subsists in sciences at the stage of a method, and not as an original design, by definition a non-empirical approach*" (Charbonnat, 2007).

The declaration of the Interacademy Panel on the teaching of evolution is clear: "*Human understanding of value and purpose are outside of natural science's scope. However, a number of components – scientific, social, philosophical, religious cultural and political – contribute to it. These different fields owe each other mutual consideration, while being fully aware of their own areas of action and their limitations*".

Evolution in the educational context

Evolution in French curricula

Between 1871, when Darwin's *The Descent of Man* was published, and 1960, the year when evolution was introduced into French school curricula, several decades went by before French school curricula included the zoological nature of *Homo sapiens*. In 1735, Linnaeus in his *Systema naturæ* proposed including man among

the primates. The idea of evolution, and therefore of family ties between the species, made progress in the late eighteenth century with the work of Buffon (1744-1829), and later of Lamarck (1744-1829), and is mentioned for the first time in 1833 in a ministerial circular. The great paleontologist Georges Vat, a notorious anti-evolutionist and inspector at the royal Council for state education, goes a long way towards explaining this difference. Pierre Clément uses the expression "*didactic transposition time*" to indicate the time lag (now very short) between a discovery and its being taken into account in curricula and textbooks (Quessada & Clément, 2007). In addition, the 1902 secondary education reform drew up new syllabuses attesting to the place of sciences and their educational role, in particular when these are experimental sciences. It founded the "scientific humanities" the spirit of which has since guided natural science, and later life and earth science syllabuses.

Monique Dupuis & Jean-Claude Herve (2008) have recently analysed the contents of life and earth science syllabuses (formerly known as "natural science"). Evolution has been taught in French syllabuses (at secondary level) for about fifty years, moving from the study of palaeontology documents to thinking about the concept of a common origin for living beings, from cellular and molecular biology. The latest syllabuses, especially for the first years of secondary education, show that "*evolution has never been as present in the syllabuses*" and is the "*major unifying topic of earth and life sciences*" in the early years of secondary schooling, as well as in the later ones, where it is represented in all the *baccalauréat* series.

❑ 1950-1989

Since the nineteen-fifties, teaching evolution has been part of the final year science syllabus. "experimental sciences", final year of the D (biology) *baccalauréat*, then final year S. Also during this period, evolution was often dealt with more summarily due to the discrepancy between the density of the syllabuses and the small amount of time devoted to the subject; this was also true of the study of DNA. From 1950 to 1989, syllabuses changed only slightly and did not include the new data on genetics. The 1989 syllabus marked a turning point: concerning all *baccalauréat* series, it stood out by the fact that scientific knowledge was updated to include data on molecular genetics (gene concepts such as exons, introns, promoting sequences, RNA messenger splicing, etc.): "*cellular biology occupies a key place, which will not be the case in future syllabuses*", the authors underline. Hominisation, already in the syllabus, was also brought up to date, even though the commentaries and handbooks still suggest a linear vision of human evolution. This syllabus was innovative, but also too ambitious (Dupuis & Herve, 2008).

❑ The 2000s

As of the year 2000, evolution united the final years *(lycée)* of secondary education - even though the contents sometimes overlapped, because the *lycée* syllabuses were written before those of the first years of secondary education (*collège*). Phylogenies, mentioned in the 1989 syllabus, become the main topic of the 1994 and the 2002 syllabuses. Help in studying them has been provided by the Phylogène software as of 2000. In the *collège* (in 2005 for the first year and 2008 for the fourth year) the syllabuses were reworked in keeping with the previous ones, stressing the teaching of evolution as a key element in life and earth sciences. This involves teaching phylogenetic classification, in keeping with research conditions. The syllabuses stressthe method of classification, without requiring the pupil at this stage to name the groups. This new approach to classification is a "major break" designed to heighten awareness to the idea of evolution and to pave the way for future study. From the teaching point of view, the syllabus writers chose to teach phylogenetic classification without referring to evolution.

The La Main à la Pâte methodology is recommended. Evolution is tackled implicitly from the first to the third year of secondary schooling, via classification in the form of interlocking groups. In the fourth year, that consideration is given to the concept of evolution itself. The syllabus stresses the scale of geological time, a key notion for understanding evolution but one that is imperceptible on a human scale, the concept of "crisis", the common origin of all living beings, and the genesis of new species from pre-existing elements - in the fourth year, the notions of genetics in the syllabus can be used to help. The mechanisms of evolution are dealt with for the first time in a *collège* syllabus, even though no provision is made for the concept of mutation. Jean-Claude Herve and Monique Dupuis ask certain questions about this teaching. For example, they underline the difficulties related to the absence of a nomenclature: according to the documents that accompany the courses, the group of fish or reptiles, which has no meaning in phylogenetic classification, can nevertheless be "*used in a determination activity*". Classification seems to be taken as self-evident whereas it should be articulated with "*its philosophical bases* […]: [it] *must convey* […] the *evolutionary history of the living world*" (Dupuis & Hervé, 2008). In addition, the authors' reading of what pupils put in examinations, and also Corinne Fortin's analyses stress that pupils can solve the exercises while nevertheless subscribing to non-evolutionary conceptions (Fortin, 1993).

For the primary school (cycle 3) Corinne Mairone notes that the 2002 syllabuses stipulate: *"the species now present on Earth derive from other species which lived before*". The concepts of relationship between living beings and common ancestors are tackled, and the syllabuses take recent work on systematics and phylogenetic classification into account (Lecointre *et al.*, 2006) – but the wording remains succinct: "*from the "evolution of living things" in 1985 we have moved to "traces of the evolution of living beings (some typical fossils); the main stages in the history of life on Earth; the concept of the evolution of living beings" in February 2002*". As a non-specialist, the 2002 school teacher "*is undoubtedly even less well-equipped than his 1989*

counterpart to make didactic choices". However, an official document lists the difficulties arising from pupils' prior ideas and offers some resources (La Main à la Pâte) which bear witness to the role of science didactics (Mairone, 2007).

❑ A socially controversial issue?

In the 1950s, a century after Darwin's work, the synthetic theory of evolution became the "*framework for the work of the vast majority of biologists, naturalists and paleontologists*". There is no scientific controversy surrounding the theory of evolution; school in France has regularly tackled and updated the teaching of evolution, without needing to consider it as "controversial". For one to wonder about the legitimacy of treating the teaching of evolution as a "controversy", it must be clearly identified as a "*socioscientific issue*" (*SSI*) as has been the case in the United States for a long time. But Ronald S. Hermann recalls that the theory of evolution is more accepted in Europe than in the United States; he puts this difference down to the politico-religious stakes and the low level of scientific knowledge of American adults concerning genetics, and underlines the role of the media in manufacturing a controversy. Moreover, deciding to teach controversy has as a corollary the recognition of this controversy: while not mentioning it causes a problem - it may be experienced as censure, or it may encourage students to seek sloppy answers elsewhere -, this debate at any event has no place in science classes, but it is important to able to express it, for example, in history or philosophy class (Hermann, 2008).

Reference may be made to the *Dossier d'actualité VST* that Agnès Cavet devoted to *Teaching controversial issues* in May 2007. She already brought up the USA controversy raised by intelligent design, and its repercussions within the American education system. But can it be said that evolution in France is a "question socialement vive",as defined by Alain Legardez (2006), i.e. a question which is "*controversial in society*", "*controversial within the reference forms of knowledge*" and "*controversial within educational forms of knowledge*"? It would undoubtedly be unfair since the controversy really affects neither reference forms of knowledge, nor educational forms of knowledge.

See also

- Simonneaux Laurence (2003). « Enseigner des savoirs "chauds" : L'éducation biotechnologique entre science et valeurs ». In Astolfi Jean-Pierre (dir.). *Éducation et formation. Nouvelles questions, nouveaux métiers*. Issy-les-Moulineaux : ESF.
- Simonneaux Laurence (2005). « L'actualité scientifique s'invite dans la classe ». *Les cahiers pédagogiques*, n° 434.
- Le Vigouroux Philippe (2008). « La place de l'évolution dans l'enseignement secondaire français ». *Science et Pseudo-sciences* ? n° 281, p. 9-15.
- Chanet Bruno & Lusignan François (2007). *Classer les animaux au quotidien : Cycles 2 et 3*. Rennes : Centre régional de documentation pédagogique (CRDP) de Bretagne.
- Chanet Bruno & Lusignan François (2008). *Teaching Evolution in Primary School : An Example in French Classrooms.* New York : Springer.

Better understanding for better learning

The science class is the place to study science according to the criteria of science. For all questions must be able to be dealt with, an interdisciplinary context is necessary, requiring training of the various teachers concerned. The task is not easy for the teacher, because the term "Darwinism" is seldom used in its scientific meaning: the historical dimension of the term may be neglected, it may be used to cover other sociological or political concerns, or intersect with social Darwinism. The path is now fraught with obstacles: it has become of key importance "*to make the meaning of scientific theories, and thereby the very nature of scientific activity, comprehensible*" (Coquidé & Tirard, 2008).

The specifications for teacher training are explicit as to the requirement of training and general culture: *"A good command of the knowledge taught is the requirement for teaching. The teacher has a thorough and broad knowledge of his/her discipline(s) and a command of the questions featuring in the syllabus* […] *; he/she has also a solid general culture which enables him/her to contribute to the construction of a common culture for the pupils*. […] *The teacher's scientific and disciplinary command means that he/she will have an attitude of scientific thoroughness helping him/her to develop multidisciplinary and transverse approaches based on convergences and complementary features between the disciplines*" It is the teacher's responsibility to "*update his/her knowledge of the discipline, of didactics and pedagogy*"(BO n° 1, 4 janvier 2007). Guy Rumelhard (2007) also considers that it is necessary "*to arm earth and life science teachers to begin the debate*" because they are still very often impregnated with the epistemology of a "school Claude Bernard": initial and in-service training is necessary to make it understood that science is "still up and running" and to endow the scientist with his status as a scholar instead of a science technician. An obsolete image of science, often still at work in science lessons, conveys distorted conceptions of the world; epistemology must be at the centre of didactic thinking, especially with regard to evolution (Mathy, 2006).

❑ Vocabulary

The first obstacle to healthy scientific and philosophical training has to do with vocabulary. Common sense and scientific sense are polysemes that maintain confusion in the mind of the general public and in that of pupils. The very term "evolution" is not safe from dangerous connotations; in the current 4th year syllabus this term is probably not always used in a strictly scientific sense: but common sense evokes *"the unfolding over time of a*

sequence of directional events"; as for the word "theory", it is synonymous for pupils with "opinion" whereas it in fact indicates "a *coherent whole of explanatory proposals for a set of observable phenomena*" (Dupuis & Hervé, 2008). The La Main à la pâte file on teaching evolution for primary teachers starts with an epistemological work: Bruno Chanet and François Lusignan state that, in French, the word "theory" has two meanings: the first meaning, "*a set of more or less organised ideas or abstract concepts, applied to a particular field*", belongs to everyday language and often corresponds to facts that are imperfectly backed up, whereas the second, *"a methodical and organised intellectual construction, of hypothetical (at least in part) and synthetic nature*", belongs to the language of sciences; this difference in meaning "*leads to much misunderstanding*". Epistemological confusions, sometimes maintained intentionally, are frequent and difficult to identify for the general public, as Lecointre shows in an on-line file on the CNRS site. We read above about the old confusions generated by the concepts of "social Darwinism" or "materialism": the connotations of several current or specialised meanings complicate the definition of scientific work for a neophyte public.

Patrick Tort points out that Darwin is often wrongly associated with inegalitarian spin-offs of the principle of natural selection (eugenic, racist or neo-Malthusian). Spencer believes that adaptation is the rule of survival in a society governed by interpersonal competition, and preaches the elimination of the least well-adapted; the social Darwinism of Spencer remained very much inspired by Lamarck but dipped also into the works of Darwin and Malthus, and is intended to apply expressly to a field that was off limits for Darwin, that of the social sciences (Tort, 2007). In his latest work, *L'effet Darwin* (2008), Patrick Tort puts down the attribution of social Darwinism to Darwin to *"a noisy ignorance*": on the contrary, *The Descent of Man*, written ten years after *The Origin of Species*, identifies the social instinct of "*sympathy*" and *"balancing interventionism*" "*of which the two essential effects are the protection of the weak and the recognition* […] *of the other as a fellow creature*", a powerful corrective measure which civilisation must bring to nature.

Acceptance by pupils of the scientific status of evolution does indeed go hand in hand with the command of an accurate epistemology. The obstacles need to be diagnosed, but it is also necessary to plan to build a "a teaching system" including real "epistemological assistance", in conjunction with debates making it possible to build "knowledge of evolution", which stands out from any metaphysical explanation, incompatible with the methodological materialism necessary in sciences. The conceptual difficulties have been known for a long time: "genetic", "time", "species": these terms are not self-evident (Aroua, 2006). Using examples, Denise Orange-Ravachol and Francoise Beorchia note the importance of the principles structuring life and earth sciences, which oftenrun against the grain of immediate thought, and wonder about the means of passing these on to pupils (Orange-Ravachol & Beorchia, 2007). In his "Second postface for teachers", Guillaume Lecointre stresses the many questions of vocabulary and general culture which underlie the epistemological and conceptual difficulties that pupils encounter: it is up to the teacher to identify them so as to be able to answer them.

See also

- Fortin Corinne (2008). « La métaphore de la parenté : Obstacle à l'idée d'évolution ? ». In Coquidé Maryline & Tirard Stéphane (dir.). *Évolution du vivant : Un enseignement semé d'embûches ?* Paris : Éditions Adapt.
- Clément Pierre (2007). « Introducing the Cell Concept with both Animal and Plant Cells : A Historical and Didactic Approach ». *Science & Education*, vol. 16, n° 3-5, p. 423-440.
- Clément P. (2008). « Relating to critical analysis of school science textbooks ». *Science Education International*, vol. 19, n° 2, p. 93-96.
- Quessada M.P., Clément P. (2007). « An epistemological approach to French curricula on human origin during the 19th & 20th centuries ». *Science & Education*, vol. 16, n° 9-10, p. 991-1006.

❑ History of sciences

The great questions of modern biology did not appear by spontaneous generation. According to Pascal Picq, there is an urgent need to return to real science teaching: "*what science is, its history, its epistemology and its methods*"; one should no longer confuse science and the applications, and evolution is "*too little and too badly taught, in particular with regard to its epistemological bases*" (Picq, 2007). Moreover, the general public has an image of science as still being based on observation, whereas sciences in general work on hypotheses: familiarity with the reality of the approach and the researcher's method is today essential, in life sciences as in other sciences. And yet the position of the researcher today is clear: it is accepted that we expect an idea to be first of all fertile before being proven and attention to the concept is then paramount: "*empirical observation stops and waits* […]*, the theory drives*". At the same time, this obviousness is difficult to get through to the general public and common knowledge is often an obstacle to scientific knowledge (Rumelhard, 2007).

Since the work of Bachelard, we know that the obstacles to knowledge are not related to the difficulty of the concepts or of what is known. A scientific culture involves knowledge of the history of sciences (Djebbar, Gohau & Rosmorduc, 2006). The fact of teaching only science, even more of it and better, would not solve the whole of the question, because what is also involved is getting people to understand what its specific features are. Science remains an unknown world for many pupils, also generally characterised by "a scientific illiteracy". It is additionally necessary to make more room for the history of sciences because current issues are constantly shaking up and reshaping knowledge; experiments for their part, remain ambiguous if they do not help one to understand the scientific approach as a whole (Pigliucci, 2007).

At European level, the Brasseur report (OECD, 2007) proposes that creationists theses might "*be presented within an educational framework other that of the scientific disciplines. The importance of teaching cultural and religious issues has already been raised by the Council of Europe. Creationist theses, like all theological approaches, could, while respecting everyone's freedom of expression and beliefs, be presented within the framework of reinforced learning of cultural and religious issues* […] *In addition, we should ask about the causes of such a calling into question of the theory of evolution. That the theory of evolution lends itself to so much attack, might, perhaps, be explained by the weakness of what it has to teach is us, particularly from the epistemological point of view*". An approach via the history of sciences, recommended by the Council of Europe and the *general principles for the teaching of the history of sciences,* is possible as of the fourth year of secondary school and is explicitly proposed in the "Activities" section: "*study of historical texts concerning evolution*" (Dupuis & Herve, 2008). Interdisciplinary practices are moreover desirable. A cross study (history and life and earth sciences) of Darwinism in the sixth year of secondary school (arts branch) shows the value of interactions between disciplines (Chanet & Cottour, 2006). In the same vein, the common introduction to all the scientific disciplines in the first year of secondary school *(collège)* postulates that *"the historical perspective gives a coherent view of sciences and techniques and their joint development. It helps present scientific knowledge as a progressive human construction and not as a set of revealed truths* […] *All the disciplines contribute to our understanding of the world. In particular, the stated objective also corresponds to that of history and geography teaching. The approaches are, however, different and complementary*".

See also

- Le Guyader Hervé (2003). « L'évolution biologique dans les théories et les faits », en ligne sur le site du CNRS.
- Allano Louis & Clamens Alex (2008). « Repenser l'enseignement de la théorie de l'évolution au lycée ». *Pour la science*, n° 367, p. 30-31
- Lecourt Dominique (2000). *L'enseignement de la philosophie des sciences* : Rapport au ministre de l'Éducation nationale, de la Recherche et de la Technologie.
- Clément P., Carvalho G., Abrougui M. *et al.* (2006). « Differences in values associated to biology, health and environmental questions among France, Portugal, Hungary, Senegal, Lebanon and Tunisia ». *IOSTE XII Meeting*, Proceedings XII IOSTE Conference, Science and Technology Education in the Service of Humankind, S.Yoong et al (ed), Universiti Sains Malaysia, p. 149-151.

❑ Textbooks and resources

School textbooks occupy a very important place in teaching: as a tool giving access to knowledge, they must be articulated with the syllabuses in use and with knowledge which is constantly being reshaped, but they are also bearers of values, whatever the subject under consideration. "*Science lessons are not neutral and the contents of the textbooks also carry ideologies and moral connotations that are very often implicit*", underlines Pierre Clément, who is working on these questions at the Lirdhist (interdisciplinary laboratory for research into didactics and the history of sciences and techniques, Université Lyon 1) and since 2004 has been coordinating a European research programme Biohead-Citizen (*biology, health and environmental education for better citizenship*). This survey shows that textbooks (in which the room allocated to evolution varies greatly according to the country) do not reflect always the rapid reshaping of knowledge, and the information often vehicles values and ideologies. Pierre Clément (2006) points out that "*the choice of scientific contents taught*" has always been correlated with social practices and a system of values. An example taken from a fourth year textbook from 1999 is significant: a photograph of two twins each riding a motor bike, with the same haircut, the same position and the same clothing, has the following caption: "*Identical twins have the same genetic programme. Do you know why?*". This deterministic message (implying that genes have programmed the way they look and the choices they make) "*vehicles fatalistic values*", while the term "programme" could be easily replaced by that of "information".

With regard to evolution, the North-American context reinforces this impression: the field of confrontation chosen is that of education (syllabuses, textbooks, pressures on teachers). In the United States life and earth science textbooks are screened for political values and classified "red" (Republican) or "blue" (Democratic) (Bowman, 2007); a Canadian textbook is dissected, giving examples of questions to ask the teacher to contradict what he is teaching about evolution, while the "*question of whether "stickers"* are *constitutional"* has found its way into American courts, showing just how essential textbooks are for the transmission of scientific knowledge. Anti-evolutionist schoolboards pepper public school textbooks with stickers stating that *"evolution is not a fact"* thereby contravening the first amendment of the American constitution (Borenstein, 2008). In addition, Massimo Pigliucci believes that many textbooks must be rewritten because they convey erroneous or obsolete conceptions which weaken the teaching of evolution, or even, in the United States, reinforce creationist opinion (Pigliucci, 2007). The obsolete diagram showing the evolution of the man, so well-known that it is almost part of our collective memory, to judge by its posterity in the field of caricature or publicity (Gould, 2004), is, however, still present in textbooks, like the image of "the scale of species" or the engraving by Haeckel, just as erroneous.

According to a report from the state education inspectorate, produced by Dominique Borne (1998), the life end earth science textbook is used relatively little, at least in lessons, in French *collèges*: only 30% of first year and 20% of second year classes use it. Teaching materials for the classroom are produced by the teachers. Parents worry about how heavy satchels are, or how little used expensive textbooks are, but do not wish to intervene in the choice of the textbooks. Borne also points out that while "*one of the functions of the inspectorate is to*

make sure they are used, […] *the publishers are completely free to interpret the syllabuses*". The textbooks are generally produced by a collective of teachers, teacher-researchers and inspectors. They are also subject to the laws of marketing and, as the author warns, *"the power of school publishers* [in particular with regard to teachers, with the usual distribution of a free copy] is likely *to deprive the ministry of any role in deciding on teaching materials*". The choice of the textbook rests ultimately with teachers during teachers' meetings between colleagues teaching the same subject.

As far as on-line **resources** are concerned, La Main à la Pâte (MAP) is doubtless the best-known for primary education: launched in 1996, upon the initiative of professor Georges Charpak and of the French Academy of sciences, it aims to promote in primary schools a scientific investigation approach explained to schoolteachers. Its methodology is recommended for applying the syllabuses (Mairone, 2007 ; Dupuis & Hervé, 2008). The MAP is highly committed to the production of scientific resources for classes, and in developing an approach to sciences which has set a standard in France and abroad, it echoes the declaration on the teaching of evolution published on 21st June 1996 by 67 Academy sciences members of the InterAcademy Panel, which denounces pressures on the teaching of evolution throughout the world and demands that "*all children receive an education in the methods and discoveries of science* [in order to] *promote understanding of natural sciences*". The resources of the MAP concerning the teaching of evolution in primary school are many and varied. Bruno Chanet and François Lusignan propose a slide presentation of phylogenetic classification for primary schools and a workshop "To think, is to classify". In the final years of secondary education, the Pylogène software, downloadable for free and used in examination questions, has, since around 2000, been helping to make the teaching of evolution (Dupuis & Herve, 2008) and its assessment easier.

See also

- Adam Lise, Alayrac Jean-Louis, Bense Dominique & Coquidé Maryline (2005). *Découvrir le monde à l'école maternelle : Le vivant, la matière, les objets*. Paris : Centre national de documentation pédagogique (CNDP).
- Quessada M.P., Clément P., Oerke B., & Valente A. (2008). « Human evolution in science textbooks from twelve different countries ». *Science Education International*, vol. 19, n° 2, p.147-162.
- Clément P. (2008). « Relating to critical analysis of school science textbooks ». *Science Education International*, vol. 19, n° 2, p. 93-96.
- Clément P..(2006). « Science and Ideology in Biology School Textbooks ». *IOSTE XII Meeting*, Proceedings XII IOSTE Conference, Science and Technology Education in the Service of Humankind, S.Yoong et al (ed), Universiti Sains Malaysia, p. 272-274.

Sciences and society

The example of teaching evolution illustrates the complexity of a scientific discourse which resonates with other discourses, other constructions of knowledge and other arenas for the transmission of knowledge. This is why "*teaching more science is not enough*" (Pigliucci, 2007). In launching workshops for thinking devoted to "sciences and societies", the national research agency (ANR) is preparing for a call for projects for topics to be proposed to the scientific community in 2009, to improve "*understanding of how knowledge is produced* […] *and of the role of those involved in this. With this in view, historical approaches that compare different cultural arenas are encouraged. Work carried out must especially help to grasp the interactions between the social, economic, cultural and political contexts, and the methods of production of knowledge* […] *All of the social science disciplines are concerned and collaboration between researchers in social sciences and the so-called "hard" sciences is highly encouraged*" The merger between the national literature and social science (ENS-LSH) and science (ENS) universities, announced for 2010, is part of a similar approach.

❑ Understanding the conceptions of teachers and pupils

The need to build a scientific relationship with living beings invites one to consider that other relationships with living beings which have their own logic in other fields, have been built up within the family and social circle: "*it is not the same thing meeting an earth worm, a partridge or a pig, if you're a stockbreeder, a hunter, a farmer; a catholic, a Muslim or a Hindu*" (Dell' Angelo-Savage, 2007). Several researchers have therefore attempted to gain better understanding of the knowledge and the beliefs concerning pupils' and teachers' relationships with living beings: Randy Moore (2007) considers that in the United States, the difficulties of teaching evolution are not only due to the characteristics of American society; he believes that one must be aware of the positions of the **teachers** themselves with regard to this theory. If they are better trained, they can get some distance on their convictions, their culture outside the classroom and the requirements of their scientific work (Moore, 2001). In primary schools in Canada, it can be seen that the lack of knowledge in the science of evolution does not allow teachers to make relevant teaching choices, puts them in a weak position with respect to their pupils and their parents when they chose to teach evolution, or makes them tend to avoid this part of the syllabus (Asghar, Wiles & Alters, 2007). A piece of knowledge may indeed have an "emotional load" and the relationship with the objects of knowledge built up elsewhere than at school may be source of conflict in school, in particular where evolution is concerned This topic may challenge the ideological and cultural convictions through which the teacher maintains a "multi-faceted" relationship and which may influence his/her teaching choices. With regard to schoolteachers in cycle 3, 96% subscribe to the theory of evolution: 82.9% are able to corroborate the theory of evolution using paleontological or biological arguments, and 40.8% have heard of creationism. They mainly use fossils and textbooks to teach this; only 3.9% resort to the Internet. Their knowledge derives

from training (50%), visits to museums (57%), what they have read (65.,8%) and the media (73.7%), and they devote from one to six sessions to this subject (Mairone, 2007).

Both initial and in-service training appear to be fundamental. The Biohead-Citizen survey, carried out on 5 189 teachers and future teachers from twelve countries concludes that "*whatever the country, and whatever the teachers' speciality (primary or secondary, biology or literature), those who have had longer training have a very significantly more evolutionary conception*" (Quessada, Munoz & Clément, 2007). Yann Lhoste looked at students preparing for the primary school teacher-training entrance examination (CRPE), majoring in "sciences and technology": *"most students refer to a linear conception of evolution* […]*; at the end of training, even if they represent the phylogenetic relationships between Australopithecus, the chimpanzee and modern man more in terms of a bush with branches everywhere, they still refer to a linear conception of evolution. It is during scientific debate that students come to an awareness of the problem of the hypothetical common ancestor*" (Lhoste, 2007).

Other research is in progress:

- the ACCESS team (continuous updating of science teachers' knowledge) from the INRP contributes to the research programme of the CNRS institute of communication sciences *(Institut des Sciences de la Communication)* entitled "scientific knowledge and teaching: from research to teaching: methods of knowledge sharing in the field of earth and life sciences". This research is based on a survey using a questionnaire aimed at life and earth science teachers in secondary schools
- the group E2 (*Enseigner l'Évolution/Teaching Evolution*) of the INRP is taking part in the research programme of the CNRS institute of communication sciences (ISCC) by working on how scientific culture is dispersed and appropriated in a society marked by knowledge sharing. It brings together teachers and researchers from various disciplines in a common approach.

As far as the **pupils** are concerned, a survey on Greek teenagers shows that they use two frames of reference concerning evolution, one scientific, one not; and that anthropomorphic conceptions as final explanations prevailover knowledge of the theory of evolution, for lack of sufficient scientific knowledge (Kampourakis & Zogza, 2008). In France, the irruption of religious arguments in scientific debates in the classroom is the sign of a new relationship to scientific knowledge. A survey on the religious register in the science class studies what pupils say and how teachers take this into account. It points to the recurring reference to the religious aspect in the life and earth science and physics classes and shows the existence of "*various conceptions of sciences, religion and teaching in teachers*" (Maurines & Pugnaud, 2007). Saïde Aroua (2006) underlines the frequent confusion of scientific and non-scientific frames of reference. In addition, evolution is one of those scientific realities which, "*while being perfectly well accepted by the scientific community, are nothing short of torment for ordinary reasoning*".

The sociologist Gerald Bronner asked sixty *baccalauréeat* holders, all of whom had been taught Darwin's theory at school, to explain why more and more elephant calves are born with the gene which prevents the formation of tusks: an "enigma" which can be "*easily solved if one uses Darwin's theory*". However, even though they sometimes use the right vocabulary (natural selection, evolution), the answers reveal a recurring reference to various manifestations of finalism (the uselessness of tusks, wanting to escape from ivory hunters), that the author also defines as "crypto-Lamarckism": while the survey does not reveal any creationist sensitivity, it does show that "*ordinary thinking has a hard time making room for chance*" (Bronner, 2007). In this context, one may have recourse to **debate**, an exercise that pupils and teachers are encouraged to use in various subjects. In conjunction with epistemological assistance, the teacher's work as a mediator helps pupils to identify the criteria of scientificness of evolution: discussions allow pupils to express their opinions, to debate them, to construct a more objective discourse (Aroua, Coquidé & Abbes, 2005) and to distinguish between the various frames of reference used for theological and scientific argument (Aroua, 2006).

See also

- Coquidé Maryline (2008). « Repérer les conceptions des élèves du primaire au lycée ». In Coquidé Maryline & Tirard Stéphane (dir.). *Évolution du vivant : Un enseignement semé d'embûches ?* Paris : Éditions Adapt.
- Deniz Hasan, Donnelly Lisa A. & Yilmaz Irfan (2008). « Exploring the factors related to acceptance of evolutionary theory among Turkish preservice biology teachers : Toward a more informative conceptual ecology for biological evolution ». *Journal of Research in Science Teaching*, vol. 45, n° 4, p. 420-443.
- Miller Jon D., Scott Eugenie C. & Okamoto Shinji (2006). « Public Acceptance of Evolution ». *Science*, vol. 313, n° 5788, p. 765-766.
- Scott Eugenie C. (2007). « What's wrong with the "teach the controversy" slogan? *McGill Journal of Education*, vol. 42, n° 2, p. 307-315.
- Lecointre Guillaume (2008). « Les facteurs de la négation de la théorie de l'évolution ». In Coquidé Maryline & Tirard Stéphane (dir.). *Évolution du vivant : Un enseignement semé d'embûches ?* Paris : Éditions Adapt.
- Forbes Cory T. & Davis Elizabeth A. (2008). « Exploring preservice elementary teachers' critique and adaptation of science curriculum materials in respect to socioscientific issues ». *Science & Education*, vol. 17, n° 8-9, p. 829-854.
- Levinson Ralph (2008). « Promoting the role of the personal narrative in teaching controversial socio-scientific issues ». *Science & Education*, vol. 17, n° 8-9, p. 855-871.

❑ Scientists' commitment

In order to be correctly perceived by citizens and to be a part of common culture, science in general and evolution in particular require commitment from scientists, who must leave their laboratories and come out into the social field, leading sessions from the nursery school to the secondary school, and getting involved in debates for the general public backed by specialised structures. The conferences must, if possible, take place outside school structures in order to work out a future common culture and to develop "scientific literacy" (Nelson, 2007).

In France, relations between science and society are placed under the aegis of the ministry for higher education and research, which has also taken over the national contact point "Science in society" directly within its research and innovation department. Various structures are concerned, including scientific, technical and industrial culture centres (CCSTI), associations coming under the 1901 law, which "*fulfil a twin function as resource centres (library, media library, information, scientific networks) and production and dissemination centres for cultural products (conferences, exhibitions, teaching kits, etc.). The CCSTI form a network of well-established structures throughout France, networking with very diverse regional partners (research environment, schools, local authorities, the industrial sector, companies, associations, media, cultural organisations, ministries). They are involved in multi-disciplinary work, for all publics, and especially for young people. They permanently innovate, seeking new forms of mediation*". The Darwin year, backed by the ministry for research, has a particularly large number of events planned.

The ministry also supports national head-end scientific and technical culture associations including the museum association and the centre for the development of scientific and technical culture, as well as various associations such as Petits Débrouillards, Planète Sciences…which organise experimental scientific and technical activities in teams, especially for young people and on an extra-curricular basis, in workshops, youth clubs and leisure centres. Major national establishments like the national natural history museum, with the Grande galerie de l'évolution, provide science research and media-promoted activities: training courses for teachers who want to update their knowledge of evolution, fun workshops to introduce young people to classification, or courses for the general public are available all year round..

See also

- Perru Olivier (2005). *Le Vivant : Approches pour aujourd'hui*. Éditions du Cerf : Paris.
- Girault Yves, Michard Jean-Guy & Colin-Fromont Cécile (2008). « Mise en scène de l'évolution dans les musées : Parti pris et problèmes ». In Coquidé Maryline & Tirard Stéphane (dir.). *Évolution du vivant : Un enseignement semé d'embûches ?* Paris : Éditions Adapt.

❑ Games and media

It is also advisable not to neglect the representations which pupils may develop outside the school context. How did they hear about evolution? In September 2008, the way the media received Spore, an on-line video game, is an example of a head-on shock between the culture of young players and the scientific propositions of teaching. Without any scientific pretension - for this is not a *serious game* – it "*casts us in the role of a god creating single celled life*", according to the game publisher's website. "*Spore will invite you to play God* […]*: the little cell that you have created* […] *will ultimately become a whole civilisation*". Each of the five phases of the game "corresponds to a stage of evolution [sic]: *Cell, Creature, Tribal, Civilization and Space*". This demiurgic stance makes it possible "*to control the destiny* [of] the *species*", and "*to decide the fate of civilisation*", unless the creature turns out to be "*dominated by a higher race*". All that is "*great fun*", but is likely to be less so for today's life and earth science teacher because, according to the game's designer, "*Spore more or less reworks the theory of evolution*".
On the other hand, the teacher is encouraged to take an interest in *serious games* which, while not intended solely for teaching, help to learn, to educate, and to develop various capacities, even though the French educational tradition is reluctant to associate play and learning and although some circumspection is required with respect to the multimedia industry, because games can easily become a support for an ideology

Laurent Tremel also stresses the importance that audiovisual products are taking on in the informal socialization that is now the rule (Tremel, 2008). Evolution is entering the field of simulations with an educational intent, such as La sphère de parenté or, to a lesser extent, Les vacances de Darwin.

The undeniable didactic spirit and the success of the eighties French television series, *Il était une fois la Vie*, shows that while anthropomorphism is a good mnemonic trick, it also passes on damaging concepts: of man as the evolutionary culmination (see in this respect an article by the scientific mediation association Plume). So some epistemological work very often needs to be planned. Paul Caro notes that audiovisual productions exploit topics and scenarios borrowed from science, that they illustrate - sometimes emphatically - specific fields, or that they produce fictions (science fiction or fantasy): the entertainment world is "swallowing up" the world of science (Caro, 2006). In addition, the Internet gives access to resources which pupils need to be taught how to decipher: side by side with the resources developed by major scientific authorities (*Sagasciences* by the CNRS, *Web-based Understanding Evolution* by *Berkeley University*, etc.), a myriad of sites with debatable scientific contents are proliferating.

In the area of **scientific popularisation**, "*scientific journalists are pulling their hair out, because some of their colleagues are confusing opinion debate and scientific debate*" (Picq, 2007); moreover, since the major news

media deal with questions that used to be the province of scientific popularisation reviews, we should now speak of the "media-promotion" of science and no longer about popularisation (Charandeau, 2008). Marc Silberstein underlines that general public magazines readily convey a false sense of scholarship likely to sow doubt in people's minds, while the debates and amendments often remain confined to learned reviews. "*Newspapers, even scientific reviews for the general public"*, adds Guillaume Lecointre, "*sell more* […] *when there is controversy*", and Patrick Tort points not only to "*media compromising*" but also "the Mandarin-style *contempt for the general public and popularisation*". The spectrum of a public that has been de-learned and manipulated is starting to form (Dubessy & Lecointre, 2003). It is true that headlines of covers such as "God and science, the new shock" (*Nouvel Observateur*, n° 2094-95), and "God against Darwin" (*La Recherche*, n° 396, 2006) give a rather black-and-white vision of the debates… whereas the reader then discovers quite different contents, full of shades of meaning and closely argued, backed up by thinking from researchers of repute. Many scientists are in fact involved in quality popularisation. A statistical study on the activity reports of the 11 000 researchers of the CNRS, carried out in 2008 by Pablo Jensen's team from the CNRS physics laboratory of the *École normale supérieure de Lyon*, shows that, in contrast to a generally accepted idea, half of the researchers are involved in popularisation of their research; those who publish frequently in academic reviews are also those who generally address the general public. Projects often bring together teacher-researchers and journalists, for example to work on preconceived ideas in sciences, especially with regard to evolution. Conferences by researchers are relayed by audiovisual media (such as the recent one by Guillaume Lecointre) and the regular publication of good general-public works in accessible editions testifies to the vitality of public interest in this field. Among these researchers, Stephen J. Gould is known for the breadth of his popularisation work. He does not hesitate "*to examine* [the great question of evolution] *through the wrong end of the telescope*" in parallel with his very specialised works (Gould, 2000b ; 2002).

See also

- Gould Stephen Jay (1989). *Wonderful Life: The Burgess Shale and the Nature of History.* New York : W. W. Norton & Company.
- Alvarez Julian (2007). *Du jeu vidéo au serious game, approches culturelle, pragmatique et formelle*. [Thèse]. Sciences de la communication et de l'information, Université Toulouse II Le Mirail ; Université Toulouse III Paul Sabatier.
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Conclusion

The image of the world, from Newton to Einstein, has changed (Simaan, 2005). Much possible, or proven confusion, even collusion, between the subject and the arguments of science on the one hand, and questioning about origin and end - which has to do with other fields - on the other, first of all force one to tirelessly point out the definition of science and the framework of its teaching. This is particularly important with regard to living beings and evolution, since these subjects open out onto debates which go beyond their scientific dimension.

The disciplinary and epistemological training of the life and earth science teacher must allow him to devote himself calmly to the teaching of science in his classroom, in accordance with the official texts, while other periods, in teacher training and in what is told to pupils, must deal with the questions of science and society. At the same time, those working in civil society - as Dominique Wolton understands the term- are brought to look further into the relationships between sciences and society; and this has become a major issue.

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