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Why do we not teach that the earth is flat?

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Abstract. Scientific explanations of the Origins (of Earth, life, species, Man…) are contested nowadays even within schools. A school curriculum is a strong political act. In the French context, as far back as 1792, republicans have put knowledge at the heart of the development of French citizenship. In *state* schools, we teach *knowledge*, not religious beliefs or opinions. This implies, however, that one must be able to tell the difference. We propose a typology using two criteria. First, is the claim upheld individually or collectively? And second, does the legitimacy of the claim come from an authority figure or from a rational justification? We emphasise the collective nature and the autonomy of the process by which scientific knowledge is validated, as the direct by-products of experimental reproducibility. These characteristics have as a consequence that science is implicitly secular on an international scale. The reproducibility of experiments relies on four fundamental cognitive expectations which are described here: initial scepticism of the facts, principle of realism, rationality and methodological materialism. Failure to fulfil these expectations discredits any claim creationism may make to qualify as scientific.

Scientific explanations of the Origins (of Earth, life, species, Man…) are sometimes contested in France within the classroom, and even within universities, at undergraduate level. "Everyone is entitled to their own beliefs…we're in a democracy!" This mantra is used from time to time by pupils during Life Science classes, in order to avoid being confronted with a lecture on biological evolution. This opposition comes from the pupils' and their families' faith, or lack of understanding e.g. those parents from the Versailles *académie*[1] who consider biological evolution to actually be a religion!

To believe what we are told rests on a relationship of authority, or trust, or both. Without trust, we could not live in society. If I have faith in nothing, not even in public services, then I do not post my letter but deliver it myself. Trust is the foundation of social life. It implies that we believe what our parents tell us, what our teachers tell us, because we cannot spend all our time verifying everything… And because the amount of knowledge to cram in is enormous. A research laboratory is a very peculiar place. It is one of the few places where one is not asked to believe, but on the contrary to test what others claim, in order to verify them ourselves. The rules of the game are different. The principle of authority, or that of trust, is not called upon: a result is not true or false because your head of research says so – at least in theory. A research laboratory does not produce beliefs, but knowledge.

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[1] A regional district in the State Education System.

Table 1. Four types of affirmations. In state schools in France, only the first type is taught.

Affirmation	**Endorsement**	**Legitimacy**
Knowledge	Collective	Rational justification
Beliefs	Individual	Authority/trust
Religious beliefs	Collective	Authority/trust
Opinions	Individual	Various

1. Knowledge, beliefs, opinions

What exactly is the difference between knowledge, belief, religious belief, and opinion? Knowledge can be distinguished from religious belief and opinion by at least two criteria (Table 1). The first criterion consists of examining how the claim is justified. The second consists of knowing if the claim is upheld collectively or individually. Knowledge is justified through reason. It is legitimate because we know why we know what we know. It is legitimate because it has withstood numerous attempts to be disproved. This is particularly true of scientific knowledge, which is regularly put to the test. Knowledge's right to be disproved gives it its strength. This is not the view that is held by many of our fellow citizens, who on the contrary, and unfortunately, see in scientific knowledge some dogmatic construction. In addition, knowledge is produced *collectively*. With regards to scientific knowledge, no result acquires the status of fact unless it is corroborated by independent research groups, over a period of time. A result that is published only once will be forgotten. The cliché of the scientist as the isolated genius is so tiresome! Scientists are never alone! They climb on the shoulders of their predecessors, often work as a team, and most importantly need their professional community to test and validate (or refute) their claims!

Belief, on the other hand, relies on trust, or even authority. It therefore brushes aside any need for rational justification. It is upheld at the level of the individual. Religious belief is particular in that is upheld collectively (in "religion" there is *Religere* which means to bind). As with other beliefs, it does not need to be justified rationally to be legitimate in the eyes of those who uphold it. If one asks a believer to justify hisfaith rationally, one attacks him without knowing it. Its legitimacy stems from an introspection (in which case it loses its collective character) or from a principle of authority, which can reside for example in a text (which is therefore considered sacred) or an authority figure.

An opinion is only upheld at the level of the individual. It legitimises itself from everything, knowledge, and possibly beliefs. True, we sometimes speak of "public opinion", but this is only a statistical average of opinions, not a process of construction.

Laboratory space is a space of knowledge. What is created there is done so rationally and collectively. Indeed, scientists leave their political opinions and metaphysical beliefs in the laboratory cloakroom. If, by accident, they do not, what they claim will be refuted by others, over a period of time. We are not talking here about the books scientists may write in a personal capacity (and where they can sometimes cross the line . . .) but original results that are published in specialised journals: scientific findings are validated not because of a political or religious allegiance, but because they derive from rationality and can be reproduced anywhere in the world. In effect, the laboratory space is a secular space and that on an international scale. To attempt to verify what a colleague has published in a specialised journal, we do not need to know their nationality, beliefs or opinions. The reproducibility of the experiments is sufficient.

2. The reproducibility of experiments relies on cognitive expectations

The reproducibility of experiments, practiced collectively, forms the basis of science's autonomy in the process of validating knowledge. A result that is reproduced by independent observers, becoming increasingly more reliable, will acquire the status of knowledge, which then becomes public property.

To be carried out, this reproducibility relies on four elementary cognitive expectations, which are rarely taught:

- First expectation: scientific inquiry can only be initiated with *an initial scepticism regarding the facts*. We experiment on the real world only because we openly ask ourselves questions, to which we expect rational and specific answers. In other words, a student arriving in a laboratory with a unique answer at his disposal for any given question would be criticized for not explaining anything. If he arrived with preconceived convictions regarding the answers to the questions asked, he would be "redirected". If what is to be discovered is already written, we have straight away only a parody of science. This happens every time a force external to science dictates what needs to be found. There are three forces antagonistic to scientific inquiry. Commercial forces need the veneer of science to boast the superiority of a given product to sell. What needs to be proven is given in advance. Ideological forces also need to distort science to justify themselves. Lyssenko's genetics and Nazi anthropology provide the most classic examples. Religious forces proceed in a similar way when they invoke science to justify a sacred text, a mystical intuition or a dogma, be it Pierre Teilhard de Chardin's theology or so-called "*scientific*" creationism arising from Anglo-Saxon Protestantism, or when a sacred text is used to validate science from the outside and *a posteriori* in the way of Muslims. Let us take for example the scientist that builds phylogenies. From a selection of species sampled from the living world, the question is "who is closest to whom than to a third? How are their relationships organised?" Even if we start the investigations with a range of possible answers in our head, this range remains completely alterable and leaves room for surprises. A large part of our endeavour consists of checking whether what we find in the end is not an artefact, a mistake (by multiplying data sources, for example). This is easily understandable: we want to make sure we avoid publishing mistakes that will be refuted tomorrow. If the surprise stands up to inquiry, if nothing indicates that it is due to an error, then it is published. Some are convinced that scientists spend their time wanting to demonstrate propositions, not to say preconceptions: one should say instead that they spend their time testing what they unwittingly find.
- Second expectation: science is methodologically realistic, in the following sense: the outside world exists independently and anteriorly to the perception that we have of it and to the descriptions that we make of it. In other words, the world of ideas does not have an ontological precedence over the physical world: the physical existence of things is not subordinate to the validity of the concepts used to comprehend them. If I carry out experiments and publish them, it is in the hope that an unknown colleague will prove me right by finding the same thing as me. I therefore assume that the physical world will manifest itself to him like it does to me. I see no sense in scientific endeavour as the pursuit of the project of universal knowledge if this realism is not in place. If we question why it is important to restate such a principle, one only needs to read the texts arguing for strong cognitive relativism.
- Third expectation: scientific methods call upon the *rationality* of the observer. Rationality consists simply of respecting logic and the principle of parsimony. These are attributes of the observer, not of the objects under observation. This logic is unavoidable. No scientific proof can suffer faults of logic: the immediate sanction is its refutation. Any student in a laboratory who commits faults of logic is corrected. The universality of logic, supported by the fact that the same mathematical discoveries have been made in a convergent manner by different civilisations, would have an explanation rooted in nature: namely natural selection. In addition, parsimony is also unavoidable. The theories or scenarios that we accept concerning the world are the most economical in terms of hypotheses. The more the facts are consistent among themselves and the less the theory they support needs undocumented extraneous hypotheses. The most parsimonious theories are therefore the most consistent ones. Parsimony is a property of a theory; it is not the

property of a real object. It is not because we use parsimony in the construction of phylogenetic trees that we assume that biological evolution was parsimonious, as some think wrongly. The principle of parsimony is used everywhere in science, but it can also be used outside of science, every time we need to behave like rational beings. The police detective is, on our television screens, the most conspicuous user of the principle of parsimony. He reconstructs a murder with an economy of hypotheses, but it is not for that reason that the murderer opened the least number of doors, shot the least number of bullets and used the least amount of petrol to get to the scene of the crime.

– Fourth expectation: science follows a *methodological materialism*: all that is experimentally accessible in the real world is material or of material origin. What is material is changeable (by definition), that is to say it is endowed with energy. In other words, science does not know how to work with categories defined *a priori* as immaterial (spirits, life forces, phlogiston, souls, spectres, ghosts, angels, etc.): this contributes to its definition. At this stage, an explanation is required: although science took off thanks to materialist philosophy, it does not mean it is that philosophy. Scientists today do not have a collective objective of a philosophical nature. The philosopher Pascal Charbonnat reminds us that "*Materialism in science persists only in its methodology and not as a conception of the origin, which is by definition a non-empirical approach*". It is in this sense that we speak of "methodological materialism". To make things clear, let us illustrate this using a contradiction: a student who would summon *a priori* immaterial entities, inaccessible in the real world, and therefore not amenable to experimentation, would call upon either an irrefutable explanation (i.e. untestable), or an *ad hoc* explanation (in which case he would be lacking parsimony), or both. He would then be requested to formulate experimentally testable hypotheses.

We would now like remark on the status of mathematics. We often question its place as a "non-experimental" science, according to the scheme based on the four cognitive expectations. Mathematics is not fundamentally experimental. It is the efficient formalism of our rationality, in that it is the often indispensable companion of most scientific disciplines. It projects our reason often well beyond what is observable in the material world. This property allows us to make coherent predictions regarding the observations that can be expected in this world. Mathematics subscribes to the methodological materialism of science, because at no point does it postulate or require that a formalised entity, predicted but as of yet unobserved, should be immaterial.

As we said, these four cognitive expectations *determine the reproducibility of experiments.* They characterise experimental sciences, and by the same token define science through its methodology. We will point out that this definition is the largest possible; much larger than the scientific criteria upheld by popperians, and going beyond an imprecise and regrettable split between "hard sciences" and "soft sciences". Lastly, without going into the various types of creationism which are politically organized worldwide (which is not the topic here), and who actively work to infiltrate state schools or stop the teaching of evolution, we can easily show that all the forms that make "scientific" claims are clearly in breach of at least one of the four expectations. For example, the classic "creationist science" of Henry Morris and Duane Gish infringes the first and fourth criteria, whereas Philipp Johnson's *Intelligent Design* infringes the fourth criterion: it is a form of providentialism derived from William Paley's natural theology.

3. The educational sphere is a political sphere

In France, as far back as 1792, the Republic has taken the bold step to base the possibility of citizenship on a common core of knowledge. As a result, we have decided to teach *knowledge* in schools, not opinions or religious beliefs. Our republican democracy exists precisely by the fact that we benefit from

a common base in our rational representation of the real world. In France, to refuse scholarly knowledge in the name of democracy is therefore a contradiction. It also constitutes a breach in two ways. The first breach is of an epistemological nature: the scientific sphere is independent and secular; the acceptability (or not) of a result does not depend on its compatibility (or not) with a religious dogma. The second breach is political: what goes on in the classroom follows certain rules. To become a united society is to first of all have a shared knowledge base. It is not the teachers' role be sparing with knowledge – which, let us say it again, is autonomous in its process of validation, and whose teaching has the force of *law* – but it is up to the parents, the theologians or the spiritual leaders of each religion to provide an articulation between the metaphysical questioning of the pupils and the knowledge acquired at school. If this principle is not respected, not only will it become impossible to teach biology (there would be too many sensitivities to take into account), but political communitarianism (in its North American version) would slowly creep in. If, in a French context, we can wonder why we need to state these fundamental principles again, it is because they have been forgotten. To convince ourselves of this need, one only needs to consider what kind of biology is being taught in other countries. In Turkey for example, since 2003 Intelligent Design (a type of Anglo-Saxon providentialism) has taken on the role of theory of Biology. Evolution is not taught in secondary schools in certain European countries (Romania, Greece), and its teaching is contested in many others, sometimes by high-ranking politicians (Italy, Bulgaria, Poland, Ireland . . .).

French democracy guarantees rights and demands obligations at the level of the individual, not at the level of religious communities. The "right to religious difference", claimed by some, leads to differences in rights, which is not in the French republican project. This project states that, for us to be equal in rights and obligations, we need to have a common core of knowledge, including to *know* (and not believe) that evolution exists: it is a scientific fact.