



HAL
open science

A Textbook Case Revisited. Knowledge as mode of existence

Bruno Latour

► **To cite this version:**

Bruno Latour. A Textbook Case Revisited. Knowledge as mode of existence. Hackett; Edward J.; Lynch; Michael; Wajcman; Judy; Amsterdamska; Olga. The Handbook of Science and Technology Studies, MIT Press2, pp.83-112, 2007, 9780262083645. hal-00972922

HAL Id: hal-00972922

<https://sciencespo.hal.science/hal-00972922v1>

Submitted on 3 Apr 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**A Textbook Case Revisited –
Knowledge as a Mode of Existence**
*Bruno Latour, Sciences Po Paris,
a chapter for the STS Handbook*

“Would it not be possible to manage entirely without something fixed? Both thinking and facts are changeable, if only because changes in thinking manifest themselves in changed facts”

Ludwick Fleck (1981 [1935]: 50)

“Knowledge and science, as a work of art, like any other work of art, confers upon things traits and potentialities which did not previously belong to them. Objections from the side of alleged realism to this statement springs from a confusion of tenses. Knowledge is not a distortion or a perversion which confers upon its subject-matter traits which do not belong to it, but is an act which confers upon non-cognitive materials traits which did not belong to it.”

John Dewey (Experience and Nature p. 381-382)

Costello — “I do not know how much longer I can support my present mode of existence.” Paul — “What mode of existence are you referring to?” Costello — “Life in public”.

JM. Coetzee (Slow Man, 2005)



Photo Verena Paravel

I was struck by the huge label: “A Textbook Case Revisited”. Every time I visit New York, I spend some time at the Natural History Museum, on the top floor, to visit the fossil exhibit. This specific time however, it was not the dinosaur section that attracted my attention but the new presentation of the horse fossil history. Why should anyone revisit textbooks? What happened was that in a marvelous presentation, the curators had presented in two parallel rows two successive versions of our *knowledge* of the horse fossils. You did not simply follow the successive fossils of the present horse evolving in time, you could also see the successive versions of our understanding of this evolution evolving in time. Thus, not only one but two sets of parallel lineages were artfully superimposed: the progressive transformation of horses, and the progressive transformation of our interpretations of their transformations. To the branching history of life was now added the branching history of the science of life, making for an excellent occasion to revisit another textbook case: this one about what exactly is meant in our field by the affirmation that “scientific objects have a history”.

In this chapter, I will tackle three different tasks: a) I will reformulate with the use of this example the double historicity of science and of its subject matter; b) I will remind the reader of an alternative tradition in philosophy and science studies which might help refocus the question; and finally c) I will offer what I believe is a fresh solution to the definition of knowledge acquisition pathways.

Part I: Knowledge is a vector

An interesting experiment in staging the collective process of science

The reason why I was so struck by this parallel between the evolution of horses and the evolution of the science of horse evolution, is that I have always found puzzling a certain asymmetry in our reactions to science studies. If you tell an audience that scientists have entertained in the course of time shifting representations of the world, you will get nothing in answer but a yawn of acceptance. If you tell your audience that those transformations were not necessary linear and did not necessarily converge regularly in an orderly fashion toward the right and definitive fact of the matter, you might trigger some uneasiness and you might even get the occasional worry: “Is this leading to relativism by any chance?” But if you now propose to say that the objects of science *themselves* had a history, that they have changed over time, too or that Newton has “happened” to gravity, and Pasteur has “happened” to the microbes, then everyone is up in arms, and the accusation of indulging in “philosophy” or worse in “metaphysics” is soon hurled across the lecture hall. It is taken for granted that “history of science” means the history of our knowledge about the world, *not* of the world itself. For the first lineage, time is of the essence, not for the second.¹ Hence for me the teasing originality of this Natural History Museum exhibit.

But first, let us read some of the labels: “This collection represents one of the most famous evolutionary stories of the world”. Why is it so famous? Because, says the caption, “Horses are one of the best studied and most frequently found groups of fossils”. But why “revisit” it instead of just present it “as we now know it”?

“The horses in this exhibit are arranged to contrast two versions of horse evolution. Those along the front curve show the classic “straight-line” concept, that over time, horses became larger, with fewer toes, and taller teeth. We now know, however, that horse evolution has been much more complex,

¹ I leave aside in this piece that almost all scientific disciplines, in recent times, have shifted from a Parmenidian to an Heraclitean version: every science is now narrated in a way that takes time into account, from the Big Bang, to the history of Earth geology or Earth climate. In this sense, the narrative mode made familiar to us by historians has triumphed and physicists would tell us about the “historical emergence of particles” in the same mode. But this does not mean that those new Heraclitean versions of science will cross the path of the history of science more often than when the Earth, the Sky and the Matter were supposed to be immutable. In other words, it is just as difficult for historians of cosmology to link their time narratives with those of physicists than it would have been in the time of Laplace when the cosmos had not yet any intrinsic history. This is what makes this public display so telling — and what explains the continuing success of the late Stephen Jay Gould, who was one of the rare writers to link the two histories so artfully.

more like a branching bush than a tree with a single main trunk. The horses in the back row show just how diverse this family of mammals has actually been”.

To be sure, practicing scientists know perfectly well that their research more often takes the form of a “branching bush” than that of a “straight line”, but the nice innovation of this exhibit is that those intertwined pathways are rarely shown to the public, and even more rarely shown to parallel the hesitating movement of the objects of study themselves. Each of the two rows is further commented on by the following captions:

“The story of horses: the classic version”:

“In the nineteenth and early twentieth century, scientists arranged the first known horse fossils in chronological order. They formed a simple evolutionary sequence: from small to large bodies, from many to fewer toes and from short to tall teeth. This made evolution seem like a single straight line progression from the earliest known horse Hyracotherium to Equus, the horse we know today.”

This is contrasted with what you can see in the second row:

“The story of horses: the revised version”

“During the twentieth century, many more fossils were discovered and the evolutionary story became more complicated. Some later horses such as Calippus were smaller, not larger than their ancestors. Many others, like Neohipparion still had three toes, not one.

“If you look at the horses in the back row of this exhibit, you will see examples that don’t fit into the ‘straight line’ version.”

In addition, so as not to discourage the visitor, the curators added this nice bit of history and philosophy of science:

“In fact, in any epoch some horses fit into the ‘straight line’ and others didn’t. Scientists concluded that there was no single line of evolution but many lines, resulting in diverse groups of animals each ‘successful’ in different ways at different times. This doesn’t mean that the original story was entirely wrong. Horses have tended to become bigger, with fewer toes and longer teeth. It’s just that this overall trend is only one part of a much more complex evolutionary tale.”

You could of course object that nothing much has changed since “in the end” “we now know” that you should consider evolution as a “bushy” pathway and not as a goal oriented trajectory. Thus, you could say that even if it goes from a straight line conception of evolution to a meandering one, the history of science is still moving forward along a *straight* path. But the curators are much more advanced than that: they push the parallel much further and the whole floor is punctuated by videos of scientists at work, little biographies of famous fossil-hunters at war with one another, with even different reconstructions of skeletons to prove to the public that “we don’t know for sure” — a frequent label in the show. If the evolution of horses is no longer “Whiggish”, nor is the history of science promoted by the curators. The only Whiggishness that remains, the only “overall trend” (and who in science studies will complain about that one?), is that the more recent conception of science has led us from a rigid exhibition of the final fact of paleontology to a more complex, interesting and heterogeneous one. From the “classic” version, we have moved to the what? “Romantic”? “Postmodern”? “Reflexive”? “Constructivist”? Whatever

the word, we have moved on, and this is what interests me here: objects and knowledge of objects are similarly thrown into the *same* Heraclitean flux. In addition to the type of trajectory they both elicit, they are rendered comparable by the process of time to which they both submit.

The great virtue of the innovative directors and designers of the gallery, on the top floor of the Museum, is to have made possible for the visitors to detect a parallel, a common thrust or pattern, between the slow, hesitant, and bushy movement of the various sorts of horses struggling for life in the course of their evolution, and the slow, hesitant, and bushy process by which *scientists* have reconstructed the evolution of the horses in the course of the *history* of paleontology. Instead of papering over the vastly controversial history of paleontology and offering the present knowledge as an indisputable state of affairs, the curators decided to run the risk — it is a risk, no doubt about that, especially in Bushist times² — of presenting the succession of interpretations of horse evolution as a set of plausible and revisable reconstructions of the past. “Contrast”, “version”, “tale”: those are pretty tough words for innocent visitors — not to mention the skeptical scare quotes around the adjective “successful”, which is a sure way to attack the over-optimistic gloss neo-Darwinism has tended to impose on evolution.³

What fascinates me every time I visit this marvelous exhibit is that everything is moving in parallel: the horses in their evolution; and the interpretations of horses in the paleontologists’ time, even though the scale and rhythm is different -- millions of years in one line, hundreds of years in the other. Ignoring the successive versions of horse evolution that have been substituted for one another would be, in the end, as if, on the fossil side, you had eliminated all the bones to retain only one skeleton, arbitrarily chosen as the representative of the ideal and *final* Horse. And yet what I find most interesting as a visitor and a science student — admittedly biased — is that even though science had to go through different “versions”, even though bones could be displayed and reconstructed in different ways, that does not seem to diminish the respect I have for the scientists, any more than the multiplicity of past horses would preclude me from admiring and mounting a *present-day* horse. In spite of the words “contrast”,

² See the fierce attacks on science autonomy and public discussions as they are related in, for instance, Mooney’s book (2005). Against reactionaries the temptation is always to fall back on the “good old days,” but like all temptations, it should be resisted. As will become clear in this chapter, there are many other ways to fight perverted skepticism than ardent positivism.

³ This is why I don’t consider here the evolutionary epistemology that tries to replace the notion of “fit” between a representation and the world by a neo-Darwinian model in which organisms would be blindly “fitting” their environment. Naturalizing (or biologizing) epistemology does not modify the question: it is the very notion of “fit” and “fitness” that I want to “revisit” here. “Fit” is very much a remnant in biology of Kant’s philosophy of science where “adaptation” has replaced the “construction” of the world to be known by our intellectual categories. In both cases, humans would be blind to the things in themselves. This is too implausible and unrealistic a philosophy.

“version” and “revision”, this is not a “revisionist” exhibit that would make visitors so doubtful and scornful of science and of scientists that it would be as if they were requested, at the entry of the show, to “abandon all hopes to know something objectively”.⁴ Quite the opposite.

Such is the source of this present paper. While we take the successive skeletons of the fossil horses not only gratefully, but accept it as a major discovery — evolution being the most important one in the history of biology — why do we find troubling, superfluous, irrelevant, the displaying of the successive versions of the science of evolution? Why do we take evolution of animals as a *substantial* phenomenon in its own right, while we don’t take the history of science as an equally substantial phenomenon, not at least as something that defines the *substance* of knowledge? When a biologist studies the evolution of a species, he or she hopes to detect the vital characteristics that explain its present form in all its details, and the inquiry is carried out in the same buildings and in the same departments as the other branches of science; but when a historian or a science student accounts for the evolution of science, this is done in another building, away from science, and is taken as a luxury, a peripheral undertaking, at best a salutary and amusing *caveat* to warn hubristic scientists, and not as what makes up the finest details of *what* is known. In other words, why is it difficult to have a history *of science*? Not a history of our representation but of the things known as well, of epistemic things? While we take as immensely relevant for the existence of the present day horse each of the successive instances of the horse line, we are tempted to throw out and consider as irrelevant all of the successive versions that the history and reconstruction of the horse line by paleontologists have taken. Why is it so difficult to consider each of the successive interpretations as an *organism* for its own sake with its own capacious activity and reproductive risks? Why is it so difficult to take knowledge as a vector of transformation, and not as a shifting set aiming toward something that remains immobile and “has” no history? What I want to do here is to de-epistemologize and to re-ontologize knowledge activity: time is of the essence in both.

Revisiting the textbook case of epistemology

What is so nice in the labels of the museum is that they are plain and common sense. They are not coming (as far as I know) from any debunking urge, from some iconoclastic drive by the curators to destroy the prestige of

⁴ Needless to say that this “revision” does not lead to “revisionism” and even less to “negationism”. It has always seemed to me, on the contrary, that a sturdy culture of fact-making was the only way to resist the perverse inversion of positivism that is so extensive in negationism and in other types of conspiracy theories (Marcus, 1999). It is only those who recognize the fragility of fact-making who may confide safely in their solidity. Let those who believe in absolutely indisputable facts deal with the endless “objections” of nit-picking negationists: they deserve one another.

science. They display, if I can say this, a plain, healthy and innocent *relativism* — by which I mean neither the indifference to others' points of view nor an absolute privilege given to one's own point of view, but rather the honorable scientific, artistic, and moral activity of being able to *shift* one's point of view by establishing relations between frames of reference through the laying down of some instrumentation.⁵ And it is this plainness that makes a lot of sense, because, such is my claim in this first part of the paper, in principle the acquisition and rectification of knowledge should have been the easiest thing in the world: we try to say something, we err often, we rectify or we are rectified by others. If, to any uncertain statement, you allow for the addition of *time, instrument, colleagues and institutions*, you come to certainty. Nothing is more common sense. Nothing *should* have been more common sense than to recognize that the process by which we know objectively is devoid of any mysterious epistemological difficulty.

Provided, that is, that *we don't jump*. William James made a lot of fun of those who wanted to jump through some vertiginous *salto mortale* from several shifting and fragile representations to one unchanging and unhistorical reality. To position the problem of knowledge in this fashion, James said, was the surest way to render it utterly obscure. His solution, unaided by science studies or history of science, was to underline again the simple and plain way in which we rectify our grasp of what we mean by establishing a *continuous* connection between the various versions of what we have to say about some state of affairs. His solution is so well known — but not always well understood — that I can rehearse it very fast, by insisting simply on a point rarely highlighted in the disputes around the so called “pragmatist theory of truth”. Since James was a philosopher, his examples were not taken from paleontology but, quite simply, from moving through the Harvard campus! How do we know, he asks, that my mental idea of a specific building — Memorial Hall — does “correspond” to a state of affairs?

“To recur to the Memorial Hall example lately used, it is only when our idea of the Hall has actually terminated in the percept that we know 'for certain' that from the beginning it was truly cognitive of that. Until established by the end of the process, its quality of knowing that, or indeed of knowing anything, could still be doubted; and yet the knowing really was there, as the result now shows. We were virtual knowers of the Hall long before we were certified to have been its actual knowers, by the percept's retroactive validating power.” (James, 1996 [1907]: 68).

All the important features of what should have been a common sense interpretation of knowledge-making trajectories are there in one single paragraph. And first, the crucial element: knowledge is a *trajectory*, or, to use a more abstract term, a *vector* that projects “retroactively” its “validating power”. In other words, we don't know *yet*, but we *will* know, or rather, we will know

⁵ In case of doubt, the word “relationism” can be substituted to the loaded term relativism which has two opposite meanings depending whether it is the Pope Benedikte XVI or Gilles Deleuze who uses it.

whether we *had known* earlier or not. Retroactive certification, what Gaston Bachelard, the French philosopher of science, called “rectification”, is of the essence of knowledge. Knowledge becomes a mystery if you imagine it as a jump between something that has a history and something that does not move and has no history; it becomes plainly accessible if you allow it to become a continuous vector where *time* is of the essence. Take any knowledge at any time: you don’t know if it is good or not, accurate or not, real or virtual, true or false. Allow for a successive, continuous path to be drawn between several versions of the knowledge claims and you will be able to decide fairly well. At time t it cannot be decided, at time $t+1$, $t+2$, $t+n$, it has *become* decidable provided of course you engage along the path leading to a “chain of experiences”. What is this chain made of? Of “leads” and of substitutions as James makes clear by another example, not about horses or buildings, this time, but about his dog. The question remains the same: how do we render comparable my “idea” of my dog and this “furry creature” over there?

“To call my present idea of my dog, for example, cognitive of the real dog means that, as the actual tissue of experience is constituted, the idea is capable of leading into a chain of experiences on my part that go from next to next and terminate at last in the vivid sense-perceptions of a jumping, barking, hairy body.” (James, 1996 [1907]: 198)

This plain, healthy, and common sense relativism requires a good grounding in the “actual tissue of experience”, a grasp of “ideas”, “chains of experiences”, a movement “next to next” without interruption, and a “termination” that is defined by a change in the cognitive materials from “idea of the dog” to “the jumping, barking, hairy body” of a dog now seized by “vivid sense perceptions”.

“There is thus no breach in humanistic [a synonym for radical empiricism] epistemology. Whether knowledge be taken as ideally perfected, or only as true enough to pass muster for practice, it is hung on one continuous scheme. Reality, howsoever remote, is always defined as a terminus within the general possibilities of experience; and what knows it is defined as an experience that 'represents' it, in the sense of 'pointing to it' through a chain of other experiences that either intervene or may intervene.” (p. 201)

Contrary to Spinoza’s famous motto “the word ‘dog’ *does* bark” but only at the end of a process which is oriented as a vector, which has to be continuous, which has to trigger a chain of experiences, and which generates as a result a “thing known” and an accurate “representation of the thing”, but only retroactively. The point of James —totally lost in the rather sad dispute around the ‘cash value’ of truth— is that knowledge is not to be understood as what relates the idea of a dog and the real dog through some *teleportation*, but as a chain of experiences woven into the tissue of life in such a way that when time is taken into account and when there is no interruption in the chain, then one can provide a) a retrospective account of what triggered the scheme, b) a knowing subject —validated as actual and not only virtual— and finally c) an object known — validated as actual and not only virtual.

The crucial discovery of James is that those two characters —object and subject— are *not the adequate points of departure* for any discussion about knowledge acquisition; they are not the *anchor* to which you should tie the vertiginous bridge thrown above the abyss of words and world, but rather they are *generated* as a by-product —and a pretty inconsequential one at that— of the knowledge making pathways themselves. “Object” and “subject” are not ingredients of the world, they are successive *stations* along the paths through which knowledge is rectified. As James said, “there is no breach”; it is a “continuous scheme”. But if you interrupt the chain, you remain undecided about the quality of the knowledge claims, exactly as if the *lineage* of one horse species were interrupted due to a lack of offspring. The key feature for our discussion here is not to ask from any statement, “Does it correspond or not to a given state of affairs?” but rather, “Does it lead to a continuous chain of experience where the former question can be settled retroactively?” This paper is entirely about uncovering the difference between the “continuous scheme” and what I will call “the teleportation scheme”.⁶

But the problem with James (apart from his use of the unfortunate ‘cash value’ metaphor) is that he took examples of buildings and dogs for drawing his continuous scheme, of entities that were much too mundane to prove its common sense point. It is actually the problem with most classical philosophers: they take as their favorite examples mugs and pots, rugs and mats, without realizing that those are the worst possible cases for proving any point about how we come to know because they are *already much too well known* to prove anything about how we come to know. With them, we never feel the *difficulty* of the knowledge-making pathways, and we take the result of the by-product of the path —a knowing mind and an object known— as the only two real important components of any given state of affairs. With those all too familiar termini, it seems easy to stage the situation where I ask: “Where is the cat?” and then without any long, difficult, tortuous pathway, to point out and say: “Here on the mat”. This lazy way of taking it would be innocuous enough except when, after

⁶ “Continuous” is a confusing term here which should be understood, in James, as contrasting only with “*salto mortale*”, with the big gap between “word” and “world”. So “continuous” is not used here to deny that, once you look at the “tissue of experience”, you will not recognize series of small gaps, discontinuities that are due to the complete heterogeneity of their constituents. For instance, in James’ own example, there is a gap between the anticipation of the dog and the warm furry sensation once the dog is there. Those tiny discontinuities have been shown in many science studies through the work of Hutchins, Latour, Lynch, Netz. But no matter if you talk about “intellectual technologies” (Hutchins, 1995), “chains of custody” (Lynch & McNally, 2005), “chains of reference” (Latour, 1999), or “diagrams” (Netz, 2003), the succession of varied media are like pearls — discontinuous yes, but along the same thread. The knowledge trajectory is thus *continuous* in the first meaning of the word (against the language/world distinction) but is of course *discontinuous* when the set of micro gaps —the pearls on the thread— in the making is considered. Having done much work to show the micro-discontinuity necessary for the circulation of immutable mobiles (Latour, 1990), I use in this paper the adjective “continuous” only in the first sense.

having based your theory of knowledge acquisition on such mundane, banal and utterly familiar objects, you feel sure that what really counts are the subject and the object (the name “dog” on the one hand and the “barking dog” on the other). Then you will tend to think that knowledge *in general* is made of one big jump from one of those components to the other. You are replaying Act I Scene 1 of first empiricism.⁷ Of course, it is perfectly true that, once we have become familiar with the pathway, we can most of the time safely ignore the intermediary steps and take the two termini as representative of what knowledge is. But this forgetting is an artifact of familiarity.

Even worse is that we try to use the model of knowledge acquisition adapted to the mundane, familiar object, to raise “The Big Question” of knowledge acquisition about new, unknown, difficult to focus upon, and sophisticated objects like planets, microbes, leptons, or horse fossils, for which there is not yet any pathway or for which the pathway has not become familiar enough to be represented by its two endpoints. We tend to treat new entities for which it is absolutely crucial to maintain the continuous scheme as if they had become familiar objects already. And yet, for any new objects, the whole framework that had been defined on mundane objects breaks down entirely, as the last three centuries of epistemology have shown, because there is no way you can use the object/subject tool to grasp any *new* entity. The teleportation scheme based on mundane and habitual states of affairs gives not the slightest clue on how to lay down the continuous path that might provide objectivity on new states of affairs.⁸

Breaking the habits of thought due to the use of mundane artifacts

To realize how much in line with common sense James’ basic point is, we have to part company with him and consider cases where the “chain of experience” and the successive versions leading “next to next” to certainty, should be easily documentable, visible, and studiable. This is what science studies and history of science has shown in the last thirty years. To the too familiar James’ dog example, we have to substitute, for instance, the difficulty of

⁷ I call first empiricism the effort from Locke to James (excluded) to define knowledge around the invention of matters of fact; and second empiricism the efforts from James to science studies (as I see them) to develop what I call “matters of concern” (see Latour, 2004a).

⁸ It is true that clever novelists such as Baker (1988), artful historians such as Petroski (1990), and daring philosophers such as James himself, may put mundane artifacts to good use by unfolding what is not revealed in the two termini of “user” and “tool”. But this is precisely the problem: they have to be clever, artful and daring -- all qualities that are much too infrequent in the rest of us. It is much easier to take new unknown objects so as to render fully visible the trajectory and its retroactive process of “certification”. (In many ways the problem with James was his considerable lightness of touch: people misunderstood this lightness for superficiality; had he written as badly as Derrida he would be the Heidegger of the 20th century.)

paleontologists to make sense of dispersed and hard to interpret fossils. As soon as we do so it will become obvious to all that we never witness a solitary mind equipped with “ideas” of horse evolution trying to jump in one step to the “Horse Evolution” out there. Not because there is no “out” and no “there”, but because the “out” and the “there” are not *facing* the mind: “out” and “there” are designating nothing more than stations along the chain of experience leading through successive and continuous rectifications to other revised versions (“termini” in James’ parlance, but there are always more than two). If there is one thing that has made philosophy of science so lame, it is to have used mats and cats, mugs and dogs, in order to discover the right frame of mind to decide how we know with accuracy objects like black holes and fossils, quarks and neutrinos. It is only by studying controversial matters of fact *before* they can be treated matters of factually, that you can witness the obvious phenomenon of the pathways —what I call networks—⁹ in plain light before they disappear and leave the two by-products of object and subject to play their roles as if they had *caused* the knowledge of which they are only the provisional *results*.

No one has seen this better than Ludwick Fleck whose interpretation of “thought collective” is very close to that of the chain of experiences outlined by James. In spite of the expression “thought” in “thought collective”, what Fleck has clearly in mind is the sort of heterogeneous practices laboratory studies has since rendered familiar to us. It is interesting to notice here that Fleck’s theory itself has been misrepresented by the idea of “paradigm” thrown onto him by Thomas Kuhn’s foreword to the English translation of his book (Fleck, 1981). “Paradigm” is typically the sort of term that has meaning only in the abyss-bridging scheme. It reintroduces the knowing subject (now pluralized) as one of the two anchors of the activity of knowledge together with the supposed “thing in itself”. The two are facing one another and the whole question is where you situate any statement along this bridge: nearer the mind’s categories or closer to the thing to be known? This is exactly the position of the problem out of which Fleck (who had to invent sociology of science from scratch) had to extract himself.

When you take the example not of dogs and cats but for instance of the pioneering efforts of syphilis specialists to stabilize the Wasserman reaction (the main example in the book), then the whole situation of knowledge acquisition is modified. With Fleck, as with James, we are at once thrown into the Heraclitean flow of time. The wording might still be ambiguous but not the direction taken:

⁹ But with a new meaning that is to be shown in the last section. Once again, networks are made of many small discontinuities between different media. They are continuous only in the sense that they don’t attempt to jump over the abyss between words and world. The confusion between the two words “continuous” and “discontinuous” will be lifted in the next section.

“It is very difficult, if not impossible, to give an accurate historical account of a scientific discipline (...) It is as if we wanted to record in writing the natural course of an excited conversation among several persons all speaking simultaneously among themselves and each clamoring to make himself heard, yet which nevertheless permitted a consensus to crystallize.” (Fleck, 1981: 15-16).

Notice that the metaphor of crystallization is not opposed to but follows from that of the flow of experience in an “excited conversation”. Because of Kuhn’s framing of Fleck’s problem in the foreword to the English translation, readers have often forgotten that the subtitle of the book was even more explicitly historical than James’ argument: the “genesis” of the scientific “fact”. No more than James, Fleck is talking here about the emergence of our *representations* of a state of affairs: it is the *fact itself* that he is interested in following up through its emergence. He wants to tackle facts much like paleontologists want to reconstruct the horse line, not the ideas we entertained of the horse line. Only a Kantian can confuse the phantoms of ideas with the flesh of facts.

“This is how a fact arises. At first there is a signal of resistance in the chaotic initial thinking, then a definite thought constraint, and finally a form to be directly perceived. A fact always occurs in the context of the history of thought and is always the result of a definite thought style” (Fleck, 1981: 95).

What’s the difference, one could object, with the notion of a paradigm projecting one’s category onto a world that is subjected to an inquiry? The difference lies in the philosophical posture; it comes from what time does to all the ingredients of what is here called “thought style”. Fleck does not say that we have a mind zooming toward a fixed—but inaccessible—target. It is the fact that “occurs”, that emerges, and that, so to speak, offers you a (partially) new mind endowed with a (partially) new objectivity. Witness the musical metaphor used to register the process of coordination that will account for the stabilization of the phenomenon:

“It is also clear that from these confused notes Wassermann heard the tune that hummed in his mind but was not audible to those not involved. He and his coworkers listened and “tuned” their “sets” until these became selective. The melody could then be heard even by unbiased persons who were not involved.” (p.86). Fleck (ibid.) adds “something very correct developed from them, although the experiments themselves could not be called correct”.

Fleck’s originality here is in breaking away from the visual metaphor (always associated with the bridge-crossing version) and in replacing it by the progressive shift from an uncoordinated to a coordinated movement. I wish the dancing together to a melody to which we become better and better attuned, could replace the worn out metaphor of an “asymptotic access” to the truth of the matter. Fleck derides the visual metaphor by calling it the *veni, vedi, vici* definition of science!

“Observation without assumption which psychologically is non-sense and logically a game, can therefore be dismissed. But two types of observation, with variations along a transitional scale appears definitely worth investigating: (1) the vague initial visual perception, and (2), the developed direct visual perception of a form.” (p. 92)

We find here the same direction of the argument as in James: knowledge flows in the same direction as what is known. It is a “transitional scale”. But the scale does not go from mind to object with only two possible anchors, it goes from vague perception to direct—that is, directed!— perception through an indefinite number of intermediary stations, not just two. That is the big difference in posture. Notice the daring and quite counter-intuitive reversal of metaphors: it is only once the perception is “developed”, that is, equipped, collected, attuned, coordinated, artificial, that it is also “direct”, whereas the initial perception appears retrospectively to have been simply “vague”. Hence this magnificent definition of what it is to be skilled and learned into perception, what it is to graduate into the coherence of fact genesis:

“Direct perception of form (Gestaltsehen) requires being experienced in the relevant field of thought. The ability directly to perceive meaning, form and self-contained unity is acquired only after much experience, perhaps with preliminary training. At the same time, of course, we lose the ability to see something that contradicts the form. But it is just this readiness for directed perception of form that is the main constituent of thought style. Visual perception of form becomes a definitive function of thought style. The concept of being experienced, with its hidden irrationality, acquires fundamental epistemological importance.” (p. 92)

Fleck does not say, as in the usual Kantian-Kuhnian paradigm metaphor, that “we see only what we know beforehand”, or that we “filter” perceptions through the “biases” of our “presupposition”. Such a gap-bridging idea is on the contrary what he fights against because then time could not be part of the substance of fact genesis. This is why he reverses the argument and fuses the notion of “direct” grasp of meaning, with being “directed” and “experienced”. It is not a subtle hair-splitting nuance, it is a radical departure, as radical in science studies as what James had done to philosophy. Because, if “direct” and “directed” go together, then we are finally through with all this non-sense about being *obliged to choose* between having categories (or paradigms) or grasping the facts of the matter “as they are”. It is because of his shift in philosophical posture, Fleck is able for the first time (and maybe for the last one in science studies!) to take the social, collective, practical elements *positively* and not negatively or critically.¹⁰

“Every epistemological theory is trivial that does not take this sociological dependence of all cognition into account in a fundamental and detailed manner. But those who consider social dependence a necessary evil and unfortunate human inadequacy which ought to be overcome fail to realize that without social conditioning no cognition is even possible. Indeed, the very word ‘cognition’ acquires meaning only in connection with a thought collective.” (p. 43)

¹⁰ I guess most science students will say that they “of course” take positively the social aspects they unfold in their writing, but this is because they have simplified the philosophical task enormously and left aside the ontological question. By “positive”, I mean here factors which are conducive to the genesis of the durable fact of the matter itself. It is noticeable that those who have made exception to this rule, like Pickering (1995) for instance, have been greatly influenced by pragmatism.

Trivial after thirty years of science studies? Not at all! Radical, revolutionary, still very far in the future.¹¹ Why? Because if you read carefully the way in which he engages the social metaphors in the process of discovery, they are in no way a *substitute* for the knowing subject. Fleck, apparently connected to James or at least to pragmatism, has picked up the general tenor of pragmatism in a unique way.¹² “Social” and “collective” are not there to serve as an expansion or a qualification on Kant’s epistemology at all. They are mobilized to ruin the whole idea that there is a mind facing an object above the abyss of words and world. When he deals with the collective, social, and progressive “aspects” of science, it is not because he has abandoned the idea of grasping reality, but just for the opposite reason, because he wants at last a *social ontology* not a social epistemology.

“Truth is not ‘relative’ and certainly not ‘subjective’ in the popular sense of the word. (...) Truth is not a convention but rather (1) in historical perspective, an event in the history of thought, (2) in its contemporary context, stylized thought constraints.” (p. 100)

“Truth is an *event*”, and so is the emergence of the horse in nature, and so is the emergence of the knowledge of the horse lineage. So for Fleck as for James, the key features to be outlined are that: a) knowledge is a vector ; b) ideas are there and have to be taken seriously but only as the beginning of a “chain of experience” (“experimentations” for Fleck); c) successive rectification and revision are not peripheral but are the substantial part of the knowledge acquisition pathways; d) rectification by colleagues is essential; e) so is institutionalization — becoming familiar, black-boxing novelty in instruments, tuning, standardizing, getting used to a state of affairs, etc.; f) direct perception is the end and not the beginning of the process of fact genesis. Fact is the provisional end of the vector and all the questions of correspondence between statements and states of affairs can indeed be raised but cannot be answered except retrospectively and provided the *Dankollektiv* is kept in place without interruption.

¹¹ Not once for instance, does Ian Hacking (1999) even contemplate in a book that claims to bring science studies to its sense, that it would be possible not to think along the gap-bridging scheme: if social then not real, if real then not social, or maybe you want “a little bit of both”? No, we want *none of it*, this is what Fleck would answer, the whole position of the problem is unrealistic.

¹² According to Ilana Lowy, there is actually a possible direct connection between pragmatism and Fleck through the teaching in Warsaw of the Polish pragmatist philosopher Wladyslaw Bieganski (1857-1917) — see her foreword to the French edition (Fleck, 2005).

Part II: Knowledge raises no epistemological questions

Two orthogonal positions for knowledge making pathways

Those comments on James, Fleck and science studies are simply to remind us that, as John Searle (pers.com. 2000) quipped “science raises no epistemological question”. I agree with him entirely, and James would have agreed with him also — no matter how incommensurable their various metaphysics. If by “epistemology” we name the discipline that tries to understand how we manage to bridge the gap between representations and reality, the only conclusion to be drawn about it is that this discipline has no subject matter whatsoever, because we *never* bridge such a gap — not, mind you, because we don’t know anything objectively, but because *there is never such a gap*. The gap is an artifact due to the wrong positioning of the knowledge acquisition pathway. We imagine a bridge over an abyss, when the whole activity consists of a drift through a chain of experience where there are many successive event-like termini and many substitutions of heterogeneous media. In other words, scientific activity raises no especially puzzling epistemological questions. All its interesting questions concern *what* is known by science and *how* we can live with those entities but certainly not *whether* it knows objectively or not — sorry for those who have scratched their head about this last one for so long. Skepticism, in other words, does not require much of an answer.

If we had to summarize what I have called here the healthy common sense relativism expressed in the labels of the Evolution gallery, in James’ radical empiricism, in Fleck’s trajectories, or in many good (that is, non debunking) histories of controversies in science, we could end up with a portrayal of a knowledge path, freed from epistemological questions. Yes, we err often, but not always because, fortunately, *a) we have time; b) we are equipped; c) we are many; d) we have institutions*. A pair of diagrams could summarize the shift in emphasis necessary to absorb the next much more difficult point about the ontology implied by such a common sense description.

In the “teleportation scheme”, the great problem of knowledge is to bridge the gap between two distinct domains totally unrelated to one another, mind and nature. Thus what counts most is to place the cursor along the gradient going from one of the limit —the knowing subject— to the other —the object

known. In this positioning of the problem of knowledge, the key question is to decide whether we move forward —toward the unmoving target of the object to be known— or backward — in which case we are thrown back to the prison of our prejudices, paradigms, or presuppositions.

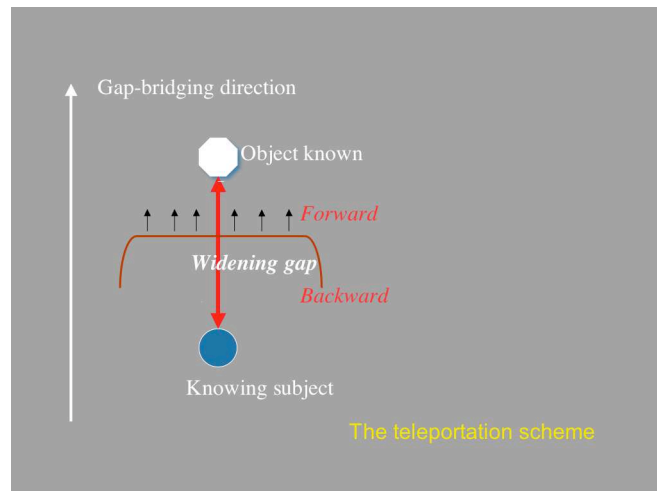


Figure 1

But the situation is entirely different in the “continuous scheme” invoked by James, Fleck and much science studies.¹³ Here, the main problem is not to decide whether a statement goes backward or forward along the subject/object pathway (vertically in the diagram above) but whether it goes backward or forward *in time* (orthogonally in the diagram below).¹⁴ Now the main problem of knowledge is to deploy the continuous chain of experience to multiply the crossing points at which it will be possible to *retroactively* decide whether we *had been* right or wrong about a given state of affairs. Going “forward” now means that we become more and more “experienced”, “cognizant”, “attuned” to the quality of the collective, coordinated, instituted knowledge. There is no gap to be bridged, and no mysterious “correspondence” either, but there is a huge difference in going from few crossing points to *many*.

¹³ You can find some more instances recently of the historicization of the objects of science, not only of our representations, in the book edited by Daston (2000) on the biography of scientific objects.

¹⁴ “In time”, should mean here “in process”, because there are many philosophies that obliterate even time. On this see obliteration, see Stengers’ work especially her Whitehead (2002), and my review of it (2005).

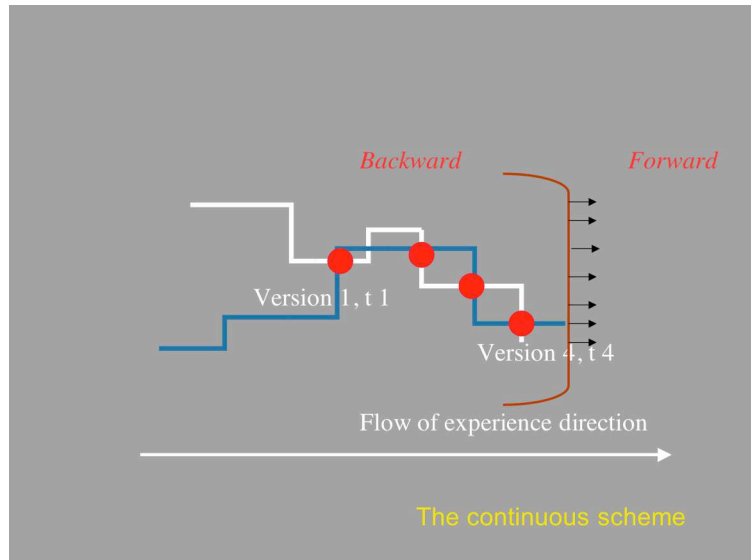


Figure 2

It is rather funny to consider that so much saliva (including mine) has been spent for or against a “correspondence theory of truth” by which proponents and critiques of the theory have always meant a jump between object and subject without ever inquiring about the *type of correspondence*. Trains and subways would have offered a better metaphor for defining what we mean by a correspondence: you don’t shift from one subway line to the next without a continuous platform and corridors laid out allowing you to *correspond* on schedule. So James and Fleck are certainly proponents of a “correspondence theory of truth” —if you keep in mind the train metaphor— whereas they would strongly object to the “*salto mortale* theory of truth”. If you accept renewing the metaphor, then you move forward when you go from a simple, isolated, poorly-equipped, and badly maintained straight line, to a complex network of well kept-up stations allowing for many correspondences to be established. So “forward” means going from a bad to a good network.¹⁵ Anyone living in a big city with or without a good public transportation networks will grasp the difference.

I said earlier that those time dependant paths could be visible only if you choose to consider, as science studies has done, newer and more complex objects than mugs and rugs. But it is interesting to come back briefly to the mundane cases on which the discontinuous scheme has been honed, once we

¹⁵ It is also the limit of anti-Whiggishness in history of science. Although it is a healthy position to start an inquiry, it becomes quickly counter-productive when you have to act as if there was no asymmetry between going forward and going backward. The second scheme is clearly asymmetrical as far as the arrow of time is concerned.

have tried to follow objects which are less familiar and where it is easier to document the pathways. A lot of energy has been devoted in the course of time to answer skeptics about the so-called “errors of the senses”. The classic topos, visited over and over again in the course of philosophy, is that I might not be certain, for instance, whether or not a tower seen from afar is a cylinder or a cube. But what does that prove against the quality of our knowledge? It is perfectly true to say that, at first, I might have misread its shape. But so what? I simply have to walk *closer*, I *then* see that I *was* wrong —or else I take my binoculars, or someone else, a friend, a local inhabitant, someone with a better eyesight to correct me. What could be simpler than this retort? Horse fossils at first seemed to align themselves in a straight line going always in the same direction. Then more fossils were collected, many more paleontologists entered into the discipline, the straight line had to be rectified and revised. How could this feed skepticism? To be sure, those rectifications raise interesting questions: why do we err at first —but not always? How come that the equipment is often deficient — and yet quickly upgraded? How come that checks and balances of other colleagues often work — and sometimes fail to do so? But not one of those interesting historical and cognitive science questions should invite us to skepticism. When Descartes asks us to take seriously the question whether or not the people walking in the street might not be automats, the only sensible answer should have been: “But René why don’t you go down in the street and check for yourself? Or at least ask your valet to go check it for you?”. *Ego cogito* might be open to question, but why don’t you try *cogitamus*?

The claim that there lies a Big Epistemological Question, so big that if it is not answered it threatens for good the quality of our science and then of our civilization, comes simply from a defect in the first scheme: *there is no place in it for time*, nor for instrument, nor for people, nor for rectification, nor for institution.¹⁶ Or rather there is some place for the successive versions on the *subject* pole side but none for what happens to *the object itself*. More exactly, it is because there is no room for the parallel movement in time of the facts themselves, that the object becomes isolated “in itself” and “for itself”. To use the first diagram again, when you add the history of our representations, you register such a distortion that a widening gap is now yawning. It was not there in the second diagram. Then, but only then, skeptics have a field day. If we have changed our “representations” of the object so often, while the goal, the target, has not changed at all, this could only mean that our mind is weak, and that “we will never know for sure”. We will remain for ever inside our representations.

¹⁶ Notice that Descartes tried to ascertain the absolute certainty of his *ego cogito* exactly at the time of the invention of collective science — another proof that philosophers are pretty bad informants for what happens at their time.

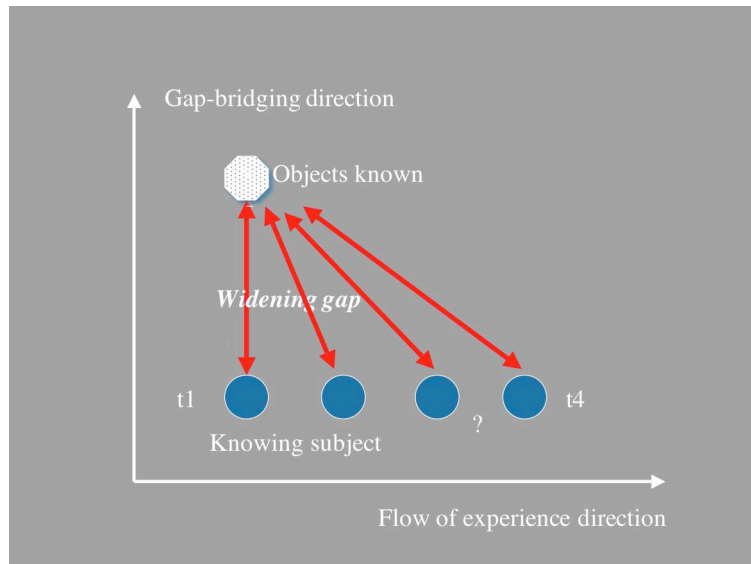


Figure 3

Does this prove that skepticism is right? No, it simply proves that epistemology has been silly in proposing such a target for knowledge. It is as if it had offered its throat to be sliced: the temptation to cut it was too great to be resisted. If you think of it, never has any statement been verified by following the vertical dimension of the diagram. Even to check if a cat is on the mat, you have to engage yourself in the second dimension — the horizontal one in the diagrams and it is only *retroactively* that you can then say: “I *was* right in saying that my sentence ‘the cat is on the mat’ corresponded to a state of affairs”. Contrary to the bad reputation pragmatism often gave its own argument, the time dimension it has so clearly detected in knowledge production is not an *inferior* way of knowing that should be substituted for the higher and more absolute one “because this one, alas, remains inaccessible”. The continuous scheme is not an ersatz for the only legitimate realist way to know; on the contrary, it is the teleportation scheme that is a complete artifact. The only way to obtain objective knowledge is to engage, orthogonally, into one of those trajectories, to go with the flow of experience.¹⁷ From the dawn of time, no one has ever managed to jump from a statement to a corresponding state of affairs without taking time into account and without laying down a set of successive versions connected by a continuous path. To be sure, a statement might have led, “next to next”, as James said, to a chain of experiences heading toward a

¹⁷ It is strange that such a daring philosopher as James caved in to the enemy, so to speak, and denigrated his own position by accepting to say that it was “good enough to pass muster” for practical purposes only. In that sense, pragmatism is certainly the wrong label for what I am trying to present here.

provisional terminus allowing, through a substitution of sensory data, a retrospective judgment about what it was “virtually” earlier. But no statement has ever been judged by its truth content “if and only if” some state of affairs corresponded to it.¹⁸

Thus, the puzzle for me is not: “How can we decide that a statement about state of affairs is true or false”, but rather, “How come we have been asked to take seriously an attempt to transform knowledge production into an impossible mystery, a jump above the abyss?” The true scandal is not to ask, “How come there are bloody relativists attacking the sanctity of science by denying that the gap between representations and objectivity can be bridged”, but instead to ask, “How come a trench has been dug into the paths whose continuity is necessary for any knowledge acquisition?”

If there is no sense in qualifying knowledge out of time, why then does time have to be taken out? Why do we consider that adding, time, rectification, instruments, people, and institutions could be a threat to the sanctity and truth conditions of science when they are its *very stuff*, when they are the only way that exists to lay down the continuous path allowing for ideas to become loaded with enough intersections to decide retroactively if they had been correct or not? In the case of the history museum, does it distract visitors to know that there were paleontologists fighting one another, that fossils had a market value, that reconstitutions have been modified so often, that we “don’t know for sure”, or, as another label states, “While it’s intriguing to speculate about the physiology of long extinct animals we cannot test these ideas conclusively”? The more fossils there are, we feel that the more interesting, lively, sturdy, realistic, and provable are our representations of them; how come we would feel less certain, less sturdy, less realistic about those same representations when they multiply? When their equipment is visible? When the assembly of paleontologists is made visible?

The puzzle I now want to address is not, “Are we able to know objectively with certainty?” but rather the following: “How have we come to doubt that we are able to know objectively, to the point of seeing as proofs of skepticism and relativism the obvious features that allow truth conditions to be met?” I am turning the tables here, against those who have so often accused science students of immorality! After having meekly or provocatively answered those charges for so long, it is time to counter-attack and to doubt the moral high ground they have occupied with no title whatsoever.

¹⁸ This was the basis of Gabriel Tarde’s (republished, 1999) alternative syllogistic. Tarde, like James, like Dewey, like Bergson, was very much part of this vast movement to renew philosophy, science and society, and absorb the shock of Darwinism, which has been very much lost during the 20th century and that we spend so much effort in trying to retrieve.

Part III: Knowledge is a mode of existence

A real difficulty in the knowledge acquisition pathways

One possible answer is that we have been asking from objective science something it could not possibly deliver and should not even try to deliver, thus opening a large hole into which skepticism could penetrate. And that epistemologists, instead of confessing, “Okay we were wrong to ask this from science”, have kept thinking that their main duty was to *fight* against skepticism, instead of fulfilling their only duties: to make sure that the truth conditions of science be met, by allowing for time rectification, for the improvement of instruments, for the multiplication of check and balances by colleagues and people, and generally by strengthening the institutions necessary for certainty to be kept up.

What is this added difficulty? Why was this extra baggage added to the burden of science production? One of the answers probably has to do with a denial of the formative quality of time. In the same way as before Darwin individual horses had to be considered as mere *tokens* of the ideal Horse *type*, it has seemed difficult to accept that you could gain certainty by the humble means of rectification, instrumentation, colleagues and institutions. Actually the parallel goes deeper: in the same way that Darwin’s revolutionary insights have really never been swallowed by our intellectual mores and have been instantly replaced by an enterprise to re-rationalize them, it happens that epistemology has never considered that it was enough to let the succession of ideas, plus instruments, plus colleagues, proceed at their own pace in order to obtain a sturdy enough certainty. To the lineages of tokens, they still want to add the *type*. Although there is no God leading the evolution of horses any more, there seem to be still a God, at least an Epistemological Providence, leading the *knowledge* of the horse lineage.

But another reason might have to do with the sheer difficulty of accounting for knowledge formation. It has been noted very often that, although science itself as an activity is a time-dependent, human-made, humble practice, the *result* of its activity —after a while, that is— offers a time-independent, not human made, quite exhilarating objectivity. After all, facts are generated. This is the main conclusion of the constructivist schools in science studies: at some point in the course of the fabrication, facts emerge that are no longer enlightened by the revelation that they have been fabricated or have to be carefully maintained. The double nature of facts —as fabricated and as unfabricated— has become a cliché of history of science and of science studies.

The limit of constructivism is that we have *trouble focusing on the two aspects* with equal emphasis: either we insist too much on the messy, mundane, human, practical, contingent aspects, or too much on the final, extramundane, non-human, necessary, irrefutable elements. Quite apart from the temptation to use the results of science to make a mess of politics,¹⁹ it is perfectly true to say that objectivity as a practice is simply difficult to understand and square with our common metaphysics and our common ontology — by “common” I mean what has been made to be common by the first empiricism.

Remember that the puzzle I am trying to understand is not, “How come we manage to know objectively some distant states of affairs,” —we do, no question about that— but rather, “How come, in spite of the obvious quality of our knowledge-acquisition pathways, we have engaged objectivity production into an impasse where knowledge becomes a mystery?” The reformulation I am now proposing is the following: “There must be a strange feature in objectivity production that has provided the temptation to engage this innocent, healthy, and rather common sense activity into an impasse that seemed productive for reasons utterly unrelated to objectivity per se” (one of them being politics, but this is not the object of this chapter). What then is this strange feature?

We have to admit that something happens to a state of affairs when it is engaged into knowledge acquisition. The dog of James’ example, the horse fossils of paleontology, Pasteur’s microbes, all undergo a transformation; they enter into a new path, and they circulate along different “chains of experiences” once they are known. This transformation is coded by epistemology —wrongly, as I have proposed earlier— as a grasping by a knowing subject. And we now understand why: the vertical dimension of the gap-bridging scheme above is unable to detect any important transformation in the object known. Instead, it simply registers retroactively what happens *once* we know for sure: object and subject “correspond” to one another well; they are, as Fleck would have said, coordinated to the same tune, and are “directly perceived”. We have become able to detect the source of the artifact created by such a view: it takes the consequence, a knowing subject, for the anchor of a mysterious bridge leading to something that is *already* an object waiting to be known objectively. This is the reason that, while the knowing subject appears to have a history, a movement, a

¹⁹ I have shown elsewhere (Latour, 2004b) that an absolute, unmediated and timeless indisputable form of knowledge could seem, in some situations, to offer a solution to an entirely unrelated problem: that of producing agreement among rival parties in the noisy, smelly and crowded agora, an agreement that normal procedures, proper to political debates, could not generate. This is what I have called *political epistemology*. In this interpretation, epistemology would never have aimed at fostering science ecology, but rather at introducing into politics a source of certainty that could play the role of the court of appeal in case of debates that could not be closed to the satisfaction of the parties. The funny thing is that even though it was a terrible description of science’s own way of achieving certainty, it was used nonetheless -- and still is -- as a template, an ideal, to shame the sordid ways in which politics could provide agreement.

series of revisions and rectification, the object itself —the future “thing in itself”— does not move (see Figure 3). Hence the opening of the “breach” which volumes of epistemology have tried to fill: *one terminus moves and not the other*. Skepticism engulfs the open space. And yet if the genesis of fact is an event, this eventfulness should be equally shared with the discoverers as well as with the discovered.

Reparative surgery: distinguishing pathways

To grasp this difference in a way that does not make again the same “mistake” as epistemology, it is important to consider first how the object moved *before* being grasped by the knowledge pathways. How was the dog jumping and barking before James tried to make sure his “idea of the dog” “co-responded” to the dog? To phrase it in my rather infamous way: “What was the way of life for microbes *before* Pasteur engaged them into the pathways of 19th century microbiology?”²⁰ If we answer, “Well, they were sitting there, *an sich*, waiting to be known”, we at once reopen the gap, the breach, the cleft that no amount of ingenuity will fill in. On the other hand, if we answer: “They date from the moment when the philosophers or the scientists designate them”, we open the can of worms of relativism —in the papal pejorative meaning of the word— and soon risk settling upon one of the various idealist positions, no matter how sophisticated we try to be. And yet, in the continuous scheme, something must *have happened* to the tissue of experience in which the various entities we are considering now move in the same direction. What was absurd according to the scenography sketched in the first diagram (knowing and known were on two different metaphysical sides of a gap), becomes almost common sense in the scenography of the second diagram: knowing and known share at least a common “general trend” — and this is why we end up knowing so objectively.²¹ To reuse James’ metaphor, we should now ask, “What is the fabric of the common tissue?”

It is clear that one character at least is common to all the threads: they are made of vectors that are all aligned, so to speak, in the same struggle for existence. All the horses, at the time when they were alive, were struggling to subsist in a delicate and changing ecology, and racing along reproductive paths. For them, too, no doubt about it, there was a difference between going forward or backward! It was the difference between surviving as a horse or becoming extinct. Whatever definition of knowledge we choose, we could agree that such

²⁰ I have developed this point at some length in the middle chapters of *Pandora’s Hope* (1999), but without having fully grasped the notion of mode of existence I put forward here.

²¹ Again, we should resist the temptation here to follow evolutionary epistemology and to unify prematurely all of the components by saying that “of course” they are all “parts of nature”. As I have shown elsewhere what is wrong in naturalisation is not its sturdy materialism but its premature unification (Latour, 2004b). The point has been made even more forcefully and with much greater empirical precision by Philippe Descola’s major book (2005).

a path must have a different bent, a different movement forward, that it must be made of different segments from what happens to the very few fossilized bones unearthed, transported into crates, cleaned up, labeled, classified, reconstructed, mounted, published in journals, and so on, once paleontologists have crossed path with the ancient horses.

Whatever your metaphysics, you would agree that there must be a nuance between being a horse and having a tiny fraction of the horse existence made visible in the Natural History Museum. The least provocative version of this crossing point is to say that horses benefitted from a *mode of existence* while they were alive, a mode which aimed at reproducing and “enjoying” themselves — enjoyment is Alfred North Whitehead’s expression— and that, at the intersection with paleontologists, some of their bones, hundreds of thousands of years later, happened to enter into *another mode of existence* once fragments of their former selves had been shunted, so to speak, into paleontological pathways. Let’s call the first mode, *subsistence* and the second, *reference* (and let’s not forget that there might be many more than two modes).²²

I am not saying anything odd here: everyone will accept that an organism striving for life does not carry on exactly in the same way as a bone being unearthed, cleaned up, collectively scrutinized and published about. And yet I have to be careful here to avoid two misrepresentations of this expression: “not being exactly the same”.

First, I hope it is clear that I am not try to revive the romantic cliché of “rich life” versus “dead knowledge” — even though romanticism might have seized rightly on one aspect of this difference. Because for a bone to be carried along the paleontogogical networks, this is a life just as rich, interesting, complex, and risky as for the horse to roam through the great plains. I am just saying that it is not *exactly the same* sort of life. I am not opposing life and death, or object and knowledge of the object. I am simply *contrasting two vectors* running along the same flow of time, and I am trying to characterize both of them by their different mode of existence. What I am doing is simply refusing to grant existence to the object while knowledge itself would be floating around without being grounded anywhere. Knowledge is not the voice-over of a nature film on the Discovery channel.

The second misrepresentation would be to forget that knowledge acquisition is also a pathway, just as much a continuous chain of risky transformations as

²² The expression “mode of existence” is from Etienne Souriau (Souriau, 1943) and see my commentary of this book (Latour, 2007). The question of their number and definition is the object of my present work. Mode of existence is a banal expression clearly linked to the exploration of alternative ontologies. Witness its use in a recent novel by Coetzee (2005), where Elizabeth Costello the writer and her character, Paul, are negotiating what it is they do to one another in a striking parallel with the questions raised in science studies: Costello — “I do not know how much longer I can support my present mode of existence. Paul — What mode of existence are you referring to? Costello — Life in public.”

the subsistence of horses. Except that the latter goes from one horse to the next through the *reproduction* of lineages, while the other one goes from a sandy pit to the History Museum through many segments and transformations, in order to maintain “immutable mobiles”, drawing what I have called a *chain of reference*.²³ In other words, my argument makes sense only if we fill in the line going through all the transformations characterizing this second mode of existence without limiting the move at its two putative termini. We know what happens when we forget this long chain of intermediaries: we lose the reference, and we are no longer able to decide whether a statement is true or false. In the same way, when the horse fails to accomplish the reproductive feat, its lineage just dies away. One is a vector that can stop if there is a discontinuity along the path, but *so is the other!* The difference does not come, in other words, from the *vector character* of those two types of entities, but from the *stuff* out of which the successive segments of the two vectors are made. The tissue of experience is the same, but not the thread out of which it is woven. That is the difference I try to convey by the notion of mode of existence.

A few philosophers have learned from Whitehead that it might become possible again, after James’s redescription of knowledge, to distinguish those two modes of existence instead of confusing them. Whitehead has called this confusion of the way a horse survives and the way a bone is transported through the paleontologists’ knowledge acquisition pathways, “the bifurcation of nature”. His argument is that we have been confusing how we know something with how this something is carried over in time and space. This is why he concluded that there is no question which would be clarified by adding that it is known by a subject — a big challenge for science students who pride themselves in doing just that!

“There is now reigning in philosophy and in science an apathetic acquiescence in the conclusion that no coherent account can be given of nature as it is disclosed to us in sense-awareness, without dragging in its relations to mind.” (Whitehead, 1920: 26)

What he was against was in no way that we know objectively — like Searle, like James, like myself, like all the practicing scientists, he would not be interested for a minute in opening to doubt the certainty-acquisition networks. What Whitehead does is to give an even more forceful rendering of the slogan that “science does not raise any interesting *epistemological* questions.” Precisely for this reason, Whitehead did not want to *confuse* the procedures, the pathways necessary for the mode of existence called knowledge, with the modes of existence that he calls organisms.

²³ I have tried even to document this movement and the many intermediary steps through a photo essay (see Latour, 1999: Chapter 2, “Circulating Reference”). Everything that maximises the two opposite qualities of “immutability” and “mobility” (see Latour, 1990 and the whole book by Lynch and Woolgar [1990]).

“Thus what is a mere procedure of mind in the translation of sense-awareness into discursive knowledge has been transmuted into a fundamental character of nature. In this way matter has emerged as being the metaphysical substratum of its properties, and the course of nature is interpreted as the history of matter.” (Whitehead, 1920: 16, emphasis added)

Hence the most famous sentence:

“Thus matter represents the refusal to think away spatial and temporal characteristics and to arrive at the bare concept of an individual entity. It is this refusal which has caused the muddle of importing the mere procedure of thought into the fact of nature. The entity, bared of all characteristics except those of space and time, has acquired a physical status as the ultimate texture of nature; so that the course of nature is conceived as being merely the fortunes of matter in its adventure through space” (ibid.: 20)

Space and time are important “procedures of thought” for the mode of existence of acquiring knowledge along the pathways going, for instance, from sand pits to museums, but they are not to be confused with the ways “individual entities” manage to remain in existence. What Whitehead has achieved single-handedly is to overcome the impasse in which the theory of knowledge has engaged certainty production, by allowing both of them to go *their own separate ways*. End of the muddle of matter.²⁴ Both have to be respected, cherished and nurtured: the ecological conditions necessary for organisms to reproduce “next to next” along continuous paths; and the ecological conditions for reference to be produced “next to next” along continuous paths. It would be a “fraud”, Whitehead argues, to mix them up.

“My argument is that this dragging in of the mind as making additions of its own to the thing posited for knowledge by sense-awareness is merely a way of shirking the problem of natural philosophy. That problem is to discuss the relations inter se of things known, abstracted from the bare fact that they are known.” (...) “Natural philosophy should never ask, what is in the mind and what is in nature.” (idem p.30).

Here is the philosophical crossroad: one path is indicated in German: *An sich*, the other in Latin: *inter se*. The cosmological consequences of Whitehead’s reparative surgery are enormous.²⁵ What I want to take from Whitehead is simply the possibility of giving ontological weight to what is usually defined as objective knowledge. From the very success of our development of scientific enterprises, epistemology has wrongly concluded that they were two termini — forgetting to fill in the pathways continuously— and it added that, of those two termini *only one* —the object— had some ontological import, while the other one, the subject anchor, had the mysterious ability to produce knowledge about the first as if knowledge itself had no ontological weight. Hence the odd use of the word “representation” or “idea”. Rocks and mugs and cats and mats have an ontology, but what is known about them does not. Because of this clumsy

²⁴ On the interpretation of this book, see Stengers (2002). I have tried to supplement this history of matter as an epistemological confusion, by connecting it to the history of art (see Latour ????: *res extensa* is an artefact of perspective drawing).

²⁵ A sizeable body of philosophers informed by science studies have taken the challenge of Whitehead, chief among them Stengers; but see also Didier Debaise (2006).

framing of the question, science students, intimidated by epistemology, have taken their own discovery of the pathways they were describing as being “merely” about human made, mundane, word-like, discourse, without realizing that they had in effect unearthed a new, valid, sturdy, and completely mature mode of existence. They behave as if they had simply complicated or enriched the “word” side of the *same bridge* that had obsessed first empiricism, while the “world” side had remained intact or even had recessed even further from any grasp and into the Kantian *An sich*.

My claim is that, without Whitehead’s reparative surgery, historians of science could never take seriously in their own discoveries that they had redirected attention to a type of vector affecting *both* the words and the worlds *inter se*. This is why, to counteract this trend, I wish to use the same expression “mode of existence” for both vectors: those for subsistence, those for reference. Provided, that is, we do not grant to “what” is known the confusing two set of traits: *moving forward like an organism to subsist and moving forward like a reference to generate objective knowledge*. In other words, science students so far never dared to transform the chains of reference into a mode *of being*. And yet it is all quite simple: knowledge is *added* to the world; it does not suck things into representations or, alternatively, disappear in the object it knows. It is added to the landscape.

How much ontological weight has the Book of Nature?

We might now be in position to give some interesting meaning to the proposition I made at the beginning that history of science should mean the history of what is known as well as of the knowledge itself. This is the proposition that I staged in the, after all, not so provocative statement, “Newton *happens* to gravity”, or “Pasteur *happens* to the microbes and the paleontologists to the bones of horses”. We can summarize what we learned in this chapter by considering the same process —knowledge acquisition— viewed from two different frames of reference. The first one, which I have called after James “the summersault scheme”, is characterized by a) a vertical connection b) established between two points —object and subject; c) one of them moves through successive versions while the other does not; d) the connection between the two is not marked and can be interrupted at any moment. In the second frame, which I have called “continuous”, we have a) vectors in undetermined numbers b) flowing into the same direction of time c) with many crossing points such that d) the intermediary steps are continuously linked and constantly traceable (see figures 1 and 2).

My contention is that no realistic interpretation of knowledge production can be provided by the first frame: the only conclusion will be either that we forget entirely about the successive versions of the subject side —history of science

should be rated X— or else that we abandon all hopes to know “for sure”, and we wallow in various schools of idealism and subjectivism. If this last view is correct, then the curators of the Gallery were wrong or disingenuous to put in parallel the lines of horses through evolution and the successively revised versions by paleontologists of this evolution. They should be kicked out of the museum as dangerous relativists, revisionists, and social constructivists. They are mere pawns in the Bushists’ war on science, they are crypto-Derridians embedded into collections of fossilized bones to pervert good positivist American school-children.

However, a realistic version of knowledge production may be provided by the second frame of reference because no attempt is made there to confuse the movements of horses in evolution and the circulation of bones into paleontological pathways, and yet, there are enough shunts, enough points of articulation, to generate many provisional termini for knowledge to be certified — that is, rectified, equipped with instruments, corrected by colleagues, guaranteed by institutions and “directed” as Fleck said. More importantly, the pathways that connect the intersection points have continuous, recognizable, documentable material shapes. Is it plausible that, after thirty years of science studies, a sturdy correspondence theory of truth might finally be within grasp? (Remember I am patterning the metaphor after the metropolitan lines not the teleportation version.)

What authorizes me to say that the second frame is better? This is the crux of the matter. In the first frame, all the attention is concentrated on two loci: the object intact out there, and the subject that has shifting versions “in there”. In the second frame, the two anchors have disappeared: there is no longer one subject and there is no longer one object. Instead there are threads woven by the criss-crossing pathways. How could I take this second version as being more realistic? It is like saying that a Picasso portrait is more realistic than a Holbein or an Ingres. Well, but it might be, that is the whole point. Because what is now made fully visible in the second frame —and that is the ground for my claim— are the knowledge acquisition pathways that are generating, as so many byproducts, successive temporally marked versions of the objects and the subjects — now in the plural. It might be, I agree, a great loss not to be able to hold fast any more to the two termini of the object and subject. But consider, I beg you, the gain: the long and costly paths necessary to produce objective knowledge are now fully highlighted. The choice is now clear, and the question is for the reader to decide what is to be favored most. Do you prefer to highlight object and subject with the immense danger of opening a mysterious gap in between, the famous “out there” with the risk that skeptics will soon swarm in that gap much like crocodiles in a swamp ready to swallow you whole. Or do you prefer to deemphasize the questionable presence of object and subject and to underline the practical pathways necessary to nurture the production of

objective knowledge? Now this is, in my eyes at least, what relativism should always provide: a clear choice between what you gain and what you lose depending on which frame of reference you decide to cling to.²⁶ Now you may choose.

The reason for my own choice is that it offers a fresh solution to the difficulty I mentioned earlier: the quasi impossibility, after years of epistemology and then of science studies, to focus satisfactorily both on the mundane human, discourse-based aspects of science and the non-human, unfabricated, object-based aspects of the same activity. The reason for this impossibility was the choice of an inappropriate frame of reference — it's like in movies where, a full century after Lumière, in shooting a dialog between two characters, the cameraman still cannot focus simultaneously on the foreground and the background, even though our eyes, outside the movie theatre, do it at once with no effort at all. But if you accept for one minute to see the fabric of science through the second frame, the two elements snap into focus at once: it becomes perfectly true to say that science is *not* man-made, even though you need a lot of work to carry a bone from a sand pit to a Museum, a lot of colleagues to rectify what you say about it, a lot of time to make sense of your data, and a well endowed institution to keep scientific truth valid. The bones have been made to behave in a completely different mode of existence that is just as foreign to the ways ideas behave in our mind as to the ways horses galloped on the great plains.²⁷

An additional benefit of the second frame is that it squares nicely with the usual requirements of the philosophy of mathematics: mathematical constructs have to be non-human and yet constructed, just like the pathways I am highlighting which are badly handled if you try to hold them in between objects out there and ideas in there — and the situation is even worse if you try a little bit of both... All mathematicians are alternatively Platonists and constructivists, and rightly so. And yet they have to work every day, to consummate, as the saying goes, enough loads of coffee cups to figure out theorems and to construct a world that in itself has the mysterious quality of being applicable to the real world. Those requirements are contradictory only if the first frame is applied, but not in the second, since being able to establish connections on paper between objects is precisely the service rendered, from the times of the Babylonians to today, to the knowledge acquisition pathways. Is not allowing the transportation through deformation without deformation —that is the

²⁶ It should be clear from the examples, that the first model is actually a *consequence* of the second when the knowledge uncertainty has stabilized to the point that it seems common sense to say that there is “a dog” here and the word “dog” there.

²⁷ It could be interesting to see how much more reasonable is this solution than that of the “anthropic principle” which implies too much predestination for my taste. But what is nice in the anthropic principle is at least to have taken into consideration knowledge and known as events that happen to all.

invention of *constants*— what mathematics is all about?²⁸ And is this not exactly what is required to “lay down”, so to speak, the networks necessary to make the solar system, the bones, the microbes and all the phenomena movable, transportable, codable in a way that makes objective knowledge possible? Objects are not made to exist “out there” before one of those pathways has been continuously, “next to next” as James said, filled in by mathematical grids. But it is entirely true to say that once they are uploaded into those pathways, stars, planets, bones and microbes *become* objective and generate objectivity in the minds of those occupied to welcome, to lay out, or to install them.²⁹ Objective knowledge is not first in the minds of scientists who, then, turn to the world and marvel at how their ideas “fit” with the entities out there: objective knowledge is what circulates and then *grants* the entity seized by the networks another mode of existence and *grants* the minds seized by them a level of objectivity no human ever dreamed of before the 17th century — or rather they *dreamed* of it in earlier times but did not have it before the collective, instrumented and material pathways of scientific organizations were fully in place.³⁰

Such is the great fallacy of those who imagine that objective science is the daughter of “human curiosity since the dawn of time” and that there is a direct epistemological line from Lucy looking over the savannah with upright posture to the Hubble telescope.³¹ No, the laying down of long range networks allowing for the shunting of many entities into objectivity-making trajectories, is a contingent history, a new feature in the world history, which did not need to be invented, and which could be still *disinvented* if enough Bushists have their ways and are able to destroy the practical conditions allowing those pathways to be continuously maintained. Is this not a way to respect the historicity of science and the objectivity of its results in a more productive fashion than what was possible in the first framework with its endless series of perilous artifacts?

²⁸ This question has made a decisive move with the publication of Netz’s book (2003) which does for Greek geometry what Shapin and Schaffer (1985) have done for the scientific revolution (even though, with some *coquetterie*, Netz claims not to want to be the Shapin of mathematical diagrams!). What he has done is to provide the first systematic *materialist* reading of formalism — but where “matter” no longer has any of the drawbacks criticized by Whitehead.

²⁹ The reason I prefer the notion of immutable mobiles is that it includes all the practices to maintain, through the invention of constants, the contradictory features of mobility and immutability of which those achieved by geometry and mathematics are only the most obvious ones, but there are many others: labeling, collecting, keeping up, listing, digitalizing, etc. (on this wide extension of knowledge pathways see for instance Bowker, 2006)

³⁰ No one has documented this granting of objectivity to passing minds, better than Ed Hutchins (1995) when he shows how the US Navy might generate provisional competences to sailors with a high turnover (1995). Objectivity is what you *gain* when you subscribe to one of the highly equipped knowledge acquisition networks. Outside of them, there is no more sense in saying that you are “objective”.

³¹ On this see the unwittingly hilarious movie *The Odysee of the species* for which Coppens was the scientific advisor: Lucy walks upright because she sees the bright future of science above the grass.

Especially important to me: is this not a better way to respect the ways to nurture the fragile ecological matrix necessary to add to the world the mode of existence of objective knowledge? What I have never understood about epistemologists is how, with their teleportation scheme, they would convince the people to invest in the devising, upkeep and enlargement of the very humble means necessary to know something with objectivity. In spite of my reputation as a “social constructivist”, I have always considered myself as one of those who tried to offer another realistic version of science against the absurd requirements of epistemology that could only have one consequence: skepticism. Here as everywhere relativity offers, in the end, a sturdier grasp than absolutism.

The operation I have offered in this chapter as a more plausible solution to an old problem is simply to reload with ontological weight the knowledge pathways instead of considering them, as we so often do even in science studies, as another and better version of “the mind facing the object”.

I am actually saying nothing out of the ordinary; this is exactly what was designated, with great philosophical accuracy, by the very metaphor that Galileo had revisited: the book of nature is written in mathematical terms.³² This mixed metaphor renewing the Bible points at exactly the same problem as the one I have proposed: yes, it is a book —and now Gingerich (2004) has shown how realistically this book pathway metaphor can be taken³³ — and, yes, it is the book in which a few of nature’s movements forward can be welcomed, transported, calculated, made to behave in new ways. But the metaphor breaks down very rapidly if you don’t consider under which ontological condition nature can be made to be written about in mathematical format. The Book of Nature metaphor provides the exact interpretation for this amazing event of the 17th century, known as “the scientific revolution”: some features of the passage of nature became shunted and loaded into pathways, so that they provide them with a new mode of existence: they became objective. This is why any history of the trajectory of stars in time has to include, as one of their intersections, Copernicus and Galileo.

³² We now have a full historical interpretation of this highly complex metaphor from Elizabeth Eisenstein’s classic (1979) to Mario Biagioli (2006) through Adrian Johns (2000).

³³ Gingerich never moves out of the material connections established by the successive prints of the initial drafts written by Copernicus, from the University of Frauenburg until some aspects of the book have been sunk into the common cosmos of astronomers through the many publications, annotations, textbooks, and popular cultures. Thus Gingerich at last gives a realistic rendering of what it means for stars and planets to become calculations on paper without losing for one second their objective weight. Or rather, it is because they are at last calculated upon, that they become objective, but only as long as the knowledge acquisition pathways are kept up. Copernicus happens to the cosmos because of this new event of being calculated upon. Naturally, as soon as you revert to the discontinuous frame of reference, stars and planets become fixed, they recede to out there, and have no history

But this is also why, according to this view, their new post-17th century existence as objects does not *allow anyone to withdraw* from the world other modes of existence which might have different pathways, different requirements for their own continuation into existence. The tissue of experience, what James called the *pluriverse*, is woven with more than one thread; this is why it is granted to us with such a dappling, glittering aspect — an aspect which has been enhanced somehow by the “revised version” offered by the curators of the Natural History Museum gallery. After all, I was simply trying here to understand the healthy meaning of the labels in the gallery of evolution I started with.

* I warmly thank Beckett W. Sterner for editing my English. Isabelle Stengers, Michael Lynch and Gerard de Vries proposed many more emendations than those I was able to carry through. Thanks to Adrian Johns and Joan Fujimura to allow me to test this argument on their friends and colleagues.

References

- Baker, Nicholson (1988) *The Mezzanine* (New York: Weidenfeld and Nicholson).
- Biagioli, Mario (2006) *Galileo's Instruments of Credit: Telescopes, Images, Secrecy* (Chicago: The University of Chicago Press).
- Bowker, Geoffrey C. (2006) *Memory Practices in the Sciences* (Cambridge, Mass: MIT Press).
- Coetzee, J.M. (2005) *Slowman* (London: Vintage Books).
- Daston, Lorraine (2000) *Biographies of Scientific Objects* (Chicago: The University of Chicago Press).
- Debaise, Didier (2006) “Un empirisme spéculatif.” Lecture de Procès et Réalité (Paris: Vrin).
- Descola, Philippe (2005) *Par delà nature et culture* (Paris: Gallimard).
- Dewey, John (1958). *Experience and Nature*. (New York: Dover Publisher).
- Eisenstein, Elizabeth (1979) *The Printing Press as an Agent of Change* (Cambridge: Cambridge University Press).
- Fleck, Ludwig (1981 [1935]) *Genesis and Development of a Scientific Fact*. (Chicago: The University of Chicago Press.)
- Fleck, Ludwik (2005 [1934]). *Genèse et développement d'un fait scientifique* (Nathalie Jas, trans.; Ilana Löwy, préface; Bruno Latour, postface) (Paris: Les Belles Lettres).
- Gingerich, Owen (2004) *The Book Nobody Read: Chasing the Revolution of Nicolaus Copernicus* (New York: Penguin).
- Hacking, Ian (1999) *The Social Construction of What?* (Cambridge, MA: Harvard University Press).

- Hutchins, Edwin (1995) *Cognition in the Wild* (Cambridge, MA: MIT Press).
- James, William (1996 [1907]) *Essays in Radical Empiricism* (London: University of Nebraska Press).
- Johns, Adrian (2000) *The Nature of the Book: Print and Knowledge in the Making* (Chicago: The University of Chicago Press).
- Latour, Bruno (1990) "Drawing Things Together," in M. Lynch & S. Woolgar (eds), *Representation in Scientific Practice* (Cambridge, Mass: MIT Press): 19-68.
- Latour, Bruno (1999) *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge, MA: Harvard University Press).
- Latour, Bruno (2004a) "Why Has Critique Run Out of Steam? From Matters of Fact to Matters of Concern," Symposium on the "The Future of Criticism," *Critical Inquiry* 30: 225-248.
- Latour, Bruno (2004b) *Politics of Nature: How to Bring the Sciences into Democracy*, Catherine Porter, trans., (Cambridge, MA: Harvard University Press).
- Latour, Bruno. (2005) "What is Given in Experience? A Review of Isabelle Stengers, 'Penser avec Whitehead'," *Boundary 2* 32: 222-237.
- Latour, Bruno (2007) ("Pluralité des manières d'être", *Agenda de la pensée contemporaine*, numéro 7, printemps 2007: 171-194.
- Lynch, Michael, and Ruth McNally (2005) "Chains of Custody: Visualization, Representation, and Accountability in the Processing of DNA Evidence," *Communication & Cognition* 38 (3/4): 297-318.
- Lynch, Michael, and Steve Woolgar (eds) (1990) *Representation in Scientific Practice* (Cambridge, MA: MIT Press).
- Marcus, George E. (1999) *Paranoia within Reason : A Casebook on Conspiracy as Explanation* (Chicago: The University of Chicago Press).
- Mooney, Chris (2005) *The Republican War on Science* (New York: Basic Books).
- Netz, Reviel (2003) *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History* (Cambridge: Cambridge University Press).
- Petroski, Henry (1990) *The Pencil: A History* (London: Faber and Faber).
- Pickering, Andrew (1995) *The Mangle of Practice: Time, Agency and Science* (Chicago: The University of Chicago Press).
- Shapin, Steven & Simon Schaffer (1985) *Leviathan and the Air Pump* (Princeton, NJ: Princeton University Press).
- Souriau, Etienne (1943) *Les différents modes d'existence* (Paris: PUF).
- Stengers, Isabelle (2002) *Penser avec Whitehead: Une libre et sauvage création de concepts* (Paris: Gallimard).
- Tarde, Gabriel (1999) *La logique sociale* (Paris: Les Empêcheurs de penser en rond).
- Whitehead, Alfred North (1920) *The Concept of Nature* (Cambridge: Cambridge University Press).

