

SCIENCE, CONTINGENCY AND ONTOLOGY

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Léna Soler (2008) makes a nice contrast between contingentist and inevitablist conceptions of science. The latter is much easier to grasp and much more intuitive. It's the idea that any community that embarks on a project akin to science will end up believing what we do. Ian Hacking once made this idea a bit more specific by saying that anything like physics must eventually arrive at Maxwell's laws. None of this is very clear. What are we thinking of when we imagine 'a project akin to science' or 'anything like physics'? How can we imagine the space of possibilities? What's in and what's out? I'm not going to agonise over such points, because I want to argue for a contingentist vision, drawing upon the history of science instead of imagining other sciences. But I think it helps to start with inevitablist, and I want to begin by talking about where our intuitions about inevitability come from. While most discussions of inevitability, contingency and associated issues are usually couched in an epistemological idiom, my suggestion is that our intuitions have an importantly ontological aspect — they are intuitions about the sort of place the world is. The rest of my talk then circles around questions of how and why I think our ontological understanding of the world needs to be modified to help us get to grips with contingency.

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Where do our inevitablist intuitions come from? By and large, they are implanted in us from a very early age by people like parents and teachers, certainly before we have developed much of a faculty for critical thought. We teach our children that, in general, the world is a fixed and lawlike place and that, in some respects at least, we already know its structure. Even I, as a card-carrying relativist, have been known to expound the principles of heliocentric astronomy to my defenceless offspring. The earth goes round the sun, I told them, in an elliptical orbit while spinning on its axis: hence day and

night and the seasons—things like that. This sort of thing goes on endlessly in homes and classrooms. Everyday features of the made environment conspire with its vision: door handles and clocks have a fixed regular structure which we can know, too. And, of course, this ontological vision just gets intensified if one moves further into the arcana of scientific education. I was about eleven when I was first introduced to the idea that world is built out of atoms and molecules, and taught how to associate that idea with some aesthetically seductive reactions in the chemistry lab, and how to do calculational tricks with it.

Growing up, at least in the mainstream of the modern west, is thus an intensive indoctrination in the ontology I just mentioned, that the world has a fixed reliable structure and we can know it: atoms and molecules, quarks and DNA, that sort of thing. And that ontology then serves to underpin our inevitablism—it makes inevitablism inevitable. If the world is built out of definite fixed entities and structures then inevitably anyone who explores the world will run into and know them. Wherever one starts from, from whatever angle, sooner or later one will run into atoms and molecules—they are what's there in the world; there's nothing else to run into. Likewise Maxwell's equations: that's how the electromagnetic field is. This, I believe, is where we're all coming from when we try to think what the world is like.

All this is obvious enough, though phrased the other way around I find it more striking. Thinking about my own education, and my childrens', and what I know about school and university curricula in general, I'm struck by an almost total absence of ontological visions that don't conjure up a regular and knowable world, that conjure up something different. We have nothing to set against what I could call the modern ontology of fixity and knowability. At some level which it is hard even to recognise, we are defenceless against it. I think this is a sad fact about child-rearing and education, but that isn't the topic of this talk. Instead, as I said, I want to build up here another ontological vision, more adequate to what I know about the history of science.

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How might one begin to dislodge inevitablist intuitions? For me, it began with a fascination with notions of incommensurability that grew out of reading Thomas Kuhn and Carlos Castaneda in the early 1970s. I was attracted to Kuhn's idea that scientists working within different paradigms somehow inhabit different worlds, and Castaneda's account of his initiation into the magical world of don Juan just made the idea more appealing. What puzzled me about it, as an erstwhile physicist, indoctrinated along the lines just indicated, was the question of how incommensurability could be

possible. What sort of a place is it that we inhabit, that we can conjure it up in such different ways as modern physics and Yaqui sorcery? I wanted an ontological picture that would make sense of that, and my first inspiration came from crystallography. I thought of the world on the analogy of a crystal that could be split along different axes, and whose different faces displayed different patterns. Each axis, on this model, would stand for a specific paradigm that, so to speak, produces its own specific world.

I like this crystal ontology. To a degree, at least, it makes sense of some striking features of the history of science, and it also constitutes an ontological antidote to inevitablism. It makes it possible to think that the angle from which we approach the world matters. Depending on the angle, the world shows itself in this way or that, and these ways don't lead into one another—there's no inevitability that they will arrive at some common point; in fact the inevitability is that they will remain forever different. Or, to put it the other way around, since the angle we come at the world is not given by the world itself, it is, in that sense, contingent. The crystal ontology is an ontology of contingency. Contingency, on this account, is not so much to do with us as human knowers as it is an attribute of the material world. But there is more that needs to be said here.

If we want to stay in this crystalline world a bit longer, we need to think more about the splitting. Just how does the world-crystal get cleaved along this or that axis? At this point mainstream philosophy of science might start talking about the Duhem-Quine thesis, the idea that many different accounts can be given of any set of data, or, more imaginatively, about Norwood Russell Hanson's arguments that scientists perceive gestalts rather than particulars and that many gestalts are possible. But while these arguments are interesting they remain in the ontological space that I am trying to get away from. They point to a line of thought which remains faithful to the idea that the world has a fixed and knowable structure, but add to that the idea that on some higher level we are capable of picking out all sorts of different patterns in it. This shifts all of the burden of contingency back onto us, and away from the world. I think we need something more radical to do justice to the history of science.

In science, we latch onto the world not via our unaided senses but through the use of machines and instruments and all sorts of contrived set-ups, and my suggestion is that we think of specific fields of machines as cleaving the world along specific axes. Instruments latch onto the world and elicit it in a certain way, and thus, so to speak, translate it into the world of science. *Constructing Quarks*, for example, includes a chapter I called 'Producing a World,' in which I documented the ways in which different fields of instrumentation in high-energy physics elicited different fields of phenomena which in turn sustained different understandings of elementary particle themselves. If we follow this line of

thought, the ontological picture gets more interesting and complicated. The original crystal metaphor locates contingency in the world itself, in nature. Duhem-Quine arguments move it back into the human realm. But if we take this instrumental aspect of science seriously, the picture starts to decentre itself. The splitting at the heart of contingency has to do with both nature and instrumentation and, lurking on the far side of instrumentation from nature, ourselves as the designers and builders of machines. We move, that is, towards a non-dualist and posthumanist ontology. I want to move further in this direction now, though this entails saying goodbye to the crystal world.

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What's wrong with the crystal ontology? No doubt many things but, most seriously, it lacks any dynamics. You split the crystal, there's a pattern on the exposed face, and that's it, nothing further happens. But science isn't like that. It evolves, continuously and discontinuously, in time. What sort of an ontology can accommodate that? How can we get dynamics into the picture?

I want to continue to focus on the way we latch onto the world through machines, and I want to emphasise that this is a nontrivial business, and especially that it is a continuing process, extended in time, not a one-off event. We can find a classic description of this process in Ludwik Fleck's history of the Wassermann reaction as a blood test for syphilis. At some early point in its history, the test had something like a 15% success rate; at some later point it went up to 70 or 80%. The test, we could say, latched onto syphilis more effectively over time. And how did this latching-on happen? It happened, according to Fleck, in a sort of trial-and-error tinkering. The scientists tried varying the prototypical recipe in all sorts of ways, and eventually arrived at a recipe that was medically useful. Fleck describes this process as one of tuning—tuning the experimental procedure to home in on a signal for syphilis. Following Fleck, and on the basis of my own studies of scientific practice, I am inclined to think of it as a *dance of agency*—a constitutive back and forth between human agents who contrive specific material set-ups, and the agency of those set-ups themselves—what they do. I documented several of these dances in *The Mangle*: Donald Glaser assembling all sorts of set-ups en route to the bubble chamber, then standing back to film what they would do, then reconfiguring the apparatus in response to its performance, and then round the circle again; Giacomo Morpurgo doing just the same in the development of his quark-search apparatus.

These dances of agency are, I think, endemic to and constitutive of scientific practice in all sorts of ways, and I now want to think about them ontologically. The first point to grasp is that they conjure up an image of the material world not as fixed, static and knowable, but as endlessly lively. The world

performs—does things—that continually surprise us. My reading of the history of science is that the world is a place of endlessly emergent performativity; I can see no reason to think we shall ever reach the bottom of it. And it is worth remarking that this is an ontological discovery. It seems, at least, that we don't, for example, live in a virtual reality simulation where novelty comes to an end when we get down to the level of the fundamental pixels—though perhaps we just haven't got there yet.

A corollary of these observations can get us back to our theme. The only way to get along in a world of endless emergence is to be light on our feet. Just as Glaser or Morpurgo never knew how their apparatus would perform next, so their responses to such material performances were also emergent, and made up on the spot, rather than given in advance. My argument in *The Mangle* was that one can discern a temporal pattern in scientific practice, centred around a notion of modelling, but that contingency and chance are an integral part of the pattern. In the end, there is something inexplicable, though not at all mysterious, about scientific practice. It just so happened that Glaser thought of building a detector like the cloud chamber but different; it just so happened that he responded to resistances in his practice the way he did, rather than some other way. What happened in this dance was not pre-ordained; it could have gone differently.

And this is the basic argument I made in *The Mangle*: science is built in dances of agency; chance is endemic to these dances; therefore one should see the state of scientific culture at any given time—meaning its fields of instruments and the facts, theories and social relations that surround them—as genuinely historical, as the product of contingent rather than necessary developments. I think this is how it is. But the picture needs a bit of elaboration.

First, a simple point. If one stays with the old ontology, of the world as a place of fixed, knowable properties, then contingency seems immensely threatening. In that kind of world, you either get the story right or you get it wrong, and to speak of contingency is to conjure up the latter, as if the scientists must be just making their stories up if they are not latching onto the structure of nature. (This is the point at which philosophers start talking about method: we have to police the scientists to rein in the contingency of their practice. From another angle, it is the standard opening into social constructivism.) But on the ontological account I am trying to develop, things look different. The sort of contingencies in scientific practice that I am pointing to are necessary counterparts of the endless emergence of the performativity of matter. They are integral to our struggles with the otherness of nature, not something to be feared or regretted. They are the mark of the fact that scientists are not in control of their own endeavours, that they are not just inventing their culture from whole cloth. We

should admire science for its dances of agency, including all of their contingencies—these are where scientists genuinely grapple with their object. This is this position I called ‘pragmatic realism.’

My second point is less straightforward. I have so far described dances of agency as if science is just an endless struggle through an unmappable and continually mutating jungle. I think this a good image to start from, but more needs to be said. In science, dances of agency have a specific structure that we need to think about. It seems to me that they—and science itself—are characterised by a certain telos, which is what I want to discuss now. What is this telos? It is, in the first instance, that dances of agency in science aim at their own self-extinction. Scientists don’t enjoy them much; they want to get out of them. I can remember doing my PhD in physics, trying to write a big computer program to fit a lot of data. Every night I’d leave the latest version to run, and every morning something would have gone wrong, which I would then have to try to fix—which annoyed me immensely: why won’t the damn thing just run?. So what does it mean to extinguish a dance of agency? In *The Mangle* I talked about special points of ‘interactive stabilisation,’ which, when achieved, are places where practice can rest for a while, and facts or whatever be reported, when the program runs—moments when the dance is temporarily over.

But still, what does this interactive stabilisation amount to? I described it as various cultural elements fitting together in some way, in contrast to the mismatches which are the usual state of affairs. I also insisted that it was impossible to give any closed definition of what this ‘fitting together’ in general amounted to. But here I want to make things difficult for myself by admitting that in this instance I missed a trick, namely that in these special moments of stabilisation some things hang together in such a way that some other things—namely, the human and the nonhuman—are split apart. When my computer program wouldn’t run, our lives were bound up together: every day I would tend it and work on it; every night it would disappoint me. When it did eventually agree to run, we could go our separate ways. Our relationship had changed. The program had at last achieved its independence from me—it had become something I could use, what I would call a free-standing machine—and I had achieved my independence from it—I was once more, in this respect at least, my own man, a free-standing human being, and not the other half of a stack of punched cards. Likewise Glaser and his bubble chamber, and Morpurgo and his electrometer.

So, if one follows this line of thought, one arrives at a more tightly specified account of the dance of agency in science: it is a dance structured through and through by an invariant telos, that of splitting the human from the nonhuman—a telos of dualisation, of making the world dual. (I think this is what Latour means by ‘purification.’)

What should we make of this? First, it is a major ontological discovery of modern science (and engineering, of course) that this dualisation can be done. I can't see that the world has to be such that dualisation would work; it just turns out to be that way. Second, we have here another reason to admire science. Going back to the earlier discussion of the dance of agency, finding these islands of dualist purity is hard and uncertain work, entailing arduous searches through spaces of material agency (and much else). Third, there is something objective and non-contingent about these islands, which needs further discussion in the present context.

Let's try a different example, for the sake of variety. In 1856, William Henry Perkin patented a recipe for the production of the synthetic dye mauve, a recipe which began: 'I take a cold solution of sulphate of aniline, or a cold solution of sulphate of toluidene, or [etc] . . . and as much of a cold solution of a soluble bichromate as contains base enough to convert the sulphuric acid in any of the above-mentioned solutions into a neutral sulphate. I then mix the solutions and allow them to stand for 10 to 12 hours, when the mixture will consist of a black powder and a solution of neutral sulphate. I then throw this mixture upon a fine filter [etc, etc].' Here Perkin is describing one of these islands of stability that science aims at, and I would be happy to read him as describing a property of the world that exists quite independently of us. My ontological intuition (though maybe I am still under the spell of my indoctrination as a physicist) is that were any being, at any time, anywhere in the universe, to mix the named chemicals and leave them to stew, they would end up with a black sludge from which one could extract a pretty coloured dye. Similarly, given the right components, any being could build a bubble chamber or a quark-detector.

So what? If I wanted to support our intuitions about the inevitability of science, I wouldn't point to rarefied theoretical constructs like Maxwell's equations; I would start with visible material achievements like Perkin's mauve recipe. Look, I would say, the world is this way and there's nothing contingent about it all. I would even be prepared to elaborate the ontological picture and start talking about 'attractors' here, as if the world pulls us into zones of stabilisation. Give this hypothetical being some aniline and bichromate and tell them to find out how to make a purple dye, and if they mess around long enough I think there's a good chance they'd find something like Perkin's recipe. (There is an argument here against Harry Collins' famous discussion of building a TEA laser.)

Let us, then, imagine, this more sophisticated ontology of a world of endless emergence that nonetheless is characterised by all sorts of basins of attraction, that we can, as it happens, settle upon and exploit. This sounds like a good description of the world to me. The question then becomes: is

this ontology consistent or inconsistent with contingency in science? It seems to point to inevitability rather than chance, but does it?

Of course, I wouldn't ask that question if I didn't think the answer was no. The key questions here, I suppose, concern finitude and uniqueness. How many of these islands of dualist stability are there in the world? Is there some finite list that all beings operating a dualist telos are destined necessarily to run into? Everything I know about the history of science suggests this is not the case, that there are, in fact, indefinitely many such islands, and that which ones we settle upon are, again, matters of contingency.

One way to motivate that thought is simply to go back to instances of incomensurability large and small. At the micro end of the scale, I think of the Morpurgo-Fairbank controversy about the existence of free quarks. Within a shared cultural context, these two physicists found different material ways of latching onto the world that pointed to diametrically opposed conclusions. At the macro end, I think of the difference between the 'old' and the 'new' paradigms, as they were called, in particle physics. Both of these achieved the dualist telos of human-nonhuman separation, but using quite different fields of machines quite differently tuned to display quite different phenomena. This last example, of course, moves us beyond the question of individual islands of stability to overall patternings, without, as I said at the start, pointing to any necessary uniqueness.

Another way to argue the point is to look more closely at the idea of an attractor. If we want to speak this way, we have to ask where attractors are? Are they just there in the material world? This is a tricky point. I stated earlier my conviction that the material world just does behave the way Perkin's mauve recipe suggests. But from my ontological perspective, the material world must have indefinitely many ways of behaving—however we configure it, it will reliably do something or other. But most of those somethings we don't care about at all. When I conjured up an imaginary being who would find the dye mauve, I had to supply her both with some named chemicals and an objective: produce a dye. Without these special material elements and a culturally situated goal I don't suppose she would ever arrive at mauve. So despite the telos of dualist purification —of making a clean split between people and things—somehow these attractors fail to respect the split. They remain themselves decentred things, existing in a nondual space that is a joint product of the material and social worlds. Only for diseased aliens obsessed with ideas of bad blood could the Wasserman reaction count as an attractor. In effect, then, we have come round in a circle. What counts as an island of dualist stability in scientific practice still depends on all the contingencies of how we approach the world that I talked about before.

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Though there are some subsidiary points that I want to address, this completes my basic line of thought, so I should briefly sum up where we have got to. I don't suppose I have settled the issue of contingency in science, but I have tried to shift the terrain on which we think about it, from epistemology to ontology. I find this shift useful and attractive because it (1) gets us closer to the practice of science itself, (2) helps us see the multiple contingencies of science more clearly, and (3) defangs the threat of contingency: seen from an ontological perspective, contingency is not the sort of thing we need to worry about; it is intrinsic to getting along with an indefinitely lively, emergent and always surprising world.

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Now for the subsidiary points. There are four of them. First, I have to recognise that in my shift from epistemology to ontology I have moved the goalposts away from the usual obsession with knowledge. The traditional question about necessity has to do with things like Maxwell's equations rather than bubble chambers and mauve recipes. In this connection, I just want to note that in *The Mangle* I did try to map out how scientists move between the machinic and the epistemic, and nothing much changes in my conclusions if we follow this transit. If anything, the position just looks bleaker for the necessitarian. The islands of dualist stabilisation I have discussed so far have been simple and obvious ones: a bubble chamber that produces particle tracks; a recipe that produces pretty clothes. My argument concerning the production of facts and theories is that they, too, are produced in dances of agency, though much more intricate and delicate and more complexly situated ones than those discussed here. If one goes into the details more contingencies appear, not less.

My second thought remains at the epistemic level. In *The Mangle* I argued that articulated knowledge is built in the creation of alignments between machinic performances and conceptual structures. And what I can see more clearly now is that the conceptual structures of science have themselves a specific and peculiar structure, precisely in that they refer only to a fixed and regular material world having a knowable structure. Another aspect of the telos of science is, then, to find islands of dualist purity that can be aligned with dualist accounts of the world—accounts of how the world functions quite independently of us, as a giant free-standing machine. The old ontology thus reappears here as something imposed on the world by science, and this, indeed, is where our ontological intuitions about science come from, from mistaking a given telos with how the world is. Again, I should say that

there is an ontological discovery here: that the world is the sort of place where these sorts of assemblages of machines and a very particular form of knowledge can be built. The Scientific Revolution was, I suppose, precisely this discovery. We can admire the construction of these assemblages as highly non-trivial achievements. But, as I have said already, we would be mistaken if we thought they somehow efface historical contingency, or obviate the case for the alternative ontological vision I have been trying to conjure up.

My third thought returns to the material plane. I have been talking about ‘islands’ of stability in our relations with nature, but I want simply to raise the question of whether this is the right metaphor. I have in my mind, for example, the idea that Perkin’s discovery of the mauve recipe was not in itself sufficient to lead to a transformation of 19th-century organic chemistry (or the establishment of a new synthetic dye industry). It was crucially important that, as it happened, extensions of Perkin’s work quickly turned up other islands of stability, other recipes, which could collectively be caught up in Kekulé’s theories of molecular structure and the benzene ring. It seems appropriate here to think of the science of chemistry developing in a process of following a ‘seam’ or ‘vein’ of attractors, located, as before, in a hybrid human/nonhuman space. (I think Deleuze and Guattari speak this way somewhere.) The idea I want to float is that perhaps all sciences are founded not on single islands of stability but on finding a vein of attractors. Robert Kohler’s classic description of *Drosophila* as a breeder reactor for genetics might point in this direction.

My fourth and last point goes in a different direction. I have, in effect, described science as a singular stance in the world—a stance that insists on imposing a specific structure on the dances of agency in which we are all enmeshed—an insistence on finding islands of dualist purification that can be connected up to accounts of a fixed and regular inhuman world. This teleological structure is not given by the world (though the world certainly conspires in it) and the whole scientific enterprise might itself thus be described as contingent. Furthermore, this scientific stance has certain characteristics that are worth noting. As Martin Heidegger argued, the modern sciences conjure up the world as a calculable ‘standing reserve’ awaiting human domination, and I think he was right in describing science and technology as integral to the mode of being that he called ‘enframing.’

Ten years ago, that observation would have seemed largely meaningless to me, because I would have found it hard to imagine any other mode of being in the world. What I have since come to realise is that there are, in fact, alternatives to the scientific stance, and I have become especially interested in projects that, so to speak, dwell on dances of agency rather than trying to bring them to an end and expunge them from our imaginations. My recent work on the history of British cybernetics has been

precisely an attempt to explore what this stance of ‘revealing’ can look like in all sorts of fields and endeavours.

My closing remark is, then, that ontological reflection does not have to remain in the realm of ideas. Just as a dualist ontology of a fixed and knowable world comes down to earth in modern science and engineering; so an ontology of emergent performativity and dances of agency manifests itself in all sorts of cybernetic projects and artefacts. By their fruits ye shall know them. If I wanted to discuss the practical merits of the ontological visions I have discussed here — which is it better to believe?—I would start from Heidegger’s idea that enframing is a ‘supreme danger’ to humanity, but that is a topic for another talk.