

JACOB BRONOWSKI AND A POST-METAPHYSICAL SCIENCE FOR EDUCATION

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Abstract

The claim that science education is better served by a conception of science that moves beyond metaphysical pre-suppositions is moot without a plausible candidate for such a post-metaphysical rendering of science. This paper takes Jacob Bronowski's philosophy of science as such a candidate and evaluates both the degree to which it is post-metaphysical and the extent to which it can be applied to re-imagining science education.

The evaluation of Bronowski's ideas is undertaken within a philosophical framework that combines the related approaches to metaphysics of several contemporary philosophers. Specifically, the paper draws upon Bruno Latour's framework for describing the dualistic attributes scientists give to Nature, relating these dualisms in turn to the bifurcation that Iain Thomson sees as definitive of Heidegger's *ontotheological* rendering of metaphysics. Finally, it connects both these interpretations of metaphysics to Mark Wrathall's six theses concerning the metaphysics of truth.

This paper shows that the strong anti-dualist stance in Bronowski's work makes possible a better integration of the dual aspects that Latour describes. Furthermore, Bronowski's emphasis on the role of the scientific imagination softens any charge of strict adherence to Wrathall's theses. While his view of science promises to overcome many of the limitations of contemporary positivist renderings of science education, Bronowski's notion of stratified stability, in combination with his valorising of human progress, risks re-introducing some unwelcome metaphysical assumptions.

I Introduction

I have argued elsewhere (Toscano 2013a; Toscano 2013b) for a re-examination of the metaphysical foundation of both science and science education with the view of better understanding how the 'science' of scientists and the 'science' of the science classroom may be related. I have suggested that questions of education policy, assessment and curriculum in science education are often shaped, and perhaps disproportionately influenced by the kinds of metaphysical assumptions or tendencies that are 'imported' directly from the sciences. Put another way, there appears to be a tacit privileging of the scientists' conception of science (along with scientists' corresponding metaphysical commitments) over those of science teachers or indeed science students. I have also tried to highlight the limitations of the metaphysical assumptions underpinning this scientific influence and put forward Heidegger's conceptions of art and 'dwelling poetically' as candidate modes of being in the world of science and science education that overcome these limitations (Toscano 2013c).

In this paper I want to extend the discussion concerning the influence of metaphysical thinking in science and science education by turning my analysis towards a concrete example of a conception of science that, I will want to argue, suffers less than traditional views of science from metaphysical tendencies and therefore stands as a potential candidate for a post-metaphysical re-framing of the 'science' of science education. The candidate conception of science under consideration is that provided by the philosophical work of Jacob Bronowski (1908–1974).

The ambition of this project extends far beyond anything that can be presented in a single paper. Bronowski's textual publications alone span 16 books, 70 essays and dozens of research paper. And we must add the dozens of talks and radio presentations; and of course his landmark television series; the *Ascent of Man*. And yet the ambition of my project is aided by Bronowski's own ambition, which was "to create a philosophy for the twentieth century which shall be all of one piece" (Bronowski, 1973, p. 15). For I shall take it for granted for the purpose of this paper that the quoted fragments from Bronowski's work presented in my analysis can be taken as parts of a unified whole; and more importantly, like a fractal, the parts carry a resemblance to Bronowski's holistic account of science.

One thing I hope to achieve in the span of this paper is provide a *prima facie* evaluation of the degree to which Bronowski's "philosophy for the twentieth century" is one which goes beyond metaphysical thinking. To this end I want to (i) put forward some criteria and provide frameworks for defining metaphysics; and (ii) by drawing upon examples from Bronowski's work, evaluate the degree to which his conception of science is far enough removed from metaphysical tendencies to count as a candidate for a post-metaphysical conception of science for education.

II Models of Metaphysics

I shall use two 'models' of metaphysics as the basis of my analysis of the 'metaphysicality' of Bronowski's philosophy of science. The first is drawn from the secondary literature on Heidegger's understanding of metaphysics. The second draws upon recent work by Bruno Latour on what I interpret as a metaphysical construction of Nature in the natural sciences. While Latour's work does not explicitly set itself as a treatment of metaphysics, I contend that when read along side the Heideggerian perspective, the implicit critique of metaphysics becomes evident. Since Latour's framework attends to science particularly, I take it as pertinent to this paper.

Heidegger and Metaphysics

The finer details of Martin Heidegger's philosophy shall remain in dispute for a long time to come – after all, no philosopher with Heidegger's prodigious and original output ought to be spared the detailed philosophical examination that continues to be levelled at his work. So it seems impertinent to posit a view on Heidegger's notion of metaphysics that claims to be incontrovertible. However, in the Heideggerian spirit of entering a hermeneutic circle, I want to venture this paper on two views of Heidegger's take on metaphysics: Ian Thomson's view that metaphysics is *ontotheological* (Thompson, 2005; Thomson 2011); and Mark Wrathall's six theses of the metaphysics of truth (Wrathall 2011).

According to Thomson, Heidegger saw in the word *ontotheology* (originally Kantian) the dual nature of metaphysics: the *ontological* and the *theological*. The ontological dimension of metaphysics carries, as expected, the meaning of an account of what *is*. The *theological* dimension, despite the immediate connotations with theism, carries the sense of that which stands as the source of what makes the entities accounted for in the ontology, the beings that they are. One could think of these aspects in terms of *existentia* (ontology) and *essentia* (theology). Thomson's claim is that the history of Western metaphysics is a series of re-castings of this ontotheological dualism: whether it manifests in setting up the distinction between form and matter; between actuality and potentiality; or the coupling of will-to-power and eternal return. Wrathall too sees the bifurcation of *being* into *essentia* and *existentia* as characteristic of the metaphysical thinking Heidegger criticised. Moreover, he claims the bifurcation is the result of our tendency to search for something that would provide a final and absolute ground to our understanding of being. The theological dimension of metaphysics serves this role.

With the idea that metaphysics is the impulse to find certainty and stability (something essential, theological) in a world that, according to the existentialist, does not afford it, we can look for those features that the metaphysician would require of entities to function as such a ground. Wrathall, in his examination of Heidegger's critique of the metaphysical thinking in Nietzsche outlines these features (Wrathall 2011, pp. 222-226). He posits the following six theses as capturing the features of metaphysics (of truth):

1. The Stability Thesis: What entities truly are is found in that about them that is stable across changes.
2. The Independence Thesis: What entities truly are is independent of the particular thoughts, practices, and attitudes we have regarding them.
3. The Uniformity Thesis: All true entities share a single, uniform characteristic style.
4. The Conformity Thesis: Our attitudes are true by conforming to the way entities are independently of our attitudes.
5. The Adjustment Thesis: The truth of entities is only accessible when we have properly adjusted our attitudes so as to orient them to reality.
6. The Cognitivist Thesis: The best attitude for grasping what things truly are is some species of cognitive attitude.

Latour on Science and Nature

Recently, the sociologist of science, Bruno Latour, delivered the six Gifford Lectures on the subject of Natural Religion (Latour, 2013). Latour approached the subject by considering the kind of entities that "gather a people". Latour sketches the features he thinks are common to all entities that gather a people, in the sense that Nature gathers naturalistic scientists or the Christian God gathers Christian people. The four features he ascribes to such entities are: exteriority, unity, animation and indisputability. One entity he considers is Nature. On comparing the features of Nature, as the entity that gathers scientists, with those of entities that gather religious communities, he concluded that Natural Religion is a pleonasm. A gloss of his argument might be: the features ascribed to Nature by scientists, make it indistinguishable from a god.

Latour points out that scientists in practice do not take Nature merely as that which is exterior, unified, under-animated and indisputable. He recognizes certain tensions in scientists' relationship to 'Nature'. Firstly, scientists take Nature as standing apart from us. The entities that make it up and the processes that occur in it are not dependent on the whims, fancies or subjectivity of human beings. Yet, Nature is only accessible through the complex network of practices of the scientists. The development of instruments, the dissemination of results, debates at conferences, fieldwork, etc., all bring Nature into the light of human consciousness. Secondly, scientists take Nature as unified, so that the complexity and variety of processes are assumed unified under discoverable laws of nature. But the degree to which the multiplicity of processes in nature can be reduced to laws of nature is often overstated. Thirdly, the Nature of the scientist is inert: Nature is not animated – it does no act. And yet we are confronted with the overwhelming impression that nature is full of activity and animation, with every entity expressing a kind of "agency", as Latour puts it. Finally, Nature is the final arbiter of truth – one cannot argue against the brute reality of Nature. But Nature only appears so after we have forgotten the scientific controversies that got us to incontrovertible 'facts'.

The Metaphysics of Science

Recalling that the aim of this paper is to evaluate Bronowski's view of science against a framework for metaphysics, it is essential to bring together the Latourian and Heideggerian perspectives on metaphysics. Only then shall we be in a position to determine to what extent Bronowski's natural philosophy does away with metaphysical thinking.

Firstly, metaphysical thinking involves a bifurcation of the ontological and the theological. That is, metaphysical thinking posits a realm of essences, or god-like entities that provide the stable ground for our encounter with what exists in the world. A post-metaphysical conception of science would eschew such a dualistic approach. Moreover, both the language and practices of science would have to carry through this commitment to overcoming dualist thinking. A non-metaphysical understanding of being, according to Heidegger is not without precedence. In Heidegger's account of the history of the question of being – his historical account of being – he gives the example of the relationship to being of the pre-Socratic Greeks (with their notions of *phusis*) as non-metaphysical. All epoch subsequent to this, contends Heidegger, carry metaphysical dualisms (for instance, the Cartesian separation of subject and object that inaugurated the Modern epoch).

Secondly, once the metaphysical distinction between ontology and theology is made, it is possible to gather a people under a theological entity that has precisely the kinds of features that Latour describes, and which also promise a secure, stable and certain ground for being in the world. We see immediately that the naturalist scientists in committing themselves to a conceptualisation of Nature as external, unified, inanimate and indisputable are setting up true Nature in contrast with the internal, multiple, animated and controversial aspects of scientific thinking and practices. The latter features, which give us access to the ontology of science, are for the naturalist scientist, insufficiently stable or objective enough to provide the basis for certainty in securing knowledge of the world. The externality and unification of Nature here is synonymous with what is expected of an entity that is supposed to secure the meaning of being and truth, namely, the characteristics captured by Wrathall's second and third theses (the Independence and Uniformity theses, respectively). On the other hand, the Stability thesis here reflects the metaphysical tendency that necessitates the ontotheological bifurcation in the first place. Likewise, the remaining three theses (Conformity, Adjustment and Cognitivist) refer to aspects of our attitude towards the truth – what Wrathall calls the “attitudinal dimension” (Wrathall, 2011, p. 220 ff) of metaphysics.

Finally, what Latour shows is that conceptions of Nature as external, unified, inanimate and indisputable have counterparts that are evident in the practices of science – we could say in a phenomenological reading of science. But more importantly for Latour, what is required is more than a mere acknowledgment by scientists of this other side. For Latour both sides need to be accommodated in a necessary tension – the kind of tension that is not resolved, or overcome, but lived with. I take his call for scientists to carry on with this necessary tension as a call to reject metaphysical bifurcation or a search for an absolutely grounding essence or entity.

III Bronowski: Beyond Metaphysics?

To summarise, the task of finding in Bronowski's philosophy of science a candidate for a post-metaphysical re-conception of science education, involves firstly determining whether his work rejects the dualisms characteristic of metaphysics; and secondly, determining the degree to which his views allow 'science' to accommodate the necessary tensions between: exteriority and interiority; independence and dependence; under-animation and animation; and indisputability and controversy.

The Dualism of Magic

It would have been easy for a scientist of Bronowski's reputation to have simply rejected magic on the grounds that it was purely metaphysical or superstitious, in that way that say his contemporary Carl Sagan did. Bronowski instead chose to carefully articulate what he meant by magic so that his criticism would fall not on its surface, but go to the very philosophical core of it. And fortunately for us, his

elaboration allows us to disentangle the pieces that make up the whole of his thought on the trouble with dualism.

No paraphrasing could better express Bronowski's view than his own definition of magic:

“My definition of magic is very simple. It is the view that there is a logic of everyday life, but there is also a logic of another world. And that other logic works in a different way and if you can only find a secret key, if you can enter into some magical practice – particularly if you can find the right form of words – then either the Almighty will be on your side, or you will collect all the votes, or people will believe because you call it peace, that it's not the same word as war, and all those other things which Orwell has portrayed so brilliantly but which really always come to the same thing: trying to command the world and particularly the opinions of other people by some formula which is other than the truth.” (Bronowski, 1978, pp. 11-12)

There is in this definition an emphatic rejection of the kinds of dualism that are characteristic of metaphysics – dualisms in which one aspect assumes the role of providing the final ground for the other. For Bronowski, magic is unworkable if it assumes that the “logic of everyday life” were somehow insufficient, that it somehow needed something or someone else to make it fully meaningful, to ground it, to stabilise it. It is remarkable that his conception of the “logic of another world” is not restricted to some supernatural being (“the Almighty”), but extends to any figure that supports an unquestioned belief in authority: “words”, “votes”, “people”, “a secret key”, or a “magical practice” can all be instruments that help maintain the metaphysical. The fact that Bronowski takes it that “the Cartesian division between mind and body...is a piece of old-fashioned magic which we had better forget” (Bronowski, 1978, p. 20) attests to the broad alignment between what he takes as magic and what Heidegger would refer to as metaphysics.

The final line of this quotation suggests that there is more to Bronowski's rejection of magic than its evocation of unnecessary dualisms and metaphysical entities. The concluding lines point to a critique of the relationship of power and control within the dualism: that the search for stability and security often serves the impulse to control or dominate – in short, a relationship in which one being(s) has absolute authority over the other(s). This critique matches in some ways with Heidegger's own outline of the Modern metaphysical epoch wherein the Cartesian subject has authority over the Cartesian object. However, what is clear from Heidegger's historical account of the epochs of being and truth is that the subject's control over objects is not the only way of being. Different metaphysical attunements to the world are possible; and the pre-Socratic, Philosophic Greek, Christian, Moderns, and Nietzschean-Technological epochs are five examples Heidegger gives to demonstrate the historical multiplicity of our understanding of truth and being (see Wrathall, 2011, p. 240 ff).

Bronowski's emphasis on the connection between magic and authority is no accident. For it allows him to distinguish between metaphysical systems in which the direction of authority shifts. This is certainly so with his distinction between Black magic and White magic. Black magic, according to Bronowski, is a commitment to a metaphysical dualism, yes, but one that would allow human beings with (often secret) access to “the logic of another world” to exercise authority over the processes or phenomena in Nature. White magic too preserves the human-Nature dualism, but instead reverse the direction of the authority. Rather than forcing the Nature to do something she would ordinarily not do, White magic requires of humans to come to understand the processes in nature in order to make use of Nature's hidden potential. While Bronowski sees the importance of the shift from Black to White magic in the historical development of science, he nonetheless rejects both views on the basis of the inherent dualism in all kinds of magic.

Exterior, Unified, Inanimate and Indisputable

Bronowski's rejection of dualism, whether expressed in terms of his critique of Black magic, White magic, Cartesian magic, or any other form of magic, provides a strong foundation for a post-metaphysical conception of science and science education. But how does Bronowski achieve the kind of integration of the traditional dualisms that Latour argues are in tension within the sciences?

Recall that Latour argues that the view of Nature as wholly independent of human affairs or influence is inconsistent with the way Nature is encountered in the practices of scientists. The examples Latour gives (the debates that go on between scientists in the laboratory, at conferences, or in the peer-reviewed literature, etc.) suggest a role for language, for discourse, in the construction of Nature "inside" science. If Nature is constructed, then it is constructed through, with and in language. But Latour also reminds us that Nature can be neither wholly "exterior" nor wholly "interior" to these language games. The atom cannot be split between the 'ontological' atom that surely exists in the journals and textbooks, and the 'essential' atom out in the real world of Nature – or as Bronowski would put it: there cannot be two logics of the atom.

Bronowski's approach to avoiding the exterior-interior dualism is to use language as the bridge that carries entities and concepts both ways across this "ontological difference" (to borrow a phrase from Heidegger). Bronowski admits to an objectification of the world, but it is not the kind of objectification inspired by the magic of Descartes. It is a kind of objectification of nature that emerges out of our place *within* Nature, as beings that are also subject to the laws of Nature – particularly the laws of evolution. As Bronowski puts it: "This objectification of the world is, in my view, a highly specific human property which is, in fact, *the linguistic property*" (Bronowski 1978, p. 48). So, in a kind of twist on the anthropic principle in cosmology, the evolution of language allows Nature to be objectified as language – and science is just one (albeit highly formalized) manifestation of language in human beings.

The role of evolution here might suggest a level of materialism or reductionism that for Bronowski is unwarranted. He does not conceive of an absolute (he might say magical) distinction between human beings and Nature.

"I do think the human brain, like every animal brain, has certain inbuilt limitations. But I do *not* think that our subsequent ways of seeing the world, and language in particular, are embedded structures. On the contrary, the philosophy that I am putting forward I would call a *constructivist* philosophy. I am saying that by this analytic point of view we make, we construct the laws of nature as we see them." (original italics; Bronowski 1978, p. 50)

The "construction" of which he speaks here is not the one-sided construction that is "interior" to the practices and discourse of science. Since Bronowski does not permit a separation of Nature into "exterior" and "interior" we may better take "construction" in his natural philosophy as a kind of self-Nature construction in harmony with the humans' reciprocal relationship with Nature. The construction may be thought to emerge from the human-Nature nexus in a way that bears a striking resemblance to the countenance of the pre-Socratic, pre-metaphysical world in which *phusis* and *poiesis* describe our relationship with being and truth.

Bronowski often describes science as the uncovering of "unity in variety" or the "search for unity in hidden likeness" (Bronowski, 1965). The search for laws of nature under which are unified a multiplicity of phenomena and process is certainly a significant part of the sciences. But the phrase "unity in variety" cannot be read independently of the preceding discussion about the role of human beings in the joint construction of Nature with humans as a part of Nature. Bronowski would not deny the possibility or actuality of constructing laws of Nature that unify phenomena, but he does not take

that unity as a process or reduction – a gradual move towards a complete and stable picture of the world:

“In the end the calculations owe their power to exactly this intellectual beauty. But what makes them beautiful? Their unity, the fact that we have a picture of the world. And when a picture of the world, when a set of axioms, can change as rapidly as it did in 1905, we all suddenly become extremely humble about the ultimacy of any scientific truth.” (Bronowski, 1978, p. 59)

Science cannot do away with the multiplicity that is generated with every experiment and every act of hypothesis. Science for Bronowski is not an exercise in problem solving, but rather the work of human beings operating with “unbounded plans” (Bronowski 1977/1985, p. 257). Every scientific act “multiplies the number of agents in the world” as Latour would put it. And what is clear from the second part of the quotation above is that there is enough multiplicity inherent in the work of science to allow for sudden shifts in our understanding of the world.

It is not just the unbounded plans of scientists that ensure enough multiplicity to disallow an absolute reduction of all entities to a single unifying law of Nature. For reason and experiment are not the only means of accessing knowledge of the world:

“Science is the organisation of our knowledge in such a way that it commands more of the hidden potential in nature...The first part of the definition summarizes in the word organisation the three-legged conjunction of reason, experiment and imagination. The second part of the definition states our belief that we progress by constantly uncovering more in nature than we knew to be there.” (Bronowski, 1968/1984, p. 266).

For Bronowski, imagination is crucial to science because it allows us to uncover and manipulate “more in nature than we knew to be there”. The imagination opens up possibilities and choices, and this in turn means that the creative scientist has to make a personal commitment to her interpretation of the results of reasoning or experimentation.

So, it is in this sense, perhaps, that the imagination allows for the animation of world in the way Latour conceives of it. The personal commitment to a choice out of a multiplicity of possibilities gives life and agency to particular features of the world over others. If the scientist were a mere inventor, a technician or even simply a discoverer the world could not be as animated as through the creative, imaginative action of the scientist. Science is creative because it is personal.

It is worthwhile drawing here a connection between what Bronowski sees as the role of the imagination in science and his wholesale rejection of the metaphysical dualism that he calls magic. The scientific imagination gives rise to the proliferation of entities and agents in the world by virtue of expanding the ontology of science with the objects of imagination – with models, metaphors and of course images. Because, according to Bronowski, science is not an exercise in reduction, progress is made through the creative act of choice – an act that is always personal and never anonymous. The personal nature of this creative act, this commitment to one picture of the world amongst many, is an invitation to a community that would share in that picture (a picture that carries with it a tentative air of indisputability). Controversy arises from such personal commitments to truth because not all people see themselves as gathered by the same world picture. One shortcut to resolving the conflict is simply to search for a secure metaphysical ground, or indeed fashion one out of the world picture to which a scientist and her scientific colleagues are disciples. But this would mean scientists fall prey to the very perversion that Bronowski sees informing magic:

“Man masters nature not by force but by understanding. This is why science has succeeded where magic has failed. Truth is the drive at the centre of science. It must have the habit of truth, not as a dogma but as a process.” (Bronowski, 1958)

Truth here is not a ‘metaphysical truth’ that has the characteristics of the one-side indisputability that Latour describes. Truth here is, as Bronowski puts it, a “process” – a dynamic and ongoing attunement to truth. I would go so far as to speculate that Bronowski’s truth, if it genuinely avoids the absolutism and authoritarianism of dogma, comes closer Heidegger’s notion of truth as *aletheia* – as “un-concealment” – rather than any correspondence model of truth (Heidegger, 1971/1935-36, p. 36 ff) which requires something absolute against which the assessment of true correspondence can be made.

Bronowski’s Stratified Stability

So far, we have considered Bronowski’s natural philosophy in terms of the integration of the four features Latour took as characteristic of the kinds of (metaphysical) entities that gather a people, namely: exteriority, unity, under-animation and indisputability. With respect to these we find that Bronowski’s strong commitment to anti-dualism has meant that his conception of science does well to integrate these four features with their respective counterparts (interiority, multiplicity, animation and controversy). We could conclude then, that Bronowski could not easily be accused of an adhering to a view of the truth of Nature summarised in Wrathall’s Independence, Uniformity and Conformity theses, respectively.

And what should be said about the Adjustment and Cognitivist theses? Well, I think Bronowski would not reject either of these theses, but I think their metaphysical tone is much subdued by the role of the imagination in Bronowski’s thinking. Recalling his claim that the “organization” of science relies on “the three-legged conjunction of reason, experiment and imagination”; we see that a cognitive engagement is necessary but not sufficient for us to “organise” the world in the way that science does. If there is a reality to which we must adjust ourselves, then it is unlikely to be a reality that excludes the fruits of our imagination. Or to put it in Bronowski’s own terms: our adjustment to reality cannot be one that involves “bounded plans” (Bronowski, 1977/1985, p. 257): the kind of adjustment we might make for instance in solving a problem. So, we may certainly plan to adjust ourselves to ‘reality’, but only in an unbounded way.

The distinction between bounden and unbounded plans is essential to Bronowski’s understanding of evolution and particularly the question concerning the direction of evolution from less complex to more complex systems and phenomena, over time. Bronowski expresses the distinction thus:

“The distinction here is between a sequence of actions which is fixed in advance by the end state that it must reach, and a train of events which is open and unbounded to the future because its specific outcomes is not foreseen...the sequence of events that constitutes an unbounded plan is invented moment by moment from what has gone before, and the outcome is not solved but created.” (Bronowski, 1977/1985, p. 257)

Evolution, and hence the arrow of time defined by evolutionary progression, would not be possible if biological processes were moved along by such unbounded plans alone. Rather than proposing a mechanism but which nature is propelled from less complex to more complex states, Bronowski suggest that the arrow of evolution has “barbs” that stop it going backwards. The “barbs” occur in nature as stable states – states that require energy to reach, but once reached provide simple and stable elements from which more complex entities and phenomena may be built. Once a stratum is reached, the elemental building blocks of that stratum are stable enough to serve as the raw material for Natures

unbound plan. Such a view of evolution couples the stability we find in nature with the indeterminacy of nature's unbounded plans.

Once again it appears that Bronowski has escaped the metaphysical straight-jacket by avoiding the pernicious elements of the Stability thesis by distributing the stability across energetic, temporal and material strata while simultaneously coupling these strata to a process that is essentially unbounded, and therefore grossly ineffective as a way of guaranteeing absolute stability – the kind of stability a good old-fashioned metaphysics would seek.

But there are two aspects of stratified stability that potentially keep Bronowski tethered to the metaphysical realm. The first is a purely analytic one. When encountered by scientists with the wrong (metaphysical) sort of attitude, the world appears to be full of stable structures (macromolecules, cells, crystals, etc) that can be accounted for by laws of nature. But likewise, scientist may encounter nature at a meta-level at which evolution (biological, chemical, physical, social) is completely unbounded. The correct attitude is a coupling of the two; but this attitude necessarily assigns a preferred direction to time: that is, it allows us the possibility of determining the direction of time by comparing the level of complexity at any two epochs. The arrow of time (the direction of time or complexity) then becomes something that we can take as stable. So, Bronowski's view may yet commit us to a metaphysical assumption with respect to temporality and complexity.

The second metaphysical tendency stratified stability introduces concerns the arrow of progress. We could take the question concerning progress as parasitic on the question concerning the metaphysics of time, in which case it is perhaps the less significant of the two questions. However, the question of progress is crucial to our evaluation of Bronowski's work precisely because of Bronowski's strong philosophical commitment to Humanism. There is, in his brand of humanism a privileging of human progress: the kind of progress that has resulted from both biological and cultural evolution.

Recalling Bronowski rejection of the Nature-human dualism as a kind of magic, it may be that the arrow of time in his work is meant to function as the means of unifying humans with Nature, say in the spirit of Heidegger's project in *Being and Time* in which temporality offers the possibility of overcoming metaphysics while acknowledging the place of Dasein in the disclosure of being.

I admit to not having an adequate response to the questions of temporality and progress here; suffice to say that these questions are vital to education because education too has the characteristics of a process that has a particular direction in time. And this recognition of the importance of the temporal in education is evident also in Bronowski's thinking:

“The duty that now falls on intellectuals is a great and quite novel educational task: to show people that personal satisfaction does *not* lie in aping the satisfaction of others ... What gives satisfaction then has to do *in the long run*: not in the day-to-day of appetite, which [...] will not do as goal, but in a policy to live be—to be a person by.” (Bronowski, 1972/1985, p. 273)

Despite Bronowski's quite strident and explicit championing of humanism, I think a post-metaphysical reading of his work reveals an influence of the temporal (the arrow of time) that is, perhaps, more closely aligned with existentialism.

“The question on which morality turns in an age of potential plenty is, What shall *I* be? It is indeed the question on the lips of every protester in the new Reformation. But it has to be a question cast all the way into the future: What shall *I* become, by virtue of what I do now, *to myself*. It is in this sense that all nature becomes one, and that we cannot afford to dishonour

any part of the creation: because separation there, a shrugging of the shoulders at greed or cruelty or vulgarity, is a permanent mark on one's own personality." (Bronowski, 1972/1985, p. 273)

The resonance with Nietzsche's appropriation of Pindar's "Become such as you are" is unmistakable.

IV Conclusion

The claim that science education is better served by a conception of science that moves beyond metaphysical assumptions or prejudices is moot without a plausible candidate for such a post-metaphysical rendering of science. This paper has taken Jacob Bronowski's natural philosophy as just such a candidate and subjected it to an evaluation of its 'metaphysicality'.

The paper drew upon a Bruno Latour's framework for describing the attributes of Nature as the entity that gathers scientists. The dualities that Latour argues give rise to tensions in scientists' encounters with Nature, echo the bifurcation that Thomson sees as definitive of Heidegger's ontotheological re-description of metaphysics. Moreover, the theological aspects of metaphysics as ontotheology are well captured by Wrathall's six theses concerning the metaphysics of truth in Nietzsche. Together, Latour's, Thomson's and Wrathall's characterization of metaphysics served as a suitable framework against which to evaluate the metaphysical aspects of Bronowski's work.

The evaluation of Bronowski's work revealed that his strong anti-dualist stance towards science makes possible an integration of the dual aspects that Latour describes, namely: exterior-interior; unified-multiple; under-animated-animated and indisputable-controversial. Furthermore, Bronowski's emphasis on the role of the scientific imagination softens any charge of strict adherence to Wrathall's six theses. However, Bronowski's notion of stratified stability, in combination with his humanism, leaves open the question of whether progress (particularly human progress) and the arrow of time makes his view of science metaphysical.

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